Delft, December 2011

Master Programme
Water Science and Engineering

Handbook 2011-2013

Disclaimer:

While UNESCO-IHE Institute for Water Education, Delft does its utmost to ensure that the programme will run as specified in this handbook, the content is subject to change. Certain modules or parts of modules may be changed, withdrawn and/or replaced by other modules. Due to logistical constraints or otherwise, participation of specified lecturers, whether from UNESCOIHE or from partner organisations cannot be guaranteed. No rights can therefore be derived from the programme as specified in this handbook.

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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
- Municipal Water and Infrastructure
- 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 Municipal Water and Infrastructure;
- 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 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 programmes are conducted over a period of 18 months during two academic years. The general planning structure is shown in the *Academic Calendar* printed in the preamble of this handbook.

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 4 credit points;
- the thesis proposal preparation of 6 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;
- 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. The (minimum) study load determination criteria for the various education activities are shown in the following table.

Activity	**Study load / contact time**
Lecture, with assignment	≥ 3 hours / hour
Assignment	1 hour / hour
Workshop	1-2 hours / hour
Fieldtrip	≥ 8 hours / day
Fieldwork	≥ 8 hours / day
Laboratory session	≥ 1-2 hours / hour

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

Active participation and attendance by students is required for all curricular activities on the schedule. 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 Exam regulations

Education and Examination Regulations 2011– 2012

For the Master Programmes in:

- Municipal Water and Infrastructure
- Environmental Science
- Water Management
- Water Science and Engineering

Approved by the Academic Board of UNESCO-IHE, 29 September 2011

3.1 General Information

Article 1 Scope of the regulations

1.1 The present regulations apply to the education and examinations within the above mentioned master programmes 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 In case of joint specialisations (see art. 3.2) the present regulations also apply for the part of the programmes offered by UNESCO-IHE.

1.3 In case a joint specialisation leads to a double degree, the rules and regulations of the partner institute will be applicable for those parts of the programme organised and implemented by the partner. Credit transfer agreements and all details of the programme offered by the partner institute are described in the cooperation agreement between UNESCO-IHE and the partner institute.

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*);

Module : a self-contained programme unit with specified learning

objectives, as stipulated in article 7.3 of the Act;

Rector : the rector of the Institute;

ECTS : the European Credit Transfer and Accumulation System;

Examination : an interim study performance assessment for a component of the programme (in the Act: *tentamen*);

Constitutent examination : an examination consisting of a number of different

parts (e.g. assignments, written or oral exams, presentations)

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

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 examination : the formal evaluation of the student performance

before graduation (in the Act: *examen*);

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

examinations.

Article 3 Programme and specialisations

3.1 The programmes are characterised as post-initial master programmes in scientific education, as stipulated in article 7.3b of the Act.

3.2 The following specialisations are distinguished within the programmes:

Municipal Water and Infrastructure programme:

1. Water Supply Engineering;

2. Sanitary Engineering;

3. Joint specialisation in Water Supply Engineering with Kwame Nkrumah University of Science & Technology, Ghana;

4. Joint specialisation in Sanitary Engineering with Kwame Nkrumah University of Science & Technology, Ghana;

5. Joint specialisation in Water Supply Engineering with Universidad del Valle, Colombia;

6. Joint specialisation in Sanitary Engineering with Universidad del Valle, Colombia; and

7. Joint specialisation in Urban Water and Management with Asian Institute of Technology, Thailand.

Environmental Science programme:

1. Environmental Science and Technology;

2. Environmental Planning and Management;

3. Water Quality Management;

4. Joint specialisation in Limnology and Wetland Ecosystems with Institute of Limnology, Austria and Egerton University, Kenya;

5. Joint specialisation in Environmental Technology for Sustainable Development with Asian Institute of Technology, Thailand; and

6. Environmental Technology and Engineering (Erasmus Mundus programme).

Water Management programme:

1. Water Resources Management;

2. Water Services Management;

3. Water Quality Management; and

4. Water Conflict Management.

Water Science and Engineering programme:

1. Hydrology and Water Resources;

2. Joint specialisation in Hydrology and Water Resources with Hohai University, China P.R.;

3. River Basin Development;

4. Coastal Engineering and Port Development;

5. Joint specialisation in Coastal Engineering and Port Development, with Hohai University, China P.R.;

6. Land and Water development;

7. Joint specialisation on Land and Water development with Sriwijaija University, Palembang, Indonesia;

8. Joint specialisation on Agricultural Water Management for Enhanced Land and Water Productivity with Asian Institute of Technology Thailand;

9. Agricultural Water Management for Arid and Semi-Arid Climates with Haramaya University, Ethiopia;

10. Hydroinformatics;

11. Joint specialisation in Hydroinformatics with Hohai University, China P.R.;

12. Joint specialisation in Hydroinformatics with Universidad del Valle, Colombia;

13. Joint specialisation in Hydroinformatics with Ain Shams University, Egypt;

14. Ecohydrology (Erasmus Mundus programme); and

15. Flood Risk Management (Erasmus Mundus programme).

Article 4 Aim of the programme

4.1 The aim of the programmes is to convey to the students the 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 programme graduates are listed in Appendix A.

Article 5 Full-time/part-time

5.1 The programmes are executed on a full-time basis.

Article 6 Study load of the programme

6.1 The minimum study load of the programmes is 106 ECTS credit points, with reference to article 7.4a, paragraph 8 of the Act.

Article 7 Programme examination

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

7.2 The programme examination is passed if all designated examinations in the programme curriculum have been successfully completed, as stipulated in article 7.10, paragraph 1 of the Act.

3.2 Academic Admission Requirements

Article 8 Admission to the programmes

8.1 Academic admission to the programmes may be granted to applicants who provide evidence of having:

a. a university level Bachelor's degree in an appropriate field for the specialisation, as listed in Appendix B, and which has been awarded by a university of recognised standing.

b. some working experience in an environment related to the specialisation. At least three years experience is normally preferred.

c. a good command of the English language, if this is not the first language. This is measured by a minimum IELTS score of 6.0, a minimum paper-based TOEFL score of 550, or a minimum computer-based TOEFL score of 213. For other tests, the results will be interpreted to show alignment with the Council of Europe's Common European Framework (CEF) levels C1 or C2.

8.2 Academic admission to the programmes will be granted on the basis of a decision taken to that effect by the Academic Registrar, upon advice of the appropriate programme coordinator.

3.3 Content of the Programme

Article 9 Composition of the specialisations and joint specialisations

9.1 The composition of each programme specialisation is defined in Appendix C.

Article 10 Practicals and participation

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

3.4 Examinations

Article 11 Sequence of the examinations

11.1 Students can sit the thesis examination only if all other examinations of the programme specialisation curriculum have been successfully completed.

11.2 Notwithstanding the stipulations in article 11 paragraph 1, successful completion of the examinations is not required for sitting subsequent examinations.

Article 12 Periods and frequency of examinations

12.1 Students can sit each oral or written examination only two times per academic year, except where indicated in subsequent paragraphs.

12.2 The date and time allocations for the first sitting are announced in the programme schedules. Examinations take place during the examination periods indicated in the academic calendar.

12.3 Groupwork, fieldwork and fieldtrips are offered and assessed once per academic year.

12.4 Students are not allowed to re-sit (constituent parts of) module examinations for which a successful result has been obtained.

12.5 Written re-examinations normally take place during the next examination period indicated in the academic calendar. The students involved are notified sufficiently in advance in writing about the date and time allocation for re-examinations. All students will take the re-sit at the same time.

12.6 Students will not be allowed to sit for further re-examinations and -assignments if they failed more than three re-examinations for the first 13 modules of the programme.

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

Article 13 The nature of the examinations

13.1 The constituent parts of a module are assessed via a combination of written and or oral examinations, assignments and presentations as indicated in the module descriptions.

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

13.3 A written examination has to take place in a period of max. 3 hours during a morning or afternoon session. A break of 15 minutes is allowed.

13.4 The nature of the examinations for each module in each programme is indicated in Appendix C, and is described separately in the in each module sheet.

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

13.6 Re-examination proceeds by re-examining one or more failed constituent parts, as would be necessary to achieve a successful examination result.

13.7 The credits for successful completion of fieldwork and fieldtrips are granted on the basis of active participation, unless stated otherwise in the module sheet.

13.8 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.

Article 14 Oral examinations

14.1 Oral examinations involve only one student at a time. During oral examinations, a second examiner is present as independent observer.

14.2 The examination of the thesis research is open to public attendance and discussion. All other oral examinations are non-public, unless stated otherwise in the module sheet.

Article 15 Exemptions and transfer of credit points

15.1 Exemptions to sit examinations 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.

15.2 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 16 Absence from examinations

16.1 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 circumstances beyond control of the student which should be supported by written evidence as far as possible.

16.2 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.

16.3 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 17 Fraud

17.1 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.

17.2 An examiner who observes or suspects fraud during the assessment of examination work is required to submit a substantiating report to the examination board.

17.3 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.

3.5 Results of Examinations

Article 18 Assessment and notice of examination results

18.1 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 successful result.

The following grading scale is used:

- 9.1-10 outstanding
- 8.6-9.0 very excellent
- 8.1-8.5 excellent
- 7.5-8.0 very good
- 7.0-7.4 good
- 6.0-6.9 sufficient
- 5.9- and below insufficient - fail

18.2 The mark for a constituted examination is determined by the weighted average of the results of the constituent parts. The weights for the constituent parts must be stated in the module sheet.

18.3 The examiner shall assess a written examination or practical paper within a period of 14 days after the date of the examination.

18.4 All written examination work of the students will be blind corrected by the examiners involved.

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

18.6 The examination committee for the thesis examination shall determine the result after the defence. The mark shall be communicated to the student before the diploma awarding.

18.7 Examiners inform the module coordinators about the results of all examinations (written and oral) via standard examination result forms. Subsequently the module coordinators inform the Education Bureau via standard forms about the final module mark.

18.8 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.

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

Article 19 Period of validity

19.1 The result of an examination, when successful, is valid for an unlimited period of time.

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

Article 20 Right to inspection of assessments

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

20.2 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.

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

3.6 Thesis Examinations

Article 21 Periods and frequency of thesis examinations

21.1 The thesis will be assessed by a thesis examination committee, consisting normally of 3 members (or in special circumstances of maximum 4 members); (at UNESCO-IHE) a professor as chairman, the mentor and one or two external examiners.

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 normally from outside the institute or in incidental cases from a chair group not involved in the supervision of the research work.

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

21.3 All students have to submit the examination version of the thesis report on the same date, i.e. the second Thursday of the month of the thesis examination.

21.4 Admission to the thesis examination is granted when the supervisor, upon recommendation of the mentor, has approved the draft thesis; in other words, the draft thesis needs to be approved as 'ready for the MSc defence'.

21.5 In exceptional cases, 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 re-sit shall be taken within three months of the first attempt.

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

21.7 The mark for the thesis examination is based on the following components: written MSc thesis report, presentation and discussion. The latter includes the ability of the student to answer questions from the examination committee and the audience.

21.8 The maximum duration of the MSc research phase is 6 months for a full time study. Extension of this period may be granted on request by the student and is subject to approval by the rector.

Article 22 Study progress and study advice

22.1 All study results that are required for evaluating the performance of the students, and the evaluation results are recorded on behalf of the Academic Board.

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

3.7 Examination Board

Article 23 Examination board procedures

23.1 The examination board is a sub-board of the Academic Board and normally meets before the monthly meeting of the Academic Board. The calendar of meetings is established and

circulated at the beginning of the academic year. Additional meetings will be set or meetings can be rescheduled whenever circumstances dictate.

23.2 For each meeting, the administrative secretary will provide all required material to properly conduct the examination board's deliberations.

23.3 Decisions of the examination board are concluded by majority vote.

23.4 The mandate of the examination board is defined by its Terms of Reference.

Article 24 Assessment of the programme examination

24.1 The student has fulfilled the requirements for the programme examination if (s)he has successfully completed all examinations of the programme.

24.2 The student has successfully completed the programme examination when the examination board takes a decision to that effect.

Article 25 Degree awarding

25.1 Students who have successfully completed the programme examination will be awarded the Master of Science degree at the next scheduled degree awarding ceremony.

25.2 The degree will be awarded with distinction if the candidate obtained a mark of 8.5 or higher for the thesis examination, and an arithmetic average mark of 8.0 or higher for all other examinations in the programme that are assessed on a numerical scale, conform article 2.1.

