Handbook WSE 2014 - 2016

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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 programme specialisations which are offered solely in Delft are conducted over a period of 18 months during two academic years. The general planning structure is shown in the *Academic Calendar*.

In the first year, the calendar is divided into 14 periods of three weeks, in which the components of the curriculum are presented as modules. After each second module, a separate week is reserved during which the examinations for the two modules take place. The first six months of the second year are reserved for completion of the MSc thesis research work.

Within each programme, the following generic components are distinguished:

- ten taught modules of 5 credit points each;
- fieldtrips and groupwork, total 10 credit points;
- a special/research topics module of 3 credit points;
- the thesis proposal preparation of 7 credit points;
- the thesis research and examination, 36 credit points.

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 Learning Objectives

Each programme specialisation has a set of learning objectives that state the knowledge, insight and skills achieved by students who successfully complete the programme. A distinction is made between discipline-specific learning objectives, which are required by the field of study, and general academic skills, which are expected from university education graduates. The programme objectives for each specialisation are provided in the programme-specific part of the handbook.

Similarly, each component 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 usually aim to achieve a further detailed subset of the overall learning objectives.

2.6 Working 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 for a specific component of the programme, and ultimately those of the programme itself. The examination for a component 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 component of the programme will be granted the credit points for that component. 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 focusing 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 Exam regulations

Click here for the separate document:

See 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

Plagiarism is classified as a serious act of fraud in the examination regulations of UNESCO-IHE and is among the most egregious forms of academic misconduct. Any participant found by the Examination Board to have plagiarized will be given a failing mark on the plagiarized assignment (including theses).

In order to better understand what constitutes plagiarism and how to avoid it, you are directed to the following online resources.

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 tutor to view. Where any direct quotations are relevant and appropriately referenced, the course tutor will be able to see this and will continue to consider the next highlighted case.

New text about plagiarism will follow…

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

Harvard Guide to using sources

- http://isites.harvard.edu/icb/icb.do?keyword=k70847&pageid=icb.page357682

Purdue University Writing Lab

- http://owl.english.purdue.edu/

University of Princeton Academic Integrity Site

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

  http://www.princeton.edu/pr/pub/integrity/pages/intro/index.htm

University of Teesside Plagiarism Guidance

- http://dissc.tees.ac.uk/Plagiarism/Plag-4.htm

4 WSE Programme

4.1 Introduction WSE programme

Welcome to the Water Science and Engineering Programme at UNESCO-IHE. This document will give you information about the course that you will be following such as the timetable, list of subjects to be studied and assessment methods.

The programme covers a wide range of subjects and I hope you find it stimulating. The staff in the programme is dedicated to providing you with an excellent learning environment, but do remember that it is you who has to provide the motivation and hard work. We hope you will find the course interesting and rewarding. We wish you every success!

4. 2 Brief Description of the Programme

- The master programme in Water Science and Engineering is designed to provide specialised education and training at post-initial master level in important aspects of water, its use and conservation. The programme is mainly intended for professionals, notably drawn from developing countries and countries in transition, dealing with water-related problems and activities, such as:
- The assessment of water needs and water availability;
- The understanding of the relevant hydrological, hydraulic, morphological and environmental processes and phenomena;
- The modelling and data management related to such processes and phenomena that give support to this understanding.
- The integration of monitoring, modelling and information systems to support safe and reliable decision making;
- The identification and characterisation of water-related problems and their impacts on society, the economy and the environment;
- The 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; and
- The evolution and mitigation of impacts on society, the economy and the environment.

The programme incorporates five specializations:

1. Hydrology and Water Resources (HWR)
2. Hydroinformatics (HI)
3. Hydraulic Engineering and River Basin Development (HERBD)
4. Hydraulic Engineering – Coastal Engineering and Port Development (HECEPD)
5. Hydraulic Engineering – Land and Water Development (HELWD)

The overall emphasis of the programme is on sciences, engineering and technology placed in a contemporary context of society, economy and environment. All five specializations are structured in a sequential build-up of educational components, which allow some interchange of topics and other educational activities between groups of students. The programme provides an excellent opportunity for students – although devoted to their selected specialization – to interact with colleagues of other specialities and to share information and learning activities in a multi-disciplinary 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 inter-specialization thinking and development.

The WSE programme is designed to stimulate active learning, or *learning by doing,* within a framework of *incremental learning*. Each module therefore comprises a carefully chosen balance of formal lectures, supervised and unsupervised workshops, case studies, field trips, individual studies etc. and self-study by the student, that establish a foundation for addressing scientific and practical problems in the later stages of the programme. The knowledge and abilities of participants are thereby gradually developed such that both disciplinary knowledge and insight in problem analysis and problem solving, and general academic skills can be deployed to good effect in subsequent groupwork and thesis studies. The latter provide a vehicle through which integration of the programme material is achieved.

4.3 Programme Structure

The course has a modular structure with teaching organised into three-week blocks. After two blocks there is a week for examinations. This structure is generally reflected in the Academic Calender in the beginning of this Handbook.

The Water Science and Engineering Programme is composed of different types of modules:

- Common modules, in which all specializations take part together;
- Specialization modules, dealing with the core subjects of the specialization; and
- Elective modules, which can be chosen by the student (after consultation of the specialization professor or co-ordinator)

The structure of the WSE-programme can in short be represented as follows:

- two common modules, treating basic knowledge of importance to all 5 WSE specializations;
- five specialization modules;
- three elective modules, with several options, open to all WSE specializations;
- two common modules in which the WSE specializations join in field trips, field work and a common study project:
- the last two two common modules (institute-wide) form the transition to the MSc research period: Research Methodologies course, summer courses and MSc thesis proposal development.

After approval of the MSc thesis proposal, the student will conduct the MSc Thesis Research (module 15), for 6 months, including report writing.

Most modules will be evaluated. Evaluation can take place in the form of exercises, tests and/or examinations (written or oral), and are all compulsory. Generally tests and examinations are scheduled in the examination week at the end of a 2-module block. When and how a subject is evaluated will be announced during the progress of the course. Every module will finally result in one weighted module mark. Some modules will result in a registration " passed" when they have been fully attended by the student. A module resulting in a mark 6 or above or " passed" will add five ECTS credits to the students account.

During the year a number of fieldtrips are organised, besides the fieldtrip abroad. For all fieldtrips credit points are obtained, therefore fieldtrips are compulsory.

Also a number of events are organised, for which no credit points will be given, e.g. MSc presentations and research seminars. However, it is strongly recommended that the students attend these events.

In the next section the overview of the WSE-programme is given, followed by a description of the specialization goals and activities

In the later sections detailed descriptions of all modules of the WSE programme can be found.

4.4 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. For some topics students can, according to their preference, focus on either surface water hydrology (modules 7A, 10A), or groundwater hydrology (modules 7B, 10B).

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 13 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.

4.5 Learning objectives HWR

Hydrology and Water Resources

Upon completion of the Hydrology and Water Resources specialization, the graduates will be able to:

a. explain 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 the natural and human-induced variability in space and time of hydrological systems;

b. 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;

c. implement 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;

d. 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;

e. design and conduct hydrological research and experiments for both application and scientific purposes, either independently or within a team-based framework;

f. describe and discuss the importance of hydrology to society and the relationship of hydrology with related disciplines such as ecology, meteorology and climatology.

Relation between learning objectives and programme components

Relation between learning objectives and programme components

	a	b	c	d	e	f
1. Introduction to water science and engineering	■	■	▒			▒
2. Hydraulics and hydrology	■	■	▒			▒
3. Earth Sciences	■	■	▒			▒
4. Hydrogeology	■	■	▒			▒
5. Surface hydrology	■	■	▒			▒
6. Water Quality		■	■	▒		
7. Data collection / Groundwater exploration and monitoring		■	■	▒		
8. Tracer hydrology and flow system analysis		■	■	■		
9. Fieldwork / fieldtrip			■	■	▒	■
10. Hydrological modelling / Groundwater modelling			■	■		
11. Water resources management			■	■		■
12. Groupwork				■		
13. Summer courses					▒	
14. MSc proposal preparation					■	
15. MSc research				■	■	■

Key: Black-objectives of primary focus; Grey -objectives of secondary focus.

4.6 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):

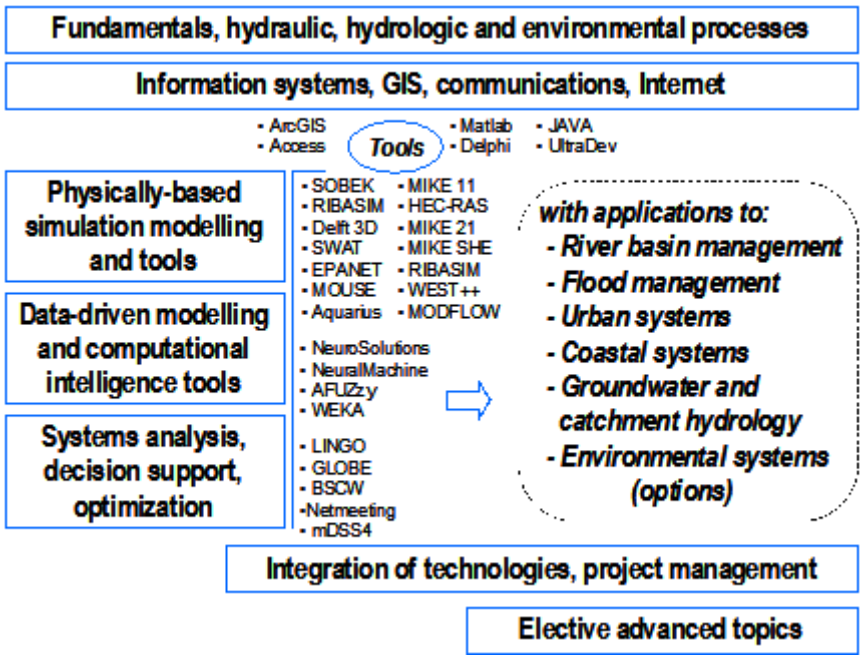

Figure 1: The general thematic structure of the Hydroinformatics specialization

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 presented in this handbook is valid for Block 2, at UNESCO-IHE.

4. 7 Learning objectives HI

Hydro informatics - Modelling and Information Systems for Water Management

Upon completion of this specialization, the graduates will be able to:

a. explain the information cycle in relation to the management of water based systems and the flow of information from data acquisition to modelling, to support for decision making;

b. explain 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;

c. implement the theory and practice of different modelling paradigms, and, in particular, physically based and data driven modelling, and to integrate them in hydroinformatics systems applied to a wide variety of hydraulic, hydrological and environmental situations;

d. explain advanced and appropriate information and communication technologies and their application to manage information relating to water management;

e. select and apply proprietary and public domain software tools and critically assess their advantages and disadvantages in application to water resources management, hazard risk assessment and forecasting, environmental planning and asset management;

f. explain the importance of the relationship of Hydroinformatics with related disciplines such as hydraulics, hydrology, ecology and information science;

g. 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;

h. provide considered advice to managers and users of advanced Hydroinformatics tools.

Relation between learning objectives and programme components

	Module titles	a	b	c	d	e	f	g	h
1	Introduction to water science and engineering				■				
2	Hydraulics and hydrology	■	■	■			■		
3	Information technology and software engineering	■	■	■	■	■	■		
4	Computational hydraulics & information systems	■	■	■	■	■	■		
5	Modelling theory and applications	■	■	■	■	■	■		
6	Computational intelligence and control systems	■	■	■	■	■	■		
7	River basin modelling	■	■	■	■	■	■		
8	Elective modules: • Introduction to river flood modelling • Urban flood modelling and disaster management • Environment and climate	■	■	■	■	■	■		
9	Fieldtrip			■	■		■		
10	Elective modules: • Flood risk management • Urban water systems modelling • Environmental systems modelling			■	■	■	■		
11	Hydroinformatics for decision support				■	■	■	■	
12	Groupwork				■	■	■	■	■
13	Summer courses				■	■	■	■	
14	MSc proposal preparation				■	■	■	■	■
15	MSc thesis				■	■	■	■	■

Key: Black-objectives of primary focus; Grey -objectives of secondary focus.

4.8 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.

4.9 Learning objectives HERBD

Hydraulic Engineering and River Basin Development

Upon completion of the Hydraulic Engineering and River Basin Development specialization, the graduates will be able to:

a. explain 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;

b. implement the major hydraulic methodologies and applications for river structures and river modelling techniques with regard to techniques for data collection, processing and analysis;

c. 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;

d. design and conduct hydraulic research, experiments and tests for both practical and scientific purposes, either independently or within a team-based framework;

e. develop and undertake critical evaluations of strategies for the implementation of river engineering works, by intelligent use of engineering and scientific principles;

f. apply and integrate relevant concepts and methodologies in the area of hydraulic and hydrological engineering and research as well as applying computational principles within the context of hydraulic engineering.

Relation between learning objectives and programme components

	a	b	c	d	e	f
1. Introduction to Water Science & Engineering	■	▒				
2. Hydraulics and Hydrology	■	■				
3. River Basin Processes and Dynamics	▒	■	■			■
4. River Basin Development		■	■	▒	■	
5. River Morphodynamics	■	■	■			
6. River Training and rehabilitation	■		▒	▒	■	■
7. River Structures	■	■		■	■	
8. Storage & Hydropower	■	■	■	■	■	
9. Fieldtrip & Fieldwork			■	■	■	
10. Flood Management and Design	■	■	■	▒	▒	
11. River Modelling		■		▒	▒	■
12. Group work			▒	■	■	▒
13. Selected Subjects & Research Methodologies				▒	▒	▒
14. MSc Thesis Proposal				▒	■	■
15. MSc Thesis Research		▒	▒	■	■	■

Key: Black-objectives of primary focus; Grey -objectives of secondary focus.

4.10 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.*

4.11 Learning objectives HECPD

Specialization: Hydraulic Engineering-Coastal Engineering and Port Development

Upon completion of the Hydraulic Engineering-Coastal Engineering and Port Development

specialization, the graduates will be able to:

a. explain hydraulic and morphologic coastal processes and nautical and logistic aspects as well as their interactions with nearshore and offshore structures;

b. apply state-of-the-art coastal engineering design techniques to advance the needs of society for infrastructure and a safe environment;

c. evaluate and implement coastal engineering solutions in a multidisciplinary and interdisciplinary environment;

d. develop strategies to cope effectively with problems related to natural coastal hazards (e.g. flooding, oil spill) and shoreline erosion problems incorporating the tension between anthropogenic coastal developments and natural coastal processes;

e. apply hydraulic, nautical, logistic and economic theories in the planning and design of coastal and ports layout and port logistics;

Relation between learning objectives and programme components

	a	b	c	d	e
1. Introduction Water Science & Engineering			■		
2. Hydraulics and Hydrology	■			▒	
3. Introduction to coastal engineering	■	▒			
4. Coastal Systems	▒		▒	■	
5. Coastal and Port Structures I	■	■		▒	
6. Coastal and Port Structures II	■	■		▒	
7. Management of Coasts and Ports I		▒	▒	■	■
8. Management of Coasts and Ports II		▒	▒	■	■
9. Field work and fieldtrip			■		
10. Geotechnical Engineering and Dredging		▒	■	■	
11. Flood Protection in Lowland Areas		▒	■	■	
12. Groupwork		▒	■	▒	▒
13 Summer Courses		■	▒		
14. MSc Research Proposal	▒	▒	▒	▒	▒
15.MSc Thesis	▒	▒	▒	▒	▒

Key: Black-objectives of primary focus; Grey -objectives of secondary focus.

4.12 Hydraulic Engineering – Land and Water Development

Academic domain and normative activities

Central to the educational and research domain of the Hydraulic Engineering - Land and Water Development (HELWD) specialization of the Mater 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 which can help address 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 HELWD specialization 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 HELWD Maters 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 HELWD Masters Programme courses and research works integrate:

· technology and management capacity;

· technology and environment (physical, social, economic, institutional, and environmental);

· agricultural and civil engineering aspects of development and management.

Course content and description

The HELWD Masters Specialization consists of a total of 15 modules - each module has a duration of three weeks. These are categorized as:

· three common WSE modules (modules 1, 2 and 12);

· five specialization specific modules (modules 3 to 7);

· three elective WSE modules (modules 8, 10 and 11);

· three Institute-wide modules (modules 13, 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 specializations; and a one-week field work, which is specialization specific.

The specialization 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 : *Water Management Systems and Agronomy I*: introduces applied hydraulics of irrigation and drainage systems, soil-water-crop yield relationships, water saving techniques, and water and drainage requirements, leading to the selection of appropriate irrigation and drainage methods and the design of an irrigation and drainage network at a tertiary unit (on-farm) level.

Module 5 : *Water Management Systems and Agronomy II:* gives participants a comprehensive understanding of applied hydraulics in irrigation and drainage systems, water-crop yield relationships, management options under land or water scarcity and water saving techniques, and the ability to estimate crop water requirements and devise complex irrigation schedules matching water demand and supply.

Module 6 : *Aspects of Irrigation and Drainage*: covers technical, economic, and sociological aspects of flow control and drainage, the selection of suitable systems and the economic feasibility of land development projects.

Module 7 : *Service Oriented Management of Irrigation Systems*: demonstrates how to formulate objectives for irrigation, design water delivery systems, draw up a service agreement and an action plan for implementation, and design irrigation monitoring and evaluation mechanisms.

Module 9 (*Field Work Part)*: this one-week practical course focuses on various types of flow measuring equipment, methods and techniques, pumps and pipes, field canals, irrigation methods and soil characteristics.

These specialization 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.

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: Conveyance Systems.

· Module 10: Irrigation and Drainage Structures.

· Module 11: Advanced Methods and Equipment

The international field trip (Module 9) familiarizes the participants with various layout, design and management of irrigation, drainage and other hydraulic systems in different parts of Europe. In module 12, 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 specialization participants.

After successful completion of the above common, specialization specific and elective modules as well as modules 9 and 12 (Group work), the participants undertake individual MSc thesis research for 6 months during modules 14 and 15.

The MSc thesis research 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 MSc theses, the participants follow Module 13 when 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 HELWD specialization 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 HELWD Specialization:

· hydraulic structures and hydraulic systems:

o *Hydraulic Performance Evaluation and Modernization of Irrigation and Drainage Systems:* Research focussed on various technical approaches and methods for analysing the performance of irrigation and drainage systems and optimizing crop, land and water productivities as well as the development of improvised approaches and techniques for modernizing irrigation and drainage systems;

o *Sediment Transport in Irrigation Canals.* Research focussed on the analysis of sediment movement in irrigation canals under different conditions and operation rules;

· environmental impacts of hydraulic works:

o *Water Saving in Irrigation.* Irrigation is the major water user in the world (80% in the emerging and least developed countries). Research is focussed on improvements in water use in irrigation in light of prevention of environmental degradation;

o *Interaction between Irrigation, Drainage and Sustainable Development.* Research on sustainable exploitation of water resources (surface water and groundwater);

· institutional and socio-economic aspects of system management:

o *Performance Analysis and Accountability Mechanisms.* Research on institutional and socio-economic aspects of irrigation and drainage system management;

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

· integrated lowland development and management:

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

o *Land and Water Management in Tidal Lowlands.* Long lasting research cooperation with various Dutch and Indonesian institutions with a focus on integrated development of tidal lowlands in Indonesia.

4.13 Learning objectives HELWD

Hydraulic Engineering-Land and Water Development

Upon successful completion of the Hydraulic Engineering - Land and Water Development Specialization, the graduates will be able to:

a. explain the latest concepts and theories of irrigation, drainage, flood protection, land reclamation and consolidation technologies for sustainable development;

b. explain the cross-sectoral linkages comprehending wider aspects of society, economy and the environment;

c. apply the latest hydraulic engineering and hydrological methods in planning, design and implementation of irrigation, drainage and flood protection schemes, independently or in a multidisciplinary team;

d. identify and cross-evaluate alternative land and water development options for areas under different land uses and assess their technical, economical, and environmental feasibility;

e. engage in or advise developers, system managers and water users on the participatory development and management of irrigation, drainage and flood protection schemes for their planning, design, implementation, operation and maintenance, financing and performance assessment;

f. acquire knowledge and understanding of contemporary research issues in the field of land and water development.

Relation between learning objectives and programme components

	a	b	C	d	e
1. Introduction Water Science and Engineering	■	■			
2. Hydraulics and Hydrology	■	■	■	▒	
3. Introduction to Land and Water Development	■	■	■	▒	
4. Water Management Systems and Agronomy I			■	▒	
5. Water Management Systems and Agronomy II			■	■	
6. Aspects of Irrigation and Drainage			■	■	
7. Service Oriented Management of Irrigation Systems			■	■	■
8. Conveyance Systems			■	■	■
9. Fieldwork/fieldtrip			■	■	■
10. Irrigation and Drainage Structures			■	■	■
11. Advanced Methods and Equipment			■	■	■
12. Group work				■	■
13. Research Methodology and Selected Summer courses					■
14. MSc Research Proposal					
15. MSc Research, Thesis Writing					

Key: Black-objectives of primary focus; Grey -objectives of secondary focus

4.14 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	
Poonam Taneja	MSc reserach co-ordinator
Mick van der Wegen	

Hydraulic Engineering - Land and Water Development

Charlotte de Fraiture	Head of Chair Group
Sur Suryadi	Specialization co-ordinator
László Hayde	
Abraham Mehari Haile	

Flood Resilience

Chris Zevenbergen	Head of Chair Group
Berry Gersonius	
Assela Pathirana	
Programme co-ordinator	Jan-Willem Foppen

5 Facilities

5.1 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

5.2 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.

5.3 Student Association Board

The Student Association Board (SAB) is composed of representatives who are elected by the students in annual elections that take place some four 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. The board also publishes its own magazine *The Informer*, in which the rich variety of contributions are entirely derived from, and produced by, the student community.

5.4 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 educational programmes. All participants will get a free UNESCO-IHE web-based e-mail box. 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.

5.5 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. Last-minute changes in schedules are indicated on the announcement board near the entrance. Two monitor screens opposite the reception desk are regularly updated with news or information on events taking place at UNESCO-IHE.

Private telephone calls can be made from card-operated phone booths located next to the reception desk. Photocopy services are available to students. There is also a facility to recharge chip-cards, which students receive from the bank to pay for small purchases without using cash. Furthermore, the building contains a meditation room, which is located on the third floor.

The restaurant provides a wide variety of reasonable-priced multicultural meals and beverages during lunchtime. The meals can be paid using the chip-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. The library, computer facilities and laboratory are described in detail below.

5.6 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.

From July 2011 until December 2011, the Library spaces are being renovated. Most of the printed collections and the reference desk have been relocated to A2 a/b on the first floor and

on account of missing the reading room, the opening hours have been changed to Monday-Friday 09-15-17.30

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

5.7 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.

5.8 Study Materials

Study materials such as textbooks, lecture notes and hand-outs are provided by the Institute. Students receive the lecture notes in their personal locker before the start of the involved lecture series. Additional material can be provided by the lecturers in the form of hand-outs. Reference works are available from the Institute library or the library of the Delft University of Technology (see above).

A number of supporting materials, such as for example PowerPoint presentations or exercise materials used by the lecturers, can be accessed or downloaded from the electronic repository. Students can login to the electronic repository from any location via the Internet web page located at http://km.ihe.nl.

Students are expected to provide other materials, such as stationary, electronic calculators and language dictionaries on their own account.

5.9 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.

Delft, October 2014

UNESCO-IHE
Institute for Water Education

Education and Examination Regulations for cohort 2014– 2016

For the Master Programmes in:

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

and
the short and online courses which are part of these programmes

Approved by the Academic Board of UNESCO-IHE, 25092014

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1 General Information

Article 1 Scope of the regulations

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

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

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 specialisations of the master programmes mentioned under art 1.1 and 3.1, separate examination regulations apply as these lead to a joint Master degree issued jointly by the UNESCO-IHE and the partner institutes:

- 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. 3.1) 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.

Article 2 Definition of terms

2.1 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*);
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;
Double (multiple) degree programme:	a master programme leading to multiple degrees;
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 board:	the committee as stipulated in article 7.12 of the Act;
Fraud:	a deception deliberately practiced in order to secure unfair or unlawful gain;

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 sheet:	a document describing a.o. the learning objectives, content, didactic methods and assessments. Modules sheets are part of the programme handbook;
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 non-degree 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 assessment:	the formal evaluation of the student performance before graduation (in the Act: *examen*);
Module assessment:	an examination consisting of a number of different parts (e.g. assignments, written or oral exams, presentations);
Examination:	an assessment for a part of the module;
Programme handbook:	a reference document for a specific programme containing generic and programme specific information, that students need to know throughout their programme;
Rector:	the rector of the Institute;
Short course:	a module offered as a face-to face non-degree course;
Student:	a person who is registered in a study programme and sits examinations;
Supervisor:	professor responsible for the work of student during the MSc thesis research phase.

Article 3 Master Programme and specialisations

3.1 The programmes are Master of Science programmes with the following specialisations:

1. Urban Water and Sanitation programme:

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

2. Environmental Science programme:

Specialisation	Location	Type of degree
1. Environmental Science and Technology	UNESCO-IHE	UNESCO-IHE degree
	UNESCO-IHE and 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 and BOKU - University of Natural Resources and Life Sciences, Vienna, Austria andEgerton University, Egerton, Kenya	Joint degree
5. Environmental Technology for Sustainable Development	UNESCO-IHE and Asian Institute of Technology, Thailand	Joint degree
6. Environmental Technology and Engineering (Erasmus Mundus programme)	UNESCO-IHE and Ghent University, Belgium, and ICTP, Prague, Czech Republic	Joint degree

3. Water Management programme:

Specialisation	Location	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	Location	Type of degree
1. Hydrology and Water Resources	UNESCO-IHE	UNESCO-IHE degree
	UNESCO-IHE and Hohai University, China P.R.	UNESCO-IHE degree
2. Hydraulic Engineering - River Basin Development	UNESCO-IHE	UNESCO-IHE degree
	UNESCO-IHE and Sriwijaija University, Palembang, Indonesia	Double degree
3. Coastal Engineering and Port Development	UNESCO-IHE	UNESCO-IHE degree
	UNESCO-IHE and Hohai University, China P.R.	UNESCO-IHE degree
	UNESCO-IHE and Sriwijaija University, Palembang, Indonesia	Double degree
4. Land and Water development	UNESCO-IHE	UNESCO-IHE degree
	UNESCO-IHE and Sriwijaija University, Palembang, Indonesia	Double degree
	UNESCO-IHE and Asian Institute of Technology Thailand	Double degree
	UNESCO-IHE and University of Nebraska -Lincoln, USA	Double degree
5. Hydroinformatics- Modelling and information systems for water management	UNESCO-IHE	UNESCO-IHE degree
	UNESCO-IHE and Hohai University, China P.R.;	UNESCO-IHE degree
	UNESCO-IHE and Universidad del Valle, Colombia	UNESCO-IHE degree
6. Ecohydrology (Erasmus Mundus programme);	UNESCO-IHE and University of Algarve, University of Lodz, University of Kiel, National University of La Plata	Multiple degree
7. Flood Risk Management (Erasmus Mundus programme).	UNESCO-IHE and Technische Universität Dresden, Universitat Politècnica de Catalunya - CIMNE, University of Ljubljana	Multiple degree

Article 4 Aim of the programmes and courses

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

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

4.3 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.

Article 5 Full-time/part-time

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

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

Article 6 Programme assessment

6.1 Students in the master programmes are eligible to sit the programme examination leading to the degree of Master of Science in the programme they are registered for.

6.2 The programme assessment is passed if all designated module assessments of the programme curriculum have been successfully completed as stipulated in article 7.10a, paragraph 1 of the Act.

6.3 Students of short courses or online courses are eligible to sit for the module assessment of the course they are registered for.

2 Content of the Programme

Article 7 Composition of the specialisations and joint specialisations

7.1 The composition of each programme specialisation is described in the programme handbooks of UNESCO-IHE and the partner institutes (in case of joint or double degree programmes)

7.2 The learning objectives of the modules, the content and assessment methods are described in the module descriptions of the handbooks.

Article 8 Participation

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

3 Examinations

Article 9 Quality assurance of examinations

9.1 An examination has to test whether a student has met the learning objectives.

9.2 Module coordinators are responsible for organising module assessments and for compiling the written examinations.

9.3 The programme committees are responsible for approving the student assessment methodologies as proposed by the module coordinators.

9.4 The Examination Board annually approves the planned examinations of the taught modules, and later deviations from that plan, as described in the module sheets and proposed by the programme committees.

9.5 All written examinations have to be peer reviewed, before being used.

9.6 The programme or specialisation coordinators are responsible for checking the module examination for clarity, completeness and consistency.

Article 10 Periods and frequency of examinations

10.1 Sequence of the module assessments will take place according to the order as described the programme handbook.

10.2 Students can sit each module assessment only two times per academic year.

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

10.4 Written and oral examinations for short and online course participants are held immediately at the end of the module. When a module is not immediately followed by an examination week, separate examinations will be drafted by the examiners for these participants.

10.5 In case of an oral and written examination for an online course, the student has to provide proof of identity to the examiner.

10.6 Students are not allowed to re-sit (constituent parts of) module assessments for which a pass has been obtained.

10.7 Written and oral re-examinations take place during the next examination period as indicated in the academic calendar. The students involved are notified sufficiently in advance by email about the date and time allocation for re-examinations. Non or misreading emails are no excuse for not participating in an re-examination. All students will take the re-sit of a written examination at the same time.

10.8 Students are not allowed to sit for further module assessments during the programme period they are registered for, if they failed three (3) different module re-examinations for the first 13 modules of the programme.

Article 11 The nature of the examinations

11.1 A module is assessed through (a combination of) written and/or oral examinations, assignments and presentations as described in the module descriptions of the programme handbook.

11.2 A written examination has to take place in a period of max. 3 hours during 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.

11.3 In case of a combination of an oral and written examination of a module during the examination week the maximum total duration of both examinations shall not exceed 3 hours.

11.4 Students have to be seated in the examination room 10 minutes before the examination is scheduled to start.
Misreading the date, time or room allocation will not be accepted as an excuse for absence from an examination or for arriving too late.

11.5 Examinations are carried out according to the guidelines described in annex C of these regulations.

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

11.7 Re-examination proceeds by re-examining one or more failed constituent module examination parts as described in the assessment part of the module sheet, as would be necessary to achieve a successful examination result.

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

11.9 MSc thesis proposal examination.
The MSc thesis proposal examination is an oral examination, organised during the week following module 14. The examination consists of a presentation of the proposal, and a discussion with the examining committee. The committee consists of the supervisor and the mentor of the student.

Article 12 Oral examinations

12.1 Oral examinations involve only one student at a time. During oral examinations, a second staff member has to be present as independent observer.

12.2 Oral examinations are non-public, unless stated otherwise in the module sheet.

Article 13 Exemptions and transfer of credit points

13.1 Exemptions to sit module assessments are generally not granted. In specific cases, the examination board may evaluate a request and conclude a decision on transfer of credit points, after receiving a favourable recommendation from the programme committee.

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

Article 14 Absence from examinations

14.1 Absence from an examination 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 a medical note stating the inability to participate; or
b. serious personal circumstances beyond control of the student which should be supported by written evidence as far as possible.

14.2 For cases in which the programme coordinator, in agreement with the chair of the examination board, decides that the absence is justified the student shall sit the examination as soon as is reasonably possible.

14.3 For cases in which the programme coordinator, in agreement with the chair of the examination board, decides that the absence is not justified the result 1.0 will be recorded.

Article 15 Fraud

15.1 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.

15.2 Plagiarism is a serious act of fraud.

15.3 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.

15.4 If the examination board, after investigation of the incident, concludes that there has been a case of fraud, the offender will be given the mark 1.0 for the examination work.

4 Results of Examinations

Article 16 Assessment and notice of examination results

16.1 Examination 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

16.2 Examination assessment results (including the thesis examination) obtained at partner institutes are represented according to the descriptions in annex D of these regulations.

16.3 The mark for a module assessment is determined by the weighted average of the results of the constituent parts. The weights for the constituent parts are stated in the module sheet. The minimum grade for each of the constituent parts should be 5.0.

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

16.5 The examiner shall assess a written examination or assignment within a period of 14 days after the date of the examination.

16.6 Examination results shall be collected, processed, recorded and notified to the students by the Education Bureau within a period of 21 days after submission of the examination work by the student.

16.7 The examiner shall determine the result of an oral examination shortly after the examination has been conducted.

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

16.9 For each examination, the student receives a written statement from the Education Bureau of the result obtained for the module assessment and, if successful, the associated credit points granted for that module.

16.10 The maximum recorded module mark after a successful re-sit is limited to 6.0.

Article 17 Period of validity

17.1 The result of a module assessment, when successful, is valid for an unlimited period of time.

17.2 Notwithstanding paragraph 1 of this article, the period of validity for which the examination board takes module assessment results into account for the programme assessment is four years.

Article 18 Right to inspection of assessments

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

18.2 Where a practical forms part of an examination, the work for that part may be returned to the students after the full assessment of the examination is completed.

18.3 Written examination work is kept in archive for a minimum of 6 years.

Article 19 Study progress and study advice

19.1 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.

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

5 Thesis Examination

Article 20 Organisation of thesis examination

20.1 The thesis will be assessed by a thesis examination committee, normally consisting of three (3) members: a professor as chairperson, the mentor and an external examiner. In special circumstances the committee may consist of more than three members. In case a PhD fellow, who is mentoring MSc students in his/her own research, is proposed as member of the committee, a fourth additional staff member is compulsory. External examiners are from outside the institute or in incidental cases from a chair group within the institute not involved in the supervision of the research work. In case of a double degree or joint degree programme, where the MSc research work is carried out under supervision of staff members of the partnering institutes, the examination committee may consist of more than three (3) members.