Article 26 Diploma and supplement

26.1 As evidence of successful completion of the programme examination, the examination board issues a diploma during the degree awarding ceremony. The diploma is signed by the Chairman of the examination board, the Rector of the Institute and the Academic Registrar.

26.2 In addition to the diploma, the graduate receives a diploma supplement stating the results achieved and credit points for each component of the programme.

Article 27 Programme certificate

27.1 Students who fail to meet the programme examination 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.

27.2 Students who fail to meet the programme examination requirements and have accumulated a minimum of 45 credits will be awarded a certificate of post-graduate study in the programme for which they are registered. Registration as student will be terminated.

3.8 Appeals

Article 28 Grounds for appeal

28.1 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.

Article 29 Procedure for appeal

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

29.2 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.

29.3 After consultations, 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.

Article 30 Evaluation of the programme

30.1 All taught components of the programme are routinely evaluated via a standardised questionnaire, which is completed by the students during a class session.

30.2 The evaluation class session for a programme component is held after students have submitted all examination material, and before the examination results are being notified to the students.

30.3 Upon explicit request by the students or a student representative, an oral evaluation discussion may be organised at any time. The purpose of such a discussion is entirely to obtain specific information or suggestions for improvement of a programme component.

3.9 Final Articles

Article 31 Amendments

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

31.2 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 32 Unforeseen situations

32.1 Situations which are not foreseen by the present regulations, will be decided on by the Academic Board, where necessary after consultation with the examination board and/or programme committees.

Article 33 Publication

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

Article 34 Period of application

34.1 These regulations take effect for the academic year 2011– 2012. Approved by the Academic Board of UNESCO-IHE on 29 September 2011

3.10 Appendix A Qualifications of Graduates ES

- [1] Knowledge and understanding:
- Knowledge of current theory and contemporary developments in Environmental Science.
- Knowledge of physical, chemical and biological processes of the environment.
- Understanding of what is meant by “sustainability” and “wise use” of natural resources.
- The ability to describe the rationale for an integrated and interdisciplinary approach for managing the environment.
- Understanding the broader scientific, engineering and socio-economic context and the role of other disciplines required for Environmental Science.

Environmental Science and Technology

- To list concepts, instruments and technologies for pollution prevention, treatment and remedial action.

Environmental Planning and Management

- Knowledge of economic, institutional and legal principles, approaches and instruments relating to the environment.
- To list and explain legislative, institutional and management principles and arrangements.

Water Quality Management

- Recognize the pollution impacts on water quality and identify remedial actions.
- To list and explain legislative, institutional and management principles and arrangements.

Limnology and Wetland Ecosystems

- Recognize the pollution impacts on water quality and identify remedial actions.

[2] Applying knowledge and understanding:

- The ability to contribute to theoretical, methodological or applied developments in environmental science.
- The ability to prepare and implement a sound plan for environmental research.
- The ability to collect, analyse and organise relevant information and to draw sound conclusions on environmental issues.

Environmental Science and Technology

- To select and apply instruments and technologies for pollution prevention, treatment and remedial action.

Environmental Planning and Management

- To contribute to managing environmental systems and organisations and to the development of the institutional arrangements of the latter.
- To design and apply models for institutional development in water policy.
- To design and facilitate stakeholder involvement in decision-making processes.
- To formulate environmental policy strategies.

Water Quality Management

- To apply experimental, statistical and modelling tools for interpreting and designing water quality management programmes.

Limnology and Wetland Ecosystems

- To apply experimental and modelling tools for managing freshwater ecosystems.
- To apply knowledge of processes and functions of freshwater ecosystems in their management and protection.

[3] Making judgements:

- The ability to decide between different environmental ideas and approaches independently, based on available information, and to assess the potential for their application, integration and further development.
- The ability to select and apply a variety of techniques, tools and procedures in order to evaluate the environmental consequences of different development and intervention scenarios.
- The ability to reflect critically on the impacts of different activities on the environment.

Environmental Science and Technology

- To develop technological solutions for environmental problems based scientific knowledge.

Environmental Planning and Management

- To enumerate ecological and socio-economic functions and values of an environmental system and related, competing stakeholder interests.
- To design environmental policies that incorporate technical, administrative and financial aspects.

Water Quality Management

- To develop on the basis of scientific knowledge, technical and managerial solutions for water quality problems.

Limnology and Wetland Ecosystems

- To develop on the basis of scientific knowledge, technical and managerial solutions for problems in freshwater ecosystems.

[4] Communication:

- The ability to report and communicate environmental results clearly, and to explain and defend the reasoning, knowledge and assumptions to a variety of audiences.
- The ability to function effectively in a multi-disciplinary team.

Environmental Planning and Management, Water Quality Management

- The capability to assess interests among different stakeholders and to facilitate decision-making processes.

[5] Learning skills:

- The ability to extend and enhance one’s own knowledge, insight and skills in a largely autonomous manner.

3.11 Appendix A Qualifications of Graduates MWI

[1] Knowledge and understanding:

- Knowledge of relevant theory and the contemporary developments in the field of study;
- Understanding of the required basic physical, applied mathematical and computing principles and the capability to integrate these within the appropriate discipline;
- Appreciation of the broader scientific, engineering and socio-economic framework, and recognition of the relevant disciplines and sub-disciplines that are related to the own discipline.

[2] Applying knowledge and understanding:

- The ability to apply disciplinary knowledge, academic capabilities and engineering skills independently and within a multidisciplinary context:
- The ability to select and apply suitable techniques and methods for analysis, assessment, planning, design, operation, rehabilitation and maintenance;
- The ability to independently formulate the appropriate questions, to identify and formulate appropriate approaches, and to pose original models, tests and/or engineering solutions;
- The ability to collect, analyse and structure required data and information and to recognise relations in them.
- The ability to prepare a research plan, including the description of the approach, the realisation of the research and the evaluation of the results.
- The attitude and the ability to contribute to theoretical, methodological or application development within the respective discipline.

[3] Making judgements:

- The ability to critically assess own investigation results, implementation feasibility and risks, and the ability to reflect on the ethical and socio-economic aspects connected with application;
- The ability to identify original ideas and approaches from the literature or other sources and assess the potential for application, integration or further development.

[4] Communication:

- The competence to clearly report and orally communicate results, the underpinning reasoning, knowledge and assumptions.

[5] Learning skills:

- The ability to extend and enhance the own knowledge, insight and skills in an autonomous manner.
- The ability to conduct independent academic research in a subsequent post-graduate (i.e., PhD) programme.

3.12 Appendix A Qualifications of Graduates WM

[1] Knowledge and understanding:

- Knowledge of current theory and contemporary developments in Water Management;
- The ability to describe the rationale for an integrated and interdisciplinary approach for managing water systems.
- Knowledge of biological, physical and chemical principles of water systems.
- Knowledge of economic, institutional and legal principles, approaches and instruments in water management.
- Understanding the broader scientific, engineering and socio-economic context and the role of other disciplines required for Water Management.

[2] Applying knowledge and understanding:

- The ability to apply the knowledge and academic capabilities acquired, in management and engineering contexts.
- The ability to contribute to managing water systems and organisations and to the development of institutional arrangements.
- The ability to collect, analyse and organise relevant information and to draw sound conclusions.
- The ability to prepare and implement a scientific research plan.
- The ability to contribute to theoretical, methodological or applied developments within the field of study.

[3] Making judgements:

- The ability to decide between different ideas and approaches independently, based on available information, and assess the potential for application, integration and further development.
- The ability to select and apply a variety of techniques, tools and procedures in order to evaluate the consequences of different development and intervention scenarios.
- The ability to reflect critically on how different activities impact on the wise use of water.

[4] Communication:

- The ability to report and communicate results clearly, and to explain and defend the reasoning, knowledge and assumptions to a variety of audiences.
- The ability to function effectively in a multi-disciplinary team.
- The capability to assess interests among different stakeholders and to facilitate decision-making processes.

[5] Learning skills:

- The ability to extend and enhance one’s own knowledge, insight and skills in an autonomous manner.

3.13 Appendix A Qualifications of Graduates WSE

[1] Knowledge and understanding:

- Knowledge of current disciplinary theory and the contemporary developments in the field of study within the context of water science and engineering;
- Understanding of the required basic physical, applied mathematical and computing principles and the capability to integrate these within the appropriate discipline;
- Appreciation of the broader scientific, engineering and socio-economic framework, and recognition of the relevant disciplines and sub-disciplines that are related to the own discipline.

[2] Applying knowledge and understanding:

- The ability to apply disciplinary knowledge, academic capabilities and engineering skills independently and within the multidisciplinary context of water science and engineering;
- The ability to select and apply suitable techniques and methods for analysis, assessment, planning, and where appropriate, design, construction, operation and maintenance;
- Able to independently formulate the appropriate questions, to identify and formulate appropriate and approaches, to pose original models, tests and/or engineering solutions;
- Ableto collect, analyse and structure required information and to recognise relations in that information;
- Able to prepare a research plan, including descriptions of the approach, the realisation of the research and the evaluation of the results, and the time planning for the research;
- The attitude and the ability to contribute to theoretical, methodological or application development within the respective discipline.

[3] Making judgements:

- Able to critically assess own investigation results, implementation feasibility and risks, and the ability to reflect on the ethical and social aspects connected with application;
- Able to identify original ideas and approaches from the literature or other sources and assess the potential for application, integration or further development.

[4] Communication:

- The adequacy to clearly report and orally communicate results, the underpinning reasoning, knowledge and assumptions, and where appropriate, to ensure the practical implementation of scientific or engineering solutions.

[5] Learning skills:

- The ability academic attitude to extend and enhance the own knowledge, insight and skills in an autonomous manner.

3.14 Appendix B Eligible Bachelor's Degrees for Academic admission

The specialisation in Water Supply Engineering accepts applicants with a BSc degree in civil, chemical, environmental, hydraulic or mechanical engineering.

The specialisation in Sanitary Engineering accepts applicants with a BSc degree in civil, environmental or chemical engineering, or in microbiology.

The specialisation in Integrated Urban Engineering accepts applicants with a BSc degree in civil engineering.

The specialisation in Hydrology and Water Resources accepts applicants with a Bachelor of Science degree in civil or agricultural engineering, earth sciences, environmental sciences, or physics.

The specialisation in Hydroinformatics accepts applicants with a Bachelor of Science degree in civil, agricultural or systems engineering, earth sciences, environmental sciences or physics.

The specialisations in Hydraulic Engineering and River Basin Development, and Hydraulic Engineering - Coastal Engineering and Port Development accept applicants with a Bachelor of Science degree in civil engineering or related field with a hydraulic engineering background.

The specialisation in Hydraulic Engineering - Land and Water Development accepts applicants with a Bachelor of Science degree in civil or agricultural engineering, or a related field.

The Water Management programme accepts applicants with a good Bachelor's degree in the fields of engineering, natural sciences, economics and the social sciences.

For the Water Resources Management specialisation, affinity with quantitative methods is essential. Similarly, for the Water Quality Management specialisation, affinity with chemistry and biology is desired. For the Water Services Management specialisation a professional background in the water utility sector is desired. And for the Water Conflict Management specialisation interest in local, national and international water management is desired.

The specialisation in Environmental Science and Technology accepts applicants with a BSc degree in civil, chemical, agricultural or environmental engineering, natural sciences, chemistry, environmental science, agriculture, or in geology.

The specialisation in Environmental Planning and Management accepts applicants with a BSc degree in civil, chemical, agricultural or environmental engineering, natural sciences, chemistry, environmental science, agriculture, geology, geography, or in environmental economics.

The specialisation in Water Quality Management accepts applicants with a BSc degree in civil, chemical, agricultural or environmental engineering, natural sciences, chemistry, environmental science, agriculture, or in geology.

The specialisation in Limnology and Wetland Ecosystems accepts applicants with a BSc degree in civil, chemical, agricultural or environmental engineering, natural sciences, chemistry, environmental Science, agriculture, or in geology.

3.15 Appendix D 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.

Students are advised to arrive at an examination in time and to be outside 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.

Written Examinations

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 will not be allowed into the room if they present themselves later than 15 minutes after the start of the examination.

Attendance list: After entering the examination room, students have to sign the 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: Each student has an allocated table with a set of answer and scratch papers with their student number printed on the cover sheet. Additional paper can be obtained from the invigilators upon request.