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

20.3 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.

20.4 Students can sit the thesis examination only if all other module assessments of the programme have been successfully completed.

20.5 When the outcome of the thesis examination, including the defence, was negative, the examination can be repeated once. The supervisor and mentor will detail the reasons for the failure in writing and clarify what is required to pass the exam. The student has to finalise the work without further supervision and 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.

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

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

20.8 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 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.

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

20.10 The maximum duration of the MSc research phase is 6 months for a full time study. In case of force majeure as supported by proving documents, extension of this period may be granted on request by the student and is subject to approval by the rector, upon advice from the Examination Board.

6 Assessment criteria, degrees and certificates

Article 21 Assessment of the programme

21.1 The student has fulfilled the requirements for the programme assessment if (s)he has:

SINGLE DEGREES:

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

JOINT DEGREES:

- For the joint degree Limnology and Wetland Management programme (LWM):
  - Successfully completed all module assessments 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 module assessments 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 module assessments taken at UNESCO-IHE, and
  - Has obtained a grade 'fair' or higher for his/her Master's thesis.

- 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 module assessments taken at UNESCO-IHE, and
  - Has obtained a grade 'fair' or higher for his/her Master's thesis.

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 module assessments taken at UNESCO-IHE, and
  - Has obtained a grade 'fair' or higher for his/her Master's thesis.

- 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 module assessments at UNESCO-IHE; and
  - Achieved a pass 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 module assessments at UNESCO-IHE; and
  - Achieved a pass for the thesis examination; and
  - Obtained a minimum of 118 ECTS.

- For the double degree programme in Land and Water development, conducted with Sriwijaija University:
  - Successfully completed all module assessments of the programme; and
  - Obtained a minimum of 106 ECTS.

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

DOUBLE / MULTIPLE DEGREES (Erasmus Mundus programmes):

- For the multiple degree programme on Flood Risk Management:
  - Successfully completed all assessments 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 multiple degree programme in Ecohydrology:
  - Successfully completed all assessments of the programme, according to the grading rules of the University of Lodz, University of Algarve, University of Kiel, University of La Plata and UNESCO-IHE; and
  - Obtained a minimum of 120 ECTS.

21.2 The student has fulfilled the requirements for the short or online course examination if he/she successfully completed the assessment of the course, i.e. the outcome of the assessment is a pass.

21.3 The student has successfully completed the programme examination or short / online course examination when the examination board takes a decision to that effect.

Article 22 Awarding of degrees and certificates

22.1 Master of Science degree.
Students who have successfully completed the programme assessment 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.

22.2 Certificate.
Students who have successfully completed the short or online course assessment will be awarded a Certificate. The Certificate is signed by the Rector of the Institute, the Course coordinator and the Academic Registrar. In addition to this Certificate the graduate receives a supplement stating the result achieved and credit points.

22.3 Students who fail to meet the master programme assessment 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.

22.4 If a student within 4 years after termination re-registers and meets (after examination(s)) the requirements of a MSc degree, he /she is obliged to return the certificate as mentioned under art 26.1.

22.5 Certificate of Graduate Study.
Students who fail to meet the programme examination 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.

22.6 With reference to art 26.1, if a student re-registers within 4 years with the aim to obtain a MSc degree, he has to redo in full all failed and missed modules and to take part in all examinations and re-examinations. Re-registration is only possible for the next academic period.

22.7 Certificate of Attendance.
Students who have successfully completed the short or online course without an assessment, 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 Rector of the Institute and the Course coordinator.

Article 23 Criteria for MSc degree with distinction

23.1 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 module assessments that are assessed on a numerical scale, conform article 2.1., and
- a recommendation of the chair of the examining 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 module assessments that are assessed on a numerical scale, conform article 2.1.
- and a recommendation of the chair of the examining 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 module assessments that are assessed on a numerical scale, conform article 2.1.
- and a recommendation from the professor responsible for the specialisation concerned.

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

7 Appeals

Article 24 Grounds for appeal

24.1 Students have the right to appeal against an examination assessment or an evaluation of the examination board within a period of ten working days after notification, if
   a. the performance of the student suffered through illness or other factors;
   b. a material administrative error in the conduct of an examination or assessment had occurred;
   c. the examination or evaluation was not conducted in accordance with the regulations; or
   d. some other material irregularity had occurred.
   e. a serious non-solved conflict has arisen between the supervisor and /or the mentor.

Article 25 Procedure for appeal

25.1 A student shall first attempt to resolve the problem through the programme coordinator, with the examiner, or the chairman of the examination committee.

25.2 If the student proceeds, the appeal shall be written in a letter stating the grounds for appeal and enclosing documentation as appropriate. The letter shall be addressed to the Rector.

25.3 The Rector shall accept or reject the appeal (after consultation with the examination board) and communicate the decision to the appellant via the Academic Registrar as soon as possible but usually within a period of ten working days.

8 Final Articles

Article 26 Amendments

26.1 Amendments to these regulations are made by separate decision of the Academic Board.

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

Article 27 Unforeseen situations

27.1 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 28 Publication

28.1 The Academic Board is responsible for the timely publication of the Education and Examination Regulations, and any amendments thereof.

Article 29 Period of application

29.1 These regulations take effect for the cohort 2014– 2016. Approved by the Academic Board of UNESCO-IHE on 25 September 2014.

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 Theory

1. Apply gained knowledge and skills in practice;

2. Understand and explain the role of sanitation in urban water cycle and its relation to public health and environment;

3. Develop rational approaches towards sustainable waste(water) management via pollution prevention, appropriate treatment, resources recovery and re-use on both centralized and decentralized level;

4. In-depth understand relevant physical, chemical and biological processes, and their mutual relationships within various sanitation components.

Methods, Techniques and Tools

5. Prepare conceptual engineering and process design of sanitation components;

6. Apply modern tools for technology selection and carry out modelling of sanitation components;

Analysis, Synthesis and Integration

7. Define and critically analyse, assess and evaluate various urban drainage and sewerage schemes, and wastewater, sludge and solid waste treatment process technologies;

8. 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;

Research

9. Identify, develop and conduct independent research including formulation of hypotheses selection and application of research methodologies, and the formulation of conclusions and recommendations;

10. Carry on desk studies, field work, and laboratory based research;

11. Contribute to the development of innovative approaches to the provision of adequate and sustainable sanitation services in developing countries and countries in transition;

General Academic Skills

12. Clearly communicate concerning both oral and written skills;

13. Continuously acquire knowledge and assimilate and implement innovative learning methods and skills in an independent manner;

14. 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 Theory

1. Have understanding of the structure of drinking water supply systems, including water transport, treatment and distribution;

2. Have understanding of water quality criteria and standards, and their relation to public health, environment and urban water cycle;

3. Have in-depth understanding of occurring physical, chemical and biological phenomena and their mutual relationships, within water supply systems;

4. Have understanding of water quality concepts and their effect on treatment process selection;

5. Have understanding of the interaction of water quality and materials applied;

6. Have understanding of hydraulic concepts and their relationship to water transport in treatment plants, pipelines and distribution networks;

Methods, Techniques and Tools

7. to design and to rehabilitate raw water abstraction, transport, treatment and distribution processes and systems;

8. Understand the importance and methods for operation and maintenance of water supply systems;

9. Understand options for centralised and urban systems versus decentralized and rural systems;

Analysis, Synthesis and Integration

10. define and evaluate project alternatives on basis of chosen selection criteria;

11. use statistical and modelling tools for simulating, prediction of performance and operation of water supply system components;

12. Understand water supply engineering within a watershed context

Research

13. conduct independent research, including formulation of hypotheses, selection and application of research methodologies, and the formulation of conclusions and recommendations;

General Academic Skills

14. Posses the learning skills to acquire continual knowledge in an independent manner;

15. communicate effectively in oral and written presentations to technical and non-technical audiences.

1.3 Urban Water Engineering and Management

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

Subject knowledge and skills

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. 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;

4. understand water infrastructure/asset planning, financing and management, and utility management;

5. familiarity with the concept of integrated water resources management (IWRM) and its application to a variety of water management problems at the urban catchment scale;

Core academic skills

6. identify, articulate, analyse and solve problems of the urban water cycle and systems, integrating theory and applications;

7. collect, summarise, analyse and interpret technical data/materials in a structured form to gain knowledge on urban water system design and operation and maintenance;

8. critically recognize and assess the need for continued-education and research on planning, design, maintenance and management of urban water systems;

9. have a working knowledge of 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;

Personal skills

10. Improved skills for independent learning;

11. enhanced reporting and presentation skills;

12. improved IT skills;

13. work independently or as part of a team;

14. manage time effectively.

2. Environmental Science Programme

2.1 Environmental Science & Technology

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

Knowledge & theory

1. demonstrate knowledge and understanding of the physical, chemical and biological processes of the environment, of the socio-economic concepts underlying the 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;

Methods, techniques & tools

5. 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;

6. apply general methods (including statistics and modelling) in scientific and technological approaches, concepts and interventions;

7. 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;

Analysis, synthesis & integration

8. 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;

Research/General academic skills

9. 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;

10. 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;

11. 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:

Knowledge & theory

1. to demonstrate knowledge and understanding of the physical, chemical and biological processes of the environment, of the socio-economic concepts underlying the functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources;

2. to describe the rationale for an integrated and interdisciplinary approach for the sustainable management of water and environmental resources;

3. to 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. to name and explain principles, concepts and instruments of major national and international water and environmental legislation and common and desired institutional and management arrangements;

Methods, techniques & tools

5. to design, optimise and interpret environmental monitoring and assessment schemes (including statistics and modelling) in order to gain an understanding of problems, trends, causes and effects;

6. to 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;

7. to 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;

8. to design and facilitate consultation- and decision-making processes between stakeholders, users and their representatives, water managers, politicians and other decision-makers;

Analysis, synthesis & integration

9. to critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural and legal contexts, and under often data-poor conditions;

10. to 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;

Research/General academic skills

11. to 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;

12. to communicate, debate and defend, clearly and systematically, findings and generated insights, and provide rational underpinning of these in oral and written presentations to a variety of audiences;

13. to 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;

14. to 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.

2.3 Water Quality Management

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

Knowledge & theory

1. demonstrate knowledge and understanding of the physical, chemical and biological processes of the environment, of the socio-economic concepts underlying the 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;

Methods, techniques & tools

5. 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;

6. interpret, design and optimise water quality monitoring and assessment schemes in the watershed;

7. apply experimental, statistical and modelling tools for interpreting and designing water quality management programmes;

Analysis, synthesis & integration

8. 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;

9. 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;

10. critically analyse and evaluate alternative water quality management programmes in the watershed under different socio-economic and legal contexts, often in data-poor conditions;

Research/General academic skills

11. 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;

12. 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;

13. 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 & theory

1. Be able to 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. Be able to 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. Be able to explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches.

4. Be able to describe different concepts to determine the value of water for various uses and users in (amongst others) economic and social terms and explain how these concepts can be used in water management at various spatial and temporal scales

Methods, techniques & tools

5. Be able to 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.

6. Be able to combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.

Analysis, synthesis & integration

7. Be able to critically evaluate technical and/or institutional water resources interventions (projects/ programmes/ policies/ agreements) through analysis of implications for the water system, its users and their interrelations at various spatial and temporal scales.

Research

8. Be able to 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.

General academic skills

9. Be able to clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.

10. Think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.

11. 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.

Two or more additional learning objectives will be added depending on the study profile of the student.

3.2 Water Resources Management

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

Knowledge & theory

1. Be able to 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. Be able to 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. Be able to explain the key concepts for integrated, multi-disciplinary and interdisciplinary analyses of water systems and describe the challenges of such approaches.

4. Be able to describe different concepts to determine the value of water for various uses and users in (amongst others) economic and social terms and explain how these concepts can be used in water resources planning at various spatial and temporal scales

Methods, techniques & tools

5. Be able to 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.

6. Be able to 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.

7. Be able to combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.

Analysis, synthesis & integration

8. Be able to define a given water resources system, and compose the water flows across time and space, including the various water uses, and describe the interdependencies these create between the various water users.

9. Be able to critically evaluate technical and/or institutional water resources interventions (projects/ programmes/ policies/ agreements) through analysis of implications for the water resources system, its users and their interrelations at various spatial and temporal scales.

Research

10. Be able to 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.

General academic skills

11. Be able to clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.

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 & theory

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.

Methods, techniques & tools

5. design and facilitate inclusive consultation and conflict management processes, such as consensus building, public participation, negotiation and mediation between actors at different levels.

6. 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.

7. do combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.

Analysis, synthesis & integration

8. define a given water resources system, assess the different functions of the water resources system and the often competing interests of water using sectors and actors, describe the interdependencies between these, and finally assess the possibilities and limitations of cooperation.

9. 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.

Research

10. 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.

General academic skills

11. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.

12. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.

13. 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 theory

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.

Methods, techniques and tools

5. interpret, design and optimize water quality assessment and monitoring programmes by applying experimental, statistical and modelling tools.

6. 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.

7. combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.

Analysis, synthesis and integration

8. 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.

9. 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.

Research

10. 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.

General academic skills

11. clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.

12. think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.

13. 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 theory

1. Be able to describe for a given water resources system the interplay between the main biophysical processes and social dynamics, in analyzing service delivery modalities.

2. Be able to 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. Be able to 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. Be able to 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).

Methods, techniques and tools

5. 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.

6. Be able to 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.

7. Be able to combine different types of method and through a process of triangulation synthesize outcomes in a coherent manner.

Analysis, synthesis and integration

8. Be able to analyze and evaluate governance processes and utility management arrangements in the water services sector, integrating technical, legal administrative, social and financial components.

9. Be able to critically evaluate technical and/or institutional interventions (projects/ programmes/ policies/ agreements) through analysis of implications for water supply and sanitation services, its users and their interrelations at various spatial and temporal scales.

Research

10. Be able to 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.

General academic skills

11. Be able to clearly and systematically communicate, argue and defend findings in oral and written presentations to a variety of audiences.

12. Think in multidisciplinary and integrated dimensions and be able to distinguish main issues from side issues.

13. 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:

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. 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;

4. 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;

5. have knowledge of contemporary research (questions) and relevant literature in the field of hydraulic engineering and river basin development;

6. critically judge and evaluate their own work and results, as well as the information of prior research or investigations;

7. adequately communicate methodologies, results, evaluations, conclusions and recommendations in written, oral and graphical form to a wide variety of audience;

8. 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;

9. 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;

10. have acquired sufficient skills in using information and communication technology for conducting studies and analyses, in addition to presentation and communication;

11. 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:

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. 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;

3. 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;

4. apply hydraulic and nautical, logistic and economic theories in the planning and design of coastal and ports layout and port logistics;

5. 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;

6. be equipped with various analytical and computational expertise necessary to solve problems in coastal and port engineering;

7. have the skills to undertake academic research that contributes to the better understanding of coastal and/or port engineering;

8. 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;

9. 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;

10. 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;

11. have experienced different aspects of learning which are integrated through different teaching methods and through independent study experiences;

12. possess critical thinking skills, the ability of both independent and team problem-solving and the sense of engineering creativity and design;

13. have acquired sufficient skills in using information and communication technology for conducting research, studies and analyses, in addition to presentation and communication;

14. develop a sense of professionalism and an appreciation for the obligations of a professional engineer;

15. 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:

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. 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;

4. have an understanding of advanced and appropriate information and communication technologies and their application to manage information relating to water management;

5. 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;

6. have a good knowledge of the relevant literature and the contemporary research questions in the field of Hydroinformatics;

7. 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;

8. critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others;

9. provide considered advice to managers and users of advanced Hydroinformatics tools;

10. appreciate and discuss the ethics and nature of the postmodern society and the role of water within it as a "right" and an "asset";

11. 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;

12. 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;

13. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner;

14. 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:

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. 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;

3. 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;

4. 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;

5. have a good knowledge of the relevant literature and the contemporary research questions in the field of hydrology;

6. design and conduct hydrological research and experiments for both application and scientific purposes, either independently or within a team-based framework;

7. critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others;

8. adequately communicate methodologies, results, evaluations, conclusions and recommendations in oral, written and graphical form to a wide variety of audience;

9. 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

10. 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:

1. have in-depth understanding and specific knowledge of:
    a. the latest concepts and theories of irrigation, drainage, flood protection, land reclamation and consolidation technologies for sustainable development;
    b. the cross-sectoral linkages comprehending wider aspects of society, economy and the environment;

2. 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;

3. identify and cross-evaluate alternative land and water development options for areas under different land uses and assess their technical, economic, institutional and environmental feasibility;

4. engage in or advise developers, system managers and water users on the participatory development and management, as well as modernisation of irrigation, drainage and flood protection schemes for their planning, design, implementation, operation and maintenance, financing and performance assessment;

5. acquire knowledge and understanding of contemporary research issues in the field of land and water development;

6. 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.

4.6 Integrated River,Lowland and Coastal Development and Management Planning (joint specialization with Sriwijaija University)

After successful completion of the programme graduates will :

1. Have in-depth understanding and specific knowledge of the current concepts and theories to support a sustainable hydraulic development of integrated river, lowland and coastal with different types of land use;
2. Have in-depth understanding and specific knowledge of the multi-disciplinary involvement in the integrated river, lowland and coastal sector with the wider aspects of society, economy and the environment;
3. Depending on their chosen specialization, master the respective major different hydraulic and environmental engineering aspects and methodologies;
4. Be able to contribute to the planning, design, development and implementation (action plan for the realisation) of the hydraulic infrastructure for integrated river, lowland and coastal development and management schemes. Depending on their chosen specialization it can be river, coastal or irrigation infrastructure;
5. Have knowledge of contemporary research questions and the relevant literature in the field of integrated river lowland and coastal development;
6. Be able to advise developers, system managers and water users on the operation and maintenance aspects of the water management and river or sea flood protection schemes in the lowland;
7. Be able to formulate and conduct hydraulic and environmental engineering research, plan development and designs in the field of integrated river lowland and coastal development, experiments and tests for both practical and scientific purposes, either independently or within a team-based framework;
8. Be able to critically judge and evaluate their own work and results, as well as the information of prior research or investigations, plans and design;
9. Be able to adequately communicate methodology, research results, plans, designs, evaluations, conclusions and recommendations in written, oral and graphical form to a wide variety of audience;
10. Be able to formulate and evaluate a concept with its alternatives for integrated river lowland and coastal development for areas with different type of land use and assess the technical and

economic feasibility, as well as the environmental sustainability of the proposed development and/or management plans;

11. Have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner.

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:

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;
   - the cross-sectoral linkages between land and water development and wider aspects of society, economy and the environment;

2. 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;

3. 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;

4. 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;

5. acquire knowledge and understanding of contemporary research issues in the fields of land and water development and agricultural water management;

6. 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;

7. 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;

8. 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 Programspecializations, (joint specialisation with Nebraska)

Upon completion of the Advanced Water Management for Food Production Program specializations, the graduates should:

1. have in-depth understanding and specific knowledge of the latest concepts and theories of irrigation, drainage, flood protection, land reclamation and consolidation technologies for food production;

2. the cross-sectoral linkages comprehending wider aspects of society, economy and the environment;

3. 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;

4. be able to identify and cross-evaluate alternative land and water development options for areas under different land uses and assess their feasibility; technologically, economically, and environmentally;

5. be able to 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;

6. to be able to identify and develop available water resources for food production;

7. to be able to enhance the of on-farm irrigation systems through better design and management;

8. understand and formulate water management methodologies to enhance crop production with limited water supplies;

9. acquire knowledge and understanding of contemporary research issues in the field of land and water development and water for food;

10. be able to 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.

4.9 Ecohydrology

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

1. demonstrate knowledge and understanding of the ecological and hydrological processes on varying spatiotemporal scales in the environment, of the socio-economic concepts underlying the functioning and exploitation of environmental systems, and of the complex inter-relationship between the protection and wise use of environmental resources;

2. 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;

3. critically analyse and evaluate a range of options and alternatives for the prevention or remediation of environmental problems, under different socio-economic, cultural contexts, and under often data-poor conditions;

4. contribute as a flexible and creative member in interdisciplinary teams in developing solutions for prevention or remediation of ecohydrological systems, 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;

5. 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;

6. 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;

7. 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.

4.10 Flood Risk management

After successful completion of the programme graduates will have:

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.

The acquired competencies (application of knowledge) include the ability to:

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;
6. occupy an independent and responsible position as a flood risk professional;
7. 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);
8. acquire independently further knowledge and techniques, and
9. operate in a team.

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 Planning Office (immediately after the exam);
5. Planning Officers verify which exam papers have been received and record this on a list;
6. the list produced by the Planning 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 Planning Office, U-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 Planning Office, than 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 planning officer if necessary.

Student card: Students are required to bring their UNESCO-IHE student card and are allowed to enter the examination room after a signal from the invigilators. Students display their student card on their table.

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.

THESIS PROPOSAL

The thesis proposal is to be submitted for assessment to the responsible professor and the mentor, who will evaluate the proposal and assign a 'satisfactory' judgement if the evaluation is passed. Additionally, a presentation by the student may be part of the evaluation.

Appendix C GRADING SYSTEMS used by partner institutes

JOINT SPECIALISATION IN:
- **SANITARY ENGINEERING**
- **WATER SUPPLY ENGINEERING**
-

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**

JOINT SPECIALISATION IN:
- **UWEM**
- **AWELWP**
- **ETSuD**

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

The grade needed to have a postgraduate degree conferred upon an individual is
- achieve a final cumulative grade point average of not less than 2.75;
- achieve a grade of excellent, very good, good or fair for the thesis, research study, project or internship

JOINT SPECIALISATION IN:
- **SANITARY ENGINEERING**
- **ENVIRONMENTAL SCIENCE**
- **HYDROINFORMATICS**

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)

JOINT SPECIALISATION IN:
- **ILDMP**

Sriwijaija University
Same system as used at UNESCO-IHE

JOINT SPECIALISATION IN:
- **LWM**

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.

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
5 (nicht genügend)	F/FX	fail

ERASMUS MUNDUS PROGRAMME: 'IMETE'

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			

* UNESCO-IHE marks in the table were calculated from interpolation, with a score of 10 at Gent University equal to a 6.0 at UNESCO-IHE, a 20 at Gent University equal to a 10 at UNESCO-IHE and a 0 at Gent University equal to a 0 at UNESCO-IHE.

ERASMUS MUNDUS PROGRAMME: 'FLOOD RISK MANAGEMENT'

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.

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).

TU-Catalonia
Scale from 0-10
MH Honors (is igiven 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

ERASMUS MUNDUS PROGRAMME: 'ECOHYDROLOGY'

University of Algarve
University of Lodz
University of Kiel
University of La Plata

Grades issued by the partners are converted according the following table:

Numerical National Marks				
CAU	ULodz	IHE	UALG	ULP
1	5	9.0 – 10	20	10
1.3	4.7 – 4.9	8.6 – 8.9	19 →	9.3 – 9.9
1.7	4.4 . 4.6	8.3 - 8.5	18 → 18.9	8.5 – 9.2
2	4.1 – 4.3	8.0 - 8.2	17 → 17.9	8.0 – 8.4
2.3	3.9 – 4.2	7.7 – 7.9	16 → 16.9	7.4 – 7.9
2.7	3.5 – 3.8	7.3 - 7.6	14 → 15.9	6.5. 7.3
3	3.3- 3.4	7.0 - 7.2	12 → 13.9	6.0 – 6.4

3.3	3.1.- 3.2	6.7 - 6.9	11 → 11.9	5.4 – 5.9
3.7	2.7 – 3.0	6.3 - 6.6	10.5 → 10.9	4.5 - 5.3
4.0	2.5 – 2.6	6. 0 - 6.2	10 → 10.4	4 - 4.4
← 4.0	← 2.5	← 6.0	← 10.0	← 4.0

Appendix D MSc modules: names, credits & assessment methods

1. Urban Water and Sanitation programme

Water supply engineering

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
UWS/01	Hydrology, Water supply and water demand management and GI	5	75		25			
UWS/02	Chemistry and public health	5	30+65		35			
UWS/03	EPT, Microbiology and Integrated Urban Water	5	70		30			
UWS/WSE/04	Surface water treatment I	5	60		20		20	
UWS/WSE/05	Surface water treatment II	5	80				20	
UWS/WSE/06	Groundwater treatment and resources	5	70		15		15	
UWS/WSE/UWEM/07	Water transport and distribution	5	60		40			
UWS/WSE/08	Advanced water treatment and reuse	5	70		20		10	
UWS/09	International fieldtrip and fieldwork	5			100			
UWS/SE/UWEM/10	Industrial effluents treatment and residuals	5	60		25			15
WSE/HI/10b/e	Urban water systems	5	40		60			
UWS/WSE/UWEM/10	Water treatment processes and plants	5	60		40			
UWS/SE/11	Faecal sludge management	5	85		15			
UWS/WSE/11a	Advanced water transport and distribution	5	60		40			
UWS/WSE/11b	Decentralised water supply and sanitation	5	60		30	10		
UWS/12	Summer courses	1						
UWS/13	Groupwork Sint Maarten	5			80	20		
UWS/14	MSc research methodology and proposal development	9		100				
UWS/15	MSc thesis research and thesis writing	36		100				

Sanitary engineering

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
UWS/01	Hydrology, Water supply and water demand management and GI	5	75		25			
UWS/02	Chemistry and public health	5	65		35			
UWS/03	EPT, Microbiology and Integrated Urban Water	5	70		30			
UWS/SE/UWEM/04	Urban drainage and sewerage	5	60		40			
UWS/SE/05	Conventional wastewater treatment	5	80		20			
UWS/SE/06	Resource oriented wastewater treatment and sanitation	5	80		20			
UWS/SE/07	Wastewater treatment plants design and engineering	5	50	25	25			
UWS/SE/08	Modelling of wastewater treatment processes and plants	5	60		40			
UWS/09	International fieldtrip and fieldwork	5			100			
UWS/SE/UWEM/10	Industrial effluents treatment and residuals	5	60		25			15
WSE/HI/10b/e	Urban water systems	5	40		60			
UWS/WSE/UWEM/10	Water treatment processes and plants	5	60		40			
UWS/SE/11	Faecal sludge management	5	85		15			
UWS/WSE/11a	Advanced water transport and distribution	5	60		40			
UWS/WSE/11b	Decentralised water supply and sanitation	5	60		30	10		
UWS/12	Summer courses	1						
UWS/13	Groupwork Sint Maarten	5			80	20		
UWS/14	MSc research methodology and proposal development	9		100				
UWS/15	MSc thesis research and thesis writing	36		100				

The programme components, credits, and the nature of the examinations in the specialisation **Water Supply Engineering and Sanitary Engineering** with **KNUST** are:

Location	Code		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	UWS/SE/06	Resource oriented wastewater treatment and sanitation	5	80		20			
	UWS/SE/07	Wastewater treatment plants design and engineering	5	50	25	25			
	UWS/SE/08	Modelling of wastewater treatment processes and plants	5	60		40			
	OR								
	UWS/WSE/06	Groundwater treatment and resources	5	70		15		15	
	UWS/WSE/UWEM/07	Water transport and distribution	5	60		40			
	UWS/WSE/08	Advanced water treatment and reuse	5	70		20		10	
	UWS/09	International fieldtrip and fieldwork	5			100			
	UWS/SE/UWEM/10	Industrial effluents treatment and residuals	5	60		25			15
	WSE/HI/10b/e	Urban water systems	5	40		60			
	UWS/WSE/UWEM/10	Water treatment processes and plants	5	60		40			
	UWS/SE/11	Faecal sludge management	5	85		15			
	UWS/WSE/11a	Advanced water transport and distribution	5	60		40			
	UWS/WSE/11b	Decentralised water supply and sanitation	5	60		30	10		
	UWS/12	Summer courses	1						
	UWS/13	Groupwork Sint Maarten	5			80	20		
	UWS/14	MSc research methodology and proposal development	9		100				
U-IHE / KI	UWS/15	MSc thesis research and thesis writing	36		100				

The programme components, credits, and the nature of the examinations in the specialisation **Sanitary and Environmental Engineering** with **Univalle** are:

Location	Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)
Univalle	C1	C1 Chemistry of Environmental Pollution	5,13	50		20		30	
	C2	C2 Environmental Pollution Microbiology	5,13	x		x	x	x	
	C3	C3 Fundamentals of Environmental Processes	5,13	60		20		20	20
	C4	C4 Environmental and Development	5,13	35		30	35		
	C5	C5 Engineering Research Introduction	3,42			100		20	
U-IHE	UWS/WSE/04	Surface water treatment I	5	60		20		20	
	UWS/WSE/05	Surface water treatment II	5	80				20	
	UWS/WSE/06	Groundwater treatment and resources	5	70		15		15	
	UWS/WSE/UWEM/07	Water transport and distribution	5	60		40			
	UWS/WSE/08	Advanced water treatment and reuse	5	70		20		10	
	UWS/SE/UWEM/04	Urban drainage and sewerage	5	60		40			
	UWS/SE/05	Conventional wastewater treatment	5	85		15			
	UWS/SE/06	Resource oriented wastewater treatment and sanitation	5	80		20			
	UWS/SE/07	Wastewater treatment plants design and engineering	5	50	25	25			
	UWS/SE/08	Modelling of wastewater treatment processes and plants	5	60		40			
	UWS/09	International fieldtrip and fieldwork	5			100			
	UWS/SE/UWEM/10	Industrial effluents treatment and residuals	5	60		25			15
	WSE/HI/10b/e	Urban water systems	5	40		60			
	UWS/WSE/UWEM/10	Water treatment processes and plants	5	60		40			
	UWS/SE/11	Faecal sludge management	5	85		15			
	UWS/WSE/11a	Advanced water transport and distribution	5	60		40			
	UWS/WSE/11b	Decentralised water supply and sanitation	5	60		30	10		
	UWS/12	Summer courses	1						
	UWS/13	Groupwork Sint Maarten	5			80	20		
Univalle	C9	Engineering research I (4 UVC)	6,84						
	C10	Engineering Research II (8 UVC)	13,68						
		MSc thesis (14 UVC)	23,94						

The programme components, credits, and the nature of the examinations in the specialisation **Urban Water Engineering and Management** with **AIT** are:

Location	Code	Module Name	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	UWS/SE/UWEM/04	Urban drainage and sewerage	2 (5.0)	60		40			
	UWS/UWEM/05	Asset management	2 (5.0)		60	40			
	WSM/06	Managing water organisations	2 (5.0)			100			
	UWS/WSE/UWEM/07	Water transport and distribution	2 (5.0)	60		40			
	WSE/HI/08B/E	Urban flood management and disaster risk mitigation	2 (5.0)	40		60			
	UWS/09	International fieldtrip and fieldwork	2 (5.0)			100			
	UWS/SE/UWEM/10	Industrial effluents treatment and residuals	2 (5.0)	60		25			15
	WSE/HI/10b/e	Urban water systems	2 (5.0)	40		60			
	UWS/WSE/UWEM/10	Water treatment processes and plants	2 (5.0)	60		40			
		Total coursework	26 (65)						
	UWS/UWEM/11	MSc thesis proposal preparation	2.8 (7.0)			x	x		
AIT		MSc thesis work	19.2 (48)			x	x		
		Grand total (coursework + thesis)	48 (120)						

2. Environmental Science programme

Environmental Science and Technology

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
ES0123	Week 1 + Introduction to environmental science	15	70		30				
ES04	Integrated project environmental science	5	70		30				
ES05T	Industrial Resource Management & Cleaner Production	5	60		35	5			
ES06TM	Environmental systems analysis	5	40		40	20			
ES07T	Environmental engineering	5	50		25 +25				
ES08T	Environmental monitoring and modelling	5	70		15		15		
ES09TMW	Foreign fieldtrip and fieldwork ES	5			50	50			
ES10TWL	Aquatic ecosystems: processes and applications	5			80+10	10			
	Electives:								
ES11T	Solid waste management	5	60		35	5			
ES11MW	Watershed and river basin management	5	70		30				
ES11X	IWRM as a tool for adaptation to climate change	5	70		30				
ES11L	Wetlands for livelihoods and conservation	5	40		40	20			
ES12	Summer courses	1			100				
ES13TMW	Groupwork ES	5			100				
ES14	MSc research methodology and proposal development	9			100				
ES15	MSc research	36			100				

Environmental Policy Making

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
ES0123	Week 1 + Introduction to environmental science	15	70		30				
ES04	Integrated project environmental science	5	70		30				
WM05	Water and environmental law	5							
ES06TM	Environmental systems analysis	5	40		40	20			
ES07M	Water and environmental policy making	5	70		30				
ES08MW	Environmental planning and implementation	5	55		30+15				
ES09TMW	Foreign fieldtrip and fieldwork ES	5			50	50			100
ES10M	Environmental assessment for water related policies and develo	5	70		30				
	Electives:								
ES11T	Solid waste management	5	60		35	5			
ES11MW	MW: Watershed and river basin management	5	70		30				
ES11X	IWRM as a tool for adaptation to climate change	5	70		30				
ES11LM	Wetlands for livelihoods and conservation	5	40		40	20			
ES12	Summer courses	1			100				
ES13TMW	Groupwork ES	5			100				
ES14	MSc research methodology and proposal development	9			100				
ES15	MSc research	36			100				

Water Quality Management

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
ES0123	Week 1 + Introduction to environmental science	15	70		30				
ES04	Integrated project environmental science	5	70		30				
WM05	Water and environmental law	5	60		40				
ES06W	Water quality assessment	5	60		15+15		10		
ES07W	Wetlands for water quality	5	60		40				
ES08MW	Environmental planning and implementation	5	55		30+15				
ES09TMW	Foreign fieldtrip and fieldwork ES	5			50	50			100
ES10TWL	Aquatic ecosystems: processes and applications	5			80+10	10			
	Electives:								
ES11T	Solid waste management	5	60		35	5			
ES11MW	Watershed and river basin management	5	70		30				
ES11X	IWRM as a tool for adaptation to climate change	5	70		30				
ES11L	Wetlands for livelihoods and conservation	5	40		40	20			
ES12	Summer courses	1			100				
ES13TMW	Groupwork ES	5			100				
ES14	MSc research methodology and proposal development	9			100				
ES15	MSc research	36			100				