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).

Calculators: Only self contained calculators with a single-line display or dual-line display and an electronic language dictionary 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 and language translation 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.

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 and Research Examinations

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.

The examination of the thesis research consists of a maximum 30 minutes presentation of the thesis work by the candidate, followed by a maximum 30 minutes examination discussion with the examination committee and, possibly, the audience.

3.16 Appendix E Result form MSC research proposal

Date:_____

The supervisor and the mentor of Mr./Ms. _____

of programme _____ with specialization _____

consider the result of the MSc Research Proposal as being:

SATISFACTORY/UNSATISFACTORY*

Title MSc Research Proposal:

_____

_____

_____

Further remarks:

_____

_____

Name and signature supervisor: Name and signature mentor:

* delete what is not applicable

3.17 Appendix F Criteria for the MSc thesis evaluation

Approved by the Academic Board (05.03.2009).
To be used by the MSc Examination committees and the participants as a guide.
(Does not replace the standard evaluation form.)

Participant's name	
Topic	
Mentor	
Supervisor	
Date	

Criteria	**possible comments**
1. THESIS	
Abstract • Are motivation and objectives presented correctly? • Are own contribution, results and conclusions presented? • Is it clearly written?	
Introduction • Does it really introduce the work? • Does it logically lead to research questions and objectives? • Are objectives and goals (specific objectives) clearly formulated?	
Background/literature review • Are enough sources covered? • Is literature relevant and up-to-date?	
Materials & methods • Are methods explained clearly enough to understand their relevance and use? • Is quality assurance/quality control adequately addressed in experimental work?	
Discussion • Is discussion systematic and comprehensive? • Does it lead to conclusions?	
Conclusions • Are objectives achieved? • Are conclusions formulated concisely? • Are recommendations for future work given?	

Criteria	possible comments
1. THESIS *(continue)*	
Tables and figures • Do captions clearly explain contents of the Figures? • Are formatting and quality adequate?	
References, proper citation • Is material from other publications properly attributed and/or cited? • Are references and citations properly formatted?	
Editorial aspects • Is structure clear and logical? • Is spelling and grammar adequate? • Are text, headings, graphs and tables understandable? • Is layout appropriate?	
2. WORK PROCESS	
Creativity • Was participant generating new ideas, critical to the results published elsewhere? • Was participant creative, what is his/her own scientific contribution?	
Critical capacity • Are the limitations of the study understood and explained? • Does the participant show a capacity for self-criticism? • Are their clear suggestions for further research priorities?	
Other aspects • Was the participant really committed to work? • Was the participant working independently? • Were comments of the supervisors and reviewers taken into account?	
3. PRESENTATION	
• Is presentation properly structured? • Is timing good? • Is the balance of material on slides appropriate (not too much / too little)? • Are all major aspects of work presented? • Are all questions answered well?	

4 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.

5 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. h e 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

6 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!

7 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.

7.1 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.

7.2 Hydrology and Water Resources

Hydrology is the science, which deals 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, water resources 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 resources management
- hydro- and geo-informatics
- modelling and simulation of rivers, catchments and groundwater systems
- effects of land-use, urbanisation
- flood risk, draught, 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 gradually 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 methodology 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 the 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.

Learning objectives

Upon completion of the Hydrology and Water Resources specialization, the graduates should:

- 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;
- be able to 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;
- 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;
- be able to 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;
- have good knowledge of the relevant literature and the contemporary research questions in the field of hydrology;
- be able to design and conduct hydrological research and experiments for both application and scientific purposes, either independently or within a team-based framework;
- be able to critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others;
- be able to adequately communicate methodologies, results, evaluations, conclusions and recommendations in oral, written and graphical form to a wide variety of audience;
- 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
- have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner. Relation between learning objectives and programme components

Relation between learning objectives and programme components

	a	b	c	d	e	f	g	h	i	j
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. Group work				■			■	■		
13. Summer courses					■	▒	■	■		
14. MSc proposal preparation					■	■	■	■		
15. MSc research				■	■	■	■	■	■	

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

7.3 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.

Learning objectives

Upon completion of the Hydroinformatics specialization, within Water Science and Engineering, the graduates should:

- a. 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
- b. 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
- c. 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
- d. have an understanding of advanced and appropriate information and communication technologies and their application to manage information relating to water management
- e. be able 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
- f. have a good knowledge of the relevant literature and the contemporary research questions in the field of Hydroinformatics
- 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. be able to critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others
- i. provide considered advice to managers and users of advanced Hydroinformatics tools
- j. be able to appreciate and discuss the ethics and nature of the postmodern society and the role of water within it as a "right" and an "asset"
- k. 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
- l. 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
- m. have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner
- n. be aware of the professional and ethical issues encountered in Hydroinformatics practice directed towards issues facing developing countries and countries in transition

Relation between learning objectives and programme modules:

Relation between learning objectives and programme modules:

	Module titles	a	b	c	d	e	f	g	h	i	j	k	l	m	n
1	Introduction to water science and engineering														
2	Hydraulics and hydrology														
3	Information technology and software engineering														
4	Computational hydraulics														
5	Modelling theory and information management														
6	Data-driven modelling and real-time control of water systems														
7	River basin modelling														
8	Elective modules: •Introduction to river flood modelling •Urban flood modelling and disaster risk mitigation •Environment and climate														
9	Fieldtrip														
10	Elective modules: •Flood risk management •Urban water systems modelling •Environmental systems modelling														
11	Hydro-informatics for decision support														
12	Group work														
13	Summer courses														
14	MSc proposal preparation														
15	MSc thesis														

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

Classification of learning objectives

- Knowledge, theory a, f, h, j, l, n
- Methodology, techniques, tools b, c, f
- Integrate, analyse, synthesise d,e, g, f, l
- Research, experiments g, h, l
- General academic skills f, g, h, i, k, l, m

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):

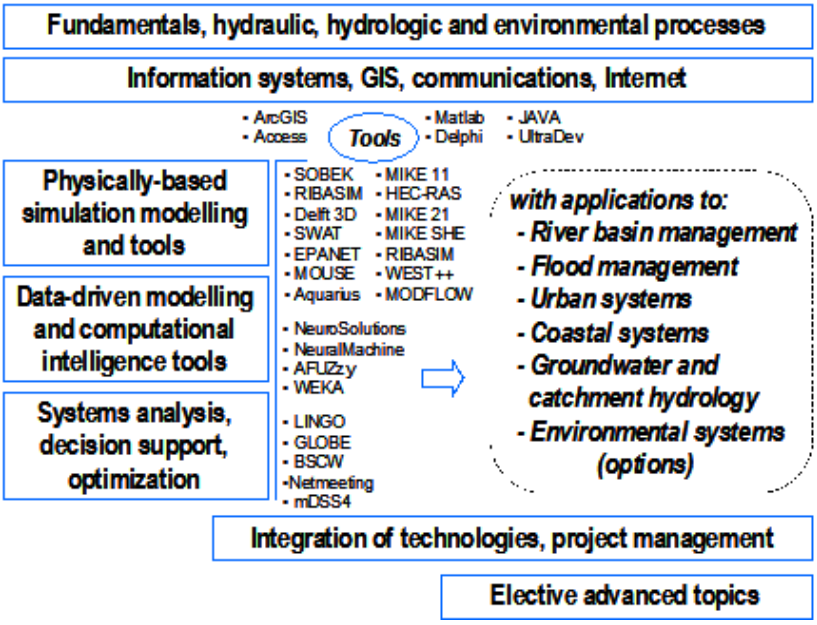


Figure 1: The general thematic structure of the Hydroinformatics specialization

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:	Schalk Jan van Andel

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:

The overview table for Block 1 is given in the following Table:

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.

Part two of the handbook presents the module descriptions of the Hydroinformatics specialisation. The descriptions of modules 1, 2 and 3, in addition to the regular variant of the Hydroinformatics specialisation, present also the IMHI variant (particularly the responsible lecturers and module mentors).

7.4 Hydraulic Engineering and River Basin Development

The Hydraulic Engineering and River Basin Development specialization educates engineers involved in design and implementation of projects for sustainable use of river systems and their resources (fresh water, floodplain space and sediments) and further develops the scientific and engineering knowledge in this field of interest through independent research.

Nowadays, fresh water resources and floodplain space are limited and therefore of significant value. The pressing need for food, energy, flood protection and domestic and industrial water supply require an efficient use and management of water resources. Traditional river engineering has had serious consequences for riverine ecosystems and land-use, causing damage to flora and fauna and sometimes exacerbating floods and droughts.

Based on the sound understanding of physical aspects of river behaviour, planning, design, construction, operation and maintenance, water resources are critically assessed for implementing sustainable water-related infrastructure, tools and management strategies in river basins.

Aims and learning objectives of the course

- Aims of the specialization Hydraulic Engineering and River Basin Development

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

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

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

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

· *River Dynamics* , this encompasses the study of the way in which water flows in rivers and the consequent transport of sediment and morphological change. The impact of measures to enhance the environment and mitigate damage is considered throughout. In an engineering context the role and design of river intakes and river training works are considered.

· *River Structures* , which is mainly directed to the design of hydraulic structures, by defining sites and designs of reservoirs, dams, intakes, hydropower plants, conveyance systems, etc. Emphasis is given not only to technical aspects but also, in a broader context to managerial, social and environmental questions associated with these engineering works.

· *Flood Risk Management* , which is mainly concerned with the engineering issues, planning, policies and structural/non-structural measures and approaches to cope with floods and mitigate

their impacts and consequences.

· *Modelling,* all the above make use of conceptual models which are often computer-based. Modelling is taught both throughout the course and in specific modules. The aim is to allow students to develop as intelligent and discerning users of models in river basin management.

- Learning Objectives

Upon completion of the Hydraulic Engineering and River Basin Development specialization, the graduates should:

a. 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;

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

c. Be able to 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. Be able to 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;

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

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

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

h. 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;

i. 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;

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

k. Have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and applications in an independent manner.

Table 1 illustrates the relation between learning objectives and course modules.

Table 1. Relation between learning objectives and course modules

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

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.*

Objectives of the course

Upon completion of the Hydraulic Engineering-Coastal Engineering and Port Development specialization, the graduates should:

a. Have advanced level of understanding of the hydraulics, coastal processes and nautical and logistic aspects and their interactions with the nearshore and offshore structure;

b. Be able to 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;

c. Be able to 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;

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

e. Will 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;

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

g. Have the skills to undertake academic research that contributes to the better understanding of coastal and/or port engineering

h. 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;

i. Be able to 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;

j. 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;

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

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

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

n. Develop a sense of professionalism and an appreciation for the obligations of a professional engineer;

o. Be aware of the professional and ethical issues encountered in engineering practice;

Checklist objectives, Hydraulic Engineering - Coastal Engineering and Port Development

Checklist objectives, Hydraulic Engineering - Coastal Engineering and Port Development

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
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.

7.5 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.*

Objectives of the course

Upon completion of the Hydraulic Engineering-Coastal Engineering and Port Development specialization, the graduates should:

a. Have advanced level of understanding of the hydraulics, coastal processes and nautical and logistic aspects and their interactions with the nearshore and offshore structure;

b. Be able to 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;

c. Be able to 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;

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

e. Will 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;

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

g. Have the skills to undertake academic research that contributes to the better understanding of coastal and/or port engineering

h. 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;

i. Be able to 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;

j. 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;

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

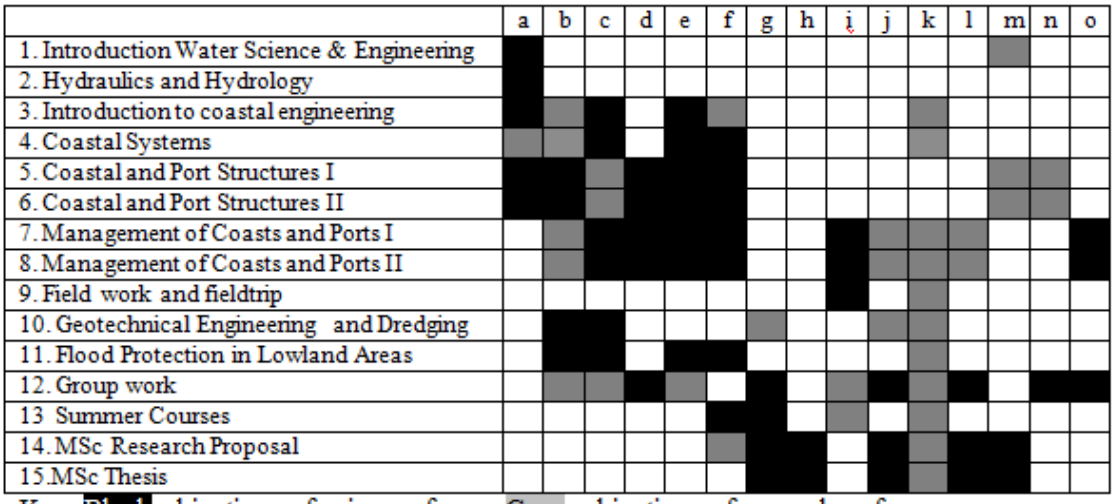
l. Possess critical thinking skills, the ability of both independent and team problem-solving and the sense of engineering creativity and design;

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

n. Develop a sense of professionalism and an appreciation for the obligations of a professional engineer;

o. Be aware of the professional and ethical issues encountered in engineering practice;

Checklist objectives, Hydraulic Engineering - Coastal Engineering and Port Development



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

7.6 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.