The programme components, credits, and the nature of the examinations in the specialisation **Environmental Science and Technology** with **Univalle** are:

Location	Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
Univalle	C1	C1 Chemistry of Environmental Pollution	5,13	50		20		30		
	C2	C2 Environmental Pollution Microbiology	5,13	x		x	x	x		
	C3	C3 Fundamentals of Environmental Processes	5,13	60		20		20	20	
	C4	C4 Environmental and Development	5,13	35		30	35			
	C5	C5 Engineering Research Introduction	3,42			100		20		
U-IHE	ES04	Integrated project environmental science	5	70		30				
	ES05T	Industrial Resource Management & Cleaner Production	5	60		35	5			
	ES06TM	Environmental systems analysis	5	40		40	20			
	ES07T	Environmental engineering	5	50		25 +25				
	ES08T	Environmental monitoring and modelling	5	70		15		15		
	ES09TMW	Foreign fieldtrip and fieldwork ES	5			50	50			100
	ES10TWL	Aquatic ecosystems: processes and applications	5			80+10	10			
		Electives:								
	ES11T	Solid waste management	5	60		35	5			
	ES11MW	Watershed and river basin management	5	70		30				
	ES11X	IWRM as a tool for adaptation to climate change	5	70		30				
	ES11L	Wetlands for livelihoods and conservation	5	40		40	20			
	ES12	Summer courses	5			100				
	ES13TMW	Groupwork ES	5			100				
Univalle		MSc thesis (14 UVC)	23,94							

The programme components, credits, and the nature of the examinations in the specialisation **Environmental Technology for Sustainable Development** with **AIT** are:

Location	Code	Module Name	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	ES05T	Industrial Resource Management & Cleaner Production	2 (5.0)	60		35	5			
	ES06TM	Environmental systems analysis	2 (5.0)	40		40	20			
	ES07W	Wetlands for water quality	2 (5.0)	60		40				
	ES08T	Environmental monitoring and modelling	2 (5.0)	70		15		15		
	ES09TMW	Foreign fieldtrip and fieldwork ES	5			50	50			100
	ES10TWL	Aquatic ecosystems: processes and applications	2 (5.0)			80+10	10			
	ES11ETSuD	MSc research proposal development	2.8 (7.0)				100			
	ES12	Summer courses	2 (5.0)			100				
		Total coursework	26 (65)							
AIT		Elective	2 (5.0)	x		x				
		MSc thesis proposal preparation	2.8 (7.0)			x	x			
		MSc thesis work	19.2 (48)			x	x			
		Grand total (coursework + thesis)	50 (125)							

The programme components, credits, and the nature of the examinations in the specialisation **Environmental Technology and Engineering** with **Prague and Ghent** are:

1 General Courses		**71**	**ECTS**
U-IHE	I002048	Introduction in Environmental Science I [en]	5
	I002049	Introduction to Environmental Science II [en]	5
	I002050	Introduction to Environmental Science III [en]	5
	I002051	Integrated Project Environmental Science [en]	5
Prague	I001978	Environmental Microbiology [en]	4
	I001977	Environmental Engineering [en]	4
	I001856	Wastewater Treatment [en]	5
	I001857	Sludge Management [en]	2
	I001976	Atmosphere Protection Technology [en]	3
	I001859	Waste Management and Treatment [en]	4
	I001860	Elective Project [en]	5
	I001980	Laboratory Training in Environmental Technology [en]	3
Ghent	I001861	Scientific Skills [en]	6
	I001512	Clean Technology [en]	3
	I001862	Environmental Fate and Management of Heavy Metals and Metalloi	5
	I001873	Microbial Re-use Technology [en]	3
	I001863	Summer School Environmental Technology and Engineering [en]	4

2 Elective Courses		**19**	**ECTS**
U-IHE	I001865	Basic Dutch for Foreigners [en]	2.0
Prague	I001864	Basics of Czech [en]	2.0
Ghent	I000675	Advanced Waste Gas Treatment [en]	3.0
	I001368	Applied Isotopes [en]	5.0
	I001549	Applied Statistics [en]	5.0
	I001974	Ecological Risk Assessment [en]	7.0
	I001522	Environmental Constructions [en]	5.0
	I001349	Environmental Ecology [en]	7.0
	I001439	Environmental Noise [en]	3.0
	I000256	Geostatistics [en]	5.0
	I000260	Life Cycle Assessment [en]	3.0
	I001554	Membrane Processes in Environmental Technology [en]	3.0
	I001755	Modeling and Control of Waste Water Treatment Plants [en]	3.0
	I001563	Quality of Groundwater Resources [en]	5.0
	I001872	Soil Degradation [en]	3.0
	I000846	Soil Water Management [en]	3.0
	I000447	Urban and Indoor Air Pollution [en]	5.0
	I001979	Internship [en]	6.0
	I001571	Environmental Legislation [en]	3.0
	I001973	Basics of Control Engineering and Process Engineering [en]	4.0
U-IHE	I001867	Cleaner Production and the Water Cycle [en]	5.0
	I001868	Constructed Wetlands for Wastewater Treatment [en]	5.0
	I001869	Ecological Sanitation [en]	5.0
	I001981	Modelling Sanitation Systems [en]	5.0
3 Master Dissertation			**30.0**

The programme components, credits, and the nature of the examinations in the specialisation **Limnology and Water Management** with **Boku and Egerton** are:

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab report (%)	Home work (%)	Integrated in modules (%)
LWM1	Basics in Limnology	9							
LWM2	Ecology of Aquatic Organisms	6							
LWM3	Basics in Applied Limnology	6							
LWM4	Aquatic Ecosystem Management	4							
LWM5	Scientific Working	3							
ES05bL	Lake Ecology	5,6	60		10	20	10		
ES06L	Stream & River Ecology	5,6	60			20	20		
ES07L	Tropical wetlands for Water Quality	5,6	60		10	20			10
ES08L	Fisheries & Aquaculture	5,6	60			20			10+10
ES09L	Data Analysis and Modeling for Aquatic Ecosystems	5,6	40		40	20			
ES10TWL	Aquatic Ecosystems: Processes and Applications	5,6			80+10	10			
ES11LM	Wetlands for livelihoods and conservation	5	40		40	20			
ES12	Summer courses	1			100				
ES13TMW	Group-work	5,6			100				
ES14	MSc research methodology and proposal development	9			100				
ES 15	LWM15: Research plan, logistics, site assessment, application & s	13,4							
	MSc-Thesis								
	LWM16: M.Sc. Research and Thesis writing	30							
	TOTAL	120							

3. Water Science and Engineering programme

River Basin Development

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WSE/01/c	Week 1 + Introduction to Water Science and Engineering	5	25+25+10		20 (x2)				
WSE/02/c	Hydrology and hydraulics	5	35 (x2)		30				
WSE/RBD/03/s	River basin hydraulics, geotechnics and remote sensing	5	25+25+25		25				
WSE/RBD/04/s	River morphodynamics	5	80		20				
WSE/RBD/05s	Data collection and analysis	5	40+20		20+20				
WSE/RBD/06/s	River Basin Development and EIA	5	40+20		10+10+20				
WSE/RBD/07/s	River structures	5		100					
WSE/RBD/08A/e	River training and rehabilitation	5	80		20				
WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
WSE/RBD/10/e	Storage and hydropower	5	45+45		10				
WSE/RBD/11/e	Modelling and operation of river systems	5	30+30		40				
WSE/12/C	Summer courses / research methodology for WSE	1			100				
WSE/13/c	Groupwork WSE	5				100			
WSE/14/c	MSc research proposal development for WSE	9			100				
WSE/15	MSc research	36			100				

Coastal Engineering and Port Development

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WSE/01/c	Week 1 + Introduction to Water Science and Engineering	5	25+25+10		20 (x2)				
WSE/02/c	Hydrology and hydraulics	5	35 (x2)		30				
WSE/CEPD/03/s	Introduction to coastal science and engineering	5	10	50+30	10				
WSE/CEPD/04s	Coastal systems	5	60	20	20				
WSE/CEPD/05/s	Port planning and infrastructure design	5			30+70				
WSE/CEPD/06/s	Coastal and port structures	5			100				
WSE/CEPD/07/s	Environmental aspects of coasts and ports	5	15+15+15+15		40				
WSE/CEPD/08A/e	Management of coasts and ports (International Port Seminar)	5				100			
WSE/CEPD/08B/e	Management of coasts and ports (ICZM)	5		100					
WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
WSE/CEPD/10/e	Geotechnical engineering and dredging	5		60	40				
WSE/CEPD/11/e	Flood protection in lowland areas	5	20	40	40				
WSE/12/C	Summer courses / research methodology for WSE	1			100				
WSE/13/c	Groupwork WSE	5				100			
WSE/14/c	MSc research proposal development for WSE	9			100				
WSE/15	MSc research	36			100				

Land and Water Development

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WSE/01/c	Week 1 + Introduction to Water Science and Engineering	5	25+25+10		20 (x2)				
WSE/02/c	Hydrology and hydraulics	5	35 (x2)		30				
WSE/LWD/03/s	Principles and practices of land and water development	5		15	70 + 15				
WSE/LWD/04/s	Design aspects of irrigation and drainage systems	5	30		20+25+25				
WSE/LWD/05s	Water management systems and agronomy	5	35		10+30+25				
WSE/LWD/06/s	Socio-economic and environmental aspects of irrigation and drai	5			25+20+30+25				
WSE/LWD/07/s	Service oriented management of irrigation systems	5		40	35+25				
WSE/LWD/08/e	Conveyance systems	5	30		15+30+25				
WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
WSE/LWD/10/e	Irrigation and drainage structures	5			45+30+25				
WSE/LWD/11/e	Innovative approaches and practices	5			40+60				
WSE/12/C	Summer courses / research methodology for WSE	1			100				
WSE/13/c	Groupwork WSE	5				100			
WSE/14/c	MSc research proposal development for WSE	9			100				
WSE/15	MSc research	36			100				

Hydroinformatics

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WSE/01/c	Week 1 + Introduction to Water Science and Engineering	5	25+25+10		20 (x2)				
WSE/02/c	Hydrology and hydraulics	5	35 (x2)		30				
WSE/HI/03/s	Hydroinformatics: modelling and information systems for water	5	40		15+15+30				
WSE/HI/04/s	Modelling theory and Computational Hydraulics	5	25+25+30		20				
WSE/HI/05s	Modelling and information systems development	5	20		30+20+30				
WSE/HI/06/s	Computational Intelligence and Operational water management	5	25+30		10+15+20				
WSE/HI/07/s	River basin modelling	5	100						
WSE/HI/08A/e	River Flood Analysis and Modelling	5	50		25+25				
WSE/HI/08B/e	Urban flood management and disaster risk mitigation	5	40		60				
WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
WSE/HI/10A/e	Flood risk management	5	60		40				
WSE/HI/10B/e	Urban water systems	5	40		30+30				
WSE/HI/11/e	Hydroinformatics for decision support	5			40+30+30				
WSE/12/C	Summer courses / research methodology for WSE	1			100				
WSE/13/c	Groupwork WSE	5				100			
WSE/14/c	MSc research proposal development for WSE	9			100				
WSE/15	MSc research	36			100				

Hydrology and Water Resources

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WSE/01/c	Week 1 + Introduction to Water Science and Engineering	5	25+25+10		20 (x2)				
WSE/02/c	Hydrology and hydraulics	5	35 (x2)		30				
WSE/HWR/03/s	Hydrogeology	5	25+25+20		10+10+10				
WSE/HWR/04/s	Surface hydrology	5	70		30				
WSE/HWR/05/s	Water quality	5	50+25		25				
WSE/HWR/06/s	Tracer hydrology and flow systems analysis	5	50+50						
WSE/HWR/07A/s	Hydrological data collection and processing	5	60				40		
WSE/HWR/07B/s	Groundwater data collection and interpretation	5	25+35+15		10+15				
WSE/HWR/08/e	Integrated hydrological and river modelling	5			50+35	15			
WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
WSE/HWR/10B/e	Applied groundwater modelling	5			70+30				
WSE/11	Water resilient cities	5		50		50			
WSE/12/C	Summer courses / research methodology for WSE	1			100				
WSE/13/c	Groupwork WSE	5				100			
WSE/14/c	MSc research proposal development for WSE	9			100				
WSE/15	MSc research	36			100				

The programme components, credits, and the nature of the examinations in the specialisation ***Land and Water Development with Asian Institute of Technology*** are:

Location	Code	Module Name	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	WSE/LWD/04/s	Design aspects of irrigation and drainage systems	5	30		20+25+25				
	WSE/LWD/05s	Water management systems and agronomy	5	35		10+30+25				
	WSE/LWD/06/s	Socio-economic and environmental aspects of irrigation and drai	5			25+20+30+25				
	WSE/LWD/07/s	Service oriented management of irrigation systems	5	40		60				
	WSE/LWD/08/e	Conveyance systems	5	30+25		15+30				
	WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
	WSE/LWD/10/e	Irrigation and drainage structures	5			45+30+25				
	WSE/LWD/11/e	Innovative approaches and practices	5			40+60				
	WSE/12/C	Summer courses / research methodology for WSE	1			100				
	WSE/13/c	Groupwork WSE	5				100			
	WSE/14/c	MSc research proposal development for WSE	9			100				
AIT		MSc research work	36							
			121							

The programme components, credits, and the nature of the examinations in the specialisation ***Land and Water Development with Sriwijajija University*** are:

Location	Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
Sriwijaija	1	Ecostatistics (PL611)	3							
	2	Lowland environmental science (PL612)	2							
	3	Environmental values & ethics (PL613)	2							
	4	Environmental law (PL614)	2							
	5	Environmental sociology (PL615)	2							
	6	Resource economics (PL626)	2							
	7	Research methods (PL627)	2							
	8	Environmental management system (PL636)	2							
	9	Integrated aspects of lowland management	3							
	10	Managing, organization and change in lowland schemes	3							
	11	Lowland hydrology	2							
	12	Soil and water data collection, monitoring and evaluation	2							
U-IHE	WSE/01/c	Week 1 + Introduction to Water Science and Engineering	5	25+25+10		20 (x2)				
	WSE/02/c	Hydrology and hydraulics	5	35 (x2)		30				
	WSE/LWD/03/s	Principles and practices of land and water development	5		15	70 + 15				
	WSE/LWD/04/s	Design aspects of irrigation and drainage systems	5	30		20+25+25				
	WSE/LWD/05s	Water management systems and agronomy	5	35		10+30+25				
	WSE/LWD/06/s	Socio-economic and environmental aspects of irrigation and drai	5			25+20+30+25				
	WSE/LWD/07/s	Service oriented management of irrigation systems	5	40		60				
	WSE/LWD/08/e	Conveyance systems	5	30+25		15+30				
	WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
Sriwijaija		Fieldtrips	3							
		Groupwork	5							
		MSc thesis work	12							
U-IHE		MSc thesis writing	24				100			

The programme components, credits, and the nature of the examinations in the specialisation **Coastal Engineering and Port Development *with Sriwijajija University*** are:

Location	Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
Sriwijaija	1	Ecostatistics (PL611)	3							
	2	Lowland environmental science (PL612)	2							
	3	Environmental values & ethics (PL613)	2							
	4	Environmental law (PL614)	2							
	5	Environmental sociology (PL615)	2							
	6	Resource economics (PL626)	2							
	7	Research methods (PL627)	2							
	8	Environmental management system (PL636)	2							
	9	Integrated aspects of lowland management	3							
	10	Managing, organization and change in lowland schemes	3							
	11	Lowland hydrology	2							
	12	Soil and water data collection, monitoring and evaluation	2							
U-IHE	WSE/CEPD/03/s	Introduction to coastal science and engineering	5	10	50+30	10				
	WSE/CEPD/04s	Coastal systems	5	60	20	20				
	WSE/CEPD/05/s	Port planning and infrastructure design	5			30+70				
	WSE/CEPD/06/s	Coastal and port structures	5			100				
	WSE/CEPD/07/s	Environmental aspects of coasts and ports	5	15+15+15+15		40				
	WSE/CEPD/08B/e	Management of coasts and ports (ICZM)	5		100					
	WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
Sriwijaija		Fieldtrips	3							
		Groupwork	5							
		MSc thesis work	12							
U-IHE		MSc thesis writing	24				100			

The programme components, credits, and the nature of the examinations in the specialisation **River Basin Development *with Sriwijajija University*** are:

Location	Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
Sriwijaija	1	Ecostatistics (PL611)	3							
	2	Lowland environmental science (PL612)	2							
	3	Environmental values & ethics (PL613)	2							
	4	Environmental law (PL614)	2							
	5	Environmental sociology (PL615)	2							
	6	Resource economics (PL626)	2							
	7	Research methods (PL627)	2							
	8	Environmental management system (PL636)	2							
	9	Integrated aspects of lowland management	3							
	10	Managing, organization and change in lowland schemes	3							
	11	Lowland hydrology	2							
	12	Soil and water data collection, monitoring and evaluation	2							
U-IHE	WSE/RBD/03/s	River basin hydraulics, geotechnics and remote sensing	5	25+25+25		25				
	WSE/RBD/04/s	River morphodynamics	5	80		20				
	WSE/RBD/05s	Data collection and analysis	5	40+20		20+20				
	WSE/RBD/06/s	River Basin Development and EIA	5	40+20		10+10+20				
	WSE/RBD/07/s	River structures	5		100					
	WSE/RBD/08A/e	River training and rehabilitation	5	80		20				
	WSE/09/c	Fieldtrip and fieldwork WSE	5						100	
Sriwijaija		Fieldtrips	3							
		Groupwork	5							
		MSc thesis work	12							
U-IHE		MSc thesis writing	24				100			

The programme components, credits, and the nature of the examinations in the specialisation ***Flood Risk Management*** are:

Location	Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
TU-Dresden		Flood Risk Management I	10	50		30 +20				
		Flood Risk Management II								
		Meteorology and Hydrology	5	100						
		GIS and Remote Sensing								
		Climate change	5	50			50			
		Hydraulic Engineering	5	100						
		Hydromechanics								
		Ecology	5	75			25			
		Statistics	5	100						
		Geodesy		100						
U-IHE	WSE/HI/06/s	Computational Intelligence and Operational water management	5	25+30		10+15+20				
	WSE/HI/07/s	River basin modelling	5	100						
	WSE/HI/08A/e	River Flood Analysis and Modelling	5	50		25+25				
	WSE/HI/08B/e	Urban flood management and disaster risk mitigation	5	40		60				
	WSE/09/c	International Fieldtrip (12 days)	5						100	
	WSE/HI/10A/e	Flood risk management	5	60		40				
	WSE/HI/11/e	Hydroinformatics for decision support	5			40+30+30				
	ES11MW	Watershed and river basin management	5	70		30				
UPC		Implications of global warming on floods and droughts	3		40	10+20+30				
		Coastal flooding: impacts, conflicts and risks	7	100						
		Debris flow and flash floods: risk, vulnerability, hazard and resili	6	40		55				5
		Applications of radar-based rainfall observations and forecasts in	3	100						
UL		Spatial planning for flood protection and resilience	5	20		40+40				
		Socio-economic and institutional framework of floods	5	25		10+20+45				
TUD/IHE/UPC/UL		MSc thesis work	30							

The programme components, credits, and the nature of the examinations in the specialisation ***Ecohydrology.***

Ecohydrology Programme Components

First Semester (Period P1a: University of Algarve or P1b: University of Lodz):
30 ECTS, 20 SWS,

Period P1a: University of Algarve integrative period – compulsory modules:
24 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
UALG 101	Dynamics of Aquatic Ecosystems	L/P/E/OT	15/10/10/4	6	Written 100%
UALG 102	Estuarine and wetland processes	L/P/TP/E/	15/15/10 /10	6	Written 100%
UALG 103	Hydrogeology and Aquifer Management	TP/OT/S	35/5/10	6	Written 100%
UALG 104	Introduction to Ecohydrology	L/P/E/OT	15/15/10/	6	Written 100%

Period P1a: University of Algarve - elective modules
6 ECTS have to be collected from the full curriculum of courses offered.

Period P1b: University of Lodz – compulsory modules
24 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
ULO 101	Ecohydrology	L/P	1/3	6	Oral 100%
ULO 102	Environmental Modelling and Statistics	L/P	1/1	3	Oral 100%
ULO 103	Ecotoxicology	L/P	2/2	5	Oral 100%
ULO 104	Emviromental/Landscape Planning	L/P	2/2	5	Oral 100%
ULO 105	Environmental Protection Politics	L/P	2/1	5	Oral 100%

Period P1b: University of Lodz – elective modules
6 ECTS have to be collected:

ULO 106	Estuarine and coastal ecohydrology	L/OT	1/1	5	Oral 100%
ULO 107	Ecological Risk Assessment	L/P	1/2	5	
ULO 109	Fish-based Assessment & River Restoration	L/P	0,7/0,6	2	
ULO 111	Long-term Ecological Research	L/P	0,7/0,6	2	
ULO 112	International Water Resources	L	0,7	1	
ULO 113	Polish Language			2	

Second Semester (Period P2a: University of Algarve or P2b: University of Lodz and Period 3: University de la Plata):
30 ECTS, 20 SWS,

Period P2a: University of Algarve, compulsory modules
18 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
UALG 201	Biogeochemical Processes and Global Changes	L/TP/E/W	15/10/10/5/2	6	Written 100%
UALG 202	Modelling marine and coastal processes	L/TP/OT	25 /30/5	6	Written 100%
UALG 203	Techniques of marine intervention	L/TP/P/E/W	20/10/ 5/10	6	Written 100%

Period P2a: University of Algarve, elective modules
12 ECTS have to be collected from the full curriculum of courses offered.

Period P2b: University of Lodz, compulsory modules
12 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
ULO 201	Applied Aquatic Ecology	L/P	1/1	4	Oral 100%
ULO 202	Phytotechnologies & Phytoremediation	L/P	1/2	5	Oral 100%
ULO 203	Wetlands & Land-Water Ecotones	L/P	1/1	3	Oral 100%

Period P2b: University of Lodz, elective modules
8 ECTS have to be collected:

ULO 204	Environmental GIS	L/P	1/1	3	Oral 100%
ULO 205	Applied Hydrology	L/P	1/1	4	Oral 100%
ULO 206	Ecohydrology Application in Urban Areas	L/P	1/1	4	oral 100%
ULO 208	Ecohydrology for Sustainable Fisheries & Aquaculture	L/P	0,7/1	3	Oral 100%
ULO 209	Watershed Pollution control	L/P	0,7/1	3	Oral 100%
ULO 210	Hydroacustic in Fisheries & Ecology	L/P	0,7/1,3	4	Oral 100%
ULO 211	Trophic Relationships in Reservoirs	L/P	0,7/1	3	Oral 100%
ULO 212	Free elective: the topic is based on the scholar mobility in the Ecohyd consortium			5	

Period P3: University de la Plata, compulsory modules
10 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
ULP 301	Environmental Hydrology and Water Resource Management	L/P/E	1/1/1	2	Written 100%
ULP 302	Aquatic Biogeochemistry	OT/P	1/1	3	Written 100%
ULP 303	Field trip	OT/P/E	1/1/1	3	Written 100%
ULP 304	Spanish language			2	

Third Semester (Period 4: UNESCO - IHE):

Period P4: 30 ECTS, 20 SWS

Period 4 UNESCO - IHE – compulsory courses
10 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
IHE 401	MSc research proposal development for WSE (WSE/14/c)	P	NA	5	Presentation (100%)
IHE 402	Hydrology and Hydraulics (WSE/02/c)	L/P	78	5	Assignment (30%) Written (70%)

Period 4 UNESCO - IHE – free elective courses
20 ECTS (four modules) may be selected from the full course offering of IHE. Selected modules should address topics related to the proposed thesis research and must be approved by the mentor and UNESCO-IHE program coordinator.

Third Semester (Period 4: CAU Kiel):

Period P4: 30 ECTS, 20 SWS

Period 4 CAU Kiel – compulsory courses
12 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
CAU 401 S 133	The Ecosystem Approach and Spatial Concepts to Manage Natural Resources (EM 3.2.2)	S	4	6	Oral 100%
CAU 402 S 142	Integrated Management of River Basins (EM 3.1.3)	L/E/S	2/1/1	6	Presentation 100%

Period 4 Christian-Albrechts-University of Kiel – elective courses
18 ECTS have to be collected:

Course	Course Name	Teaching form	SWS	Credits	Evaluation
CAU 403 S 143	Integrated Management of Wetlands (EM 3.1.4)	L/E/S	2/2/1	6	Report 100%

CAU 404 S 127	Integrated Management of Coastal Zones (EM 3.1.2)	S/E	3,5/0,5	6	Report 100%
CAU 405 S 135	Principles in Hydrology and Climatology	L/L/E	2/1/1	6	Written 100%
CAU 406 S 144 + S 145	Hydrological and hydraulic modelling	L/P	2/2	6	Report 100%
CAU 407	Free elective from the overall CAU offer confirmation by the exam board			6	
CAU 408	Thesis plan – obligatory for students doing the thesis not at CAU			6	Project 100%

Fourth Semester (Period 5):

Master Thesis (30ECTS):

Christian-Albrechts-University of Kiel
or University of Algarve
or University of Lodz
or UNESCO IHE Delft

Explanations:

Course:	Course Identification Code
Course name:	Title of the course
Teaching form:	Kind of teaching L= Lecture S= Seminar P= Practice TO=Theoretical-practical OT=Tutorial W= Workshop E= Excursion
SWS:	Hours of teaching (face to face)
Evaluations:	= Prüfungsleistungen
Oral exam	= Mündliche Prüfung
Written Examination	= Schriftliche Prüfung
Presentation	= Vortrag
Exercise	= Hausaufgabe
Project	= Protokoll
Report	= Hausarbeit

Michael McClain
Chair oft he WSE Programme Committee

The programme components, credits, and the nature of the examinations in the specialisation ***Land and Water Development with Nebraska University*** are:

	Code	Module Name	UNL credits/ ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
UNESCO-IHE	WSE/01/c	Week 1 + Introduction to Water Science and Engineering	3 (5)	25+25+10		20 (x2)				
	WSE/02/c	Hydrology and hydraulics	3 (5)	35 (x2)		30				
	WSE/LWD/03/s	Principles and practices of land and water development	3 (5)		15	70 + 15				
	WSE/LWD/04/s	Design aspects of irrigation and drainage systems	3 (5)	30		20+25+25				
	WSE/LWD/05s	Water management systems and agronomy	3 (5)	35		10+30+25				
	WSE/LWD/06/s	Socio-economic and environmental aspects of irrigation and drai	3 (5)			25+20+30+25				
	WSE/LWD/07/s	Service oriented management of irrigation systems	3 (5)		70	30				
	WSE/LWD/08/e	Conveyance systems	3 (5)			30+15+30+25				
University of Nebraska, Lincoln, USA		Field Course: Measurement Techniques in Hydrology and Irrigati	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				

4. Water Management programme

Water Resources Management

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WM/1	Week 1 + principles of integrated water resources management	5	50		25+25				
WM/2	The water resources system	5	70		30				
WM/3	Water governance	5	50		20+30				
WM/4	Water economics	5	70		30				
WM/5	Water and environmental law	5	70		30				
WM/WRM/6	Water resources assessment	5	65		35				
WM/WRM/7	Water systems modelling	5	60			40			
WM/WRM/WCM/8	Water resources planning	5	65		35				
WM/9	International fieldwork	5			30	40+30			
WM/WRM/WCM/10	Institutional analysis	5			10+10+10+70				
ES/11/X	IWRM as a tool for adaptation to climate change	5	70			30			
WM/12	Summer course	1			100				
WM/13	IWRM Groupwork	5			65+35				
WM/14	MSc proposal +Research and academic skills development	9		100					
WM/15	MSc thesis research and thesis writing	36		100					

Water Conflict Management

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WM/1	Week 1 + principles of integrated water resources management	5	50		25+25				
WM/2	The water resources system	5	70		30				
WM/3	Water governance	5	50		20+30				
WM/4	Water economics	5	70		30				
WM/5	Water and environmental law	5	70		30				
WM/WCM/6	Mediation for water conflict management	5	50		40				10
WM/WCM/7	Advanced mediation for water conflict management	5	40		50				10
WM/WRM/WCM/8	Water resources planning	5	65		35				
WM/9	International fieldwork	5			30	30+30			
WM/WRM/WCM/10	Institutional analysis	5			10+10+10+70				
WM/WSM/WCM/11	Urban water governance	5		50	20+30				
WM/12	Summer course	1			100				
WM/13	IWRM Groupwork	5			65+35				
WM/14	Research and academic skills development WM	9		100					
WM/15	MSc thesis research and thesis writing	36		100					

Water Services Management

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WM/1	Week 1 + principles of integrated water resources management	5	50		25+25				
WM/2	The water resources system	5	70		30				
WM/3	Water governance	5	50		20+30				
WM/4	Water economics	5	70		30				
WM/5	Water and environmental law	5	70		30				
WM/WSM/6	Managing water organisations	5		60	20+20				
WM/WSM/7	Water supply and sanitation systems	5	70		30				
WM/WSM/8	Financial management in the water sector	5	65		20+15				
WM/9	International fieldwork	5			30	30+30			
WM/WSM/10	Partnerships in the Water Sector	5	70		30				
WM/WSM/WCM/11	Urban water governance	5		50	20+30				
WM/12	Summer course	1							
WM/13	IWRM Groupwork	5			65+35				
WM/14	Research and academic skills development WM	9		100					
WM/15	MSc thesis research and thesis writing	36		100					

Water Quality Management

Code	Module Name	ECTS	Written exam (%)	Oral exam (%)	Assignments (%)	Oral presentation (%)	Lab Report (%)	Home work (%)	Integrated in modules (%)
WM/1	Week 1 + principles of integrated water resources management	5	50		25+25				
WM/2	The water resources system	5	70		30				
WM/3	Water governance	5	50		20+30				
WM/4	Water economics	5	70		30				
WM/5	Water and environmental law	5	70		30				
ES/6/W	Water quality assessment	5	70		20		10		
ES/07/T	Environmental engineering	5	50		25+25				
ES/07/W	Wetlands for water quality	5	60		40				
ES/08/MW	Environmental planning and implementation	5	70		30				
WM/9	International fieldwork	5			30	30+30			
ES/10/TWL	Aquatic ecosystems: processes and applications	5	80		10	10			
ES/11/MW	Watershed and river basin management	5	70		30				
WM/12	Summer course	1			100				
WM/13	IWRM Groupwork	5			65+35				
WM/14	Research and academic skills development WM	9		100					
WM/15	MSc thesis research and thesis writing	36		100					

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.