Learning objectives

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

a. have in-depth understanding and specific knowledge of:

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

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

b. 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;

c. 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;

d. 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;

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

f. 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.

Relationship between the HELWD programme components and learning objectives

	a	b	c	d	e	f
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: ■ = objectives of primary focus; ▒ =objectives of secondary focus

7.7 Programme Staff

Hydrology and Water Resources

Prof. S. Uhlenbrook, PhD, MSC	Head of core
J.C. Nonner, MSc	
Y. Zhou, PhD, MSc	
J.W.A. Foppen, PhD, MSc	
R.G.W. Venneker, PhD, MSc	
S. Maskey, PhD, MSc	Specialization coordinator
J. Wenninger, PhD, MSc	

.

Hydroinformatics

Prof. D.P. Solomatine, PhD, MSc	Head of core
Prof. A.E Mynett, PhD, MSc	
Prof. R.K. Price, PhD, MSc	
I.I. Popescu, PhD, MSc	
A. Jonoski, PhD, MSc	
A.H. Lobbrecht, PhD, MSc	
Z. Vojinovic, PhD, MSc	
B. Bhattacharya, PhD , MSc	Specialization coordinator
A.B.K. van Griensven, PhD, MSc	
S.J. van Andel, MSc	
Yunqing Xuan, PhD, MSc	
G. Di Baldassarre, PhD, MSc	

.

Hydraulic Engineering and River Basin Development

Vacancy	Head of core
M. Werner, PhD, MSc	
A. Crosato, PhD, MSc	Specialization coordinator
L. Brandimarte, PhD, MSc	
M. Marence, Phd, MSc	

.

Hydraulic Engineering - Coastal Engineering and Port Development

Prof. J.A. Roelvink, PhD, MSc	Head of core
Prof. H. Ligteringen,	
MSc R. Ranasinghe, PhD	
M. van der Wegen, PhD, MSc	Specialization co-ordinator
F. van der Meulen, PhD, MSc	
A. Dastgheib, MSc	

.

Hydraulic Engineering - Land and Water Development

Prof. E. Schultz, PhD, MSc	Head of core
L.G. Hayde, PhD, MSc	
K.C. Prasad, PhD, MS	
F.X. Suryadi, PhD, MSc	
A. Mehari Haile, PhD, MSc	Specialization co-ordinator

8 Facilities

8.1 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

8.2 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.

8.3 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.

8.4 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.

8.5 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. A photocopy service near the entrance is available to students at all times. 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, using the chip-card.

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.

8.6 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

8.7 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.

8.8 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.

8.9 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.

MASTERS PROGRAMME WSE 2011-2013 - PART 2

Table of Contents

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2011-2013**
Specialization: **Core Programme**
Module Coordinator: **P. Paron, PhD, MSc**

Module Sheet

Module Name 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 understand and be able to apply basic mathematical techniques that are relevant to water science and engineering;
- 3 understand and be able to apply basic statistical techniques that are relevant to water science and engineering;
- 4 understand the main concepts of a land and water system; understand the concepts of the sediment cycle, flooding and land-use change and how each is considered at various inter-related scales; understand the inter-relationships in the land and water system and the tools available to address the major issues in an integrated manner (including GIS and Remote Sensing).

Topics and Learning Activities

1 Water for Sustainable Development

1 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:
1 Formal lectures; small group assignments, classroom exercises and small individual assignments (small reports); practical exercises in computer lab

2 Review of Mathematics - available on-line, as a resource

2 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:
2 self study

3 Review of Statistics and Frequency Analysis

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

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

4 The Water System

4 Overview of the water system and its components: basic components of the d water resources system (geology, hydrology, rivers, sea, morphology) and their interdependency. Examples on the interdependencies are shown with examples on: sediments, floods, and land use changes. The overall integration is shown with the aid of tools.

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

Lecturing Material

• 1 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.
• 2 Handouts; Lecturing material available as on-line resource
• 3 LN00072, Van Gelder: Review of of Statistics and Frequency Analysis. Handouts
• 4 Handouts; Rondeel, H.E. Geology â€“ ln 0194/06/.

Assessment

- **30%: Assignment**
- **60%: Assignment**
- **10%: Written Exam (closed book)**

UNESCO-IHE/MSc 2011/2013-WSE/01/c: Introduction to Water Science and Engineering											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Water for sustainable development									32	Various lecturer
	Review of Mathematics - available on-line, as a resource									24	I. Popescu
	Review of Statistics and Frequency Analysis	4	4						8	20	P. van Gelder
	The Water System (B. Schultz)	8							8	16	B. Schultz
	The Water System (A. Mehari Hailie)		6						6	12	A. Mehari Haile
	The Water System (P. Paron)	8							8	20	P. Paron
	The Water System (Z. Voijnovic)	6	2						8	16	Z. Vojinovic
	Total	**26**	**12**						**38**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: WSE-HECEPD, WSE-HELWD, WSE-HERBD, WSE-HI, WSE-HWR, WSE-HELWD Sriwijaya
Module Coordinator: S. Maskey, PhD, MSc

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 (Z. Vojinovic, P. Paron, Suryadi):

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

Excursion Delta Works (...):
Excursion to hydraulic engineering flood protection works in the south-western delta of The Netherlands.

Lecturing Material

- Maskey S., Roelvink D. and Brandimarte L., 2010. A Short Introduction to Free Surface Hydrodynamics - LN0436.10.1
- Hayde L.G., 2010. Applied Hydraulics, Manual Hydraulic Laboratory Exercises, Water Science and Engineering – LN0434/10/1
- 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
- De Heer, Geurtsen, Bijnsdorp, 2005. Handout Visit to the Deltaworks.
- 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)**
- **35%: Written exam (open book)**
- **30%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/02/c: Hydrology and Hydraulics											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**FREE SURFACE HYDRODYNAMICS**										
1.1	Introduction to Free Surface Hydrodynamics	4							4	10	A. Mynett
1.2	1-D Channel Flow (Uniform/Non-uniform/Unsteady)	6	2						8	18	S. Maskey
1.3	Exercise - Uniform and Non-uniform Flow Computations		4						4	8	L. Brandimarte/S. Maskey
1.4	2-D and 3-D Shallow Water Equations	4							4	12	D. Roelvink
1.5	Hydraulics Laboratory			2	4				6	6	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	6							6	12	Z. Vojinovic
3.2	GIS Exercise		4	4					8	12	P. Paron/Suryadi
3.3	Remote Sensing Exercise		4	4					8	12	P. Paron
4	**EXCURSION DELTA WORKS**						8	8	8	8	
	Total	**32**	**14**	**20**	**4**		**8**		**78**	**144**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2011-2013**
Specialization: **WSE-HECEPD**
Module Coordinator: **A. Dastgheib, MSc**

Module Sheet

Module Name Introduction to Coastal 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 short waves, especially in shallow water.
- 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 (P. van Gelder, D. Roelvink, A. Dastgheib)

Introduction to the contents to be covered within the specialization Coastal Engineering and Port Development; introduction to Coastal Engineering: water wave mechanics, regular waves, introduction to irregular waves, wave generation, propagation and transformation, tides and water level fluctuations, surf zone hydrodynamics, harbour hydrodynamics, coastal zone processes, density differences and siltation.

Learning Activities:

lecture, exercise

Short Waves (E. Bouwmeester)

Preliminaries on waves, basic equations of fluid flow, surface gravity water wave problem, properties of small-amplitude surface gravity water waves, phase-averaged properties of water waves, wave statistics, diffraction of waves around breakwaters, waves in water of gradually varying depth, breaking, reflection and run-up of waves on a slope, wave induced set-up and longshore currents.

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 (M. Rajabalinejad)

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

Lecturing Material
- Verhagen: Introduction of Coastal Engineering - LN0179
- Roos, A.: Tides and tidal currents – LN0211
- P. Lubking : Soil Mechanics LN174/04/1

- Handouts Short waves
- Handouts Introduction to Coastal Engineering

Assessment
- **30%: Written Exam (closed book)**
- **30%: Written Exam (closed book)**
- **30%: Oral Exam**
- **10%: Oral Exam**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/03/s: Introduction to Coastal Engineering											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Introduction to Coastal Engineering**										
1.1	Introduction	2							2	6	D. Roelvink
1.2	Water Fluctuations (Waves)	2	2						4	8	A. Dastgheib
1.3	Siltation	6							6	20	P. van Gelder
2	**Short Waves**	10	10						20	40	E. Bouwmeester
3	**Tides and Tidal Currents**	10	12						22	42	A. Roos
4	**Soil Mechanics**	8	4						12	24	M. Rajabalinejad
	Total	**38**	**28**						**66**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: HE-LWD
Module Coordinator: A. Mehari Haile, PhD, MSc

Module Sheet

Module Name Introduction to 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 (M. Rajabalinejad)

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, B.Schultz (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, B.Schultz and L. G. Hayde (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 â€“ ln0174/04/
- B.Schultz, 2008: Land and water development. 2008.
- L.G.Hayde, 2009. Irrigation and Drainage System Design - ln0321/09/1
- L.G. Hayde, 2007. Canal design â€“ ln0326/07/1

Assessment

- **15%: Assignment**
- **15%:**
- **70%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/03/s: Introduction to Land and Water Development											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Soil Mechanics	6	8						6	26	M.Rajabalinejad
	Land and Water Development	8							8	24	Bart Schultz
	Introduction to Irrigation and Drainage Systems	6							6	18	L.G. Hayde
	Irrigation and Drainage Main System Design		36						36	72	Bart Schultz and L.G.Hayde
	Total	**20**	**44**						**56**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: P. Paron, PhD, MSc

Module Sheet

Module Name River Basin Hydraulics, Hydrology and Geology	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, and hydrology.

Learning Objectives

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

- Gain a deep understanding of hydraulic concepts useful in river basin structure design and management
- Understand the dynamics and variability of the hydrological cycle for river basin management
- Gain an introduction to geological and geotechnical concepts relevant to river basin development including field investigation methods

Topics and Learning Activities

Applied Hydraulics (A. Mynett)

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

Learning Activities:

Lectures

Water in the River Basin (M. Werner)

Quantitative processes and dynamics of the hydrological cycle. Characterisation and climatology of the river basin; variability and trends at different scales. Dynamics of surface flow, sub-surface flow, reservoirs, and groundwater storage in the river basin.

Learning Activities:

Lecture, no exercises

Geology for Water Engineering (P. Paron/M.Marence)

Rock forming minerals and their recognition; rock types and geological structures; field methods for geological investigation; geotechnical characterization of soil and rocks; rock mass classification. Exercises on rock identification, geological and topographical map reading, interpretation of geotechnical drilling logs.

Learning Activities:

Lectures, exercise, workshop

Lecturing Material

- Handouts, reading list
- Handouts, reading list
- Handouts, reading lists

Assessment

- **40%: Written Exam (open book)**
- **30%: Written Exam (open book)**
- **30%: Written Exam (open book)**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/03/s: River Basin Hydraulics, Hydrology and Geology											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Applied Hydraulics	13		1						40	A. Mynett
	Water in the River Basin	8								24	M. Werner
	Geology for Water Engineering	20	8	4						76	P. Paron; M. Marence
	Total	**41**	**8**	**5**						**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Prof. D.P. Solomatine, PhD, MSc**

Module Sheet

Module Name Information Technology and Software Engineering	Module Code WSE/HI/03/s	Credits 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
- Carry out practical GIS applications related to aquatic systems using ArcGIS software
- Know and be able to apply main notions and principles of algorithmic design and other areas of computer science
- Select, configure and operate a personal computer
- 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 these principles in developing water related prototype software using the rapid application development (RAD) environment on a PC

Topics and Learning Activities

Information and communication technology. D.P. Solomatine (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. Some notions of artificial intelligence.