UNESCO-IHE - Academic Calendar 2014/2016

YEAR 1	2014											2015												
	October		November					December				January				February				March				
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
Mon	13	20	27	03	10	17	24	01	08	15	22	29	05	12	19	26	02	09	16	23	02	09	16	23
Tue	14	21	28	04	11	18	25	02	09	16	23	30	06	13	20	27	03	10	17	24	03	10	17	24
Wed	15	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	04	11	18	25	04	11	18	25
Thu	16	23	30	06	13	20	27	04	11	18	25	01	08	15	22	29	05	12	19	26	05	12	19	26
Fri	17	24	31	07	14	21	28	05	12	19	26	02	09	16	23	30	06	13	20	27	06	13	20	27
Sat	18	25	01	08	15	22	29	06	13	20	27	03	10	17	24	31	07	14	21	28	07	14	21	28
Sun	19	26	02	09	16	23	30	07	14	21	28	04	11	18	25	01	08	15	22	29	08	15	22	29
		(2x5 ECTS)							(2x5 ECTS)									(2x5 ECTS)						
		Module 1			Module 2				Module 3						Module 4			Module 5			Module 6			

YEAR 1	2015							fieldtrip			..								Groupwork			..							
	April				May					June				July				August					September				October		
Week	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	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
Tue	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
Wed	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
Thu	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
Fri	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
Sat	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
Sun	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
	(2x5 ECTS)							(1x5 ECTS)			(2x5 ECTS)							1	(1x5 ECTS)				..	(2+7 ECTS)					
	Module 7			Module 8				Module 9			Module 10			Module 11				M12	Module 13				..	Module 14					

YEAR 2	2015										2016																	
	October	November					December				January					February				March				April				
Week	43	44	45	46	47	48	49	50	51	52	53	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Mon	19	26	02	09	16	23	30	07	14	21	28	04	11	18	25	01	08	15	22	29	07	14	21	28	04	11	18	25
Tue	20	27	03	10	17	24	01	08	15	22	29	05	12	19	26	02	09	16	23	01	08	15	22	29	05	12	19	26
Wed	21	28	04	11	18	25	02	09	16	23	30	06	13	20	27	03	10	17	24	02	09	16	23	30	06	13	20	27
Thu	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	04	11	18	25	03	10	17	24	31	07	14	21	28
Fri	23	30	06	13	20	27	04	11	18	25	01	08	15	22	29	05	12	19	26	04	11	18	25	01	08	15	22	29
Sat	24	31	07	14	21	28	05	12	19	26	02	09	16	23	30	06	13	20	27	05	12	19	26	02	09	16	23	30
Sun	25	01	08	15	22	29	06	13	20	27	03	10	17	24	31	07	14	21	28	06	13	20	27	03	10	17	24	01

Legend

- = Lecture period
- = Examination days
- = MSC thesis writing
- = Holiday/free time
- = Opening acad. year
- = Diploma awarding
- = Summer course

Chistmas: 25/26 Dec 2014
Good Friday: 3 April 2015
Easter: 5/6 April 2015
Kingsday: 27 April 2015
Liberationday: 5 May 2015
Ascencion: 14 May 2015
Pentecost: 24/25 May 2015
Chistmas: 25/26 Dec 2015
Good Friday: 25 March 2016
Easter: 27/28 March 2016

Water Science and Engineering Programme Overview 2014-2016

			HWR Hydrology and Water Resources	HI HydroInformatics Modelling and Information Systems for Water Management	HERBD Hydraulic engineering River Basin Development	HECEPD Hydraulic Engineering Coastal Engineering and Port Development	HELWD Hydraulic Engineering Land and Water Development
Students enter: Sriwijaija and Erasmus Mundus Ecohydrology	1	……..-19/10 20/10-26/10	Week ONE Introduction (ALL)				
		27/10-02/11 03/11-09/11	Introduction to Water Science and Engineering (WSE/01/c)				
	2	10/11-16/11 17/11-23/11 24/11-30/11	Hydrology and hydraulics (WSE/02/c)				
	..	01/12-07/12	Examination Week				
	3	08/12-14/12 15/12-21/12	Hydrogeology (WSE/HWR/03/s)	Hydroinformatics: modelling and information systems for water management (WSE/HI/03/s)	River basin hydraulics, geotechnics and remote sensing (WSE/HERBD/03/s)	Introduction to coastal science and engineering (WSE/HECEPD/03/s)	Principles and practices of land and water development (WSE/HELWD/03/s)
	..	22/12-28/12 29/12-04/01	Free Period				
	3	05/01-11/01	3 continue..	3 continue..	3 continue..	3 continue..	3 continue..
Students enter: Univalle, Hohai, AIT and Ain Shams	4	12/01-18/01 19/01-25/01 26/01-01/02	Surface hydrology (WSE/HWR/04/s)	Modelling theory and Computational Hydraulics (WSE/HI/04/s)	River morphodynamics (WSE/HERBD/04/s)	Coastal systems (WSE/HECEPD/04/s)	Design aspects of irrigation and drainage systems (WSE/HELWD/04/s)
	..	02/02-08/02	Examination Week				
Students enter: Haramaya	5	09/02-15/02 16/02-22/02 23/02-01/03	Water quality (WSE/HWR/05/s)	Modelling and information systems development (WSE/HI/05/s)	Data collection and analysis (WSE/HERBD/05/s)	Port planning and infrastructure design (WSE/HECEPD/05/s)	Water management systems and agronomy (WSE/HELWD/05/s)
Students enter: Erasmus Mundus Flood Risk Management	6	02/03-08/03 09/03-15/03 16/03-22/03	Tracer hydrology and flow systems analysis (WSE/HWR/06/s)	Computational Intelligence and Operational water management (WSE/HI/06/s)	River basin development and EIA (WSE/HERBD/06/s)	Coastal and port structures (WSE/HECEPD/06/s)	Socio-economic and environmental aspects of irrigation and drainage (WSE/HELWD/06/s)
	..	23/03-29/03	Examination Week				
Students leave: Erasmus Mundus Ecohydrology	7	30/03-05/04 06/04-12/04 13/04-19/04	Hydrological data collection and processing (WSE/HWR/07A/s) or Groundwater data collection and interpretation (WSE/HWR/07B/s)	River basin modelling (WSE/HI/07/s)	River structures (WSE/HERBD/07/s)	Environmental aspects of coasts and ports (WSE/HECEPD/07/s)	Service oriented management of irrigation systems (WSE/HELWD/07/s)
	8	20/04-26/04 27/04-03/05 04/04-10/05	Click HERE TO CHOOSE YOUR MODULE 8 (2014-2016 NOT YET AVAILABLE)				
			Integrated hydrological and river modelling (WSE/HWR/08/e)	River Flood Analysis and Modelling (WSE/HI/08A/e) or Urban flood management and disaster risk mitigation (WSE/HI/08B/e)	River training and rehabilitation (WSE/HERBD/08A/e)	Management of coasts and ports - International port seminar - (WSE/HECEPD/08A/e) or Management of coasts and ports - Integrated coastal zone management - (WSE/HECEPD/08B/e)	Conveyance systems (WSE/HELWD/08/e)
	..	11/05-17/05	Examination Week				
	9	18/05-24/05 25/05-31/05 01/06-07/06	Fieldtrip and fieldwork WSE (WSE/09/c)				
Students leave: Sriwijaija	10	08/06-14/06 15/06-21/12 22/06-28/06	Applied groundwater modelling (WSE/HWR/10B/e)	Flood risk management (WSE/HI/10A/e) or Urban water systems (WSE/HI/10B/e)	Storage and hydropower (WSE/HERBD/10/e)	Geotechnical engineering and dredging (WSE/HECEPD/10/e)	Irrigation and drainage structure (WSE/HELWD/10/e)
Click HERE TO CHOOSE YOUR MODULE 10+11 (2014-2016)							
	11	29/06-05/07 06/07-12/07 13/07-19/07	Water resilient cities - (WSE/11) or Hydroinformatics for decision support - (WSE/HI/11/e) or Modelling and operation of river systems - (WSE/HERBD/11/e) or Flood protection in lowland areas - (WSE/HECEPD/11/e) or Innovative approaches and practices - (WSE/HELWD/11/e) or Watershed and river basin management - (=> ES11MW) or A module from another Programme				
	..	20/07-26/07	Examination Week				
Students leave: Ersamus Mundus Flood Risk Management, Ain Shams and AIT	12	27/07-02/08	SUMMER COURSE (WSE/12/c)				
	13	03/08-09/08 10/08-16/08 17/08-23/08	Groupwork WSE (WSE/13/c)				
	..	24/08-30/08	Examination Week				
	..	31/08-06/09	Free				
	14	07/09-13/09 14/09-20/09 21/09-27/09 28/09-04/10 05/10-11/10	MSc preparatory course and thesis research proposal (WSE/14/c)				
	..	12/10-18/10	Examination Week				
Students leave: Haramaya	15	19/10/15 …. …… …… …… …. 10/04/16	MSc research work (6 months) (WSE/15)				
Hohai and Univalle finish	..	11/04-17/04 18/04-25/04	Final Examination Week(s) - Diploma awarding 28/04/2016				

MASTERS PROGRAMME WSE 2014-2016 - PART 2

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WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Foppen, J.W.A.

Module Sheet

Module Name Week 1 + Introduction to Water Science and Engineering	Module Code WSE/01/c	Credits 5

Target Group	Prerequisites
Entry level with a background in engineering, geoscienence, and related disciplines	Entry requirements of the WSE-programme

Learning Objectives

Upon completion of the module participants will be able to..

- 1 Discuss and explain 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 programme at UNESCO-IHE;
- 2 Reviewing, understanding, and applying:
  a) Mathematical concepts and techniques relevant to water science and engineering;
  b) Statistical and frequency analysis concepts and techniques that are relevant to water science and engineering;
- 3 Understand processes at the surface of the Earth that form and sculpt landscapes. Geologic processes comprise sedimentation compaction, tectonic uplifts and subsidence, and act on a long time scale. Geomorphologic processes comprise the action of water, wind, ice, fire, and living things on the surface of the Earth, along with chemical reactions that form soils and alter material properties. Geomorpological processes act on an intermediate time scale. Furthermore, in the very recent past during the anthropocene, humans have profoundly altered the landscape. Human induced processes are relatively short term, and occur rapidly. Many of these factors are strongly mediated by climate. What is the role of water as an agent of change, and how do water systems respond to these various driving forces?

Topics and Learning Activities

1 Water for Sustainable Development

Water issues in the world, societal relevance, existing platforms for water issues, problems of floods and droughts, drinking water, virtual water, river basin development and management, sanitation, navigation, water conflicts; particular focus on water related issues in developing countries. Water for food. Water resources management.

Learning Activities:

Plenary lectures, Key note speeches, invited lectures

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 harmonic analysis.

Learning Activities:

Formal lectures and exercises

3 Review of Statistics and Frequency Analysis

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

Learning Activities:

Formal lectures; small group assignments, classroom exercises and small individual assignments (small reports); practical exercises in computer lab

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 interacting with the water system. Overview of the human influences shaping the Earth's surface. The overall integration is shown with the aid of exercises and practicals.

Learning Activities:

Formal Lectures, exercises, practical, and computer lab

5 Fieldwork

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

Learning Activities:
Field trip

Lecturing Material

• 1 Various material, handouts, and references: Lecturing material available as on-line resource
• 2 Price, R. & Popescu, I.: Review of Mathematics
Handouts: Lecturing material available as on-line resource
• 3 LN00072, Van Gelder, P.: Review of Statistics and Frequency Analysis
Handouts: Lecturing material available as on-line resource
• 4 (a) Comprehensive Assessment of Water Management in Agriculture. 2007. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute. (b) FAO, Water Report n.38, 2012: Coping with water scarcity. An action framework for agriculture and food security. (c) Schultz, Bart and Stefan Uhlenbrook. 'Water security' - what does it mean, what may it imply? In: Water for a changing world. Developing local knowledge capacity. Edited by G.J. Alaerts and N.L. Dickinson. Proceedings International Symposium at the occassion of the 50th anniversary of UNESCO-IHE, 13-15 June 2007, Delft, the Netherlands. CRC press/Balkema, Leiden, the Netherlands, 2009.
• 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
• 6 De Heer, Geurtsen, Bijnsdorp, 2005. Handout Visit to the Deltaworks.

Assessment

- **25%: Written Exam (closed book) -- Review of Mathematics**
- **20%: Assignment -- Review of Statistics and Frequency Analysis**
- **10%: Written Exam (open book) -- The Earth System (Anthropocene)**
- **20%: Assignment -- The Earth System (Geology)**
- **25%: Written Exam (closed book) -- The Earth System (Geomorphology)**

2014/2016-WSE/01/c: Week 1 + Introduction to Water Science and Engineering											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Water for sustainable development									Various lecturer
	Review of Mathematics	**8**		**4**				**12**	**28**	I. Popescu
	Review of Statistics and Frequency Analysis	**6**	**4**					**6**	**22**	P. van Gelder
	The Earth System - Anthropocene	**4**		**2**				**6**	**14**	C. de Fraiture
	The Earth System - Geology	**6**	**8**	**6**				**12**	**32**	P. Paron
	The Earth System - Geomorphology	**8**	**6**	**6**				**14**	**36**	A. Seijmonsbergen
	Field Excursion Deltaworks					**8**		**8**	**8**	
	Total	**32**	**18**	**18**		**8**		**58**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HECEPD, WSE-HELWD, WSE-HERBD, WSE-HI, WSE-HWR, WSE-HELWD Sriwijaya
Module Coordinator: Maskey, S.

Module Sheet

Module Name Hydrology and hydraulics	Module Code WSE/02/c	Credits 5

Target Group	Prerequisites
All WSE participants; and participants of Joint International Master Programmes IMHI, IMCEPD and IMHWR (following the programme in partner institutes).	Entry requirements for WSE

Learning Objectives

Upon completion of the module participants will be able to..

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

Topics and Learning Activities

Free-Surface Hydrodynamics (A. Mynett, J.A. Roelvink, S. Maskey, L. Brandimarte):

Development of hydrodynamic equations as well as their applications to uniform and non-uniform flow and different methods of solution. Steady flow situations: uniform flow in channels; shear stress distribution; velocity distribution. Sub-critical and supercritical flows. Non uniform flow; rapid and gradually varied flow; computation of water surface profiles. Flow through hydraulic structures, Unsteady flow: equations of Saint-Venant, methods of solution, kinematic and diffusive waves, flood waves. Introduction to 2D flows and applications.

Learning Activities:

Lecture, exercise

Hydraulics Laboratory (L. Hayde):

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.

Learning Activities:

Laboratory exercise

Engineering Hydrology (S. Uhlenbrook, P. de Laat):

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, unit hydrograph method.

Workshop exercises on extreme value distribution, data completion/double mass analysis, hydrological modeling

Learning Activities:

Lecture, workshop, exercise

Geographical Information Systems and Remote Sensing (W. Bastiaansen, S. Suryadi, J.L. Alfonso, Z. Vekerdy):

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 9.

Learning Activities:

Lecture, exercise

Lecturing Material

• Maskey S., Roelvink D. and Brandimarte L., 2010. A Short Introduction to Free Surface Hydrodynamics - LN0436.10.1
• Hayde L.G., 2011. Applied Hydraulics, Manual Hydraulic Laboratory Exercises, Water Science and Engineering – LN0434/11/1
• De Laat, P.J.M. and Savenije H.H.G., 2009. Hydrology - LN0262/09/01
• De Laat, P.J.M., 2011. Workshop on Hydrology - LN0192/11/2
• Schotanus D., Velickov S. and Vojinovic Z., 2005. Learning ArcGIS - LN0227/05/1
• Vojinovic Z., 2007. Introduction to GIS and Remote Sensing - LN0323/07

Assessment

- **35%: Written Exam (open book) -- (Free-Surface Hydrodynamics)**
- **35%: Written exam (open book) -- (Engineering Hydrology)**
- **30%: Assignment -- (GIS and Remote Sensing)**

2014/2016-WSE/02/c: Hydrology and hydraulics											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**FREE SURFACE HYDRODYNAMICS**									
1.1	Introduction to Free Surface Hydrodynamics, 1-D Channel Flow	8						8	24	A. Mynett
1.2	1-D Channel Flow (Uniform/Non-uniform/Unsteady)	6	2					6	20	S. Maskey
1.2	Exercise - Uniform and Non-uniform Flow Computations			6				6	6	L. Brandimarte & S. Maskey
1.3	2-D and 3-D Shallow Water Equations	4						4	12	D. Roelvink
1.4	Hydraulics Laboratory	2			4			6	14	L. Hayde
2	**ENGINEERING HYDROLOGY**									
2.1	Engineering Hydrology - Lectures	12						12	36	S. Uhlenbrook
2.2	Engineering Hydrology - Workshop/Exercises			10				10	10	P. de Laat
3	**GIS AND REMOTE SENSING**									
3.1	Introduction to GIS and Remote Sensing	4						4	12	W. Bastiaansen & L. Alfonso
3.2	GIS Exercise			2	4			6	10	L. Alfonso & S. Suryadi
3.3	Remote Sensing Exercise			2	6			8	14	Z. Vekerdy
	Total	**36**	**2**	**20**	**14**			**70**	**158**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **Zhou, Y.**

Module Sheet

Module Name Hydrogeology	Module Code WSE/HWR/03/s	Credits 5

Target Group	Prerequisites
Participants in Hydrology and Water Resources specialisation	Approved BSc degree and basic hydrology/hydraulics and earth sciences subjects

Learning Objectives

Upon completion of the module participants will be able to..
- understand groundwater occurrences, aquifer classification and aquifer properties in various geological settings;
- understand the concepts related to groundwater storage, recharge and discharge;
- understand steady state and transient groundwater flow processes and their physical description;
- the ability to apply analytical solutions to solve steady state and transient groundwater problems;
- determine groundwater balances and to carry out pumping test analyses.

Topics and Learning Activities

Hydrogeology (T.Y. Stigter)

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.

Learning Activities:
Lectures and exercises.

Steady Groundwater Hydraulics (Y. Zhou)

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.

Learning Activities:
Lectures and exercises.

Transient Groundwater Hydraulics (T.N. Olsthoorn)

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.

Learning Activities:
Lectures and exercises.

Lecturing Material
- Nonner, J.C. Introduction to Hydrogeology, Taylor and Francis Publishers, 2012
- Zhou, Y. Steady Groundwater Flow, Lecture note, LN0433/10/1
- Olsthoorn, T.N. Transient Groundwater Flow, Analytical Solutions, Lecture note, LN0080/08/1

Assessment

- **25%: Written Exam (closed book) -- Hydrogeology**
- **25%: Written exam (closed book) -- Steady Groundwater Hydraulics**
- **20%: Written Exam (closed book) -- Transient Groundwater Hydraulics**
- **10%: Assignment -- Hydrogeology**
- **10%: Assignment -- Steady Groundwater Hydraulics**
- **10%: Assignment -- Transient Groundwater Hydraulics**

2014/2016-WSE/HWR/03/s: Hydrogeology											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Hydrogeology	**16**		**4**				**20**	**52**	Tibor Stigter
	Steady Groundwater Hydraulics	**14**		**4**				**18**	**46**	Y. Zhou
	Transient Groundwater Hydraulics	**12**		**6**				**18**	**42**	T.N. Olsthoorn
	Total	**42**		**14**				**56**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Alfonso Segura, J.L.**

Module Sheet

Module Name	Module Code	Credits
Hydroinformatics: modelling and information systems for water management	**WSE/HI/03/s**	**5**

Target Group	Prerequisites
Participants in WSE Programme - Hydroinformatics, including the IMHI participants (following the courses at partner institutions).	Acquaintance with computing

Learning Objectives

Upon completion of the module participants will be able to..

- Explain the main principles of computer organisation and operation, local and wide-area networking including Internet, main types of software
- Use GIS procedures and tools related to aquatic systems using ArcGIS software
- Apply main notions and principles of algorithmic design and other areas of computer science
- Know about the methodologies, architectural approaches and project management techniques of software engineering. Define requirements, analysis, and design for software code development and associated procedures and systems architecture
- Apply the main principles of software engineering. Define requirements, analysis, and design for software code development
- Develop computer code

Topics and Learning Activities

Information and communication technology. G. Corzo (IHE)

ICT and society. Computer systems organisation. Systems software: operating systems, compilers. Application software. Computer networks and Internet. Professional use of the World-Wide Web Main notions of computer science: algorithms, linear and non-linear data structures, file systems

Learning Activities:

Lectures, workshop

Introduction to MatLab. L. Alfonso (IHE)

General knowledge of the Matlab environment and its Desktop Tools, Matrices and Linear Algebra, data analysis and statistical analysis, data import and export, basic programming, functions

Learning Activities:

Exercises

Advanced GIS. S. Velickov (Hydrologic Research)

Exercises in GIS: advanced topics

Learning Activities:

Exercises

Software Engineering. D.P. Solomatine, L. Alfonso and G. Corzo (IHE)

Main notions of software engineering. Software development process: waterfall approach; prototyping; specification; design; documentation; validation. Computer programming: variables, structures, operators, statements, loops, functions. Advanced use of MATLAB: graphics and 3D visualization, graphical user interfaces, statistics, solving differential equations and water related problems

Learning Activities:

Lectures, exercises, workshops

Fieldtrip to Deltares

Fieldtrip to Deltares (Delft)

Learning Activities:

Fieldtrip

Lecturing Material

- Solomatine, Lecture Notes on Information Technology and Computer Science: An Introduction

- Xuan and Alfonso, Lecture Notes Introduction to MATLAB
- Solomatine, Lecture Notes on Software Engineering: An Introduction
- Velickov, Lecture Notes on GIS and Remote Sensing

Assessment

- **40%: Written Exam (closed book) -- Information Technology and Software Engineering**
- **15%: Assignment -- Introduction to MatLab**
- **15%: Assignment -- GIS**
- **30%: Assignment -- Software Engineering**

2014/2016-WSE/HI/03/s:Hydroinformatics: modelling and information systems for water management										
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Information and communication technology	**4**		**4**				**8**	**16**	Corzo
	Introduction to MATLAB				**8**			**8**	**16**	Alfonso
	Advanced GIS				**8**			**8**	**16**	Velickov
	Software engineering	**10**		**10**	**20**			**40**	**80**	Solomatine, Alfonso, Corzo
	Fieldtrip to Deltares					**8**		**8**	**8**	
	Total	**14**		**14**	**36**	**8**		**72**	**136**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Paron, P.**

Module Sheet

Module Name River basin hydraulics, geotechnics and remote sensing	Module Code WSE/HERBD/03/s	Credits 5

Target Group	Prerequisites
students and professionals with a basic knowledge of hydraulics, hydrology and earth science	Basic knowledge of hydraulics

Learning Objectives

Upon completion of the module participants will be able to..

- understand hydraulic concepts useful in river basin structure design and management
- gain solid knowledge of optical remotely sensed data collection and analysis for water resources and river basin development
- manage geotechnical (soil and rock) concepts relevant to river basin development

Topics and Learning Activities

I. Applied Hydraulics (A.Mynett)

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

Learning Activities:

Lectures, exercise

II. Remote Sensing for Water Resources (P.Paron/M.Smith)

(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.

Learning Activities:

Lectures, exercise, workshop

III. Rock mechanics (M.Marence)

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

Learning Activities:

Lectures, exercise

IV. Soil mechanics (to be assigned)

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.

Learning Activities:

Lectures, exercise

Lecturing Material

- Handouts, reading list will be provided by lecturers

Assessment
• 25%: Written Exam (open book) -- I. Applied hydraulics-Written exam with: multichoice and discursive answers
• 25%: Assignment -- II. Remote Sensing-Assignment
• 25%: Written Exam (closed book) -- III. Rock mechanics-Written exam with: multichoice and discursive answers
• 25%: Written Exam (open book) -- IV. Soil mechanics-Written exam with: multichoice and discursive answers

2014/2016-WSE/HERBD/03/s: River basin hydraulics, geotechnics and remote sensing											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Applied Hydraulics	11		1				12	34	A. Mynett
	Remote Sensing for Water Resources	6		9	10			25	47	P. Paron/M. Smith/H.vd Kwast
	Rock mechanics	7			3			10	27	M. Marence
	Soil mechanics	8			4			12	32	J. Salazar
	Total	32		10	17			59	140	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HECEPD
Module Coordinator: Ranasinghe, R.W.M.R.J.

Module Sheet

Module Name Introduction to coastal science and engineering	Module Code WSE/HECEPD/03/s	Credits 5

Target Group	Prerequisites Basic knowledge of hydraulics

Learning Objectives

Upon completion of the module participants will be able to..

- Understand the basics of coastal engineering.
- Analyse the behaviour of waves in oceanic and coastal waters
- Describe tides and tidal currents and be familiar with methods for tidal computations.
- Understand the principle of soil mechanics.

Topics and Learning Activities

Introduction to Coastal Engineering (D. Roelvink)

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

Learning Activities:

lecture, exercise

Waves (L. Holthuisen)

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 distribution, Rayleigh distribution, surface elevation, wave period, crest height, wave height, extreme values); long-term (initial value distribution, peak-over-threshold, yearly maximum).
Linear wave theory: constant depth (mass and momentum balance equations, boundary conditions, velocity potential function, particle velocity, particle path, dispersion, phase and group velocity, pressure, energy, energy transport, nonlinearities); varying depth (shoaling, refraction, diffraction, tides and currents, reflections, radiation stress, wave set-up and set-down).
Waves in oceanic and coastal waters: idealized conditions (dimensionless growth curves, universal spectra); oceanic and coastal wave predictions (energy balance equation, swell, generation by wind, quadruplet and triad nonlinear wave-wave interactions, wave breaking, and bottom friction).

Learning Activities:

lecture, exercise

Tides and Tidal currents (A. Roos)

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.
Astronomic analysis of tide generating force, harmonic analysis of the tide , prediction of tides, equations for tidal waves in two dimensions, effect of Coriolis, tidal motion in seas and oceans, analytical tidal computations, Lorentz method, numerical tidal computations, examples and applications, effects of tides on morphology.

Learning Activities:

lecture, exercise

Soil Mechanics (J. R. Salazar)

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.(lectures and exercise in together with HELWD and HERBD)

Learning Activities:

lecture, exercise

Introduction to Matlab

One lab session to teach students how to use Matlab

Lecturing Material

- Verhagen: Introduction of Coastal Engineering - LN0179

• Roos, A.: Tides and tidal currents – LN0211
• P. Lubking : Soil Mechanics LN174/04/1

• L. H. Holthuijsen: QWaves in Oceanic and Coastal Waters (Cambridge press)

Assessment

- **10%: Written Exam (closed book) -- Introduction to Coastal Engineering**
- **50%: Written exam (closed book) -- Waves**
- **30%: Written Exam (closed book) -- Tides and tidal currents**
- **10%: Assignment -- Soil Mechanics**

2014/2016-WSE/HECEPD/03/s: Introduction to coastal science and engineering											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Introduction to Coastal Engineering**	**2**						**2**	**6**	D. Roelvink
2	**Waves**	**14**		**22**				**36**	**64**	L. Holthuijsen
3	**Tides and Tidal Current**	**10**		**12**				**22**	**42**	A. Roos
4	**Soil Mechanics**	**6**		**6**				**12**	**24**	J. Salazar
5	**Introduction to Matlab**			**4**				**4**	**4**	
	Total	**32**		**44**				**76**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: HE-LWD
Module Coordinator: Mehari Haile, A.

Module Sheet

Module Name Principles and practices of land and water development	Module Code WSE/HELWD/03/s	Credits 5

Target Group	Prerequisites
Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development	Basic knowledge in alterative land and water development approaches, irrigation and drainage systems, soil physical and chemical properties

Learning Objectives

Upon completion of the module participants will be able to..

- Refresh knowledge about engineering properties of soil, its classification, stresses, strength and deformation.
- Understand the importance of irrigation and drainage for global food production and economics.
- Understand the relevance, concept, elements and needs of irrigation and drainage.
- Be able of making a preliminary layout and design of gravity irrigation and drainage networks.

Topics and Learning Activities

Soil Mechanics, J.R. Salazar Rivera

Elements of soil mechanics; soil particles, grain size distribution, soil clasification, Attberg limits, soil. A quick refreshing of the knowledge in soil mechanics with: 1 hour of instruction and 1 hour of Q&A. Instruction topics: the 1st period, soil classification and stresses in the soil, the 2nd period, strength of soil and the 3rd period, deformation of soil (Lectures and exercises in cooperation with HECEPD and HERBD).

Learning Activities:
lectures, exercises

Part A: Land and Water Development, C. de Fraiture(UNESCO-IHE)

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.

Learning Activities:
lectures

Part B: Introduction Irrigation and Drainage Systems, L.G.Hayde (UNESCO-IHE)

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 dâ€™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.

Learning Activities:
lectures

Part C: Irrigation and Drainage Main System Design, P. Karimi (UNESCO-IHE)

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.

Learning Activities:
lectures, exercises, individual assignments, written reports

Lecturing Material

- Lubking, 2004. Soil mechanics .. ln0174/04/
- B.Schultz, 2008: Land and water development. 2008.
- L.G.Hayde, 2011. Irrigation and Drainage System Design .. ln0321/11/1
- L.G. Hayde, 2007. Canal design .. ln0326/07/1
- L.G. Hayde, 2010. Basic Principles of Irrigation and Drainage .. ln0439/10/1

Assessment

- **15%: Assignment -- Soil Mechanics**

- **15%: Oral exam -- Land and Water Development**
- **70%: Assignment -- Irrigation and Drainage Main System Design**

2014/2016-WSE/HELWD/03/s: Principles and practices of land and water development											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Soil Mechanics	**6**	**8**					**6**	**26**	M.Rajabalinejad
	Land and Water Development	**8**						**8**	**24**	C. de Fraiture
	Introduction to Irrigation and Drainage Systems	**6**						**6**	**18**	L.G. Hayde
	Irrigation and Drainage Main System Design	**18**		**18**				**36**	**72**	K. Prasad and L.G.Hayde
	Total	**38**	**8**	**18**				**56**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **Venneker, R.G.W.**

Module Sheet

Module Name Surface hydrology	Module Code WSE/HWR/04/s	Credits 5

Target Group	Prerequisites
Students WSE/HWR Programme	Previous modules in the WSE/HWR Programme

Learning Objectives

Upon completion of the module participants will be able to..

- Explain the global hydrological cycle and water budget, the global energy budget, and the relation between, hydrology, climate, soils and vegetation.
- 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.
- Independently apply the understanding with analytical methods and conceptual models to quantitatively assess the surface hydrology for situations at catchment scales.

Topics and Learning Activities

Part I: 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.

Learning Activities:

Class lectures, exercises, application of simple computer models, independent study and practice

Part II: Soil water and evaporation

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

Learning Activities:

Class lectures, workshop assignments, independent study and practice

Part III: 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.

Learning Activities:

Workshop presentations and applications using the NAM model

Lecturing Material

- Surface Hydrology, lecture notes
- Workshop Hydrology, lecture notes
- Soil-Water-Plant Relations, lecture notes
- Presentation and exercise materials

Assessment

- **70%: Written Exam (closed book) --**
- **30%: Assignment --**

2014/2016-WSE/HWR/04/s: Surface hydrology											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Radiation, energy and hydrological balances**	**12**			**6**			**18**	**48**	Dr. R. Venneker
2.1	Soil water and evaporation I	7			4			11	29	Dr. R. Venneker
2.2	Soil water and evaporation II	7			4			11	29	Dr. J. Wenninger
3	**Conceptual catchment modelling**	**6**			**6**			**12**	**30**	Dr. J. Wenninger
4	**Examination**									
	Total	**32**			**20**			**52**	**136**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Popescu, I.I.**

Module Sheet

Module Name **Modelling theory and Computational Hydraulics**	**Module Code** **WSE/HI/04/s**	**Credits** **5**
Target Group Hydroinformatics participants	**Prerequisites** Basic Mathematics ; Hydraulics;	

Learning Objectives

Upon completion of the module participants will be able to..

- Explain the structure of the 1D, 2D and 3D flow equations as representations of conservation laws and know when to use the full dynamic equations and their approximations
- Understand and explain the foundations of mathematical modelling, its relationship to systems and control theory, main modelling paradigms, selecting modelling software
- 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
- Classify differential equations in terms of ODE/PDE and determine the nature of a given PDE, as well as indicating the nature of the initial and boundary conditions for well posed elliptic, parabolic and hyperbolic problems.
- Implement finite difference schemes to solve ordinary and partial differential equations.
- Analyse a numerical scheme and indicate if the scheme is likely to exhibit numerical diffusion, dispersion and/or instability and implement different numerical schemes for water related problems

Topics and Learning Activities

Equations of Water Flow (I. Popescu, IHE)

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 .

Learning Activities:

Formal lectures; classroom exercises;

Modelling Theory and Uncertainty (D. Solomatine, IHE)

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)

Learning Activities:

Formal lectures; workshops in computer lab;

Numerical Methods I (I. Popescu, IHE)

Introduction to differential equations; Differential equations in fluid dynamics; Initial and boundary value problems; Method of characteristics; Finite differences for ODE's; Finite differences for PDE's; exercises

Consistency, stability convergence. Fourier analysis of numerical solutions. Multi-dimensional problems. Diffusion in 2D.

Learning Activities:

Formal lectures; classroom exercises; home assignments; exercises, workshops.

Lecturing Material

- Price: Lecture notes on Mathematical Basis of Computational Hydraulics
- Popescu: Lecture notes on Numerical methods for Differential Equations

Popescu: Computational Hydraulics

- Solomatine: Lecture notes on Uncertainty analysis in modelling

Price: Lecture notes on Modelling theory and practice

• Power point presentations

Assessment

- **25%: Written Exam (closed book) -- on Equations of Water Flows**
- **25%: Written exam (closed book) -- on Modelling Theory and Uncertainty**
- **20%: Assignment -- on Numerical Methods I**
- **30%: Written Exam (closed book) -- on Numerical Methods I**

2014/2016-WSE/HI/04/s: Modelling theory and Computational Hydraulics										
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Equations of Water Flows**	**12**			**4**			**16**	**44**	I. Popescu
2	**Modelling theory and uncertainty**	**8**		**6**				**14**	**30**	D. Solomatine
3	**Numerical Methods I**	**12**		**4**	**12**			**28**	**64**	I. Popescu
	Total	**32**		**10**	**16**			**58**	**138**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Crosato, A.**

Module Sheet

Module Name River morphodynamics	Module Code WSE/HERBD/04/s	Credits 5

Target Group	Prerequisites
Environmental and Civil Engineers. Professionals dealing with river training and rehabilitation works. Scientists interested in the morphodynamics of alluvial systems.	Basic knowledge of river hydraulics (uniform and non-uniform flows, backwater curves) and of river hydrology (discharge variations, floods)

Learning Objectives

Upon completion of the module participants will be able to..
- understand some basic principles of river morphology and river morphological changes.
- assess long-term and short-term impacts of human interventions.
- understand the basics of river biogeomorphology.
- perform 1-D morphodynamic modelling of rivers with mobile bed.

Topics and Learning Activities

Principles of River Morphodynamics (A. Crosato)

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.
Learning Activities:
Lessons and exercises.

River Morphodynamics in Engineering Projects (E. Mosselman)

Flooding caused by sedimentation.
River bifurcations.
River bank erosion.
River navigation.
Learning Activities:
Lessons and exercises.

1-D modeling of Rivers with Mobile Bed (SOBEK-RE) (K. Sloff)

SOBEK-RE: model description and exercises dealing with the simulation of temporal bed level changes (delopment of a trench or shoal, effects of interventions)
Learning Activities:
Lessons and exercises.

Lecturing Material
- Sloff, K., 2007. SOBEK-RE exercises. Handout.
- Mosselman, E. 2001. Morphological development side channels. Handout.
- Crosato, A., 2006. Morphological Response at the reach scale (LN0381).
- Crosato, A., 2009. River morphodynamics. Brief introduction (LN0421).

Assessment

- **20%: Assignment --**
- **80%: Written exam (open book) -- 3hr**

2014/2016-WSE/HERBD/04/s: River morphodynamics											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Principles of River Morphodynamics**	**25**		**7**	**1**		**5**	**38**	**99**	A. Crosato MSc. PhD.
2	**River Morphodynamics in Engineering Projects**	**7**		**3**			**2**	**12**	**30**	E. Mosselman MSc. PhD.
3	**1-D modeling of Rivers with Mobile Bed**			**12**				**12**	**12**	K. Sloff MSc. PhD.
	Total	**32**		**22**	**1**		**7**	**62**	**141**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Coastal Engineering and Port Development**
Module Coordinator: **Roelvink, J.A.**

Module Sheet

Module Name Coastal systems	Module Code WSE/HECEPD/04/s	Credits 5

Target Group	Prerequisites
Students in coastal engineering and port development	Basic knowledge of waves and hydraulics

Learning Objectives

Upon completion of the module participants will be able to..

- basically understand processes in coastal hydrodynamics and morphology;
- assess processes related to salt intrusion and density currents;
- 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.

Topics and Learning Activities

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 Transverse and longshore sand transport under the influence of waves and currents, modern longshore transport formulae and coastline computations, analytical formulae and background of mathematical models. Introduction to various hard protection methods (groins, artificial headlands ,offshore breakwaters)

Learning Activities:

Lectures and assignments

Modelling and Numerical Aspects

The course aims to introduce numerical aspects, so that people will become aware of the limitations and characteristics hydronamic numerical models.

The course starts with a short review of differential equations, principles of discretisation and discretisation of shallow water equations in 1D. Further, it will introduce concepts like the Courant number, and the stability and accuracy of numerical implicit and explicit schemes. Emphasis will be on coastal engineering applications, including tides, short waves and morphological phenomena.

Learning Activities:

Lectures and assignments

Lecturing Material

- Collection of recent papers on morphological modeling

- Os, A.G. van, Salt intrusion and density currents - Lecture notes In 0286/98/
- Numerical methods for differential equations, Popescu
- Roelvink and Reniers, A guide to modeling coastal morphology, World Scientific, 2011.

Assessment

- **70%: Written Exam (open book) -- Coastal hydrodynamics and morphology (Roelvink, Ranasinghe)**
- **30%: Assignment -- Numerical methods (Popescu)**

2014/2016-WSE/HECEPD/04/s: Coastal systems											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Coastal Hydrodynamics and Morphology	**4**		**4**				**8**	**16**	M. van der Wegen, MSc. PhD.
	Coastal Hydrodynamics and Morphology	**14**		**16**				**30**	**58**	prof. J.A. Roelvink, MSc. PhD.
	Coastal Hydrodynamics and Morphology	**10**		**2**				**12**	**32**	R.W.M.R.J. Ranasinghe, MSc., PhD.
	Modelling and numerical aspects	**2**	**20**	**8**				**10**	**34**	I.I. Popescu, MSc., PhD.
	..									
	..									
	Â									
	Total	**30**	**20**	**30**				**60**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Mehari Haile, A.

Module Sheet

Module Name Design aspects of irrigation and drainage systems	Module Code WSE/HELWD/04/s	Credits 5

Target Group	Prerequisites
Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development.	Good knowledge of global, regional and local land and water development perspectives, irrigation and drainage system design and soil characteristics

Learning Objectives

Upon completion of the module participants will be able to..

- 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
- 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
- Discuss crop water requirements, drainage requirements and understand their mutual relationship
- Determine the boundary conditions required for water delivery and distribution systems at field level
- Select appropriate irrigation and drainage methods under different physical and agricultural circumstances
- Make a preliminary layout and design of a gravity irrigation and drainage network at tertiary level.

Topics and Learning Activities

Applied Hydraulics of Irrigation Systems I, L.G. Hayde (UNESCO-IHE)

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, and 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.

Learning Activities:
lecture, Exercise

Soil-Water-Plant Relations, P.J. M. de Laat (UNESCO-IHE)

Physical and chemical properties of soils: texture; structure; density; colour; temperature; specific surface of particles; structure of clays; cation exchange capacity; exchange equations; sodification 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.

Learning Activities:
lecture, Exercise

Irrigation Methods, R. Cuenca (Oregon State Univ. USA)

Surface and sub-surface irrigation, sprinkler and drip irrigation, surface irrigation methods (furrow, border and basin): classification, advance and recession curves, operation and management aspects, efficiency and uniformity definitions, recent developments, surface irrigation design.

Learning Activities:
Lecture, Exercise

Irrigation and Drainage - Tertiary Unit Design I, A. Mehari Haile (UNESCO-IHE)

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.

Learning Activities:
lecture, Exercise

Lecturing Material

- Hayde,L.G., 2011. Applied Hydraulics; Synopsis, LN 0378/11/1
- Hayde, L.G., 2011. Applied Hydraulics; Manual Flop, Gradually Varried Flow Profiles, LN0333/11/1
- Hayde, L.G., 2011. Applied Hydraulics; Supplementary notes,LN0442/11/1
- Hayde, L.G., 2011. Applied Hydraulics; Gradually Varried Flow, LN0443/11/1
- de Laat, 2006. Soil-Water-Plant relations.
- Mehari Haile, A., Depeweg,H., Fadul, E.M. 2012. Design and layout of tertiary units

Assessment

- **20%: Assignment -- Applied Hydraulics of Irrigation Systems I**
- **30%: Written exam (closed book) -- Soil Water Plant Relations**
- **25%: Assignment -- Irrigation Methods**
- **25%: Assignment -- Irrigation and Drainage - Tertiary Unit Design I**

2014/2016-WSE/HELWD/04/s: Design aspects of irrigation and drainage systems											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Applied Hydraulics of Irrigation Systems I	**6**	**4**	**6**				**12**	**28**	L.G. Hayde
	Soil-Water-Plant Relations	**8**	**4**	**10**				**18**	**38**	P.J.M. De Laat
	Irrigation Methods	**8**	**2**	**6**				**14**	**32**	R.H. Cuenca
	Irrigation and Drainage - Tertiary Unit Design I	**10**	**2**	**10**				**20**	**42**	A. Mehari Haile
	Total	**32**	**12**	**32**				**64**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **HWR**
Module Coordinator: **McClain, M.E.**

Module Sheet

Module Name Water quality	Module Code WSE/HWR/05/s	Credits 5

Target Group	Prerequisites
All WSE students	No special prerequisites

Learning Objectives

Upon completion of the module participants will be able to..

- Apply basic chemical principles and determine reactions that play a role in the determination and evolution of water quality;
- Determine the various (contaminant) transport mechanisms taking place in (sub)surface hydrology;
- Apply appropriate methods to monitor, analyze and assess the water quality characteristics of hydrological systems.

Topics and Learning Activities

Hydrochemistry (Appelo)

Rock weathering and the role of silica and carbonate minerals; cation exchange and oxidation-reduction reactions. Contaminant and pollution transport mechanisms, such as advection, dispersion, and mass exchange.Hydrochemical modeling using PHREEQC. Includes an introduction to the laboratory.

Learning Activities:
Lectures and exercises.

Organic matter and nutrient biogeochemistry (McClain)

Carbon cycling: organic matter and biochemical oxygen demand;
Nutrient cycling: nitrogen, phosphorus, and eutrophication;
Exercises with QUAL 2K
Learning Activities:
Lectures and exercises.

Water quality standards, monitoring, and assessment (McClain)

Water quality standard setting; collection and analysis of water quality monitoring data; water quality assessment techniques.
Learning Activities:
Lectures and project.

Lecturing Material

- Lecture Notes
- Appelo, C.A.J. and Postma, D. 2005. Geochemistry, Groundwater, and Pollution, Taylor and Francis Publishers.
- Qual2K Manual

Assessment

- **50%: Written Exam (open book) -- Hydrochemistry**
- **20%: Written exam (open book) -- Organic matter and nutrient biogeochemistry**
- **30%: Assignment -- Water quality monitoring and assessment**

2014/2016-WSE/HWR/05/s: Water quality											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Biogeochemistry**									McClain
1.1	Forms and causes of water pollution	3						3	9	
1.2	Carbon Cycling	3						3	9	
1.3	Nutrient Cycling	3						3	9	
	..									
2	**Water Quality Monitoring**									McClain
2.1	Water quality standards	2						2	6	
2.2	Designing a monitoring program	3						3	9	
2.3	Physico-chemical and bio-Monitoring	3						3	9	
2.5	Case study - monitoring program design			8				8	8	
	..									
3	**Hydrochemistry**									Appelo
3.1	From Rainwater to Groundwater	3						3	9	
3.2	Flow and retardation	3						3	9	
3.3	Law of mass action and activity	3						3	9	
3.4	Carbonate chemistry I	3						3	9	
3.5	Carbonate chemistry II	3						3	9	
3.6	Cation exchange I	3						3	9	
3.7	Cation exchange II	3						3	9	
3.8	Sorption and silicates	3						3	9	
3.9	Redox Reactions	3						3	9	
	Total	**44**		**8**				**52**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Solomatine, D.P.**

Module Sheet

Module Name Modelling and information systems development	Module Code WSE/HI/05/s	Credits 5

Target Group	Prerequisites
Participants of WSE Programme - Hydroinformatics. Participants of the Erasmus Mundus MSc Programme in Flood Risk Management.	Modules 1-4

Learning Objectives

Upon completion of the module participants will be able to..

- 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
- Know about the main notions and types of information and knowledge systems and implement information systems using database technolog
- Understand the process of a river model building: data analysis, model calibration and verification.
- Specify, design and build a simple modelling system with graphical user interface using MATLAB

Topics and Learning Activities

Numerical Methods II, I. Popescu (IHE)

Introduction to finite volume method. Introduction to finite element method. Exercises.

Learning Activities:

Lectures, exercises

Database, information and knowledge systems. D.P. Solomatine and S.J. van Andel (IHE)

Introduction. Society, information and knowledge.

Data models. Information entities and relations. Relational data model. Normalisation of tables. Semantic data model. Main types of information systems. Management information systems. Exercises to develop an entity-relationship model, and implement it in a DBMS.

Learning Activities:

Lectures, exercises

River modelling. I.Popescu and Kun Yan (IHE)

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

Learning Activities:

Exercises

Modelling system development. L. Alfonso and G. Corzo (IHE)

Developing modelling and graphical user interface components of a water-based system using standard numerical and graphics toolboxes (in the MATLAB environment).

Learning Activities:

Excercises, workshop

Lecturing Material

- Popescu: Lecture notes on Numerical methods
- Solomatine: Lecture notes on Database, information and knowledge systems
- Mike11 User manual, Sobek User manual

Assessment

- **30%: Assignment -- Numerical Methods II**
- **20%: Written exam (closed book) -- Database, Information and Knowledge Systems**
- **20%: Assignment -- Modelling Systems Development**
- **30%: Assignment -- River Mmodelling**

2014/2016-WSE/HI/05/s: Modelling and information systems development											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Numerical Methods II	**8**			**10**			**18**	**44**	Popescu
	Database, Information and Knowledge Systems	**6**		**6**	**4**			**16**	**32**	Solomatine, van Andel
	River modelling	**4**		**14**				**18**	**26**	Popescu and Kun Yan
	Modelling system development	**2**		**16**	**4**			**22**	**30**	Alfonso and Corzo
	Total	**20**		**36**	**18**			**74**	**132**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Werner, M.G.F.**

Module Sheet

Module Name Data collection and analysis	Module Code WSE/HERBD/05/s	Credits 5

Target Group	Prerequisites
Engineers, geoscientists, and other professionals with an interest for data collection and analysis, including field monitoring techniques, remote sensing & GIS methods.	Experience with basic statistics, basic GIS & Remote Sensing, and hydrology and hydraulics are welcome

Learning Objectives

Upon completion of the module participants will be able to..
- 1 Gain an in-depth knowledge of the monitoring schemes and field techniques for water and sediment sampling.
- 2 Be able to apply methods for validation and processing of data, including developing flood frequency statistics.
- 3 Gain an introduction to the concepts of deterministic and probabilistic design for river and coastal structures.

Topics and Learning Activities

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, and sediments. Quality control of data and optimisation of data collection networks, management of data in the river basin; organisations, roles, and responsibilities. Spatial and temporal scales, statistical methods for describing data variability, including flood frequency analysis.

Learning Activities:

Lectures and exercises

2 Deterministic & Probabilistic Design

Introduction to deterministic and probabilistic design; safety & risk. Principles; failure risks; events and fault trees; comparison with traditional design approaches. Applications to river & coastal engineering structures; flood defence; river training and bank protection works. Exercise on the application of probabilistic design methods to hydraulic structure.

Learning Activities:

Lectures and exercises

Lecturing Material
- 1 Hydrometry, W. Booiten, 3rd Edition, UNESCO-IHE Lecture Notes Series, 2008
- 2 Hand-outs provided by the instructor
- 2 Hand-outs and Lecture Notes provided by the instructor, reading list

Assessment

- **40%: Written Exam (open book) -- Data collection in the River Basin.**
- **10%: Assignment -- Data collection in the River Basin**
- **30%: Written Exam (closed book) -- Deterministic and Probabilistic design. Part One (A formula sheet will be provided)**
- **20%: Assignment -- Deterministic and Probabilistic design: Part Two (Four marked assignments)**

2014/2016-WSE/HERBD/05/s: Data collection and analysis											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Data collection in the River Basin	**24**		**16**				**40**	**88**	M. Werner
	Deterministic & Probability Design	**12**		**14**				**26**	**50**	P. H.A.J.M. van Gelder
	Total	**36**		**30**				**66**	**138**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HECEPD / Short Course
Module Coordinator: Dastgheib, A.

Module Sheet

Module Name Port planning and infrastructure design	Module Code WSE/HECEPD/05/s	Credits 5

Target Group	Prerequisites
	Short Waves, Tides and Tidal Currents, Coastal Processes

Learning Objectives

Upon completion of the module participants will be able to..

- 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
- Explain the administration models of ports and the various steps in port masterplanning
- 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 infra structure in the port
- Choose the equipments needed in a Container Terminal and Design the Terminal
- 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
- Include uncertainty in port planning and management

Topics and Learning Activities

Maritime transport (A. Dastgheib)

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

Learning Activities:

lecture

Port Planning (A.Dastgheib , C. Klaver, P. Taneja)

Port Master Planning : flexibility and uncertainty, port functions and organization, port planning methodology, planning process, planning tasks, exercise; Design of Wet Areas: ship maneuvering and hydrodynamic behavior, approach channels, maneuvering areas within the port, port basins and berth areas, morphological aspects; Design of Container Terminals: terminal services, terminal components, types of terminals, terminal capacity, terminal dimensions; Introduction to queuing theory as a tool on port planning and traffic simulations.

Learning Activities:

lecture, exercise

Marine Structures (L. Groenewegen)

Introduction, site selection, investigations at chosen site, determination of design parameters and normal design sequence of offshore jetties, typical lay-out and components of offshore berthing structures, design criteria, structural considerations, theories and techniques used, process of assessment of construction method and choice of construction equipment, practical recommendations, design of smaller jetties, examples. Exercise on design of Marine structures: determination of design parameters, lay-out, design criteria, functional and structural design.

Learning Activities:

lecture

Excursion Port of Rotterdam and Maeslantkering

Visit terminals in the Port of Rotterdam, see aspects of cargo handling and the logistic chain.Visit the innovative storm surge barrier Maeslantkering.

Learning Activities:

Field trip

Lecturing Material

- Ligteringen, H.: Ports and Terminals, VSSD
- Groenveld, R.: Service Systems in Ports and Inland waterways – VSSD
- PIANC, Approach Channels: A Guide for Design (Electronic Version)

Assessment

- **30%: Assignment -- Port Planning**
- **70%: Assignment -- Marine Structures**

2014/2016-WSE/HECEPD/05/s: Port planning and infrastructure design										
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Maritime Transport**			**4**				**4**	**4**	A. Dastgheib
2	**Port Planing**		**8**						**8**	
2.1	Port Functions	2						2	6	P.Taneja
2.2	Int. to Master Planing	2						2	6	P.Taneja
2.3	Adaptive Port Planing	2						2	6	P.Taneja
2.4	Design of Wet Areas	2						2	6	A. Dastgheib
2.5	Planing of Land Areas	2						2	6	A. Dastgheib
2.6	Container Terminals	4						4	12	C. Klaver
2.7	Queuing Theory	6						6	18	A. Dastgheib
3	**Marine Structures**	**16**		**12**				**28**	**60**	L. Groenewegen
4	**Excursion Port of Rotterdam and Maeslantkering**					**8**		**8**	**8**	
	Total	**36**	**8**	**16**		**8**		**60**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Mehari Haile, A.

Module Sheet

Module Name Water management systems and agronomy	Module Code WSE/HELWD/05/s	Credits 5

Target Group	Prerequisites
Prospective Water Science and Engineering experts, particularly those specializing in Land and Water Development	Irrigation and drainage system design, preliminary teriary unit layout and design, plant water relationships

Learning Objectives

Upon completion of the module participants will be able to..

- Analyse and evaluate and to apply the hydraulic principles for pipe flow in irrigation and drainage engineering.
- Present, process and interpret results of hydraulic laboratory measurements in a technical report
- Explain the principles of the hydrological cycle, the basic characteristics of precipitation and evaporation, the principles of reservoir operation.
- Apply some statistical tools used in hydrology, rainfall-runoff relations and design floods
- Have an understanding of water-crop yield relationships, management options under land or water scarcity and water saving techniques and be able to determine crop water requirements.

Topics and Learning Activities

Applied Hydraulics of Irrigation Systems II, L.G.Hayde, (UNESCO-IHE)

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. PROFILE to calculate the basic flow parameters (water depth, discharge, shear stress) in an open channel, namely irrigation and/or drainage canals. 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.

Learning Activities:
lectures, exercises

Hydraulics Laboratory 2, L.G. Hayde (UNESCO-IHE)

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. Pipe flow: velocity distribution and friction losses. Discharge-depth relationship.

Learning Activities:
lectures, class exercises, laboratory works

Irrigation and Drainage - Tertiary Unit Design II, A. Mehari Haile (UNESCO-IHE) and Eiman M. Fadul (Hydraulic Research Station, Sudan)

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.

Learning Activities:
lectures, class exercises, individual and group assignments, written reports

Agronomy, A. Mehari Haile (UNESCO-IHE)

Functions of water in the plant, development of root systems, transpiration, plant factors affecting transpiration, measurement of transpiration, water deficit and plant growth, water yield curves, crop-production functions, determination of optima under land or water scarcity conditions, calculate crop water requirements, select suitable planting dates, calculate yield decreases due to water stress, assess the effects of staggering on irrigation requirements, establish acceptable levels of water stress to reduce irrigation requirements, case studies on deficit irrigation, water use efficiency modification in different irrigation systems, agricultural practices to improve water use efficiency. Exercise CROPWAT.

Learning Activities:
lectures, exercises, individual and group assignments, written reports

Lecturing Material

- Hayde, L.G., 2011. Applied Hydraulics; Manual Flop, Gradually Varried Flow Profiles, LN0333/11/1
- Hayde,L.G., 2011. Applied Hydraulics; Synopsis, LN 0378/11/1
- Hayde, L.G., 2011. Applied Hydraulics; Pipe flow, LN0444/11/1
- Hayde, L.G., 2011. Applied Hydraulics; Manual Hydraulics Laboratory Exercises 2, LN0422/11/3
- Mehari Haile, A. 2012. Irrigation Agronomy, An Agricultural Approach. Forthcoming

Assessment

- **35%: Written Exam (closed book) -- Applied Hydraulics of Irrigation Systems II**
- **10%: Assignment -- Hydraulics Laboratory 2**
- **30%: Assignment -- Irrigation and Drainage, Teriary Unit Design II**
- **25%: Assignment -- Agronomy**

2014/2016-WSE/HELWD/05/s: Water management systems and agronomy											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Applied Hydraulics of Irrigation Systems II	**12**	**4**	**12**				**24**	**52**	L.G. Hayde
	Hydraulics Laboratory 2				**8**			**8**	**16**	L.G. Hayde
	Irrigation and Drainage - Tertiary Unit Design II	**10**	**4**	**8**				**18**	**42**	A. Mehari Haile
	Agronomy	**8**		**6**				**14**	**30**	A.Mehari Haile
	Total	**30**	**8**	**26**	**8**			**64**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: HWR
Module Coordinator: Foppen, J.W.A.

Module Sheet

Module Name Tracer hydrology and flow systems analysis	Module Code WSE/HWR/06/e	Credits 5

Target Group	Prerequisites
Interested students.	Approved BSc degree and basic hydraulics/hydrology, earth sciences, hydrogeology, and water quality.

Learning Objectives

Upon completion of the module participants will be able to..

- apply knowledge of the concepts of tracer hydrology, with emphasis on environmental isotopes.
- apply knowledge of the concept of hydrochemical facies analysis.
- independently use these methodologies to quantitatively assess characteristics of hydrological flow systems.
- carry out comprehensive hydrological flow systems analyses in surface water and groundwater systems in different hydro-climatic regions and geological conditions.

Topics and Learning Activities

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 use of tracer techniques will illustrate the determination of flow pathways, residence times of the water, the hydraulic properties of flow systems and the mixing of different water compartments.

Learning Activities:

The learning objectives will be achieved through class lectures explaining background and methodologies, practical application exercises, which are to be worked out as assignments, and group exercises.

Flow Systems Analysis

Introduction: definitions, use of Systems Analysis in practice, examples;
Characteristics of the natural flow field: Toth's description of Groundwater Flow Systems,
Hydrochemical Facies Analysis: Defining the facies and classification of water types, indexes and temperature, identification of groundwater origin, mapping and interpretation;

Learning Activities:

Lectures, exercises, and a 1 day fieldwork to the Halsteren Laag (a small brook).

Lecturing Material

- Hand-outs
- Lecture Notes

Assessment

- **50%: Written Exam (closed book) -- Part Tracer Hydrology**
- **50%: Written exam (closed book) -- Part Flow Systems Analysis**

2014/2016-WSE/HWR/06/e: Tracer hydrology and flow systems analysis											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Tracer Hydrology**	**16**				**2**	**4**	**22**	**62**	Wenninger
2	**Tracer Hydrology**	**4**						**4**	**12**	Araguas (IAEA)
3	**Flow Systems Analysis**	**12**		**8**		**6**	**4**	**30**	**62**	Foppen
	Total	**32**		**8**		**8**	**8**	**56**	**136**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Solomatine, D.P.**

Module Sheet

Module Name Computational Intelligence and Operational water management	Module Code WSE/HI/06/s	Credits 5

Target Group	Prerequisites
Participants in WSE programmme - hydroinformatics, Participants in Erasmus Mundus Flood Risk Management Programme, Participants in short course "Computational intelligence and operational water management"	

Learning Objectives

Upon completion of the module participants will be able to..

- Understand and apply the main optimisation techniques
- Understand and explain how real-time control systems work
- Identify the potential of control to solve hydrological problems
- Sketch a general plan for a regional real-time control system
- 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
- Correctly classify a modelling problem as a physically-based, data-driven, or hybrid

Topics and Learning Activities

Introduction to optimisation, D. P. Solomatine (IHE)

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 sector.

Learning Activities:

Formal lectures
Classroom - computer exercises
Exercises and workshops: optimal water allocation; automatic model calibration

Operational water management, L. Alfonso, S. J. van Andel (IHE), A. Szollosi-Nagy (IHE), A. Lobbrecht (Hydrologic)

Introduction to operational water management and real-time control; modelling for control; optimal control problems; characterisation of control systems; operational forecasting; data assimilation

Learning Activities:

Formal lectures
Classroom - computer exercises
Classroom workshops on case study analysis
One day field trip to North-West Netherlands

Data driven modelling and computational intelligence, D. P. Solomatine (IHE), B. Bhattacharya (IHE), A. Szollosi-Nagy (IHE)

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.

Learning Activities:

Formal lectures
Classroom - computer exercises
Exercises and workshops: using data driven methods in hydrological forecasting.

Lecturing Material

- Solomatine. Lecture notes on Data-driven modelling.
- Solomatine. Reader on optimization.
- Mitchell. Machine learning. McGraw-Hill, 1997.
- Witten and Frank. Data mining. Morgan-Kaufman, 2000.
- Abrahart, See, Solomatine (eds.). Practical hydroinformatics: computational intelligence and technological developments in water applications. Springer, 2008.
- Lobbrecht et al. Lecture notes on Real time control of water systems
- Optimisation software: GLOBE, MS-Excel Solver; Exercises
- Data-driven modelling software: WEKA, NeuralMachine; Exercises

Assessment

- **10%: Assignment -- Real-time control of water systems (PID exercise)**
- **15%: Assignment -- Operational water management (Case study)**
- **25%: Written Exam (closed book) -- Operational water management and real-time control**
- **30%: Written Exam (open book) -- Data driven modelling and computational intelligence**
- **20%: Assignment -- Data driven modelling and computational intelligence**

2014/2016-WSE/HI/06/s: Computational Intelligence and Operational water management											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Introduction to optimisation**	**4**		**4**	**2**			**10**	**20**	D.P. Solomatine
2	**Operational water management**	**12**		**20**				**32**	**56**	L. Alfonso, S.J. van Andel, Szollosi-Nagy, A.H. Lobbrecht
3	**Data driven modelling and computational intelligence**	**14**		**22**				**36**	**64**	D.P. Solomatine, B. Bhattacharya
	Total	**30**		**46**	**2**			**78**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: HERBD
Module Coordinator: Beek, E. van

Module Sheet

Module Name River Basin Development and EIA	Module Code WSE/HERBD/06/s	Credits 5

Target Group	Prerequisites
Students of Hydraulic Engineering and River Basin Development	Working knowledge in topics such as Hydrology, Hydraulics, Sediment and Morphology, Water Quality, Ecology and River Dynamics.

Learning Objectives

Upon completion of the module participants will be able to..

- Understand the concepts of River Basin Development, including Integrated Water Resource Management (IWRM); Familiarise participants with potential uses of water resources and development options, factors affecting these and problems involved; Understand the principles and advances in integrated planning, development and multi-sectoral management of water resources; Understand the concepts behind and approaches of Environmental Impact Assessment (EIA).
- Make a plan for the development of a river basin, including alternative strategies out of which decision makers can choose from and the impacts these alternative strategies have on the criteria that indicate the development goals of the basin. As part of that they should be able to describe likely environmental impacts on the water environment (from WRD projects, explain the principles of environmental (social) impact assessment (EIA/ESIA) and distinguish and describe the different methodologies available to environmental assessment. Based on that they should be able to apply EIA for a RBD plan and communicate the results to others.
- Understand the basic of economics in RBD and the importance of good governance for the implementation of RBD plans and the operational management of river basins.
- Use 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

Topics and Learning Activities

Water Resources Development (Eelco van Beek)

Potentials and uses of water resources and factors affecting these, including the scope and role of hydraulic engineering in WRM/WRD projects. Principles and advances in integrated planning and multi-sectoral management of water resources, including (modelling) concepts of water systems analysis, decision support, performance criteria and evaluation techniques for the development of water resources in river basins. General planning and implementation principles, including legal and institutional aspects, of a wide variety of hydraulic engineering works. Case studies and exercises to respectively illustrate lessons learnt and best practices as well as gaining hands-on experience with essential components of WRD.

Learning Activities:

Lectures and small assignments

Environmental Impact Assessment for WRM Projects (Hendrike Clouting and Rinus Vis)

Concepts of EIA, process, legal and follow up requirements. General planning principles and EIA composition. Impact identification and evaluation, mitigation development and hierarchy. Best practice guidance. Case studies and hands on experience during exercises and workshops.

Learning Activities:

Lectures, Exercises & Case Study

River Basin Development Exercise (Agnese Boccalon)

Workshop on River Basin Development integrating the above aspects(based on a case study in the Nile Basin), emphasizing (i) problem analysis, policy making, planning, environmental and engineering aspects, (ii) integration of scales in time and space (basin, river stretch and floodplain) (iii) exercises and computer simulations on water supply and demand and floodplain management and (iv) components of Environmental Assessment.

Learning Activities:

Exercise in computer lab

Lecturing Material

- Beek, E van and D.P. Loucks, D. 2005. Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications, UNESCO Publishing, Paris
- Beevers, L. and H. Clouting, Environmental Assessment (EIA/SEA). UNESCO-IHE Lecture notes

• Various Handouts
• Description RBD (Nile) exercise, including RIBASIM manual

Assessment

- **40%: Written Exam (closed book) -- Water Resources Development**
- **10%: Assignment -- Water Resources Development**
- **20%: Written Exam (closed book) -- Environmental Assessment for WRM Projects**
- **10%: Assignment -- Environmental Assessment for WRM Projects**
- **20%: Assignment -- River Basin Development Exercise (Nile)**

2014/2016-WSE/HERBD/06/s: River Basin Development and EIA										
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Water Resources Development	**24**	**4**					**24**	**76**	Eelco van Beek
	Environmental Aspects of WRM projects	**6**		**4**				**10**	**22**	Henrike Clouting
	Environmental Aspects of WRM projects	**4**		**4**				**8**	**16**	Rinus Vis
	River Basin Development Exercise	**2**		**20**				**22**	**26**	Agnese Boccalon
	Total	**36**	**4**	**28**				**64**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HECEPD / Short Course
Module Coordinator: Dastgheib, A.

Module Sheet

Module Name Coastal and port structures	Module Code WSE/HECEPD/06/s	Credits 5

Target Group	Prerequisites
	Short Waves, Tides and Tidal Currents, Coastal Processes

Learning Objectives

Upon completion of the module participants will be able to..

- 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.
- Have an overview of structures and vessels used in the offshore industry, their behaviour under conditions of winds, waves, currents, environmental loading.
- 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.

Topics and Learning Activities

Design of Breakwaters (J. W. van der Meer, A. Dastgheib)

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.

Learning Activities:

lecture, exercise

Physical Scale Modelling (J. Van Overeem)

Overview of physical models, outline of the factors determining the design of scale models, reproduction of various hydraulic phenomena, focused on morphodynamics.

Learning Activities:

lecture

Offshore Engineering (A.Aalbers)

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.

Learning Activities:

lecture

Lecturing Material

- Van de Meer, J.W., Ligteringen, H: Breakwater Design, Lecture notes ln0026/14
- Van de Meer, J.W., Dastgheib, A. : Excersise Breakwater Design Lecture notes ln0027/14
- Overeem, J. van: Scale models for coastal processes - Lecture notes hh143/14
- Electronic Version of papers and PIANC Report

Assessment

- **100%: Assignment -- Design of Breakwaters**

2014/2016-WSE/HECEPD/06/s: Coastal and port structures										
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	**Design of Breakwaters**	22						22	66	J. van der Meer
2	**Design of Breakwaters**		8				16	16	56	A. Dastgheib / J. Van der Meer
3	**Physical Scale Modelling**	4						4	12	J. van Overeem
4	**Offshore Engineering**			6				6	6	A.Aalbers
	Total	26	8	6			16	48	140	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Suryadi, F.X.**

Module Sheet

Module Name Socio-economic and environmental aspects of irrigation and drainage	Module Code WSE/HELWD/06/s	Credits 5

Target Group	Prerequisites
All Land and Water Development participants.	Main and tertiary irrigation system design, agronomy, soil plant water relationship.

Learning Objectives

Upon completion of the module participants will be able to..

- Select a suitable flow control system, the appurtenant flow control structures and to specify the operation rules of the structures and social implications of applied irrigation techniques for different users
- Assess the sediment transport in irrigation canals and to evaluate the effect of various operation scenarios on the sedimentation; make a design of the horizontal and vertical alignment of irrigation canals considering various sediment conditions and modes of operation and maintenance;
- Discuss the importance of all environmental and social aspects that complete the determination of the feasibility of any land development project
- Describe the economic feasibility of land development projects and have a first understanding of financial reporting

Topics and Learning Activities

Economic & Financial Analyses (Dr. Y. Jiang, MSc. UNESCO-IHE)

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.

Learning Activities:

lecture, exercise

Sociological aspects (J.W. Librand, WUR Wageningen)

Interpretation of social effects of irrigation, organisation of irrigation projects. Case studies on central aspects of irrigation schemes, such as governmental or private control; function of irrigation groups (membership and maintenance); applied technology, distribution and control. Case studies based on the participantsâ€™ experience. Topics: function of sociologists, use requirements and distribution of water.

Learning Activities:

lecture, exercise

Environmental Impact Assessment of Irrigation and Drainage, W. Buydens (Royal Haskoning, Belgium)

Environment as a system; environmental impacts. Examples; Environmental impact assessment (EIA); social process; legal requirements and the environmental impact statement (EIS); assessment methodologies and procedures. Description of the irrigation environment. Sustainable water resources management: definitions, integrating environment and development, case study Uzbekistan, environment and integrated water resources planning. Selected environmental issues: irrigation induced salinity, impact on water quality and quantity of receiving waters, moisture management in semi-arid temperate regions, irrigation and health hazards, equity and sustainability. Environment and project appraisal: the ICID environmental checklist, a simulation-optimisation model, economic appraisal of environmental impacts, case study wetlands in Nigeria.

Learning Activities:

lecture, exercise

Main Drainage Systems & Salinity Control in Field Level (H. P. Ritzema, Alterra-Wageningen University; P. H. J. Hollanders, Principal Water Board of Delfland)

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.

Learning Activities:

lecture, exercise

Field Trip to North-West Netherlands

Get acquainted with some hydraulic engineering and water management aspects in North West Netherlands. Locks, pumping stations, navigation systems, flood protection.

Lecturing Material

- Dahmen, 2000. Financial and economic analysis.
- Gittinger, J.P. Economic Analysis of Agricultural Projects
- Schenk-Sandbergen, 2003. Reader, Sociological Aspects of Irrigation
- Ritzema, H. 2009. Main Drainage Systems
- Buydens, 2011. Environmental and Sustainability Aspects of Irrigation and Drainage
- Buydens, 2006. Environmental Aspects of Irrigation and Drainage - Selected Readings
- Buydens, 2001. Environmental Effects of Irrigation and Drainage: the Upper Penganga Project
- ICID, 1993. ICID checklist of possible environmental effects.