Learning Activities:
Lectures, workshop

MATLAB, L. Alfonso (IHE)

Matlab Desktop Tools, Matrices and Linear Algebra, solving differential equations, data analysis and statistical analysis, data import and export, programming, graphics and 3d visualization, graphical user interfaces.

Learning Activities:
Exercises

Geographic Information Systems (GIS). S. Velickov (Bentley Systems)

Additional exercises and assignments in GIS (in addition to the exercises provided in Module 2).

Learning Activities:
Exercises

Software Engineering. D.P. Solomatine (IHE) and B. Bhattacharya (IHE)

Main notions of software engineering. Software development in Object Pascal. Delphi rapid application development environment. Exercises.
Software development process: Waterfall approach; Prototyping; Software specification; Software design; Functional and object oriented design
Interface design; Software documentation; Software validation; Testing strategies; Marketing of software. Exercises and workshops in software development.

Learning Activities:
Lectures, exercises, workshops

Fieldtrip to Deltares

Fieldtrip to one of the top technological institutes, Deltares
Learning Activities:
Fieldtrip

Lecturing Material

- Solomatine, Lecture Notes on Information Technology and Computer Science: An Introduction
- Solomatine, Lecture Notes on Software Development with Borland Delphi
- Solomatine, Lecture Notes on Object Oriented Programming: A Practical Introduction
- Schotanus, Lecture Notes on GIS and Remote Sensing
- Solomatine, Lecture Notes on Software Engineering: An Introduction
- Shrestha and Siek, Lecture Notes onTechnical Computing with Matlab

Assessment

- **40%: Written Exam (closed book)**
- **15%: Assignment**
- **15%: Assignment**
- **30%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HI/03/s: Information Technology and Software Engineering											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Information technology	4		4					8	16	Solomatine
	Introduction to MATLAB		8						8	16	Alfonso
	Geographical Information Systems (GIS)		8						8	16	Velickov
	Software engineering	10	20	10					40	80	Solomatine, Bhattacharya
	Fieldtrip to Deltares			8					8	8	
	Total	**14**	**36**	**22**					**72**	**136**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2011-2013**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **J.C. Nonner, MSc**

Module Sheet

Module Name Earth Sciences	Module Code WSE/HWR/03/s	Credits 5

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

Learning Objectives

Upon completion of the module participants will be able to..
- to be familiar with basic geology and geomorphology;
- be acquainted with remote sensing and aerial photo interpretation for geomorphologic interpretation;
- learn statistical and geostatistical methods for spatial and temporal data analysis.

Topics and Learning Activities

Geology (H.E. Rondeel)

Concepts related to geological time, mineral and rock composition and geological structures; identifying the major minerals and rocks and their qualitative properties; reading and interpretation of geological maps.

Geomorphology (A.C. Seymonsbergen)

Principles and concepts of geomorphology and landscape evolution related to climate and weathering, fluvial geomorphology and spatial drainage system development; reading and interpretation of geomorphological maps; interpretation of aerial photography.

Hydrogeostatistics (Y. Zhou)

Statistical descriptors and its 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 hypotheses; variograms; estimation of variograms using measurements; spatial interpolation with Kriging.

Learning Activities:

Computer workshops with basic statistics, regression analysis, time series analysis, and Kriging interpolation.

Lecturing Material
- Rondeel, H.E. Geology, Lecture note, LN0194/08/1.
- Seymonsbergen, A.C. Geomorphology, Lecture notes and handouts.
- Zhou, Y., Hydrogeostatistics, Lecture notes, LN041/09/1.

Assessment

- **30%: Written Exam (closed book)**
- **35%: Written Exam (closed book)**
- **20%: Written Exam (closed book)**
- **15%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/03/s: Earth Sciences											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Geology	8	4	4					16	36	Rondeel PhD
	Geomorphology	8	8	8					24	48	Seymonsbergen PhD
	Hydrogeostatistics	14		8					22	58	Zhou PhD
	Total	**30**	**12**	**20**					**62**	**142**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Coastal Engineering and Port Development**
Module Coordinator: **Prof. J.A. Roelvink, PhD, MSc**

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 processe 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

Salt Intrusion and Density Currents

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.

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

-Handout on Coastal Hydrodynamics and Morphology, Roelvink and Reiniers

- Os, A.G. van, Salt intrusion and density currents - Lecture notes In 0286/98/
- Numerical methods for differential equations, Popescu

Assessment

- **60%: Written Exam (open book)**
- **20%: Oral Exam**
- **20%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/04/s: Coastal Systems											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Coastal Hydrodynamics and Morphology	4	4						8	16	M. van der Wegen, MSc. PhD.
	Coastal Hydrodynamics and Morphology	16	16						32	64	prof. J.A. Roelvink, MSc. PhD.
	Coastal Hydrodynamics and Morphology	8	2						10	26	R.W.M.R.J. Ranasinghe, MSc., PhD.
	Salt intrusion and density currents	6			2				8	20	M. van der Wegen, MSc. PhD.
	Modelling and numerical aspects	2	8						10	14	I.I. Popescu, MSc., PhD.
	Total	**36**	**30**		**2**				**68**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2011-2013**
Specialization: **Core Programme**
Module Coordinator: **A. Crosato MSc. PhD.**

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)**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/04/s: River Morphodynamics											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Principles of River Morphodynamics**	25	12						37	99	A. Crosato MSc. PhD.
2	**River Morphodynamics in Engineering Projects**	7	5						12	31	E. Mosselman MSc. PhD.
3	**1-D modeling of Rivers with Mobile Bed**			12					12	12	K. Sloff MSc. PhD.
	Total	**32**	**17**	**12**					**61**	**142**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: A. Mehari Haile, PhD, MSc

Module Sheet

Module Name	Module Code	Credits
Water Management Systems & Agronomy I	WSE/HELWD/04/s	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) and Eiman M. Fadul (Hydraulic Research Station)

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., 2008. Applied Hydraulics; Synopsis, LN 0378/08/1
- Hayde, L.G., 2007. Applied Hydraulics; Manual Flop, Gradually Varried Flow Profiles, LN0333/07/1
- de Laat, 2006. Soil-Water-Plant relations.
- Mehari Haile, A. Eiman M., Fadul and Depeweg, 2011. Design and operation of tertiary units.

Assessment

- **20%: Assignment**
- **30%:**
- **30%: Assignment**
- **20%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/04/s: Water Management Systems & Agronomy I											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Applied Hydraulics of Irrigation Systems I	6	6						6	30	L.G. Hayde
	Soil-Water-Plant Relations	8	12						8	40	P.J.M. De Laat
	Irrigation Methods	8	8						8	40	R.H. Cuenca
	Irrigation and Drainage - Tertiary Unit Design I	8	4						6	30	A. Mehari Haile and Eiman M. Fadul
	Total	**30**	**30**						**28**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **I.I. Popescu, PhD, MSc**

Module Sheet

Module Name Computational Hydraulics	Module Code WSE/HI/04/s	Credits 5

Target Group	Prerequisites
Hydroinformatics participants	Basic Mathematics ; Hydraulics & Computational Fluid Dynamics ;

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
- Classify differential equations in terms of ODE/PDE and determine the nature of a given PDE
- Indicate the nature of the initial and boundary conditions for well posed elliptic, parabolic and hyperbolic problems. Apply the method of characteristics to solve equations
- 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
- Build a river flood model using SOBEK 1D and 2D, including specification of geometry and boundary conditions

Topics and Learning Activities

Mathematical Formulation of Fluid Flow Equations (G. di Baldassarre, 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; home assignments;

River Modelling (A. Verwey, Deltares)

Physics of flood generation; flood wave propagation in natural rivers; introduction to SOBEK 1D; exercises on flood waves in regular channels; exercise and workshop on modelling floods in a real 1D system; introduction to SOBEK 2D; exercise and workshops on modelling channel-flood plain interactions.

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 ODEâ€™s; Finite differences for PDEâ€™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 in computer lab;

Lecturing Material

- Price: Lecture notes on Mathematical Basis of Computational Hydraulics
- Popescu: Lecture notes on Numerical methods for Differential Equations
- Verwey: Lecture notes and PowerPoint slides: River flood modelling
- Modelling software: SOBEK1/2D; Exercise on SOBEK1/2D
- Power point presentations

Assessment

- **35%: Written Exam (closed book)**
- **35%: Assignment**
- **30%: Written Exam (closed book)**

UNESCO-IHE/MSc 2011/2013-WSE/HI/04/s: Computational Hydraulics											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Mathematical formulation of fluid flow**	16		4					20	52	G. Di Baldassarre, PhD, MSc
2	**River Modelling**	4		10					14	22	A. Verwey, MSc
3	**Numerical Methods I**	12	8	8					28	60	I. Popescu, PhD, MSc
	Total	**32**	**8**	**22**					**62**	**134**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2011-2013**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **Y. Zhou, PhD**

Module Sheet

Module Name Hydrogeology	Module Code WSE/HWR/04/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 (J.C. Nonner)

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, Darcyâ€™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.

Transcient 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, 2006
- Zhou, Y. Steadyn 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)**
- **25%:**
- **20%: Written Exam (closed book)**
- **10%: Assignment**
- **10%: Assignment**
- **10%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/04/s: Hydrogeology											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Hydrogeology	12	8						20	52	J.C. Nonner
	Steady Groundwater Hydraulics	12	6						18	48	Y. Zhou
	Transient Groundwater Hydraulics	8	8						16	40	T.N. Olsthoorn
	Total	**32**	**22**						**54**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: WSE-HECEPD / Short Course
Module Coordinator: A. Dastgheib, MSc

Module Sheet

Module Name Coastal and Port Structures I	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..

- 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 scaling factors and know how to design a scale model to reproduce certain hydraulic phenomena.

Topics and Learning Activities

Maritime transport (A. Dastgheib)

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

Learning Activities:

lecture

Breakwaters (J. van der Meer, J. Wouters)

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, construction methods, case studies.

Applications using BREAKWAT, exercise on design of rubble mound and vertical type breakwaters, geometrical design guideline for submerged breakwaters, application and exercise on design of submerged breakwaters.

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, scale effects

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

- Meer, J.W. van der, Ligteringen, H: Breakwater Design, Lecture notes ln0026/06/
- Meer, J.W. van der: Infram publications Nrs 1,2,3,5,6, Lecture notes hh478/01/1
- Meer, J.W. van der, Wouters, J : Exercise Breakwater Design, Lecture notes ln0027/08/1
- Meer, J.W. van der, Lem, J.C. van der, Handout Breakwater,
- PIANC: Analysis of rubble mound breakwaters â€“ Report (Electronic Version)
- Overeem, J. van: Scale models for coastal engineering - Lecture notes hh143/97/1
- Kruk, de Heer: Merchant shipping and Cargo Handling - ln0231/06/ , 2006

Assessment
- **100%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/05/s: Coastal and Port Structures I											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Maritime Transport**	4							4	12	A. Dastgheib
2	**Breakwaters**	20							20	60	J. van der Meer
3	**Breakwaters**		16						16	56	J. Wouters / J. Van der Meer
4	**Physical Scale Modelling**			6					6	6	J. van Overeem
5	**Offshore Engineering**			6					6	6	A.Aalbers
	Total	**24**	**16**	**12**					**52**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: A. Mehari Haile, PhD, MSc

Module Sheet

Module Name	Module Code	Credits
Water Management Systems & Agronomy II	WSE/HELWD/05/s	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, ChÃ©zy, 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 ChÃ©zy. 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) and Eiman M. Fadul (Hydraulic Research Station, Sudan)

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., 2007. Applied Hydraulics; Manual Flop, Gradually Varried Flow Profiles, LN0333/07/1
- Hayde,L.G., 2008. Applied Hydraulics; Synopsis, LN 0378/08/1
- Hayde, L.G., 2010. Applied Hydraulics; Pipe flow
- Hayde, L.G., 2010. Applied Hydraulics; Manual Hydraulics Laboratory Exercises 2, LN0422/10/3,
- Mehari Haile, A., Eiman M.Fadul, Jaspers, F., 2011. Agronomy and Water deficit in Irrigation, An Agricultural Approach.