Assessment

- **25%: Assignment -- For Economic & Financial Analyses**
- **20%: Assignment -- For Sociological aspects**
- **30%: Assignment -- For Environmental Impact Assessment of Irrigation and Drainage**
- **25%: Assignment -- For Main Drainage Systems & Salinity Control in Field Level**

2014/2016-WSE/HELWD/06/s: Socio-economic and environmental aspects of irrigation and drainage											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Economic and Financial Analysis	8		6				14	30	Dr. Yong Jiang
2	Sociological Aspects	6		6				12	24	JanWillem Liefbrand
3	Environmental Impact Assessment of Irrigation and Drainage	8		6				14	30	Dr. W. Buydens
4	Main Drainage Systems and Salinity Control in Field Level	8						8	24	Dr Ir H.P. Ritzema
5	Main Drainage Systems and Salinity Control in Field Level	8						8	24	Ir P.H.J. Hollanders
6	Field Trip to North-West Netherlands					8		8	8	F.X. Suryadi, PhD, MSc
	Total	38		18		8		64	140	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Hydrology and Water Resources
Module Coordinator: Venneker, R.G.W.

Module Sheet

Module Name Hydrological data collection and processing	Module Code WSE/HWR/07A/s	Credits 5

Target Group	Prerequisites
Students of the WSE/HWR Programme, and selected short course participants	Good foundation and understanding in hydrology, hydrometeorology, and the water resources-related interactions taking place in hydrological basins

Learning Objectives

Upon completion of the module participants will be able to..

- Comprehend the need for hydrological data and information, and the roles and functions of National Hydrological Services.
- Comprehend the activities involved in water resources-related data collection, processing, storage and retrieval.
- Explain the principles and concepts used in hydrological observing networks and routine data collection.
- Apply standard methods for processing and analyzing hydrological data to prepare water resources information.
- Apply hands-on experience with collecting, processing and comparative analysis of hydrometeorological station data.

Topics and Learning Activities

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.

Learning Activities:

Class lectures, exercises in processing and analysis of hydrological data, and assessment of hydrological observing networks.

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.

Learning Activities:

This part is conducted in small groups and involves a short oral presentation at the end of the module. Students are expected to work largely independent, under supervision and guidance, as required. The results are to be recorded in a written report.

Excusion

A one-day excursion is part of this module to provide examples of practical hydrological data monitoring activities in the Netherlands.

Lecturing Material

- Presentations, Lecture notes, and exercise materials.
- Book: Boiten, W. Hydrometry 2nd edition, CRC Press, 2008.

Assessment

- **60%: Written Exam (closed book) --**
- **40%: Lab report --**

2014/2016-WSE/HWR/07A/s: Hydrological data collection and processing											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Hydrological data processing and analysis**	**28**		**20**				**48**	**104**	Dr. R. Venneker, Dr. T. Bogaard, Dr. Y Zhou
2	**Practical hydrometeorological data collection and evaluation**	**4**		**20**				**24**	**32**	Dr. R. Venneker
3	**Excursion**									
4	**Examination**									
	Total	**32**		**40**				**72**	**136**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **Stigter, T.Y.**

Module Sheet

Module Name Groundwater data collection and interpretation	Module Code WSE/HWR/07B/s	Credits 5

Target Group	Prerequisites
MSc students in Hydrology and Water Resources, short course participants involved in groundwater and environmental impacts investigation and monitoring activities.	Approved BSc degree and basic hydraulics/hydrogeology subjects

Learning Objectives

Upon completion of the module participants will be able to..
- understand the underlying principles of methods applied to groundwater exploration and monitoring;
- plan a groundwater investigation programme and interpret the results of such a programme;
- understand and interpret hydro(geo)logical time series and spatial data
- learn methods and procedures used in groundwater monitoring;
- design a groundwater monitoring network and to assess the required measurement frequencies.

Topics and Learning Activities

Groundwater Surveys (T.Y. Stigter)

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. Then follow outlines on well drilling and well logging techniques and the interpretation of results. Finally, the practical set up and execution of pumping tests and the interpretation of test results is being dealt with.

Learning Activities:

Lectures will be given and problem-solving exercises will be carried out by the participants. Software for the interpretation of geophysical measurements, GEWin-Excel, and pumping test data, AquiferTest and Excel Worksheets, will be introduced. Qualitative and quantitatve groundwater monitoring equipment will be demonstrated.

Hydrogeostatistics (Y. Zhou)

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.

Learning Activities:

Lectures and computer workshops with basic statistics, regression, time series and kriging.

Groundwater Monitoring (Y. Zhou)

Principles and concepts of groundwater monitoring, following up on material dealt with in module HY06. 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.

Learning Activities:

Computer workshops are organised to learn the methods for the design of groundwater monitoring networks.

Exercise Geophysics Breevenen (N. van der Moot)

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. The interpreted data are used to characterize the sedimentary groundwater system in the area.

Learning Activities:

Computer exercise using the GEWin-Excel package are used to become familiar with the interpretation methods and to complete an assignment.

Lecturing Material
- Nonner, J., Stigter, T., Introduction to groundwater exploration, Lecture notes
- Zhou, Y., Hydrogeostatistics, Lecture notes
- Zhou, Y., Groundwater monitoring, Lecture notes, LN0053/09/1

• Van der Moot, N., Exercise Breevenen, Lecture notes.

Assessment

- **35%: Written Exam (closed book) -- Groundwater Surveys**
- **15%: Written exam (closed book) -- Hydrogeostatistics**
- **15%: Assignment -- Hydrogeostatistics**
- **25%: Assignment -- Groundwater Monitoring**
- **10%: Assignment -- Exercise Geophysics Breevenen**

2014/2016-WSE/HWR/07B/s: Groundwater data collection and interpretation										
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Groundwater Surveys	**13**		**13**				**26**	**52**	Stigter PhD
	Hydrogeostatistics	**10**		**8**				**18**	**38**	Zhou PhD
	Groundwater Monitoring	**12**		**8**				**20**	**44**	Zhou PhD
	Exercise Geophysics Breevenen			**6**				**6**	**6**	vd Moot MSc
	Total	**35**		**35**				**70**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Jonoski, A.**

Module Sheet

Module Name River basin modelling	Module Code WSE/HI/07/s	Credits 5

Target Group	Prerequisites
Participants in WSE programmme - hydroinformatics; Participants in Erasmus Mundus Flood Risk Management Programme; Participants in short course "River Basin Modelling"	Hydrology and Hydraulics

Learning Objectives

Upon completion of the module participants will be able to..

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

Topics and Learning Activities

River basin management, Eelco van Beek (IHE), W. van der Krogt (Deltares)

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.

Learning Activities:
Attending lectures;
Exercises and workshops in a computer lab;
Self study;

Groundwater modelling, A. Jonoski (IHE)

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.

Learning Activities:
Attending lectures;
Exercises and workshops in a computer lab;
Self study;

Catchment modelling, M. Butts (DHI), A. Jonoski (IHE) and I. Popescu (IHE)

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;

Learning Activities:
Attending lectures;
Exercises and workshops in a computer lab;
Self study;

Lecturing Material

• Loucks and van Beek. Water Resources Planning and Management, UNESCO, 2006 - Selected chapters;
Refsgard: Introduction to hydrological modelling: Modelling of the processes of the land phase of the hydrological cycle

• PowerPoint slides:
van Beek: River Basin Management;
Jonoski: Groundwater modelling;
Butts: Catchment modelling;

• Handouts:
Jonoski: Groundwater modelling using MODFLOW;
Jonoski and Popescu: Catchment modelling with MIKE SHE;
van der Krogt: RIBASIM user manual;

• Modelling software: RIBASIM, MODFLOW; NAM and MIKE-SHE; MIKE11

Assessment

• 100%: Written Exam (closed book) -- The exam will include questions from all topics of this module.

2014/2016-WSE/HI/07/s: River basin modelling											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**River basin management**	**6**		**4**	**4**			**14**	**30**	E. van Beek, W. van der Krogt
2	**Groundwater modelling**	**8**		**6**	**6**			**20**	**42**	A. Jonoski
3	**Catchment modelling**	**12**		**10**	**10**			**32**	**66**	M. Butts, A. Jonoski, I. Popescu
	Total	**26**		**20**	**20**			**66**	**138**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Brandimarte, L.**

Module Sheet

Module Name River structures	Module Code WSE/HERBD/07/s	Credits 5

Target Group	Prerequisites
	Working knowledge in Applied Hydraulics, Sediment Transport and River Dynamics

Learning Objectives

Upon completion of the module participants will be able to..

- 1) to analyze the interaction between flow and hydraulic structures in natural open channels
- 2) to create preliminary hydraulic design of selected river structures
- 3) to determine the consequences of different design solutions on the natural river behavior

Topics and Learning Activities

I. River Structures (Dr. L. Brandimarte/Mazzoleni)

Hydraulic structures in mountain river training
Check dams and debris dams: interaction between flow and structures; principles of design and operation
Hydraulic structures in low land river training and flood protection
Interaction between flow and structures; principles of design and operation
Levee systems: failure, deisgn and maintenance.
Hydraulic structures auxiliary to engineering works
Spillways; Bottom outlets; Energy dissipaters: principles of design and operation
Learning Activities:
** Frontal lectures*
** Individual and group exercises on the hydraulic analysis and design of selected hydraulic structures*
** Critical analysis of selected peer reviewed papers*

** Case study: the Vajont dam disaster*

III. Design of low land hydraulic structures (Dr. M. Maglionico, University of Bologna)

Engineering solution in the design of low land hydraulic structures for flood control.
Learning Activities:
** Frontal lectures*
** Analysis of layouts of low land structures*
** Critical analysis of selected peer reviewed papers*

Lecturing Material

- Handouts and references provided by Lecturers
- Jansen, P.Ph., 1979. Principles of River Engineering. The non-tidal alluvial river. Delft University Press, the Netherlands.

Assessment

- **100%: Oral Exam --**

2014/2016-WSE/HERBD/07/s: River structures											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	I. River Structures	**17**		**5**	**18**			**40**	**92**	L. Brandimarte, PhD, MSc
	II. River Structures	**1**		**5**				**6**	**8**	M. Mazzoleni, MSc
	III. Design of low land structures	**12**						**12**	**36**	M. Maglionico, PhD, MSc
	Total	**30**		**10**	**18**			**58**	**136**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Wegen, M. van der**

Module Sheet

Module Name Environmental aspects of coasts and ports	Module Code WSE/HECEPD/07/s	Credits 5

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

Learning Objectives

Upon completion of the module participants will be able to..

- 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 and the relevant technical, legal and institutional aspects.
- 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.
- Be able to apply the engineering principles in solving a combined coastal/port problem.
- Have a better insight in the natural characteristics and physical processes of coastal ecosystems.
- 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".

Topics and Learning Activities

Coastal Ecosystems and Management (F. van der Meulen)

An introduction to the main system characteristics (physical processes and contributing elements) of the important coastal lowland environments (mangroves, beaches and dunes, estuaries, wetlands)and guidelines for their management. Also the impact of human activities and of climate change on these systems are discussed.

Learning Activities:

Interactive Lectures and short exercises

Coastline Management (R. Ranasinghe)

Introduction to coastline management (issues and strategies. Hard and soft coastline protection methods (groynes, seawalls,offshore emergent and submerged breakwaters, beach nourishment, coastal setback lines (probabilistic methods, case study.

Learning Activities:

Lectures and case study

Coast and Port Project (D. Roelvink, A. Dastgheib)

Feasibility study of a small marina on the Dutch coast. Initial design of layout, analyses of impact of adjacent beaches, assessment of dredging needs, using Matlab based coastal modelling or XBeach.

Learning Activities:

Lectures and Group work

Environmental Issues in Port development and Port operation (T.Vellinga)

Integration of environmental issues in port planning and design; Environmental aspects which affect port-layout; Land use planning, visual amenity, dangerous goods, dredging and disposal of dredged material, prevention nuisance, contamination of soil and groundwater, reception of ballast water and waste and wetlands and nature areas. Relevant aspects for environmental impact assessment. Green Ports strategy including explanation. Working with Nature and Early Stakeholder Involvement. Examples.

Learning Activities:

Lectures

Salt Intrusion, Density Currents and siltation (M. van der Wegen)

Theoretical treatment of two-layer system, selective withdrawal, application of Bernoulli equation and two-layer system theory, exchange flows in locks. Basic considerations on estuarine circulation patterns, interfacial flow phenomenon, breaking of internal waves, mixing, dispersion, salt intrusion processes and modeling aspects,

examples.Siltation in port, basins and navigation channels

Lecturing Material

• T. Vellinga and M Geense, 2004, Environmental Issues in Port Development and Port Operation.
Readers to be provided during the course (T. Vellinga)
• Van der Meulen, Frank, Coastal Ecosystems and Management An Introduction. LN0355.12.1.
Handouts to be provided during the course.

Assessment

- **15%: Written exam (closed book) -- Coastal Ecosystems and Management**
- **15%: Written Exam (closed book) -- Coastline Management**
- **15%: Written Exam (closed book) -- Environmental Issues in Port dvelopment and Port operation**
- **15%: Written Exam (closed book) -- Salt Intrusion, Density Currents and siltation**
- **40%: Assignment -- Coast and Port Project**

2014/2016-WSE/HECEPD/07/s: Environmental aspects of coasts and ports										
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Coastal Ecosystems and Management	6						6	18	Dr. F. van der Meulen
2	Environmental Issues in Managment and Planning of Ports and Coasts	8						8	24	Prof. T. Vellinga
3	Coastline Management	6						6	18	Dr. R. Ranasinghe
4	Coast and Port project	6	32	12				18	62	Prof. J. A. Roelvink; Dr. A. Dastgheib
5	Siltaition	6						6	18	Dr. M. van der Wegen
	Total	32	32	12				44	140	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HELWD, WSE-HELWD Sriwijaya, WSE-HELWD-AIT, WSE-HELWD Haramaya, WSE-HELWD
Module Coordinator: Fraiture, C.M.S. de

Module Sheet

Module Name Service oriented management of irrigation systems	Module Code WSE/HELWD/07/s	Credits 5

Target Group	Prerequisites
All Land and Water Development participants.	Agronomy, irrigation methods, management and socio-economic aspects of irrigation systems, irrigation flow control and conveyance systems.

Learning Objectives

Upon completion of the module participants will be able to..

- Be able to formulate objectives for irrigation development, modernization and management and understand the consequences for irrigation management and users
- Comprehend various forms and levels of irrigation management organizations and different levels of water delivery service and associated costs
- Have gained insight into the laws, legislations, and traditions pertaining to the development and use of water resources for agriculture
- Be able to identify the relation between water rights arrangements and water delivery, allocation and decision-making
- Understand the rationale for and mechanisms of water pricing
- Be able to design water management plans including justifiable decisions on: -agreements between stakeholders; - asset management; - monitoring and evaluation and benchmarking systems for assessing system performance

Topics and Learning Activities

Management of irrigation & drainage systems, K. Prasad

- Terminology and definitions, management approaches, objectives in irrigation, interest groups, conflicting objectives, 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 supplies, irrigation scheduling.
- 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, cost of service, maintenance, financial arrangements, service agreements, specification and conditions of service, organizational structures, cost recovery, farmers' participation, role of line agencies and accountability mechanisms in water management institutions.

Learning Activities:

Lecture, role play and groupwork

Water law and water rights, J. Gupta (UNESCO-IHE) and guest lecturer WUR

- Origin, evolution, sources, elements and history of national water law and the later influence of environmental law including elaboration of irrigation law.
- Influence of local, regional, national laws and regulations on irrigation and drainage plans.

Learning Activities:

Lecture

Asset management and water pricing, M. Kok (HKV-Lijn in Water) and C. de Fraiture

- Asset management concepts: types of assets, life cycle, economic life, useful life, residual life;
- Asset register; Asset management functions, asset planning strategies, asset O&M, performance monitoring, rehabilitation, modernization, replacement, disposal, rationalization;
- Development and implementation of asset management plans for irrigation systems, related organizational aspects, Management Information System.
- Water pricing: rationale, types of pricing and its application in practice.

Learning Activities:

Lecture and excercise

Performance of irrigation systems, Robina Wahaj (FAO)

- Monitoring & Evaluation and benchmarking for performance assessment: indicators, parameters, targets,

standards.
- Objectives, need for and requirements for assessing performance of irrigation systems.
- Introduction to different systems of assessing performance
- Performance method MASSCOTE; concept and practical use and implications

Learning Activities:

Lecture

Field trip, C. de Fraiture (UNESCO-IHE)

Visit to Delfland Water Board; greenhouse and greenhouse innovation centre; Kinderdijk

Lecturing Material

• Malano and van Hofwegen, 2006. Management of Irrigation and Drainage Systems - A Service Approach, IHE Monograph 3
• Kok, 2000. Asset Management
• Gupta, 2005. Water and Environmental Law and Institutions

• FAO, 2001. Benchmarking performance in the irrigation and drainage sector

Assessment

• 40%: Written Exam (open book) -- Based on the lectures of the module
• 60%: Assignment -- Based on topics 1-4 (include all)

2014/2016-WSE/HELWD/07/s: Service oriented management of irrigation systems										
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Management of Irrigation & drainage systems**	**10**	**10**					**10**	**40**	K.C. Prasad, PhD
2	**Asset management**	**8**	**4**					**8**	**28**	Dr. M.Kok
3	**Water Law and rights**	**8**						**8**	**24**	J. Gupta, PhD & Hoogesteger
4	**Irrigation performance assessment**	**8**						**8**	**24**	R. Wahaj
5	**Role play and assignment**		**28**	**6**				**6**	**34**	de Fraiture
	Fieldtrip					**8**		**8**	**8**	de Fraiture
	Total	**34**	**42**	**6**		**8**		**48**	**158**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: ALL WSE
Module Coordinator: Maskey, S.

Module Sheet

Module Name Integrated hydrological and river modelling	Module Code WSE/HWR/08/e	Credits 5

Target Group	Prerequisites
All WSE participats and short course participants with hydrology/hydraulics/water resources/civil engineering background.	Approved BSc degree and appropriate hydrology and/or water engineering subjects.

Learning Objectives

Upon completion of the module participants will be able to..

- 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;
- Distinguise components of hydrological modelling software for hydrodynamic simulation, catchment process simulation and surface water quality simulation;
- Translate a given hydrological problem into a model definition using available data;
- 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; and
- Independently carry out a hydrological modelling study and to report the results.

Topics and Learning Activities

Introduction to Hydrological/Catchment Modelling (S. Maskey):

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).

Learning Activities:

Lecture, group exercise, presentation and discussion.

River Flow and Water Quality Modelling (S. Maskey, A. van Griensven):

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.

Learning Activities:

Lecture, computer exercise

Catchment Modelling (R. Venneker):

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.

Learning Activities:

Lecture, computer exercise

Lecturing Material

- Maskey S., Hydrological/catchment modelling and river flow modelling - Lecture notes and tutorials.
- HDI, MIKE 11: A Modelling System for Rivers and Channels, Short Introduction Tutorial - LN0209.05.01.
- Guinot V. and Venneker R., Physically-based hydrological modelling - Lecture notes and tutorials.
- Maskey S., 2007. Surface Water Quality Modelling - LN0306/07/1.

Assessment

- **15%: Presentation -- (Hydrological modelling - components/methods/tools)**
- **50%: Assignment -- (River flow and water quality modelling)**
- **35%: Assignment -- (Catchment modelling)**

2014/2016-WSE/HWR/08/e: Integrated hydrological and river modelling											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Introduction to integrated hydrological and river modelling**	**4**			**4**			**8**	**20**	S. Maskey
2	**River flow and water quality modelling**									
2.1	River flow hydrodynamic modelling	4			12			16	36	S. Maskey
2.2	River water quality modelling	6			8			14	34	A. van Griensven and S. Maskey
3	**Catchment modelling (lecture and exercise)**	**4**			**18**			**22**	**48**	R. Venneker
2.3	River water quality modelling (exercise)									S. Maskey
	Total	**18**			**42**			**60**	**138**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management, Option 8a**
Module Coordinator: **Popescu, I.I.**

Module Sheet

Module Name River Flood Analysis and Modelling	Module Code WSE/HI/08A/e	Credits 5

Target Group	Prerequisites
Water Science and Engineering and Short Course participants	Hydraulics and hydrology

Learning Objectives

Upon completion of the module participants will be able to..

- Understand and explain the main flood management problems;
- Understand and explain the governing processes of flood generation and propagation;
- Identify the proper modelling methodology for a given problem;
- 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;
- Understand and analyse the main sources of uncertainty in flood modelling

Topics and Learning Activities

Climate change and its impact on flooding(P.D.A. Pathirana, IHE)

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.

Learning Activities:

Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab

Introduction to 1D2D and 2D modelling(I. Popescu, IHE)

Introduction to the basic principles of 1D2D and 2D modelling.

Learning Activities:

Formal lectures;

River Flood Modelling and Flood Routing (A.Jonoski, S.J. van Andel, B. Bhattacharya, I.Popescu, IHE)

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

Learning Activities:

Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab

Uncertainty in flood modelling (D. Solomatine, IHE)

Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab

Lecturing Material

- Lecture notes on River flood management and flood routing

Presentation slides;
Modelling packages with user manuals;

Assessment

- **25%: Assignment -- A set of assignments on HEC-HMS will be given during modelling with HEC-HMS. these will be assesed.**
- **25%: Assignment -- A set of assignments on HEC-RAS will be given during flood routing and HEC-RAS. These will be assesed.**
- **50%: Written Exam (closed book) -- Written Examination on the topics of "River Flood Modelling and Flood Routing"**

2014/2016-WSE/HI/08A/e: River Flood Analysis and Modelling											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Climate change and its impact on hydrology (together with option HUS)**	**4**		**2**				**6**	**14**	A. Pathirana
2	**Introduction to 1D2D, 2D modelling**	**4**						**4**	**12**	I. Popescu
3	**River flood analysis and modelling**	**24**		**24**				**48**	**96**	A. Jonoski, S.J. van Andel, B. Bhattacharya, I. Popescu
4	**Uncertainty in Flood Modelling**	**4**						**4**	**12**	D. Solomatine
	Total	**36**		**26**				**62**	**134**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Vojinovic, Z.**

Module Sheet

Module Name Urban flood management and disaster risk mitigation	Module Code WSE/HI/08B/e	Credits 5

Target Group	Prerequisites
Participants in WSE programmme; Participants in short course "Urban Flood Management and Disaster Risk Mitigation"	Basic knowledge of hydrology and hydraulics

Learning Objectives

Upon completion of the module participants will be able to..

- A change to proactive management of water-related disasters in urban areas requires an identification of the risk, the development of strategies to reduce that risk, and the creation of policies and programmes to put these strategies into effect.
  This course introduces current theory and practice of flood risk estimation and modelling of floods in urban areas. It provides hands-on practice with industrial standard software. The main objective of this course is to provide the most up-to-date information on the topic of urban flood modelling and disaster management and to enable participants to be more effective in applying modelling tools and techniques for urban flood management.
  Different modelling approaches are considered and they range from data driven to physically based, from conceptual to detailed 1D-2D modelling. These approaches are then embedded in the wider context of flood risk assessment and disaster management. This wider context considers everything from how the urban planning process should take place in areas with potential flood risks, to urban hydrology, climate change, flood hazards, environmental impacts, public health issues and the conceptual design of flood protection schemes.

  The first learning objective is to develop enhanced understanding of the effects of climate variability on the hydrology that affects urban areas
- Understand the structure, service provided and failures of the service for urban stormwater /drainage networks; Urban Drainage Asset Management and Optimisation, and learn how to model these systems and how to apply a typical modelling product (MOUSE, MIKE11, MIKE21 and SWMM)
- 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)
- Learn how to build safe and reliable urban drainage models and how to evaluate system performance against different standards (engineering, environmental, public health, etc.), and develop understanding of novel techniques for modelling the complex geometry and interaction between surface water (including floodplains), sub-surface flows and urban drainage infrastructure (1D and coupled 1D/2D)
- Learn how to produce different flood risk maps in a GIS environment and how to calculate different types of flood damages, and
- 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

Topics and Learning Activities

Application domains of Hydroinformatics: floods, urban systems and environment, R. K. Price (IHE), Z. Vojinovic (IHE) and A. Mynett (IHE)

Introduction to floods and flooding. Introduction to urban floods and urban water systems. Introduction to environmental systems.

Learning Activities:

Lectures

Climate change and its impact on hydrology, P.D.A. Pathirana(IHE)

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.

Learning Activities:

Lectures

Ethics of risk, N. Doorn

Introduction to the basic theory of ethics and its application to the flood risk management.

Learning Activities:

Lectures

Mathematical foundation of 2D urban flood modelling, I. Popescu (IHE), S. Djordjevic (UoE)

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.

Learning Activities:

Lectures

Exercise

Urban Flood Modelling and Evaluation of Flood Risks, Z. Vojinovic (IHE), O. Mark (DHI), S. Djordjevic (UoE)

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.

Learning Activities:

Lectures

Exercise

Structural and Non-structural Urban Flood Management Measures, Z. Vojinovic (IHE), O. Mark (DHI), B. Gersonius (IHE)

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.

Learning Activities:

Lectures

Exercise

Managing Urban Flood Disasters, Z. Vojinovic (IHE), D. Sakulski (UNU)

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.

Learning Activities:

Lectures

Exercise

Lecturing Material

• Vojinovic, Z. and M.B. Abbott, 2011, Flood Risk and Social Justice: From Quantitative to Qualitative Flood Risk Assessment and Mitigation, 2011, IWA Publishing

Assessment

- **40%: Written Exam (closed book) -- All Topics**
- **60%: Assignment --**

2014/2016-WSE/HI/08B/e: Urban flood management and disaster risk mitigation											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)	
	Application domains of Hydroinformatics: floods, urban systems and environme	**4**		**2**				**6**	**14**	R.K. Price, A.E. Mynett, Z. Vojinovic	
	Climate change and its impact on hydrology	**4**		**2**				**6**	**14**	P.D.A. Pathirana	
	Ethics of risk	**2**						**2**	**6**	N. Doorn	
	Introduction to 1D2D, 2D modelling	**7**		**7**				**14**	**28**	I. Popescu, S. Djordjevic	
	Urban flood modelling and evaluation of flood risks	**9**			**3**			**12**	**33**	Z. Vojinovic, O. Mark	
	Structural and non-structural measures	**4**			**2**			**6**	**16**	Z. Vojinovic, O. Mark, B. Gersonius	
	Managing urban flood disasters	**6**			**4**			**10**	**26**	D. Sakulski	
	Total	**36**		**11**	**9**			**56**	**137**		
MSc module - UNESCO-IHE											

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Crosato, A.

Module Sheet

Module Name River training and rehabilitation	Module Code WSE/HERBD/08A/e	Credits 5

Target Group	Prerequisites
Environmental and Civil Engineers. Professionals dealing with river training and rehabilitation. Professionals dealing with mountain rivers. Scientists interested in river morphodynamics, sediment processes and ecohydraulics.	Basic knowledge of river hydraulics (uniform and non-uniform flows, backwater curves). Basic knowledge of river hydrology (discharge variations, floods). Basic knowledge of river morphodynamics (short- and long-term river response) (Module 4 HERBD).

Learning Objectives

Upon completion of the module participants will be able to..

- assess the feasability of river training works and their effects in low-land and mountain rivers.
- assess the feasability of river rehabilitation and effects on the river morphology.
- understand basic principles of mountain river morphodynamics.
- understand basic principles of ecohydraulics.

Topics and Learning Activities

River Training and Rehabilitation (A.Crosato)

River training, concepts and examples.
Concept of river rehabilitation and effects of rehabilitation works on the river morphology.
Learning Activities:
Lessons and exercises.

River Training in the Netherlands (H. Havinga)

Main characteristics of Dutch rivers (hydraulic behaviour, sediment).
Works to enhance navigation and river rehabilitation in the Netherlands.
Learning Activities:
Lessons and discussions

Mountain River Training (M. Peviani)

Main characteristics mountain rivers (hydraulic behaviour, sediment, non-alluvial parts).
Structures to reduce sediment transport and bank erosion. Examples from existing rivers.
Learning Activities:
Lessons and exercises.

Ecohydraulics (A. Mynett)

Principles of ecohydraulics.
Learning Activities:
Lessons and exercises.

Preliminary design of selected river training works (L. Brandimarte)

Design of bank protection works.
Learning Activities:
Lessons and exercises.

Lecturing Material

- Jansen, P.Ph., 1979. Principles of River Engineering. The non-tidal alluvial river. Delft University Press, the Netherlands.
- Handouts.

Assessment

- **20%: Assignment --**
- **80%: Written exam (closed book) --**

2014/2016-WSE/HERBD/08A/e: River training and rehabilitation											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
	River Training and Rehabilitation	**8**			**4**			**12**	**32**	A. Crosato MSc. PhD.
	River Training in the Netherlands			**6**				**6**	**6**	H. Havinga MSc.
	Mountain River Training	**14**			**10**			**24**	**62**	M.A. Peviani MSc. PhD.
	Principles of ecohydraulics	**6**						**6**	**18**	A. Mynett Prof. MSc. PhD.
	Preliminary design	**6**			**2**			**8**	**22**	L. Brandimarte
	Total	**34**		**6**	**16**			**56**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HECEPD, WSE-HELWD, WSE-HERBD, WSE-HWR, WSE-HI / Short Course
Module Coordinator: Taneja, P.

Module Sheet

Module Name Management of coasts and ports (International Port Seminar)	Module Code WSE/HECEPD/08A/e	Credits 5

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

Upon completion of the module participants will be able to..

- Learn about the international character of a port; the supply chain and port logisics; economic aspects of ports, and port organisations. Learn about strategic planning; design and construction of port infrastructure; life cycle approach, and port maintenance. Get acquainted with practical aspects of port management and engineering.

Topics and Learning Activities

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.
Learning Activities:
lecture, exercise, field trip, simulation game

Lecturing Material

- Ligteringen, H.: Ports and Terminals, VSSD 2007
- Kruk, de Heer: Merchant shipping and Cargo Handling - ln0231/06/, 2006
- Groenveld, R.: Service Systems in Ports and Inland waterways - VSSD
- Handouts

Assessment

- **100%: Presentation -- International Port Seminar**

2014/2016-WSE/HECEPD/08A/e: Management of coasts and ports (International Port Seminar)											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Port Seminar	12		70		34		116	140	
	Total	12		70		34		116	140	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Wegen, M. van der

Module Sheet

Module Name Management of coasts and ports (integrated coastal zone management)	Module Code WSE/HECEPD/08B/e	Credits 5

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

Upon completion of the module participants will be able to..

- 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, be aware of the need of interdisciplinary cooperation in the development of coastal zone management schemes.
- have a better insight in the natural characteristics and physical processes of coastal ecosystems and their management.
- asses possible impacts of human activities (with a special emphasis on port development) and climate change on coastal systems .
- think of innovative alternatives for engineering and management, for example via "building with nature" and a port expansion simulation gaem

Topics and Learning Activities

1. ICZM Seminar (H.J.Verhagen, M.van der Wegen and others)

The guiding line through the whole course is the idea that a coastal zone should be regarded as an integrated system. During the lectures , various aspects of integrated coastal zone management are discussed. Several case studies from a number of countries are given. A demonstration of the relevancy of Integrated Coastal Zone Management is given in an exercise in which for a given case, a fictive estuary (Pesisir Tropicana) the participants have to set up and evaluate several alternatives for developments in the coastal zone. The exercise is completed by a simulated session of a "coastal commission" where a selection is made between the various alternatives.

Learning Activities:

The course consists of lectures, demonstrations, groupwork and workshops.

2. Port expansion simulation game

A comprehensive exercise on port expansion management. Port visits in the Netherlands and neighbouring countries

Learning Activities:

The course consists of a workshop and field visits.

Lecturing Material

- 1. Verhagen, H.J, Pesisir Tropicana, a case study in Coastal Management, Lecture notes ln0090/04/
- 1. Verhagen, H.J. et.al.: The Coast in Conflict, Lecture notes ln0088/06/
- 1. ICZM Seminar Handouts.

Assessment

- **100%: Oral Exam --**

2014/2016-WSE/HECEPD/08B/e: Management of coasts and ports (integrated coastal zone management)											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	ICZM Seminar	**4**		**60**			**8**	**72**	**96**	H.J.Verhagen, M.vander Wegen and others
	Port expansion workshop			**24**		**16**		**40**	**40**	A. Dastgheib, P. Taneja
	Total	**4**		**84**		**16**	**8**	**112**	**136**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Suryadi, F.X.**

Module Sheet

Module Name Conveyance systems	Module Code WSE/HELWD/08/e	Credits 5

Target Group	Prerequisites
All Land and Water Development participants.	A general knowledge about irrigation and drainage systems, basic and applied hydraulics.

Learning Objectives

Upon completion of the module participants will be able to..

- Make simple unsteady flow computations for open channels and closed conduits
- 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
- 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 in pipes and to evaluate the results
- Understand the factors that influence the functioning of a surface drainage system; Design a surface drainage system included polder systems
- Explain the use of modern tools as RS and GIS in combination with the use of computer models
- Have a basic insight in the need and format of laws pertaining to the development and use of water resources and have a general understanding of law, legislation, common law and traditions

Topics and Learning Activities

Unsteady flow / DUFLOW (F. X. Suryadi, UNESCO-IHE)

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; method of characteristics in open channels, flood waves in rivers.

Introduction on hydrodynamic models and the general structure of the DUFLOW model; application of Duflow for water quantity analysis in irrigation and drainage networks; a/o. 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 control structures.

Learning Activities:

lecture, exercise

Sediment Transport in Irrigation Canals (N. Mendez, UCLA, Venezuela)

Properties of transported material and of water; initiation of particle motion; transportation mechanics, bed forms, alluvial roughness; examples of computation of sediment transport in irrigation canals.