Assessment

- **35%: Written Exam (closed book)**
- **10%: Assignment**
- **30%: Assignment**
- **25%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/05/s: Water Management Systems & Agronomy II											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Applied Hydraulics of Irrigation Systems II	12	12						12	50	Bart Schultz. and L.G. Hayde
	Hydraulics Laboratory 2		8						4	16	L.G. Hayde
	Irrigation and Drainage - Tertiary Unit Design II	8	8						10	40	A.Mehari Haile and Eiman M. Fadul
	Agronomy	8	5						8	34	A.Mehari Haile and Eiman M. Fadul
	Total	**28**	**33**						**34**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: HERBD
Module Coordinator: M.G.F. Werner, PhD, MSc

Module Sheet

Module Name River Basin Development	Module Code WSE/HERBD/05/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; Familiarise participants with potential and uses of water resources, factors affecting these and problems involved; principles and advances in integrated planning, development and multi-sectoral management of water resources; and the concepts of RB planning and management
- Describe likely environmental impacts on the water environment (from WRD projects); Explain the principles of environmental (social) impact assessment (EIA/ESIA); Distinguish and describe the different methodologies available to environmental assessment; Plan the different stages in evnironmental assessment; Apply a method to a given example and communicate that method to others.
- Understand the necessity for the integration of these topics/approaches in (international) projects
- 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 Exercises

Environmental Assessment for WRM Projects (Hendrike Clouting, Lindsay Beevers, Rinus Vis)

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

Learning Activities:

Lectures, Exercises & Case Study

River Basin Development Exercise (Wil van der Krogt, Karen Meijer)

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.& Loucks, D. 2005. Water Resources Systems Planning and Management: An Introduction to Methods, Models and Aplications, UNESCO Publishing, Paris
- Beevers, L., 2008. Environmental Assessment (EIA/SEA). UNESCO-IHE Lecture notes
- Various Handouts

Assessment

- **25%: Written Exam (closed book)**
- **25%: Assignment**
- **15%: Written Exam (open book)**
- **10%: Assignment**
- **25%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/05/s: River Basin Development											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Water Resources Development	20	4						24	68	Eelco van Beek
	Environmental Aspects of WRM projects	6		6					12	24	Henrike Clouting
	Environmental Aspects of WRM projects	4		4					8	16	Rinus Vis
	River Basin Development Exercise		16						16	32	Wil vd Krogt & Karen Meijer
	Total	**30**	**20**	**10**					**60**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Prof. D.P. Solomatine, PhD, MSc**

Module Sheet

Module Name Modelling Theory and Information Management	Module Code WSE/HI/05/s	Credits 5

Target Group	Prerequisites
Participants of WSE Programme - Hydroinformatics	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 technology using MS-Access
- Understand and explain the 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
- Understand the essence of data collection and analysis, model calibration, models integration, appreciate a number of examples of using models in solving water-related issues (floods, urban waters, coastal management)
- Understand and use main principles and methods of analysing and predicting models uncertainty
- Specify, design and build a simple modelling system with graphical interface using rapid application development environment (Delphi) for software implementation

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

Data base, 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. Distributed and client-server architectures. OLAP, data warehousing, data mining. Management information systems. Knowledge bases and expert systems. Knowledge management systems, main notions and tools.

Learning Activities:

Lectures, exercises

Modelling theory and uncertainty. D.P. 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 waters, coastal management).

Main principles and methods of analysing and predicting models uncertainty, with exercises.

Learning Activities:

Lectures, exercises, workshop

Modelling system development. D.P. Solomatine and L. Alfonso (IHE)

Developing modelling and graphical components of a water-based system using standard numerical and computer graphics toolboxes, and rapid application development environment Delphi.

Learning Activities:

Excercises, workshop

Lecturing Material

- Popescu: Lecture notes on Numerical methods
- Solomatine: Lecture notes on Database, information and knowledge systems
- Price: Lecture notes on Modelling theory and practice
- Solomatine: Lecture notes on Uncertainty analysis in modelling

Assessment
- **30%: Assignment**
- **15%: Assignment**
- **20%: Assignment**
- **35%: Oral Exam**

UNESCO-IHE/MSc 2011/2013-WSE/HI/05/s: Modelling Theory and Information Management											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Numerical Methods II	8	12						20	48	Popescu
	Database, Information and Knowledge Systems	6	4	6					16	32	Solomatine, van Andel
	Modelling theory and uncertainty	8	2	2					12	30	Solomatine
	Modelling system development	2	4	16					22	30	Solomatine
	Total	**24**	**22**	**24**					**70**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **Dr. R.G.W. Venneker**

Module Sheet

Module Name Surface Hydrology	Module Code WSE/HWR/05/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**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/05/s: Surface Hydrology											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Radiation, energy and hydrological balances**	12		6					18	52	Dr. R. Venneker
2	**Soil water and evaporation**	14		8					22	60	Dr. ir. P. de Laat
3	**Conceptual catchment modelling**	6		6					12	28	Dr. J. Wenninger
4	**Examination**								3		
	Total	**32**		**20**					**55**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: WSE-HECEPD / Short Course
Module Coordinator: A. Dastgheib, MSc

Module Sheet

Module Name Coastal and Port Structures II	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..

- Have an insight in the design and construction, the interaction between all influencing conditions and factors and the construction procedures of berthing structures (bulk cargo terminals etc). Application in a design excercise.
- Design the layout of a port and understand how to review the activities in a port in relation to design. Know how to apply the planning process for the lay-out of a port and development of various types of terminals.

Topics and Learning Activities

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

Port Master Planning: 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.
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, exercise

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 2007
- Groenveld, R.: Service Systems in Ports and Inland waterways – VSSD
- PIANC, Approach Channels: A Guide for Design (Electronic Version)

Assessment

- **60%: Assignment**
- **40%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/06/s: Coastal and Port Structures II											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Port Planing**										
1.1	Port Functions	2							2	6	H. Ligteringen
1.2	Int. to Master Planing	2							2	6	H. Ligteringen
1.3	Adaptive Port Planing	2							2	6	P.Taneja
1.4	Design of Wet Areas	2							2	6	H. Ligteringen
1.5	Planing of Land Areas	2							2	6	H. Ligteringen
1.6	Container Terminals	4							4	12	C. Klaver
1.7	Queuing Theory	6							6	30	A. Dastgheib
2	**Marine Structures**	16	12						28	60	L. Groenewegen
3	**Excursion Port of Rotterdam and Maeslantkering**						8	8	8	8	
	Total	**36**	**12**				**8**		**56**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: F.X. Suryadi, PhD, MSc

Module Sheet

Module Name 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 (R. Namara, IWMI â€“ Ghana)

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 (L. Ch. Schenk-Sandbergen, Retired from Univ. Amsterdam)

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

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

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

- Suryadi, 2010. Flow control in irrigation and drainage systems.
- 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

Assessment

- **25%: Assignment**
- **20%: Assignment**
- **30%: Assignment**
- **25%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/06/s: Aspects of Irrigation and Drainage											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Economic and Financial Analysis**	8	8						16	36	Dr R.E. Namara
2	**Sociological Aspects**	6	8						14	28	Dr. L. Schenk-Sandbergen
3	**Flow Control Systems**	8	8						16	40	F.X. Suryadi, PhD, MSc
4	**Main Drainage Systems and Salinity Control in Field Level**	8							8	36	Dr Ir H.P. Ritzema
5	**Main Drainage Systems and Salinity Control in Field Level**		8						8		Ir P.H.J. Hollanders
6	**Field Trip to North-West Netherlands**						8	8	8		
	Total	**30**	**32**				**8**		**70**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: P. Paron

Module Sheet

Module Name Data Collection and Analysis	Module Code WSE/HERBD/06/s	Credits 5

Target Group	Prerequisites
Engineers, geoscientists, and other professionals with a keen interest for data collection and analysis, either in the field and using 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..

- Gain an in-depth knowledge of the monitoring schemes and field techniques for water and sediment sampling
- Gain an in-depth knowledge of the Remote Sense (RS) and GIS applications in the analysis and monitoring of water resources, using commercial and open-source software and data
- Gain an introduction to the concepts of deterministic and probabilistic design for river and coastal structures

Topics and Learning Activities

Data collection in the River Basin

Collection, management, and analysis of data in the river basin; Data measurement and analysis for water resources and floods, water quality, sediments and ecology. Quality control of data and optimisation of data collection networks, management of data in the river basin; organisations, roles, and responsibilities. Establishing baseline situation. Monitoring impacts.

Learning Activities:

Lectures and exercises

Remote Sensing

Review of basic concepts and foundations of RS; Sensors and photographic system; Multispectral, Thermal, Hyperspectral & Radar sensing; Digital image processing (enhancement, filtering, and band combination) and analysis (supervised and unsupervised classification; intro to object-oriented segmentation); Field data for RS validation; Freely available data sources and software. EOS for Water Resources: Terrain model analysis; River Remote Sensing; Compound indexes derived from RS data for water resource management; Multitemporal analysis (land use/land cover, soil erosion, soil moisture, lake and river channel changes, river bathymetry, flood extent, etc). Kite Aerial Photography.

Learning Activities:

Lectures and exercises; indipendent study

Deterministic & Probability 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

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

Assessment

- **30%: Assignment**
- **30%: Assignment**
- **40%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/06/s: Data Collection and Analysis											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Data collection in the River Basin	8								24	M. Werner
	Remote Sensing for water resources	10	24	8						74	P. Paron
	Deterministic & Probability Design	10	8							42	P. H.A.J.M. van Gelder
	Total	**28**	**32**	**8**						**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: Prof. D.P. Solomatine, PhD, MSc

Module Sheet

Module Name Data-Driven Modelling and Real-Time Control of Water Systems	Module Code WSE/HI/06/s	Credits 5

Target Group	Prerequisites
Participants in WSE programmme - hydroinformatics Participants in HIFRM Erasmus Mundus Programme Participants in short course "Data driven modelling and real-time control of water systems"	WSE-HI Module 5

Learning Objectives

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

- 1. Understand the main optimisation techniques
- 2. Understand and explain how real-time control systems work
- 3. Identify the potential of control to solve hydrological problems
- 4. Sketch a general plan for a regional real-time control system
- 5. Know the main techniques of data-driven modelling from machine learning (neural networks, model trees, fuzzy systems, etc.) and select proper methods and tools for building data-driven models
- 6. Correctly classify a modelling problem as a physically-based, data-driven, or hybrid

Topics and Learning Activities

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

Classical optimisation. Linear and non-linear optimisation. Derivative-based and direct methods. Dynamic programming. Global (multi-extremum) optimisation. 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

Real time control of water systems, A. Lobbrecht (IHE), S. J. van Andel (IHE), L. Alfonso (IHE), A. Szollosi-Nagy (IHE)

Introduction to Real-Time Control; Modelling hydrological systems and optimal control problems with AQUARIUS; Control-systems functions and techniques; Hardware and software components; Data assimilation; Control systems in industry; Identifying control system components.

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. MLP and RBF networks. Instance-based learning. 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: Lecture notes on Real time control of water systems
- Modelling software: AQUARIUS; Exercises
- Modelling and optimization software: WEKA, GLOBE, NeuralMachine; Exercises
- Optimisation software: LINGO; Exercises

Assessment

- **10%: Assignment**
- **25%:**
- **20%: Assignment**
- **25%: Written Exam (closed book)**
- **20%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HI/06/s: Data-Driven Modelling and Real-Time Control of Water Systems											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Introduction to optimisation**	4	2	4					10	20	D.P. Solomatine
2	**Real-time control of water systems**	16		12					28	60	A.H. Lobbrecht
3	**Data driven modelling and computational intelligence**	14		18					32	60	D.P. Solomatine
	Total	**34**	**2**	**34**					**70**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: HWR
Module Coordinator: J.W.A. Foppen, PhD, MSc

Module Sheet

Module Name Water Quality	Module Code WSE/HWR/06/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 subsurface hydrology;
- apply appropriate hydrochemical methods to analyse and assess the water quality characteristics of hydrological systems.