Learning Activities:

lecture, exercise

Water Management System Modelling and GIS (F. X. Suryadi, UNESCO-IHE)

Water management system of land and water development, modelling, related to design, operation and maintenance (including hydraulic control structures, pumping stations, etc.); calibration, verification and sensitivity analysis, and hydraulic performance of the water management system.

With the application of GIS, land suitability, drainability and irrigability of an area will be modelled analysed and evaluated.

Learning Activities:

lecture, exercise

Groundwater irrigation (Prof. E. Harvey, Phd, University of Nebraska, Lincoln, USA)

. Introduction to groundwater flow: characteristics of subsurface flow systems, physical properties of porous media, homogeneity, isotropy; 1-3D Darcy equation; Steady state and unsteady state confined/unconfined aquifer and radial flow; see page flow;

. dynamic exchange between groundwater and surface water throughout the hydrological cycle;

. potentials and constraints of groundwater irrigation;

. groundwater use for irrigation is significant and increasing and in general it provides irrigators with a reliable source of water that can be used in a flexible manner;

. access and use of groundwater is under the irrigators direct control for responding to crop needs as they arise (given vailability of a reliable source of energy for pumping);

. pressurized groundwater irrigation center pivot systems;

. investment in the construction and equipping of groundwater irrigation systems;

. interrelated concepts of groundwater resource 'sustainability' and 'overexploitation';

. side-effects if groundwater abstraction exceeds average medium-term replenishment.
Learning Activities:
lecture, exercise

Lecturing Material
- Technical Reference and User's guide DUFLOW
- Suryadi, 2010. GIS and computer modelling of Water Management Systems.
- Suryadi, 2010. Unsteady flow.
- Van den Akker, C. 1994. Groundwater flow.

Assessment

- **30%: Written Exam (open book) -- For Unsteady Flow/DUFLOW**
- **15%: Assignment -- For Sediment Transport in Irrigation Canals**
- **30%: Assignment -- For Water Management System Modelling and GIS**
- **25%: Written Exam (open book) -- For Groundwater flow**

2014/2016-WSE/HELWD/08/e: Conveyance systems											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Unsteady Flow / Duflow**	**10**		**10**			**2**	**22**	**46**	F.X. Suryadi, PhD, MSc
2	**Sediment Transport in Irrigation Canals**	**6**		**6**				**12**	**24**	Dr. N.V. Mendez
3	**Water Management System Modelling and GIS**	**8**		**12**			**2**	**22**	**42**	F.X. Suryadi, PhD, MSc
4	**Groundwater Irrigation**	**8**		**4**				**12**	**28**	Prof. E. Harvey, PhD
	Total	**32**		**32**			**4**	**68**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HELWD, WSE-HWR, WSE-HECEPD, WSE-HERBD, WSE-HI
Module Coordinator: Ruijter van Steveninck, E.D. de

Module Sheet

Module Name Fieldtrip and fieldwork WSE	Module Code WSE/09/c	Credits 5

Target Group	Prerequisites
	A general knowledge about water management, hydraulic engineering, hydrology and water and environment

Learning Objectives

Upon completion of the module participants will be able to..

- Demonstrate a multidisciplinary overview of actual technical, research and organizational activities in the field of water management, hydraulic engineering and hydrology.
- Report detailed technical information received.
- Select and apply different, appropriate field instrumentation and measurement methods in practice and organise the measurement.
- Critically analyse field results, and identify/recognise possible areas of error or uncertainty.
- Integrate quantitative measurements with qualitative terrain observations and prior information to evaluate and analyse the relevant predominant processes in a study area.
- Apply this assimilation of data to engineering cases.

Topics and Learning Activities

Field trip (Various staff UNESCO-IHE)

One week study tour (specializations HWR, HERBD, HECEPD, HELWD)
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.
Learning Activities:
Field trip, Lectures

Two week study tour in Florida, USA (specialisation 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.
Learning Activities:
Field trip, Lectures

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.

HELWD 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.
Learning Activities:

Fieldwork

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.

Learning Activities:

Fieldwork

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.

Learning Activities:

Fieldwork

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.

Learning Activities:

Fieldwork

HELWD 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.

Learning Activities:

Fieldwork

Lecturing Material

- Fieldtrip Information and Documentation, (handout)
- HWR and HERBD: Foppen, Nonner, Beevers : Hydro(geo)logical Fieldwork Dignes-les-Bains Field manual
- A variety of existing data, thematic maps and aerial photographs of the fieldwork area.
- HELWD: Hayde, 2011. Field Experiments in Irrigation LN0451/11/1.

Assessment

- **100%: Homework --**

2014/2016-WSE/09/c: Fieldtrip and fieldwork WSE											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Fieldtrip and Fieldwork**					**140**		**140**	**140**	various
	Total					**140**		**140**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **Zhou, Y.**

Module Sheet

Module Name Applied groundwater modelling	Module Code WSE/HWR/10B/e	Credits 5

Target Group	Prerequisites
Participants in Hydrology and Water Resources specialisation and Professionals working in water and environmental resources assessment and management	Approved BSc degree and appropriate groundwater and/or water engineering subjects

Learning Objectives

Upon completion of the module participants will be able to..

- be familiar with the principles and procedures of groundwater modelling;
- construct a groundwater model using state of the art modelling software;
- use the model for simulation of groundwater flow, contaminant transport and salt water intrusion;
- apply groundwater modelling techniques for groundwater resources management and protection.

Topics and Learning Activities

Groundwater Modelling (Y. Zhou)

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.

Learning Activities:

Introduction to PM8; introduction to MODFLOW; introduction to PMPATH; introduction to MT3D; exercises and case study.

Saline Groundwater Modelling (G. Oude Essink)

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.

Learning Activities:

exercises and case study.

Lecturing Material

- Zhou, Y., Applied Groundwater Modelling, Lecture notes, LN0113/09/1.
- Oude Essink, G., Density Dependent Groundwater Flow, Lecture notes, LN0302/04/1.

Assessment

- **70%: Assignment -- Groundwater Modelling**
- **30%: Assignment -- Density Dependent Groundwater Flow**

2014/2016-WSE/HWR/10B/e: Applied groundwater modelling										
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Groundwater modelling	**16**			**24**			**40**	**96**	Â Y. Zhou
	Saline groundwater modelling	**10**			**8**			**18**	**46**	G. Oude Essink
	Total	**26**			**32**			**58**	**142**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Bhattacharya, B.**

Module Sheet

Module Name Flood risk management	Module Code WSE/HI/10A/e	Credits 5

Target Group	Prerequisites
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'	Hydraulics, hydrology, river basin and flood modelling, statistics

Learning Objectives

Upon completion of the module participants will be able to..

- On completion of this module the participants are able to:
  Understand and explain the main principles of flood risk management;
- Understand the Hydroinformatics tools available for flood risk management;
- Conceptualise the main principles of EU flood directive and have knowledge about European experience in flood risk management;
- Understand and explain the main principles of flood forecasting and warning and uncertainty issues associated with flood forecasts;
- Utilise their hands-on experience in the step-by-step modelling procedure to build flood inundation models, 1D2D flood models and flood risk maps.
-

Topics and Learning Activities

Flood risk management, B. Bhattacharya (IHE), P. Samuels (HR Wallingford), F. Klijn (Deltares), M. Werner (IHE)

1. 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. 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. Flood forecasting: Flood forecasting, principles and approaches, examples, workshop, flood damage assessment.

4. Dutch experiences in FRM: Dutch practices of FRM, history, principles and practices, Room for the River project.

Learning Activities:

Formal lectures; classroom exercises; home assignments

Advanced river flood modelling, I. Popescu (IHE), B. Bhattacharya (IHE), G. Di Baldassarre (IHE) and S. J. van Andel (IHE)

1D2D river flood modelling (using Sobek). Flood inundation modelling (using HEC-RAS). Flood risk mapping (using HEC-RAS and ArcGIS).

Learning Activities:

Classroom exercises; home assignments; exercises and workshops in computer lab;

Lecturing Material

- 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;

Assessment

- **30%: Written Exam (open book) --**
- **30%: Assignment -- Presentation and assignment report on case studies**
- **40%: Assignment -- Flood risk mapping, flood inundation modelling**

2014/2016-WSE/HI/10A/e: Flood risk management											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Introduction to flood risk management**	**8**		**2**				**10**	**26**	B. Bhattacharya
2	**Flood risk analysis and case studies**	**11**		**1**				**12**	**34**	P. Samuels
3	**Dutch experiences in FRM**			**4**				**4**	**4**	F. Klijn
4	**Flood forecasting**	**5**		**3**				**8**	**18**	M. Werner
5	**1D2D modelling**				**12**			**12**	**24**	S van Andel & I. Popescu
6	**Inundation modelling and mapping**			**2**	**6**			**8**	**14**	I. Popescu & A. Almoradie
7	**Flood risk mapping**				**10**			**10**	**20**	B. Bhattacharya
8	**Fieldtrip**			**4**				**4**	**4**	B. Bhattacharya
	Total	**24**		**16**	**28**			**68**	**144**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2014-2016**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Vojinovic, Z.**

Module Sheet

Module Name Urban water systems	Module Code WSE/HI/10B/e	Credits 5

Target Group	Prerequisites
Participants in WSE programmme; Participants in short course "Urban Water Systems"	Basic knowledge of hydrology and hydraulics

Learning Objectives

Upon completion of the module participants will be able to..

- Water supply/distribution, sanitation and drainage are vital aspects for the economic and social development of all urban communities. Reliable, sustainable and affordable water management systems form the key to enhancing the quality of life of billions of people throughout the world. This module covers the essential aspects of clean water supply and distribution and wastewater disposal (sewerage, treatment and flooding), providing an understanding of how these systems work and how to use tools for simulating their performance.

  The first learning objective is to understand the complexity of urban water systems, and the interactions of their different components. Asset management and optimisation of systems
- Understand the structure, service provided and failures of the service for a) urban water distribution, b) wastewater drainage networks and c). wastewater treatment plants
- Know how to model these systems and to have used a typical modelling product (EPANET, MOUSE/SWMM and WEST++)
- Describe how to use the models to assess the performance of the systems
- Understand the processes controlling the water quality of the receiving waters from urban drainage effluents
- Know how to model water quality processes in sewer/drainage systems and impacts on receiving waters with a typical modelling product (MOUSE, MIKE 11, MIKE21, SWMM)

Topics and Learning Activities

Introduction to urban water systems, Z. Vojinovic (IHE)

General introduction to urban water systems; problems of providing potable water to large cities and collecting wastewater and storm water, especially in developing countries.

Learning Activities:

Lectures

Water distribution modelling, N. Trifunovic (IHE), D. Savic (University of Exeter)

Introduction to water distribution; services provided, end users, structure and concepts of distribution networks, modelling concepts. Water distribution modelling; familiarisation with EPANET software, use of EPANET for simple benchmark cases, application to standard problems, asset management and multi-objective optimisation of water distribution systems.

Learning Activities:

Lectures
Exercise computer lab

Wastewater and Stormwater Systems modelling, O. Mark (DHI), Z. Vojinovic (IHE)

Introduction to wastewater and stormwater collection; services provided, beneficiaries, structure and concepts of sewerage networks, composition of wastewater and stormwater flows, free-surface and pressurised pipe flows, flow measurements and instrumentation, water quality sampling, advection-dispersion, sediment transport and water quality modeling in pipe networks, real-time control, inflow and infiltration. Familiarisation with MOUSE software, operating MOUSE on standard pipe networks, process of setting up, calibrating and verifying a simple network model using flow survey data, exercises highlighting particular features of sewerage system performance and asset rehabilitation. Asset management and multi-objective optimization in systems management and rehabilitation, asset condition modelling.

Learning Activities:

Lectures
Exercise computer lab

Wastewater treatment modelling, I. Nopens (University of Ghent), P. Vanrolleghem (University of Laval)

Wastewater treatment plants; primary, secondary and tertiary levels of treatment, modelling hydraulics, primary

treatment processes, chemical and biological secondary treatment processes, modelling using WEST++; wastewater treatment plant modelling; familiarisation with WEST++, treatment works layout, modelling of individual processes, exercises on whole treatment works

Learning Activities:

Lectures

Receiving water impact modelling, A. van Griensven (IHE), A. Mynett (IHE), M. McClain (IHE) Z. Vojinovic (IHE)

Receiving water impact and sewerage rehabilitation; impact of quantity and quality of effluent flows on receiving waters, water quality objectives, classification-assessment schemes, modelling water quality in a stream, reduction of impact through sewerage rehabilitation, integrated modelling; sequential and parallel simulations of integrated models, receiving water impact modelling; using MOUSE for water quality modelling in a stream due to CSO discharges (point sources), advection, dispersion and diffusion rate equations, real-time control, exercises on different parameters.

Learning Activities:

Lectures

Lecturing Material

• R.K. Price and Vojinovic, Z., 2010, Urban Hydroinformatics: Data, Models and Decision Support for Integrated Urban Water Management, 2011, IWA Publishing

Assessment

- **40%: Written Exam (closed book) --**
- **30%: Assignment -- Water Distribution**
- **30%: Assignment -- Urban Drainage**

2014/2016-WSE/HI/10B/e: Urban water systems											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
	Introduction to urban water systems	**2**						**2**	**6**	Z. Vojinovic, PhD
	Water distribution modelling	**10**			**6**			**16**	**42**	N. Trifunovic, MSc, Prof. D.A. Savic
	Wastewater and stormwater systems modelling	**8**		**4**	**8**			**20**	**44**	Dr O. Mark, Z. Vojinovic, PhD, MSc
	Wastewater treatment modelling (together with HES)	**6**		**8**				**14**	**26**	Dr Ir I. Nopens
	Receiving water impact modelling	**4**		**8**				**12**	**20**	A.B.K. van Griensven, A. Mynett, M. McClain, Z. Vojinovic
	Total	**30**		**20**	**14**			**64**	**138**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2014-2016**
Specialization: **Core Programme**
Module Coordinator: **Marence, M.**

Module Sheet

Module Name Storage and hydropower	Module Code WSE/HERBD/10/e	Credits 5

Target Group	Prerequisites
Students interested in principles of dam, reservoir and hydropower structures design	Working knowledge in Hydraulics, Hydrology and Geoscience

Learning Objectives

Upon completion of the module participants will be able to..

- understand and will get working knowledge on main principles and practices used in the analysis and hydraulic design of dams for storage, level regulation and hydropower development. Principles of design, construction and operation, monitoring and maintenance of dam structures together with water and sediment management in reservoirs will be studied.
- understand and will get working knowledge in design of the hydropower schemes and practical design of hydropower structures including power waterways, powerhouses, turbines and electrical equipment. Development and design of all types of hydropower structures including also small power plants and pump-storage plants will be studied.

Topics and Learning Activities

Dams and storage

Dams: importance, historical development & trends, examples, failures & lessons learned. Systematic engineering approach to dam design and operation. Actions on dams, stability, static and dynamic analysis, seismic actions. Foundation treatment. Monitoring surveillance & maintenance. River diversion during dam construction: general considerations, diversion schemes, cofferdams, conveyance works. Spillways and flood treatment. Case studies. Reservoir: water management and operation rules, sedimentation process, sediment management and flushing schemes. Environmental impact of dams and reservoirs.

Learning Activities:

Lectures and exercises on dam design and numerical calculations of dams.

Hydropower development

Hydropower: basic concepts, past experience and trends, context society, energy & environment. Hydropower schemes. Conventional low and high head schemes: factors principles and requirements for the design, typical arrangements and layouts, principles and experiences in analysis and design of headrace works, channels, tunnels, surge tanks and penstocks. Small-scale schemes; design and operation principles. Pump-storage plants; design
and operation principles.

Learning Activities:

Lectures and exercises on design and evaluation of hydropower schemes, design of convey systems, and turbines.

Lecturing Material

- Presentations
- Lecture notes:

Petry, B. & N. Lukovac, 2002: Engineering of dams, UNESCO-IHE.
Stematiu, D., 2005: Dam engineering, UNESCO-IHE.
Stematiu. D., 2005: Concrete Dams, UNESCO-IHE.

- Additional reading:

Jorde, K., Sommer, F. 2006: Design of Hydraulic Structures,Hydro Power Schemes.
Petry, B. & N. Lukovac, 2002: Hydraulic Structures, UNESCO-IHE Lecture notes. Mosonyi, E., 1987: Low head hydropower plants, Budapest,
Hungary.
Mosonyi, E., 1991: High head hydropower plants, Budapest, Hungary.
USBR: Design of small dams. US Bureau of Reclamation, Denver, US.
USBR: Design of arch dams. US Bureau of Reclamation, Denver, US.
Stematiu, D.: 2006. Embankments Dams. Conspress, Bucharest.
Golze: Design of small dams.

Assessment

- **45%: Written Exam (open book) --**
- **45%: Written exam (closed book) --**
- **10%: Assignment --**

2014/2016-WSE/HERBD/10/e: Storage and hydropower											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Dams and reservoirs - Introduction	2						2	6	
2	Embankment dams	2			2			4	10	
3	Gravity dams	2			2			4	10	
4	Dam design considerations and modelling	2			4			6	14	
5	Arch dams	2						2	6	
6	Dam foundation treatment and grout curtain	2						2	6	
7	Diversion, spillways and bottom outlets	2						2	6	
8	Dam safety management	2						2	6	
9	Reservoir design and environmental impact	2						2	6	
10	Hydropower - Introduction	2						2	6	
11	Hydropower schemes - Layouts and design requirements	2			2			4	10	
12	Open power waterways	2			2			4	10	
13	Power waterways	3			2			5	13	
14	Powerhouse	2						2	6	
15	Electromechanical equipment	2			2			4	10	
16	Small hydropower	2						2	6	
17	Cost control and financial analyses	2						2	6	
18	Future developments and perspectives	1						1	3	
	Total	36			16			52	140	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Taneja, P.

Module Sheet

Module Name Geotechnical engineering and dredging	Module Code WSE/HECEPD/10/e	Credits 5

Target Group	Prerequisites
Students interested in interaction between structures and geotechnics, dredging operations, dredging projects tender procedures and marine geotechnical investigations	basic knowledge in soil mechanics (see for example WSE/HECEPD/03/s)

Learning Objectives

Upon completion of the module participants will be able to..

- 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;
- 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;
- assess the need of dredging, project phasing, soil investigation and production, survey systems, cost estimating and pricing, tender procedures and contracts;
- -assess the technical and contractual aspects of geomarine investigations and will be able to set up and organise a survey programme;

Topics and Learning Activities

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).

Learning Activities:

Lectures and exercise

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.

Learning Activities:

Exercise

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.

Learning Activities:

Lectures

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's logistics).

Learning Activities:

Lectures and workshop

Lecturing Material

- Lubking, 2004. Soil mechanics - ln0174/04/
- Brinkman, 2006. Geo-Engineering 1 Earth Retaining Structures and Stability of Soil Mass – ln0190/06/
- Van der Veen, Brinkman 2005. Geo-engineering: Shallow foundations.
- Lubking P. : Details of the design for cantilever wall, sheet pile and anchor wall - Hand outs
- Peuchen J. : Marine Geotechnical Investigation, Lecture notes.
- Dredging Seminar Handbook, 2010, IADC

Assessment

- **60%: Oral Exam -- Oral exam Geo-Engineering and Sheet-pile design - Open Book**
- **40%: Assignment -- Exercise Geo-Engineering and Sheet-pile design**

2014/2016-WSE/HECEPD/10/e: Geotechnical engineering and dredging											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Geo-Engineering and Sheet Pile Design**	**18**					**8**	**26**	**78**	J. Salazar, P. Taneja,
2	**Marine Geotechnical Investigations**			**6**				**6**	**6**	J. Molle
3	**Dredging Seminar**			**32**			**8**	**40**	**56**	IADC lecturers
	Total	**18**		**38**			**16**	**72**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: HELWD
Module Coordinator: Hayde, L.G.

Module Sheet

Module Name Irrigation and drainage structures	Module Code WSE/HELWD/10/e	Credits 5

Target Group	Prerequisites
All WSE participants and from other programmes with specific interest.	A basic understanding of irrigation and drainage systems design as well as general knowledge about different types of pumps used for irrigation purposes.

Learning Objectives

Upon completion of the module participants will be able to..

- Select the appropriate type of structure for irrigation and drainage networks, to establish the boundary conditions and to prepare a preliminary hydraulic design;
- Select a suitable flow control system, the appurtenant flow control structures and to specify the operation rules of the structures and social implications of applied irrigation techniques for different users;
- 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.

Topics and Learning Activities

Irrigation Structures, L.G. Hayde (UNESCO-IHE)

Overview of the boundary conditions for design. Hydraulic background: sub-critical and critical flow over a weir. Calculation methods. Construction related aspects. Hydraulic characteristics of conveyance structures under various flow conditions: culverts, drop structures, aqueducts, siphons and inverted siphons, cross regulators and drainage structures, transitions, canal lining. Spatially varied non-uniform flow. 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.

Case studies on structure/controller design. Modern irrigation systems. Automated control systems: aspects of design, operation and maintenance.

Learning Activities:

lecture, exercise

Flow Control Systems, F.X. Suryadi, (UNESCO-IHE)

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, head works. Water level regulators; discharge regulators; discharge measurement structures. Electronic control systems: Bival control, El-flow control, Card control, Dynamic control, step controllers, PID controller. Application of different flow systems: case studies.

Learning Activities:

lecture, exercise

Pumps and Lifting Devices, M. Kay, (RTSC Ltd. UK)

Introduction, 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.

Learning Activities:

lecture, exercise

Lecturing Material

• Hayde, 2011. Irrigation Structures - Hydraulic Aspects

• A.J. Clemmens, T.L. Wahl, M.G. Bos and J.A. Replogle: Water measurement with flumes and weirs, ILRI Publication 58, 2001.

• Suryadi, 2010: Flow control in irrigation and drainage systems.

• Kay, Pumps and Lifting Devices (Hand-out)

Assessment

- **45%: Assignment -- Irrigation Structures**
- **30%: Assignment -- Flow Control Systems**
- **25%: Assignment -- Pumps and Lifting Devices**

2014/2016-WSE/HELWD/10/e: Irrigation and drainage structures											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Irrigation Structures**	**16**		**12**				**28**	**60**	L.G. Hayde, PhD, MSc, B. Clemmens PhD, MSc
2	**Flow Control Systems**	**13**		**5**				**18**	**44**	F.X. Suryadi, PhD, MSc
3	**Pumps and Lifting Devices**	**11**		**3**				**14**	**36**	M. Kay, MSc
	Total	**40**		**20**				**60**	**140**	
MSc module - UNESCO-IHE										

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Limnology and Wetland Management
Module Coordinator: Hes, E.M.A.

Module Sheet

Module Name Wetlands for livelihoods and conservation	Module Code ES11LM	Credits 5

Target Group	Prerequisites
Programme target group	Programme prerequisites

Learning Objectives

Upon completion of the module participants will be able to..

- understand the concept of ecosystem functions and services, and means of assessing it;
- develop adaptive management for wetlands in response to climate change;
- analyse problems and formulate objectives according to the Objective Oriented Planning (OOP) method;
- analyse systematically the role that stakeholders have in wetland planning and management;
- develop and carry out stakeholder interviews and surveys;
- construct a wetland management plan based on the guidelines of the Ramsar Convention.

Topics and Learning Activities

Ecosystem functions and services

Learning Activities:
lectures, field-work and data analysis

Climate change as a driver of change in wetland management planning

Learning Activities:
lectures and exercises

Objective Oriented Planning

Developing a wetland management plan according to the guidelines of the Ramsar Convention

Learning Activities:
lectures, field-work and case study

Stakeholder analysis and participatory approaches

Learning Activities:
lectures, field-work, case study and role play

Lecturing Material

- Case study descriptions
- PowerPoint presentations
- Selected scientific and other publications

Assessment

- **40%: Written Exam (closed book) --**
- **40%: Assignment -- Individual report and performance**
- **20%: Presentation -- Groupwork presentation**

2014/2016-ES11LM: Wetlands for livelihoods and conservation											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Ecosystem functions and services	8		4		16		28	44	
	Climate change as a driver of change in wetland management planning	8		4				12	28	
	Objective Oriented Planning	2		16		16		34	38	
	Stakeholder analysis and participatory approaches	2		14		8		24	28	
	Examination		2						2	
	Total	20	2	38		40		98	140	
MSc module - UNESCO-IHE										

ENVIRONMENTAL SCIENCE

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Water Resources Management & Water Quality Management
Module Coordinator: Jiang, Y.

Module Sheet

Module Name Watershed and river basin management	Module Code ES11MW	Credits 5

Target Group	Prerequisites
Young and mid-career professionals (scientists, decision-makers) with a background in water management, environmental management, and / or watershed management.	Affinity with hydrology, development economics, agronomy or geography (preferably a relevant water science or engineering related bachelorâ€™s degree or equivalent) and preferably experience in watershed and / or river basin management. Good command of English.

Learning Objectives

Upon completion of the module participants will be able to..

- describe the main natural and anthropogenic interactions at a watershed scale; and how they can be aggregated to rive basin scale
- describe the role of water in sustaining different land uses, including ecosystems
- understand the watershed planning and management approaches, specifically in terms of soil and water management
- explain temporal and spatial scales issues in hydrology
- characterize the fundamental economic issues in watersheds and river basins and the role of economic valuation of acquatic ecosystem services in watershed and river basin management

Topics and Learning Activities

Introduction

This section introduces watershed and river basin management

Learning Activities:

Lecture, group exercise/workshop

Biophysical processes and anthropogenic interactions

This section overviews biophysical processes and interactions with human activitiies in watersheds and river basins, covering soil & water management, watershed hydrology and human interventions, environmental flow, and grounwater management

Learning Activities:

Lecture, group exercise/workshop

Watershed and river basin planning

This section describes the planning process of watershed and river basin management, including technical and participatior tools to support planning processes

Learning Activities:

Lecture, group exercise/workshop

Watershed economics

This section introduces and characterises the fundamental economic issues in watersheds and river basins, explain the relevance and role of economics and economic valuation in watershed and river basin management

Learning Activities:

Lecture, group exercise/workshop

Watershed and river basin management

This section synthesizes the institutional aspects in watershed and river basin management, explains transboundary interdependencies and cooperation, and presents a case study of watershed and river basin management in the real world

Learning Activities:

Lecture, group exercise/workshop

Role play- ShaRiva

This group excercise uses hydrological simulation as a decision support tool to help understand the interdependency of different stakeholders and the importance of communication and cooperation to effective watershed and river basin management

Learning Activities:

group excercise

Field trip

Lecturing Material

- Lecture Notes
- Role play reading materials
- Lecture powerpoint slides
- Additional reading materials

Assessment

- **70%: Written Exam (closed book) --**
- **30%: Assignment --**

2014/2016-ES11MW: Watershed and river basin management											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Introduction**	**1**						**1**	**3**	Jiang
2	**Biophysical processes and anthropogenic interactions**									
2.1	Soil & Water Management	4		4				8	16	Van der Zaag
2.2	Watershed hydrology and human interventions	4		4				8	16	Ilyas
2.3	Environmental flow allocation	4		4				8	16	McClain
2.4	Groundwater Management	4		4				8	16	Guest Lecturer
3	**Watershed economics**									
3.1	Economic issues in watersheds and river basins	2						2	6	Jiang
3.2	Payment for watershed services	2		4				6	10	Jiang
3.3	Game theory	4		4				8	16	Gues lecturer
4	**Watershed and river basin planning and management**									
4.1	Planning process	2		2				4	8	Evers
4.2	Watershed and river basin management	4						4	12	Evers
4.3	Case study			4				4	4	Guest lecturer
5	**Role-play SHA-RIVA**		**12**						**12**	Ilyas
6	**Field trip**					**5**		**5**	**5**	Jiang
	Exam		**3**						**3**	
	Total	**31**	**15**	**30**		**5**		**66**	**143**	
MSc module - UNESCO-IHE										

ENVIRONMENTAL SCIENCE

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Siebel, M.A.

Module Sheet

Module Name Solid waste management	Module Code ES11T	Credits 5

Target Group	Prerequisites
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.	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

Upon completion of the module participants will be able to..

- suggest options for waste reduction at source so as to reduce quantities of waste generated;
- choose from an array of options to turn waste into economic goods;
- 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;
- assess the impact of waste and waste management on other environmental compartments;
- roughly assess financial consequences of proposed management aspects in SWM;
- conceptually develop a solid waste management scheme for an urban area.

Topics and Learning Activities

1) Introduction & Stakeholders
what is solid waste? what are the key problems (social, financial, environmental)? who are involved?
Learning Activities:
lecture, group activity/learning from each other, role play

2) Generation, collection & separation
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?
Learning Activities:
lecture, group activity/learning from each other, exercise, role play,

3) Biological processes, composting, digestion
Aerobic and anaerobic conversion of waste organics, process characteristics, fields of application, impacts on waste reduction
Learning Activities:
lecture, calculation exercise, laboratory experiment

4) Landfill technology, CDM, MBT and Incineration
What are main waste management technolgies? in more or in less developed countries? design elements, application areas? GHG issues
Learning Activities:
lecture, group activity/learning from each other, calculation exercise

5) Transboundary issues in SWM
What is Basel Convention? what is transboundary waste transport, processing and storage? What are environmental, social, economic aspects thereof?
Learning Activities:
lecture, group activity/learning from each other, role play,

6) Prevention & Recycling
How can waste generation be reduced? what are policy, economic tools? How can generated waste quickest be brought into the economic cycle?
Learning Activities:
lecture, group activity/learning from each other, calculation exercise

7) SWM planning and financing
How can all possible SWM pieces be put together to design a waste management system for a build-up area that is financially, socially and environmentally sustainable?
Learning Activities:

group activity/learning from each other, exercise, role play

Lecturing Material

• 1) PPT's; reviewed paper; BOOK: Waste Technology and Management; BOOK: Vital waste statistics
• 2) PPT's; reviewed paper; BOOK: From waste to resource; BOOK: Solid Waste Management in World Cities
• 3) PPT's; reviewed paper; BOOK: Waste Technology and Management; Video: Anaerobic degradation processes
• 4) PPT's; reviewed paper; BOOK: Waste Technology and Management; Video Bioreactor Landfill; UNEP SWM Landfill chapter
• 5) PPT's; reviewed paper; BOOK: Waste Technology and Management
• 6) PPT's; reviewed paper; BOOK: Waste Technology and Management
• 7) papers on planning practice

Assessment

• 60%: Written Exam (open book) -- MOODLE multiple choice
• 35%: Assignment -- All assignments together
• 5%: Presentation -- Participation in class or fora

2014/2016-ES11T: Solid waste management											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Introduction	6						6	18	Siebel
2	Waste prevention	4						4	12	Dijk
3	Exercise household waste generation			9				9	9	Siebel
4	Waste collection/ source separation	3						3	9	
5	Composting and biogas	6						6	18	Valencia
6	Excursion					4		4	4	Siebel
7	Informal sector	4						4	12	Rotter
8	Material cycles			4				4	4	Rotter
9	Landfill processes	3						3	9	Valencia
10	Landfill technology	3						3	9	Valencia
11	Mechanical biological treatment	4						4	12	Rotter
12	Lab landfill			3				3	3	Rotter
13	Integrated planning			8				8	8	Siebel
14	Presentations			2				2	2	Siebel
15	Assignments		13						13	
16	Exam		2						2	
	Total	33	15	26		4		63	144	
MSc module - UNESCO-IHE										

ENVIRONMENTAL SCIENCE

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Ruijter van Steveninck, E.D. de

Module Sheet

Module Name IWRM as a tool for adaptation to climate change	Module Code ES11X	Credits 5

Target Group	Prerequisites
Programme target group (Participants in the programmes at IHE) and qualified short course participants.	Programme prerequisites (BSc in a topic appropriate to UNESCO-IHE programme) and basic knowledge of water management.

Learning Objectives

Upon completion of the module participants will be able to..

- describe the expected impacts of climate change on water resources and water use sectors in relation to (other) human activities
- identify the consequences of the predicted impacts of climate change and climate variability for integrated water resources management
- integrate climatic change conditions at different time and spatial scales into (risk) management in the water sector
- justify decisions on adaption to the impacts of climate change under uncertainty

Topics and Learning Activities

Principles of Integrated Water Resources Management
Introduction into the concept of IWRM
Learning Activities:
Lecture and discussion

Climate change and impacts
The climate system and the causes of climate change and variability. Impacts of climate change on the hydrological cycle, the environment and on water use sectors. Country presentations by participants
Learning Activities:
Lectures and exercises

Vulnerability and adaptation under uncertainty
What determines vulnerability to CC. Adaptation measures and strategies how to adapt under a high level of uncertainty. Economic aspect of climate change. Integrating IWRM and climate change
Learning Activities:
Lecture, exercise and fieldtrip

Institutional aspects and stakeholder participation
The importance of involving stakeholders in water management and CC adaptation and strategies on involving stakeholders
Learning Activities:
Lecture,exercise and role play

Multi sector/multicriteria decision making
Modelling effects of CC on water resources using Climateland as a case study
Learning Activities:
Lecture and computer/modelling exercise

Lecturing Material

- Lecture notes, power point presentations, background materials

Assessment

- **30%: Presentation --**
- **70%: Written exam (closed book) --**

2014/2016-ES11X: IWRM as a tool for adaptation to climate change											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**IWRM, climate change and the hydrological cycle**	**6**						**6**	**18**	de Ruyter, van Dorland, Maskey
2	**Â Climate change: impacts and adaptation**	**17**		**6**				**23**	**57**	de Ruyter, van der Meulen, de Fraiture, Pathirana, Popes
3	**Vulnerability and adaptation under uncertainty**	**6**		**6**				**12**	**24**	Bresser, deRuyter
4	**Institutional aspects and stakeholder participation**			**6**				**6**	**6**	Kemerink
5	**Multi sector/multicriteria decision making**			**24**				**24**	**24**	Venneker/Wenninger
6	**Oral presentations**			**6**				**6**	**6**	
7	**Field trip**					**6**		**6**	**6**	Gersonius, van der Meulen
8	**Examination**			**3**				**3**	**3**	
	Total	**29**		**51**		**6**		**86**	**144**	
MSc module - UNESCO-IHE										

URBAN WATER AND SANITATION

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Ronteltap, M.

Module Sheet

Module Name Faecal sludge management	Module Code UWS/SE/11	Credits 5

Target Group	Prerequisites
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.	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

Upon completion of the module participants will be able to..

- Describe the way how excreta and faecal sludge are characterised.
- Know which technologies can be applied for which type of faecal sludge (settling tanks, planted and unplanted drying beds, etc)
- Name the key stakeholders in FSM.
- Describe the relationship between sanitation and health.
- Name the challenges in emergency sanitation and know how emergency sanitation can be addressed.
- Be familiar with the latest developments in sustainable (on-site) sanitation solutions that can be applied in high density low income areas.

Topics and Learning Activities

(Overview) 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, hard ware, 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.

Learning Activities:

The participants will be offered substantial fundamentals as well be informed with the latest insights in faecal sludge management, emergency sanitation and slum sanitation. The classes are taught by global experts in the field of FSM.

Topics in the module:

- Public Health and Sanitation

- Excreta Characterisation

- Faecal Sludge Sanitation Systems

- Non-technical aspects of FSM

- Specific circumstances

Lecturing Material

- Faecal Sludge Management Book (IWA; Editors Linda Strande, Mariska Ronteltap, Damir Brdjanovic)
- Handouts.

Assessment

- **85%: Written Exam (closed book) --**
- **15%: Assignment --**

2014/2016-UWS/SE/11: Faecal sludge management											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Public Health	6						6	18	
	Black Soldier Flies	4						4	12	
	Reinventing the Toilet Challenge	2		2				4	8	
	Emergency Sanitation	6	2					6	20	
	Co treatment	2						2	6	
	Sludge characterisation	2						2	6	
	Treatment Mechanisms	12		8				20	44	
	Institutional Aspects	4						4	12	
	Financial Aspects	2		2				4	8	
	Slum sanitation	2						2	6	
	Total	42	2	12				54	140	
MSc module - UNESCO-IHE										

URBAN WATER AND SANITATION

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Elective module
Module Coordinator: Trifunovic, N.

Module Sheet

Module Name Advanced water transport and distribution	Module Code UWS/WSE/11a	Credits 5

Target Group	Prerequisites
Engineers and scientists with keen interest in modern methods, technologies and tools used in design, operation and maintenance of water transport & distribution networks.	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

Upon completion of the module participants will be able to..

- 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;
- 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.
- recognise the GIS and remote sensing technologies, and familiarise with the GIS-based techniques for sustainable planning and management of WTD systems;
- understand the theory of transient flows, and plan the measures to prevent/control water hammer;
- select modern tools for monitoring of operation, and planning of maintenance of WTD systems.

Topics and Learning Activities

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.

Learning Activities:

Series of lectures is followed by exercise in which the case of distribution network developed during the design exercise in the module Water Transport and Distribution is tested on water quality parameters, namely the water age, source tracing and chlorine residuals, by using WaterGEMS software.

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.

Learning Activities:

Series of lectures is followed by exercise in which the case of distribution network developed during the design exercise in the module Water Transport and Distribution is optimised and tested on irregular supply and demand scenarios by using WaterGEMS software.

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.

Learning Activities:

The main learning activities are grouped around exercises and production of individual assignment. The output files produced in the exercise shall be used for hydtraulic analyses conducted by network modelling software.

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.

Learning Activities:

Series of lectures combined with software demonstrations is followed by exercise in which the case of transportation network from the design exercise Pumping Stations, developed in the module Water Transport and Distribution is teseted on water hammer using WaterGEMS software.

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.

Learning Activities:

Series of lectures is followed by a field trip to one of water supply companies in the Netherlands.

Lecturing Material

- N.Trifunovic - Introduction to Urban Water Distribution, Taylor & Francis, 2006, reprint 2008
- S.Sharma - Corrosion of Pipe Materials, lecture notes UNESCO-IHE 2009 (LN/0310/09/1)
- Electronic materials: slide presentations (MS PowerPoint), design assignments, spreadsheet hydraulic lessons (MS Excel.

Assessment

- **60%: Written Exam (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, and (4) Water hammer analysis.**
- **12%: Assignment -- GIS assignment on the exercise using ArcGIS.**

2014/2016-UWS/WSE/11a: Advanced water transport and distribution											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Water Quality in Distribution Networks	6					4	10	30	S.Sharma, S.Velickov, N.Trifunovic
2	Advanced Water Distribution Modelling	6		12			6	24	48	D.Savic, S.Velickov, N.Trifunovic
3	GIS in Water Distribution			4			4	8	16	Z.Vojinovic
4	Introduction to Water Hammer	6		4			4	14	34	E. Arpadzic, S.Velickov, N.Trifunovic
5	Advanced O&M Water Distribution Practices			4		8		12	12	K.van der Drift
	Total	18		24		8	18	68	140	
MSc module - UNESCO-IHE										

URBAN WATER AND SANITATION

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Elective Module (Open for all specializations)
Module Coordinator: Sharma, S.K.

Module Sheet

Module Name Decentralised water supply and sanitation	Module Code UWS/WSE/11b	Credits 5

Target Group	Prerequisites
Mid-career professionals, 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, consultancies.	MSc. programme entry requirements

Learning Objectives

Upon completion of the module participants will be able to..

- know different technologies/methods for small-scale water abstraction and water treatment that can be used at household or small community level
- understand the basics of sustainable sanitation technologies including nutrient reuse in agriculture (ecological sanitation), soild waste management and fecal sludge management and their implementation in small towns, peri-urban and urban poor areas of developing countries
- prepare concept design for small-scale water supply treatment and ecosan technology
- facilitate planning, financing, implementation and operation and maintenance of decentralised water supply and sanitation infrastructures based on stakeholder participation and community management

Topics and Learning Activities

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

Learning Activities:

Lecture and discussions

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)

Learning Activities:

Lectures, Workshop for calculations, Design Exercise on Multi-stage Filtration

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)

Learning Activities:

Lectures, Workshop/Discussion, Assignment, Field Trip

Management Aspects of Watsan

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)

Learning Activities:

Lectures and discussion

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.

Learning Activities:
Individual presentations and discussion

Lecturing Material

• Sharma, S. (2012) Decentralised Water Supply and Sanitation: Selected Topics UNESCO-IHE Lecture Notes LN0368/11/1
• Sharma, S. (2007) Rainwater Harvesting. UNESCO-IHE Lecture Notes LN 0357/07/1
• IRC (2002) Small Community Water Supplies. IRC TP No. 40
• Rontelap, M. (2012) Ecological Sanitation. UNESCO-IHE Lecture Notes
• Ronteltap, M. (2012) Solid Waste Management. UNESCO-IHE Lecture Notes
• van Dijk, M.P. (2012) Handouts and powerpoint presentation on (i) Institutional Arranagements and (ii) Financing and Cost Recovery Aspects

Assessment

- **60%: Written Exam (closed book) --**
- **30%: Assignment --**
- **10%: Presentation --**

2014/2016-UWS/WSE/11b: Decentralised water supply and sanitation											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Introduction**									Sharma
1.1	Module introduction			1				1	1	
1.2	Introduction to decentralised water supply and sanitation	2						2	6	
2	**Decentralised Water Supply and Treatment Systems**									Sharma
2.1	Water supply systems	3						3	9	
2.2	Rain water harvesting	2		2				4	8	
2.3	Small-scale water treatment	6	6					6	24	
3	**Decentralised Sanitation Systems**									Ronteltap, Schertenleib
3.1	Ecological sanitation	6		2		4		12	24	Ronteltap
3.2	Soild waste management in small towns and urban poor areas	4						4	12	Ronteltap/Guest Lecturer
3.3	Sanitation planning and strategic tools	2		2				4	8	Schertenleib (EAWAG)
3.4	Fecal sludge management	2		4				6	10	Schertenleib (EAWAG)
4	**Management Aspects of DWSS**									Sharma, van Dijk
4.1	Participatory planning and evaluation	2		2				4	8	Guest lecturer
4.2	Institutional arrangements	2		2				4	8	van Dijk
4.3	Financing and cost recovery aspects	2		2				4	8	van Dijk
4.4	Operation and maintenance aspects	2		2				4	8	Sharma
5	**Presentation of the Participants**			**6**				**6**	**6**	Sharma
	Total	**35**	**6**	**25**		**4**		**64**	**140**	
MSc module - UNESCO-IHE										

WATER MANAGEMENT

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Kooy, M.E.

Module Sheet

Module Name Urban water governance	Module Code WSM11	Credits 5

Target Group	Prerequisites
Young mid-career professionals who are 1) working at middle and upper level in an organization in the water sector, 2) employed in policy making institutions in the water sector, 3) working for organizations engaged in management of water resources and water services.	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. Preferred: completion of the Institutional Analysis module.

Learning Objectives

Upon completion of the module participants will be able to..

- Articulate the relevance of current urban development debates for the provision of water supply/sanitation services.
- Identify relationships between urban governance and urban water supply/sanitation infrastructure (be able to describe how they influence and inform each other) in presented case studies.
- Apply the concept of the hydro-social cycle to analyze the intersection of social issues/processes with technical issues in urban water supply and sanitation service delivery.

Topics and Learning Activities

Introduction to urban development in the global South

Trends in urbanization; description of the urbanization process; description of current infrastructure and states of access to basic services in cities of the global South.

Learning Activities:

lecture, assigned reading

Urban development & inequality

Discussion of conditions of urban poverty; description of urban poverty measurements and trends; discussion of urban poverty, inequality and exclusion as related to urban WSS infrastructure.

Learning Activities:

lecture, assigned reading

Urban growth & slum urbanism

Discussion of urban migration; low income urban settlements; peri-urbanization and urban sprawl as related to access to water/sanitation.

Learning Activities:

lecture, assigned reading

Urban resilience

Discussion of the relationship between urbanization and climate change; climate change impacts on cities in the global South; urban resiliency planning.

Learning Activities:

lecture, assigned reading

Right to the City

social movements and urban politics; grassroots urban coalitions

Learning Activities:

lecture, assigned reading

Urban waterscapes & the hydro-social cycle

urban water supply as the inter-section of social and biophysical processes; water as a socio-natural entity

Learning Activities:

lecture, assigned reading

The modern city

Integrated urban infrastructural ideal; hydraulic paradigm and urban planning ideals

Learning Activities:

lecture, assigned reading

Lecturing Material

• Students will be provided a list of articles that are required reading.

Assessment

• 20%: Assignment -- Students will work in small groups to identify how the current key challenges for urban development, discussed in week 1, relate to access to water supply and sanitation.

• 30%: Assignment -- Students will read 2-3 journal articles per topic for week 2 and submit short written assignments.

• 50%: Assignment -- Students will write a final essay to apply the concepts learned in Week 1-2.

2014/2016-WSM11: Urban water governance											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	Introduction to urban development challenges in the global South	2	4					2	10	Kooy
	Urban poverty & inequality	2	4					2	10	Pouw (UvA)
	Urban growth & slum urbanism	2	4					2	10	Kooy
	Urban resilience	2	4					2	10	Kooy
	Right to the city	2	4					2	10	Rusca
	Urban waterscapes & hydro-social cycle	2	4					2	10	Smit/Kooy
	Modern city	2	4					2	10	Kooy
	The Modern city: case study	2						2	6	guest (March)
	The Splintered city	2	4					2	10	Kooy
	The Splintered city: case study	2						2	6	Kooy
	The Informal city	2	4					2	10	Schwartz/Rusca
	The Informal city: case study	2						2	6	guest
	Essay assignment		30						30	
	Total	24	66					24	138	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Water engineering and river basin development
Module Coordinator: Gersonius, B.

Module Sheet

Module Name Water resilient cities	Module Code WSE/11	Credits 5

Target Group	Prerequisites
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.	BSc degree in Engineering or Social Sciences background; basic knowledge of urban water and flood risk management; good command of English.

Learning Objectives

Upon completion of the module participants will be able to..

- Define and assess flood and drought resilience of communities and built-up areas
- Develop short- and long-term strategies that enhance flood and drought resilience
- Explain the role of spatial planning and design philosophy in flood and drought risk management, and implement these within an overall strategy
- Analyse the need for and place of community participation and collaborative governance in enhancing flood and drought resilience

Topics and Learning Activities

Flood and drought resilience

The first week of the module introduces an approach to understand and assess flood and drought resilience of communities and built-up areas. It goes on to discuss key aspects of resilience, including the system's resistive, coping and recovery capacity. Experiences from different cities worldwide with the development of short- and long-term strategies to enhance flood and drought resilience will be addressed through formal lectures, including a field trip.

Learning Activities:

Lecture, assignment, workshop, self study.

Water Sensitive Urbanism

The second week introduces Water Sensitive Urban Design (WSUD) as a process and why it is particularly relevant to address the integrated management of the water cycle. It covers the development of WSUD and itsâ€™ contemporary meaning in exemplar cultures (Australia, UK, USA and South Africa). Also the relationship between WSUD, green infrastructure and spatial planning will be discussed, as well as how these components work together across different scale levels.

Learning Activities:

Lecture, workshop, fieldtrip, self study.

Community participation and collaborative governance

The third week of the module builds on the 2 previous weeks and explains the need for and place of community participation and collaborative governance in enhancing flood and drought resilience. Diverse topics will be addressed in a series of formal lectures, such as social/active learning, social resilience, collaborative networks and governance structures.

Learning Activities:

Lecture, workshop, self study.

Lecturing Material

- Reader with journal papers and classroom presentations

Assessment

- **50%: Oral Exam -- Topics: Flood and drought resilience; Water Sensitive Urbanism; Community participation and collaborative governance.**
- **50%: Presentation -- Topics: Flood and drought resilience; Water Sensitive Urbanism; Community participation and collaborative governance.**

2014/2016-WSE/11: Water resilient cities										
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Flood and drought resilience	6	4				8	14	46	Bachhin, Gersonius, Zevenbergen
2	Water Sensitive Urbanism	8				8	6	22	50	Ashley, Nillisen, Veerbeek
3	Community participation and collaborative governance	8					6	14	42	Anema, Rijke, Pathirana
	Total	22	4			8	20	50	138	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Roelvink, J.A.

Module Sheet

Module Name Flood protection in lowland areas	Module Code WSE/HECEPD/11/e	Credits 5

Target Group	Prerequisites
	Basic knowledge of hydraulics, basic knowledge of soil mechanics

Learning Objectives

Upon completion of the module participants will be able to..

- carry out a basic design of dikes, revetments and closure dams
- understand concepts and advances of flood risk management with due consideration of societal aspects, including flooding issues in the floodplain and coastal zone, management of flood risk, planning aspects and a variety of non-structural measures
- understand and apply concepts and advances in tools used for coastal flood modelling and flood forecasting
- understand and apply the principles of flood frequency analysis and risk based approaches to design of hydraulic works
- understand (the practical application of) probabilistic design theory

Topics and Learning Activities

Dikes and Revetments (J. Salazar, C. Dorst)

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.

Learning Activities:

Lectures

Probablistic Design (P. van Gelder)

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.

Learning Activities:

Lectures

Storm Impact Modelling (D. Roelvink, M. van Ormond, J. van Thiel de Vries, A. van Rooijen)

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.

Learning Activities:

Lectures and Assignment

Lecturing Material

- Verhagen, H.J.: Revetments, Sea Dikes and River Levees-Lecture notes hh292/99/1
- Hassan, R.M.: handouts, Dikes and Revetments, 2002
- Groot, M.: Handouts, Geotechnical Aspects for Dikes, 2003
- Verhagen, H.J. : Design of closure of dams- Lecture notes ln0052/02
- Vrijling, J.K.: Probabilistic Design, Lecture notes ln0217/04/
- Handout: collection of tutorials and papers related to OpenEarth, Delft3D and XBeach applications.

Assessment

- **40%: Oral Exam -- Dikes and Revetments (assignment, oral discussion)**
- **40%: Assignment -- Storm impact modelling**
- **20%: Written Exam (closed book) -- Probabilistic design**

2014/2016-WSE/HECEPD/11/e: Flood protection in lowland areas											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Dikes and Revetments**	**8**		**4**				**12**	**28**	C. Dorst
2	**Dikes and Revetments**	**12**						**12**	**36**	J. Salazar
3	**Probabilistic design**	**6**		**6**				**12**	**24**	P. van Gelder
4	**Storm Impact modelling**	**2**						**2**	**6**	J. A. Roelvink
5	**Storm Impact modelling**	**6**		**5**				**11**	**23**	M. van Ormondt
6	**Storm Impact modelling**	**6**		**5**				**11**	**23**	J. van Thiel de Vries
	Total	**40**		**20**				**60**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Suryadi, F.X.

Module Sheet

Module Name Innovative approaches and practices	Module Code WSE/HELWD/11/e	Credits 5

Target Group	Prerequisites
All WSE participants and from other programmes with specific interest.	General knowledge about drip and sprinkler irrigation systems as well as GIS and remote sensing.

Learning Objectives

Upon completion of the module participants will be able to..

- Determine the requirements for water table and salinity control in irrigated areas; Understand the factors that influence the functioning of a drainage system; Design a subsurface drainage system
- Design surface and overhead pressure irrigation systems and understand the need for drainage in irrigated areas
- Explain the use of modern tools as RS and GIS in combination with the use of computer models
- Predict effects of different water qualities on agricultural crops, and stock farming and human health
- Determine the effects and related water management and land use zoning that are involved when living in flood prone areas
- Discuss the interactions between land use, water management and flood control in flood prone areas

Topics and Learning Activities

Introduction: Sprinkler and Drip, F. Reinders (ARC, South Africa)

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.

Learning Activities:
lecture, exercise

Sub-surface Drainage, H.P. Ritzema (Wageningen University and Research)

The need for drainage: water ponding, waterlogging and salinisation. Drainage systems: components of a drainage system, surface and subsurface drainage systems. Factors related to drainage: agricultural objectives, environmental aspects, and soil and hydrological conditions. Design considerations: drainage design criteria and layout. Drainage design equations: principles and applications. Introduction, background information, and preparing the layout and design of a subsurface drainage system.

Learning Activities:
lecture, exercise

Remote Sensing for Irrigation and Drainage, Z. Vekerdy (ITC)

Introduction to the principles of remote sensing and their applications in the field of irrigation and drainage.

Learning Activities:
lecture, exercise

Reuse of Low Water Quality, P. van der Steen (UNESCO-IHE)

Sources of pollution: domestic, industrial and agricultural pollution. Types of pollution: chemical, mechanical and biological pollution. Parameters used to describe the degree of pollution: Salinity, BOD, COD, Dissolved oxygen, TSS, faecal coli, heavy metals. Reuse of water: criteria for reuse for agriculture, cattle watering and water supply. Measures for improvement of water quality: water treatment.

Learning Activities:
lecture, exercise

Land Use and Water in Flood Prone Areas, C. de Fraiture (UNESCO-IHE)

Historical and recent developments of land use and flood prone areas. The importance of land use zoning. Interactions between land use, water management and flood control.

Learning Activities:
lecture

Emerging trends in irrigation such as Flood Based Farming and Private Irrigation, C. de Fraiture (UNESCO-IHE)

Flood based farming systems, small scale private irrigation systems

Learning Activities:
lecture

Lecturing Material

- Reinders, 2010. Determining pipe sizes (hand-out).
- Reinders, 2009. Sprinkler and drip (hand-out).
- Ritzema, 2007. Subsurface drainage.
- Ritzema, 2007. Exercise Sub-surface Drainage: Case Study Pan de Azucar.
- Schultz, 2006. Opportunities and threats for lowland development. Concept for water management, flood protection and multifunctional land-use. In: Proceedings of the 9th Inter-Regional Conference on Environment-Water. EnviroWater 2006. Concepts for Watermanagement and Multifunctional Land-Uses in Lowlands, Delft, the Netherlands, 17 - 19 May, 2006.
- Schultz, 2008. Extreme weather conditions, drainage, flood management and land use. In: Proceedings of the 10th International Drainage Workshop, Helsinki, Finland and Tallinn, Estonia, 6 - 11 July 2008, Helsinki University of Technology, Helsinki, Finland.
- Schultz, 2010. Land use and water in flood prone areas.

Assessment

- **40%: Assignment -- For Sprinkler and Drip**
- **60%: Assignment -- Assignment and oral discussion for Sub-surface Drainage**

2014/2016-WSE/HELWD/11/e: Innovative approaches and practices											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Sprinkler and Drip**	**8**		**8**				**16**	**32**	F.B. Reinders
2	**Subsurface Drainage**	**12**		**8**				**20**	**44**	Dr Ir H.P. Ritzema
3	**Remote Sensing for Irrigation and Drainage**	**8**		**4**				**12**	**28**	Dr. Z. Vekerdy
4	**Reuse of Low Water Quality**	**6**						**6**	**18**	N.P. van der Steen, PhD, MSc
5	**Land Use and Water in Flood Prone Areas**	**4**						**4**	**12**	Prof. C. de Fraiture, PhD, MSc
6	**Emerging trends in irrigation such as Flood Based Farming and Private Irrigatio**	**2**						**2**	**6**	Prof. C. de Fraiture, PhD, MSc
	Total	**40**		**20**				**60**	**140**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: HERBD
Module Coordinator: Popescu, I.I.

Module Sheet

Module Name Modelling and operation of river systems	Module Code WSE/HERBD/11/e	Credits 5

Target Group	Prerequisites
All participants in the WSE programme	Hydraulics & Basic mathematics

Learning Objectives

Upon completion of the module participants will be able to..

- 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.
- Provide participants practical experience with standard models and develop an understanding of modelling in river and lake systems
- Understand principles of reservoir control and optimisation, and develop operational rules for (multi-purpose) reservoir operation
- Develop critical assessment in assessing quality of model calibration and validation, verification and uncertainty

Topics and Learning Activities

Computational Hydraulics (I. Popescu, IHE; M. Krajcevski, USF)

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.

Learning Activities:

Formal lectures, home assignments, exercises and workshops in computer lab

Model quality assessment & uncertainty (M. Werner, IHE)

Practical concepts for analysing quality of models used in modelling water resources. Techniques for calibration and validation. Sensitivity analysis and uncertainty estimation. Verification methods.

Learning Activities:

Formal lectures, home assignments, exercises and workshops in computer lab

Reservoir control and optimisation (M.Werner, IHE)

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.

Learning Activities:

Formal lectures, home assignments, exercises and workshops in computer lab

Modelling Applications (I. Popescu, IHE; M. Werner, IHE,; M. Mukolwe, IHE; F. Martins, U. of Algarve; L. Beevers, Hariott Watt)

Practical experience with computational numerical models will be gained by students. Modelling exercises will be in three parts; (i) Reservoir Simulation and Optimisation; (ii) River Modelling; and, (iii) Lake Modelling. The objective of this component will be the application of the theory gained in the theoretical components of the course.

Learning Activities:

Formal lectures, home assignments, exercises and workshops in computer lab

Lecturing Material

- Popescu, I., 2004: Differential Equations and Numerical Methods.UNESCO-IHE Lecture notes.
- MOHID - Hydrodynamics user manual, 2009
- Martins, F., 2011: Modelling river and lakes using MOHID. UNESCO-IHE. Lecture notes
- Handouts

Assessment

• 30%: Written Exam (closed book) -- This component reffers to the Computational Hydraulics subject.

• 30%: Written exam (closed book) -- This component reffers to the Reservoir control and optimisation subject

• 40%: Assignment -- This component is comprised of 2 components, assignments in Reservoir control and optimisation (10%) and the assignments in Modelling applications (lakes and rivers) (30%)

2014/2016-WSE/HERBD/11/e: Modelling and operation of river systems											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Computational Hydraulics	6		8				14	26	I. Popescu (IHE)
2	Model quality assessment & uncertainty	2		2				4	8	M. Werner (IHE)
3	Reservoir control and Optimisation	12						12	36	M. Werner (IHE)
4	Modelling Applications: reservoirs				10			10	20	M. Werner (IHE)
5	Modelling Applications: lakes	4			10			14	32	F. Martins (Algarve University)
6	Modelling Applications: rivers			4	6			10	16	I. Popescu, M. Mukolwe (IHE), L. Beevers (Herriot Watt)
	Total	24		14	26			64	138	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: Jonoski, A.

Module Sheet

Module Name Hydroinformatics for decision support	Module Code WSE/HI/11/e	Credits 5

Target Group	Prerequisites
Participants from all Master Programmes of UNESCO-IHE	Hydrological and hydraulic modelling concepts; Basic programming skills

Learning Objectives

Upon completion of the module participants will be able to..

- Understand the role of system analysis in water resources planning and management
- Formulate and solve water resources problems as optimisation problems
- Distinguish and properly use different types of decision support methods for water problems
- Build simple software applications that integrate data and models across Internet
- 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

Topics and Learning Activities

Systems analysis in water resources, D.P. Loucks (Cornell University)

Definition and role of systems analysis in engineering planning; Basic concepts; Multi-objective models and the concept of trade-offs between conflictÂ¬ing objectives; Development and use of static and dynamic stochastic simulation models of river systems.; Introduction to decision support systems and geographic information systems and their use; Exercises in multipurpose integrated river basin (or regional) water resources management modelling

Learning Activities:
Attending lectures;
Computer exercises;
Home assignment;

Decision support systems, A. Jonoski (IHE) and I. Popescu (IHE)

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

Learning Activities:
Attending lectures;
Computer exercises;
Home assignment;

Software technologies for integration, A. Jonoski (IHE), L. Alfonso (IHE), G. Corzo (IHE), S. Seyoum (IHE)

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, Technologies for integrating distributed resources: web-interfaces technologies; creating web-based and mobile phone applications with assignment exercise.

Learning Activities:
Attending lectures;
Computer exercises;
Home assignment;

Integration of weather prediction and water models, S.J. van Andel (IHE)

Approaches and methods for integration of weather models with hydrological and hydraulic models. Integration of remote sensing data. Downscaling and upscaling issues.

Learning Activities:
Attending lectures;
Computer workshop;

Lecturing Material

• D.P. Loucks: Lecture Notes on Water Resource Systems Modelling: Its Role in Planning and Management (chapters 2, 3, 4, 10 and 11)
• A. Jonoski: Introduction to Decision Making and Decision Support Systems (PowerPoint Slides)
• I.Popescu: Handout DSS exercises with mDSS4
• A. Jonoski: Software Technologies for Integration (PowerPoint Slides)
• A. Jonoski, S. Seyoum, G. Corzo, L. Alfonso: Handouts Software integration exercises
• S.J van Andel: Integration of weather prediction and water models (PowerPoint Slides)
• Software:- LINGO, mDSS4, AlleyCode - web editor, Apache web server with PHP, Google maps API, Eclipse + Android

Assessment

- **40%: Assignment -- Exercise report on Systems analysis in water resources**
- **30%: Assignment -- Exercise report on Decision support systems**
- **30%: Assignment -- Exercise report on Software technologies for integration**

2014/2016-WSE/HI/11/e: Hydroinformatics for decision support											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
1	**Systems analysis in water resources**	**12**		**4**	**4**			**20**	**48**	D. P. Loucks
2	**Decision support systems**	**6**		**4**	**4**			**14**	**30**	A. Jonoski, I. Popescu
3	**Software technologies for integration**	**4**		**10**	**10**			**24**	**42**	A. Jonoski, G. Corzo, S. Seyoum, L. Alfonso
4	**Integration of weather prediction and water models**	**4**		**4**				**8**	**16**	S.J. van Andel
	Total	**26**		**22**	**18**			**66**	**136**	
MSc module - UNESCO-IHE										

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: Core Programme
Module Coordinator: Foppen, J.W.A.

Module Sheet

Module Name Summer course	Module Code WSE/12/c	Credits 1

Target Group	Prerequisites
All participants of the programme	The successful completion of at least 8 of the first 11 modules of the programme

Learning Objectives

Upon completion of the module participants will be able to..

- Discuss the latest insights, context and concepts of a contemporary issue of choice
- Able to justify his or her research in the context of UNESCO-IHE research lines, personal professional interests and preferably in local, national and regional contemporary issues.

Topics and Learning Activities

Research methodology

Selected attention to one or several aspects of epistemology, literature review, scientific research methods, statistics, writing for publication, etc.

Learning Activities:

Presentations by and debate between staff, guest lecturers and participants on issues of research methods, epistemology, contemporary issues, etc

Summer courses

Participant will need to select 1 course out of the available Summer Courses on offer during this period (each Masters programme will offer one or more Summer Course open to all participants, as long as prerequisites are met). Topics will be presented as seminars by UNESCO-IHE staff and guest lecturers on specific contemporary themes and issues. Some examples of previous Summer Courses are:
- Water and Climate
- Environmental Flows
- Conflict Resolution
- Flood resilient planning and building

Learning Activities:

Lectures, workshops, assignments

Lecturing Material

- To be announced

Assessment

- **100%: Assignment -- Pass / fail based on attendance to research methodolgy and summer course**

2014/2016-WSE/12/c: Summer course											
Nr	**Course/Topic**	**Lecture**	**Assignment**	**Workshop Case study Role play Exercise Lab session**	**Laboratory work**	**Fieldtrip - Fieldwork**	**Design exercise**	**SUM: contact hours**	**SUM: studyload hours**	**Lecturer(s)**
	Research methodology									Various
	Summer Course									Various
	Total									
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2014-2016
Specialization: WSE-HWR, WSE-HERBD, WSE-HECEPD, WSE-HI, WSE-HELWD
Module Coordinator: Stigter, T.Y.

Module Sheet

Module Name Groupwork WSE	Module Code WSE/13/c	Credits 5
Target Group	**Prerequisites** All previous modules	

Learning Objectives

Upon completion of the module participants will be able to..

- elaborate (a first outline of) an Integrated Coastal Area and River Basin Management (ICARM) Plan
- 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 development and environment
- perform specialized studies (using an engineering approach) in their own discipline to support the implementation of measures and assess their impacts and efficiency
- 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
- develop inter- and multi-disciplinary project activities in integrated teams

Topics and Learning Activities

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.

Learning Activities:

Groupwork exercise. The preparation of an ICARM Plan will be performed as a role play, requested by the "Client", played by UNESCO-IHE staff members, to several "Consulting firms", played by the students. As these firms need to include expertise for all the different disciplines, students from the five specializations of WSE will be working together in each firm. The staff members involved in the groupwork will also guide and advise the student consultants in their function of teacher as "Experts".

The consulting firms will organize themselves to execute tasks such as management of the firm and sub-groups, analyzing data, reporting and editing, presenting etc. Besides the firm and sub-group activities, each individual student will also carry his/her own responsibility for delivering a specific part of the study. Reporting and oral presentations should clearly reflect group activities and individual contributions.

Lecturing Material

- Handouts group work, information and data

Assessment

- **25%: Presentation -- Group mark Phase 1 determined by report and presentation**
- **50%: Presentation -- Individual mark Phase 2 determined by report and feedback sessions**
- **25%: Presentation -- Group mark Phase 2 determined by report and presentation**

2014/2016-WSE/13/c: Groupwork WSE											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
1	Groupwork			140				140	140	
	Total			140				140	140	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2013-2015**
Specialization: **Core Programme**
Module Coordinator: **Taneja, P.**

Module Sheet

Module Name MSc preparatory course and thesis research proposal	Module Code WSE/14/c	Credits 9

Target Group	Prerequisites
All students of the Water Science and Engineering programme	The successful completion of at least 8 of the first 11 modules

Learning Objectives

Upon completion of the module participants will be able to..

- 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
- list available literature and replicate main arguments expounded in the literature on the specified research topic
- demonstrate analytical problem-analysis skills and the ability to distil the strategic issues to be addressed in the research phase
- 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 stage of the research project
- 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 it in light of contemporary thinking in a specific field of study

Topics and Learning Activities

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.

Learning Activities:

Reading and discussing

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.

Learning Activities:

Writing of the proposal

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

Learning Activities:

Presentation of the proposal

Lecturing Material

- MSc thesis Protocol
- How to write an MSc thesis – Wendy Sturrock

Assessment

• 100%: Presentation -- The MSc research proposal needs to be approved by the mentor and the professor before the student can actually start the research work

2014/2016-WSE/14/c: MSc preparatory course and thesis research proposal											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	MSc research proposal drafting		**188**						**188**	Mentor
	MSC research proposal presentation				**4**			**4**	**8**	Mentor and professor
	Total		**188**		**4**			**4**	**196**	
MSc module - UNESCO-IHE										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2013-2015
Specialization: Core Programme
Module Coordinator: Taneja, P.

Module Sheet

Module Name MSc research work	Module Code WSE/15	Credits 36

Target Group	Prerequisites
Programme target group	Programme prerequisites

Learning Objectives

Upon completion of the module participants will be able to..

- 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 of the research topic; Formulate research questions and hypotheses.
- Conduct research, independently or in a multidisciplinary team by selecting and applying appropriate research methodologies and techniques, collecting and analysing data.
- Formulate well-founded conclusions and recommendations based on a comprehensive discussion of the results
- 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.
- 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.

Topics and Learning Activities

Lecturing Material

Assessment

• 100%: Assignment -- The MSc work is assessed based on the written report, the final presentation, the defense

2014/2016-WSE/15: MSc research work											
Nr	Course/Topic	Lecture	Assignment	Workshop Case study Role play Exercise Lab session	Laboratory work	Fieldtrip - Fieldwork	Design exercise	SUM: contact hours	SUM: studyload hours	Lecturer(s)
	MSc Research		928	80				80	1008	
	Total		928	80				80	1008	
MSc module - UNESCO-IHE										