Topics and Learning Activities

Water Quality

Refreshing the basic principles of aquatic chemistry, focusing on chemical equilibria, acid-base reactions and precipitation reactions;

Learning Activities:
A mix of lectures, exercises, and laboratory sessions

Hydrochemistry

Role of silica and carbonate minerals, cation-exchange reactions and oxidation-reduction reactions. Eventually, the mechanisms of the various contaminant and pollution transport mechanisms, such as advection, dispersion and mass exchange. Hydrochemical modelling code PHREEQC imparts the student to advanced methods for assessing the chemistry-related characteristics of hydrological systems.

Learning Activities:
Lectures

Lecturing Material

- Lecture Notes
- Book: Appelo and Postma

Assessment

- **40%: Lab Report**
- **60%: Written exam (open book)**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/06/s: Water Quality											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Water Quality**										Foppen
1.1	Determining the quality of water				8				8	16	
1.2	Chemistry review: equilibrium reactions, acids and bases, precipitation reactions	12							12	36	
1.3	Exam				4				4	4	
2	**Hydrochemistry**										Appelo
2.1	Carbonate minerals	7							7	21	
2.2	Cation exchange reactions	7							7	21	
2.3	Transport: advection, dispersion, mass exchange	7							7	21	
2.4	PHREEQC introduction	7							7	21	
2.5	Exam								3	3	
	Total	**40**			**12**				**55**	**143**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: R.W.M.R.J. Ranasinghe, PhD

Module Sheet

Module Name Management of Coasts and Ports I	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 the physical and statistical aspects of ocean waves and how to do time-series analysis in connection with ocean waves.
- 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.
- 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.
- Get acquainted with some hydraulic engineering and water management works in North West Netherlands.

Topics and Learning Activities

Ocean Waves (Dr L.Holthuijsen)

Waves, as generated by winds over the ocean, are considered on three time scales: In the first time scale the sea surface elevation is assumed to be a stationary Gaussian process with zero mean. The relationships between the variance density spectrum of this process on the one hand and the short term statistics on the waves on the other, are given (e.g. Rayleigh distribution, extremes in limited durations). In the second time scale the development of wave fields over the ocean is considered in terms of wave generation and propagation. The processes of generation and propagation are considered with spectral models and parametric models. The long term statistics of waves are addressed in the third time scale. Observation techniques. Applications using SWAN model.

Learning Activities:

Lectures

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

Lecturing Material

• Holthuijsen, L.H.: Waves in Oceanic and Coastal Waters, TU Delft, Fac. Civil Engineering (Mrs Kievits, 015 2781953)

• T. Vellinga and M Geense, 2004, Environmental Issues in Port Development and Port Operation.

Readers to be provided during the course (T. Vellinga)

Assessment

- **40%: Written Exam (closed book)**
- **30%: Assignment**
- **15%: Written Exam (closed book)**
- **15%: Written Exam (closed book)**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/07/s: Management of Coasts and Ports I											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Ocean Waves**	22							22	66	Dr. Ir. L.H. Holthuijsen
2	**Ocean Waves**		4						4	8	Dr. Ir. L.H. Holthuijsen; Dr. Ir. N.Booij
3	**Coastline Management**	6							6	18	Dr. R. Ranasinghe
4	**Coast and Port project**	6							6	24	Prof. J. A. Roelvink; Ir. A. Dastgheib
5	**Environmental Issues in Managment and Planning of Ports**	8							8	24	Prof. T. Vellinga .
	Total	**42**	**4**						**46**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: K.C. Prasad, PhD, MSc

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..

- Formulate policy objectives for irrigation development and management
- 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
- Identify water delivery arrangements including suitable flow control amenable to objectives
- Comprehend different levels of water delivery service and associated costs
- Conceptualize legislative, organisational and financial attributes of service oriented management of irrigation systems and Draw up service agreements considering cost recovery and accountability
- Design asset management programs and action plans for implementation and
  Devise monitoring & evaluation and benchmarking systems for assessing system performance

Topics and Learning Activities

Management of Irrigation Systems, K. Prasad (UNESCO-IHE) and H. Malano (University of Melbourne)

Terminology and definitions, management cycle, objectives in irrigation, interest groups, conflicting objectives. Activities in irrigation management. Water delivery policies: entitlement to water, operational objectives (adequacy, equity, reliability), cropping policies. Water delivery systems: arranged, on request, on-demand supplies, irrigation scheduling. Monitoring & Evaluation and benchmarking for performance assessment, related parameters, targets, standards.

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, organisational structures, cost recovery, farmers' participation, role of other institutions and accountability mechanisms in water management institutions.

Water Law, J. Gupta (UNESCO-IHE)

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.

Asset Management, M. Kok (HKV-Lijn in Water)

Defining asset management; Asset management concepts: types of assets, life cycle, economic life, useful life, residual life; Asset register; Asset management functions, asset planning strategies, asset creation/acquisition, asset O&M, performance monitoring, rehabilitation, modernisation, replacement, disposal, rationalisation; Asset economics, investment profiles, service cost; Asset audit and renewal, risk assessment and renewal decision making, value engineering; Development and implementation of asset management programmes, related organisational aspects, Management Information System.

Field Trip, K. Prasad (UNESCO-IHE)

Visit to the Association of Water boards (Unie van Waterschappen); Kinderdijk and its; and Greenhouse for pepper/paprika production.

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

• Van Hofwegen and Jaspers, 2005. Analytical Framework for Integrated Water Resources Management - Guidelines for Assessment of Institutional Frameworks, IHE Monograph 2. (Optional)

Assessment

• 70%: Oral Exam
• 30%: Assignment

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/07/s: Service Oriented Management of Irrigation Systems											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Management of Irrigation Systems**	10	14						16	88	K.C. Prasad, PhD, MSc and Prof. H. Malano
2	**Water Law**	4							4	8	Prof. J. Gupta, PhD
3	**Asset Management**	10	8						18	36	Dr.Ir. M. Kok
4	**Fieldtrip**						8	8	8	8	
	Total	**24**	**22**				**8**		**46**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2011-2013**
Specialization: **Core Programme**
Module Coordinator: **L. Brandimarte, PhD, MSc**

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)

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

Hydraulic structures auxiliary to engineering works
Spillways; Bottom outlets; Energy dissipaters: principles of design and operation
Pipes and hydraulics of pressurized flow. Long pipes theory.
Learning Activities:
** Frontal lectures*

** Individual and group exercises on the hydraulic analysis and design of selected hydraulic structures*

** Case study: the Vajont dam disaster*

II. Design Flood Estimation (Dr. Giuliano Di Baldassarre)

Statistical analysis of flood data, probabilistic models, parameter estimation, model selection, statistical tests, goodness-of-fit, flood quantiles, uncertainty in flood frequency analysis
Learning Activities:
** Frontal lectures*

** Exercises on the estimate of flood design for hydraulic structure design*

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.*

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
- **80%: Oral Exam**
- **20%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/07/s: River Structures											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	I. River Structures	18	18	6					42	96	L. Brandimarte, PhD, MSc
	II. Design Flood Estimation			4					4	4	G. Di Baldassarre, PhD, MSc
	III. Design of low land structures	12							12	36	M. Maglionico, PhD, MSc
	Total	**30**	**18**	**10**					**58**	**136**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: A. Jonoski, PhD, MSc

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 HIFRM Erasmus Mundus Programme Participants in short course "River Basin Modelling"	Hydrology and Hydraulics; Fluid dynamics; Information technology and computer science; Numerical methods;

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.
- Know how to model flow processes in porous media
- Use MODFLOW to simulate groundwater flow in the saturated zone
- Know how to model hydrological processes in catchment rainfall-runoff
- Use NAM to simulate rainfall runoff in a natural catchment
- Know how to 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, A. van Griensven (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 SWAT and RIBASIM.

Learning Activities:
Attending lectures;
Exercises and workshops in a computer lab;
Home assignment (report);

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; Exercise report

Learning Activities:
Attending lectures;
Exercises and workshops in a computer lab;
Home assignment (report);

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; Exercise report.

Learning Activities:
Attending lectures;
Exercises and workshops in a computer lab;
Home assignment (report);

Lecturing Material

• Lecture Notes:

Price and van Griensven: River basin management;-

Refsgard: Introduction to hydrological modelling: Modelling of the processes of the land phase of the hydrological cycle;-

• PowerPoint slides:

van Griensven: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;-

van Griensven: SWAT;-

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

Assessment

- **10%: Assignment**
- **20%: Assignment**
- **30%: Assignment**
- **40%: Oral Exam**

UNESCO-IHE/MSc 2011/2013-WSE/HI/07/s: River Basin Modelling											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**River basin management**	4	4	8					16	28	A. Van Griensven, W. van der Krogt
2	**Groundwater modelling**	8	4	8					20	40	A. Jonoski
3	**Catchment modelling**	12	16	4					32	72	M. Butts, A. Jonoski, I. Popescu
	Total	**24**	**24**	**20**				**40**	**68**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydrology and Water Resources
Module Coordinator: Dr. R.G.W. Venneker

Module Sheet

Module Name 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**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/07A/s: Data Collection and Processing											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Hydrological data precossing and analysis**	20	20						40	100	Dr. R. Venneker, Dr. T. Bogaard
2	**Practical hydrometeorological data collection and evaluation**	4		24					14	30	Dr. R. Venneker
3	**Excursion**								8	8	
4	**Examination**								3		
	Total	**24**	**20**	**24**					**65**	**138**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydrology and Water Resources
Module Coordinator: J.C. Nonner, MSc

Module Sheet

Module Name Groundwater Exploration and Monitoring	Module Code WSE/HWR/07B/s	Credits 5

Target Group	Prerequisites
Participants in Hydrology and Water Resources, short course participants involved in groundwater and environmental impacts investigation and monitoring activities.	Approved BSc degree and basic hydraulics/hydrology 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 to interpret the results of such a programme;
- 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 Exploration (J.C. Nonner)

This subject deals with the exploration of groundwater resources and follows particularly on module HY03. The first part deals with methods including desk studies, hydro-geological 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. Software for the interpretation of Schlumberger geophysical measurements, GEWin-Excel and pumping test data, AquiferTest, is being introduced. Practical experience will be obtained during the fieldwork in module HY09.

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 netwroks.

Case Study Breevenen (N. van der Moot)

Insight into the interpretation of geophysical measurements is gained trough a number of exercises and analysis of results from a typical case study using the GEWin-Excel package. The case study area is located in the northeastern part of The Netherlands where geophysical measurements and borehole data are used to characterise the sedimentary groundwater system in the area.

Lecturing Material

- Nonner, J., Introduction to groundwater exploration, Lecture notes.
- Van der Moot, N., Case study Breevenen, Lecture notes.
- Zhou, Y., Groundwater monitoring, Lecture notes, LN0053/09/1

Assessment

- **40%: Written Exam (closed book)**
- **20%: Written Exam (closed book)**
- **20%: Assignment**
- **20%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/07B/s: Groundwater Exploration and Monitoring											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Groundwater Exploration	12	20						32	76	Nonner MSC
	Groundwater Monitoring	10		10					20	50	Zhou PhD
	Case Study Breevenen		4	4					8	16	van der Moot MSc
	Total	**22**	**24**	**14**					**60**	**142**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: WSE-HECEPD, WSE-HELWD, WSE-HERBD, WSE-HWR, WSE-HI / Short Course
Module Coordinator: A. Dastgheib, MSc

Module Sheet

Module Name Management of Coasts and Ports II (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, 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 â€“ VSSD
- Handouts

Assessment

- **100%: Presentation**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/08A/e: Management of Coasts and Ports II (International Port Seminar)

Nr	Course/Topic	lecture	exercise	workshop	labwork	fieldwork	fieldtrip	selfstudy	contact hours	studyload hours	Lecturer(s)
1	**Port Seminar**			80			40	40	120	140	
	Total			**80**			**40**		**120**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: F. van der Meulen, PhD

Module Sheet

Module Name	Module Code	Credits
Management of Coasts and Ports II (Integrated Coastal Zone Management Semin	WSE/HECEPD/08B/e	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 and climate change on coastal systems.
- think of innovative alternatives for engineering and management, for example via "building with nature"

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. Coastal Ecosystems and Management (F. van der Meulen)

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

Learning Activities:

The course consists of interactive lectures and short excercises.

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.
- 2. Van der Meulen, Frank, Management of Coastal Ecosystems an introduction. Lecture notes

Assessment

- **70%: Oral Exam**
- **30%: Oral Exam**

ESCO-IHE/MSc 2011/2013-WSE/HECEPD/08B/e: Management of Coasts and Ports II (Integrated Coastal Zone Management Sem											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	ICZM Seminar	5		67			8	8	80	111	H.J.Verhagen, M.vander Wegen and others
	Coastal Ecosystems and Management	6		6					12	24	F.van der Meulen
	Total	**11**		**73**			**8**		**92**	**135**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: F.X. Suryadi, PhD, MSc

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
- Determine the requirements for water table and salinity control in irrigated areas; Understand the factors that influence the functioning of a surface drainage system; Design a surface drainage system
- 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 flow (C. van den Akker, Retired from TU Delft)

Characteristics of subsurface flow systems; Physical properties of porous media, homogeneity, isotropy; Fundamental equation of flow, 1â€“3D Darcy equation; Continuity, 1â€“3D mass and volume balances; Steady state confined/unconfined aquifer and radial flow; Unsteady state confined/unconfined aquifer and radial flow; Seepage flow.

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%: Assignment**
- **15%: Assignment**
- **30%: Assignment**
- **25%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/08/e: Conveyance Systems											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Unsteady Flow / Duflow**	10	12						22	50	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						20	36	F.X. Suryadi, PhD, MSc
4	**Groundwater Flow**	8	4						12	30	Prof. C. van den Akker, PhD, MSc
	Total	**32**	**34**						**66**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: A. Crosato MSc. PhD.

Module Sheet

Module Name River Training and Rehabiliatation	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 during field trip.

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.

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%:**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/08A/e: River Training and Rehabiliatation											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**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	12	6						18	42	A. Mynett Prof. MSc. PhD.
	Total	**34**	**20**	**6**					**60**	**142**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: HERBD
Module Coordinator: M.G.F. Werner, PhD, MSc

Module Sheet

Module Name Flood and Drought Management	Module Code WSE/HERBD/08B/e	Credits 5

Target Group	Prerequisites
All WSE participants	Basic knowledge of hydrology and hydraulics

Learning Objectives

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

- Understand the concepts of integrated risk management for floods and droughts.
- Understand the basics of flood hydrology and hydraulics, and methods to quantify, model and map flood hazard.
- Understand methods of evaluating the impact of flooding, both positive and negative, and how these can be combined with hazard in assessing flood risk.
- Understand the role of structural and non-structural measures in reducing flood risk, including practical aspects of short term, medium term and seasonal forecasting for floods and droughts
- Develop an understanding of characterisation of drought and the role of drought indicators
- Understand the basics of drought management policy, and understand the role of drought mitigation and adaptation

Topics and Learning Activities

Flood Risk Management (Micha Werner, Guiliano di Baldassare, Berry Gersonius)

Introduction to concepts of integrated flood risk management, including structural and non-structural measures, damage mitigation, education and preparedness, and flood forecasting and warning, emergency response. The module will discuss concepts of hazard including hydrological and hydraulic aspects of floods, flood frequency estimation, and flood mapping. Flood vulnerability assessment and flood resilience will be discussed. Challenges in flood management in different continents will be addressed through lectures and case studies. Basic exercises are included to foster understanding.

Learning Activities:
Lectures and Exercises

Drought Management (Ana Iglesias, Micha Werner)

Introduction to concepts of drought and managing drought risk. Drought monitoring practices and the use of drought indicators for characterising meteorological, hydrological & agricultural drought. Understanding of drought climatology and drought forecasting. Policy response to drought, drought management planning and drought mitigation and adaptation.

Learning Activities:
Lectures and Exercises

Flood Modelling Exercises (Guiliano di Baldassare, Micha Werner)

Flood risk assessment modelling exercise, focusing on flood hazard modelling, flood hazard mapping, and flood damage assessment. Developing and testing simple flood mitigation strategies.

Learning Activities:
Exercises in computer lab

Lecturing Material

- Extracts from lecture note on Flood Management
- Various Handouts

Assessment

- **60%: Written Exam (open book)**
- **40%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/08B/e: Flood and Drought Management											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Flood Risk Management	12		8					20	44	Micha Werner
	Flood Risk Management	4							4	12	Guiliano di Baldassare
	Flood Risk Management	4		4					8	16	Berry Gersonius
	Drought Management	8							8	24	Ana Iglesias
	Drought Management	4		4					8	16	Micha Werner
	Flood Modelling Exercise		16						16	32	Micha Werner
	Total	**32**	**16**	**16**					**64**	**144**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Hydroinformatics: modelling and information systems for water management, Option 8a**
Module Coordinator: **I.I. Popescu, PhD, MSc**

Module Sheet

Module Name Introduction to River Flood Modelling	Module Code WSE/HI/08A/e	Credits 5

Target Group	Prerequisites
Water Science and Engineering participants	Basic knowledge of 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 (geometry, bathymetry, boundary conditions, forcing) needed to carry out a practical study with MIKE11, SOBEK 1D or HEC-RAS package;
- Know how the river flood model may be used for structural and non-structural measures for flood mitigation

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:

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

Environmental processes and water quality, H. J. Lubberding (IHE)

Environmental processes. Water quality problems from a modelling point of view: outfalls, BOD-DO, eutrophication, toxic substances, best technical means approach, water quality objectives approach; Properties of the natural system from a modelling point of view, residence times, time scales of transport processes compared with those of water quality processes, spatial scales of phenomena, link between transport of substances and water quality processes.

Learning Activities:

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

Climate change and its impact on hydrology, 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

New data sources to support flood modelling, G. di Baldassarre (UNESCO-(IHE)

Introduction to new generation of data to support river flood modelling. Remote sensing, satelite and air-borne flood imagery, wireless sensors to assist innundation modelling, freely and globaly available space -borne data to monitor floods.

Learning Activities:

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

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

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

Learning Activities:

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

River Flood Modelling and 1D Flood Routing (R.K. Price, I. Popescu, B. Bhattacharya)

Nature and characteristics of floods: flood analysis â€“ e.g. flood probability - probability and return period analysis of hydrological events and design floods - and estimation of peak flows (using Flood Estimation

Handbook (FEH and ReFH) methods, catchment characteristics method, storm hydrographs and unit hydrograph methods.
River Flooding Modelling:
The significance of overbank flow, floodplain behaviour and stage discharge prediction (using the Ackers Method and Conveyance Estimate System); Modelling flood propagation - flood routing; Hydrological methods â€“ Muskingum, reservoir routing, HEC-HMS; 1D hydraulic flood routing/modelling in rivers; The Conveyance Estimate System; modelling resistance for discharge estimation;
Introduction to â€˜HEC-RASâ€™ software; Discussion of sustainable flood alleviation methods
Learning Activities:
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

- **50%: Assignment**
- **50%: Oral Exam**

UNESCO-IHE/MSc 2011/2013-WSE/HI/08A/e: Introduction to River Flood Modelling											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Application domains of Hydroinformatics: floods, urban systems and environment (common for all three**	4		2					8	14	Prof. R.K. Price, PhD
2	**Climate change and its impact on hydrology (together with**	4		2					6	14	Prof. S. Uhlenbrook, PhD, MSc
3	**Introduction to 1D2D, 2D modelling (together with option HUS)**	2							4	8	I. Popescu, PhD, MSc
4	**River flood modelling and 1D flood routing**	8	22	2					32	70	I. Popescu, PhD, MScPhD
5	**Environmental processes and water quality**	4		2					6	14	H.J. Lubberding, PhD, MSc
6	**New data sources to support flood modelling**		2	2					6	14	G. di Baldassarre, PhD,MSc
	Total	**22**	**24**	**10**				**8**	**62**	**134**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: Z. Vojinovic, PhD, MSc

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..

- 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 a systemâ€™s 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

Environmental processes and water quality, H. J. Lubberding (IHE)

Environmental processes. Water quality problems from a modelling point of view: outfalls, BOD-DO, eutrophication, toxic substances, best technical means approach, water quality objectives approach; Properties of the natural system from a modelling point of view, residence times, time scales of transport processes compared with those of water quality processes, spatial scales of phenomena, link between transport of substances and water quality processes.

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)

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, R. K. Price (IHE), 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

- **10%: Written Exam (closed book)**
- **50%: Assignment**
- **40%: Written Exam (closed book)**

UNESCO-IHE/MSc 2011/2013-WSE/HI/08B/e: Urban Flood Management and Disaster Risk Mitigation											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Application domains of Hydroinformatics: floods, urban	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
	Environmental processes and water quality	4		2					6	14	H.J. Lubberding
	Introduction to 1D2D, 2D modelling	2		2					4	8	I. Popescu
	Urban flood modelling and evaluation of flood risks	14	4						18	50	Z. Vojinovic, O. Mark
	Structural and non-structural measures	4	3						7	18	Z. Vojinovic, O. Mark
	Managing urban flood disasters	4	4						8	20	R.K. Price, Z. Vojinovic
	Total	**36**	**11**	**8**					**55**	**138**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Hydroinformatics: modelling and information systems for water management**
Module Coordinator: **Giuliano Di Baldassarre, PhD, MSc**

Module Sheet

Module Name Environment and Climate	Module Code WSE/HI/08C/e	Credits 5

Target Group	Prerequisites
	Basic knowledge of hydrology and hydraulics

Learning Objectives

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

- get familiar with the application domains of hydroinformatics, with focus on the environment
- understand and explain the chemical and biological processes affecting water quality in the natural environment
- get experience in several modelling paradigms to represent the environmental and ecological processes
- Understand and explain the principles of modelling land use change and climate change, and develop probabilistic risk assessments
- Have a more ecologically sound approach to river basin management whereby emphasis is placed on allowing the physical processes to drive the ecological healing by natural evolution, rather than an instantaneous engineering fix

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:

Formal lectures

Environmental processes and water quality, H. J. Lubberding (IHE)

Environmental processes. Water quality problems from a modelling point of view: outfalls, BOD-DO, eutrophication, toxic substances, best technical means approach, water quality objectives approach; Properties of the natural system from a modelling point of view, residence times, time scales of transport processes compared with those of water quality processes, spatial scales of phenomena, link between transport of substances and water quality processes.

Learning Activities:

Formal lectures; classroom exercises; exercises in computer lab and case study analysis

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:

Formal lectures; classroom exercises; exercises in computer lab and case study analysis

Spatial Modelling using PCRaster and Land use modelling using CLUE (Willem van Deursen and Peter Verburg)

The PCRaster Environmental Modelling language is a computer language for construction of iterative spatio-temporal environmental models. It runs in the PCRaster interactive raster GIS environment that supports immediate pre- or post-modelling visualisation of spatio-temporal data.

Introduction to land use modelling in relation to water modelling and management; Modelling scenarios of land use change and theid impacts and feedbacks on the hydrological system; Handson training for the tool CLUE.

Learning Activities:

Formal lectures; classroom exercises; exercises in computer lab and case study analysis

Probabilistic assessment of environmental risks, G. Di Baldassarre (IHE)

The concepts of environmental vulnerability, hazard, risk. Description of the most common sources of uncertainty and variability in the risk assessment process. Deterministic and probabilistic risk assessment. Example applications of probabilistic approaches for assessing risk

Learning Activities:

Formal lectures; classroom exercises; exercises in computer lab and case study analysis

Downscaling of climate change scenarios (Yunqing Xuan)

Introduction to the concept of downscaling, general downscaling methods used to fit GCM data into catchment modelling in studying climate change impacts on local scale. Exercise: downscaling for the Nzoia river basin.

Learning Activities:

Formal lectures; classroom exercises; exercises in computer lab and case study analysis

Climate change and uncertainty, A. van Griensven (IHE)

Analysis uncertainties related to climate change. Application of Monte-Carlo and other samplingbased methods. Bayesian averaging and model ensembles. Exercise: uncertainty analysis of the SWAT model

Learning Activities:

Formal lectures; classroom exercises; exercises in computer lab and case study analysis

Lecturing Material

• Lubberding: Lecture notes on Environmental processes

Di Baldassarre, van Griensven, and Xuan: Lecture notes on risk, uncertainty and ensemble modelling

Solomatine and Shrestha. Lecture Notes: Introduction to uncertainty analysis.

Mynett: papers on Environmental Hydroinformatics

Assessment

• **100%: Written Exam (open book)**

UNESCO-IHE/MSc 2011/2013-WSE/HI/08C/e: Environment and Climate											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Application domains of HI: floods, urban systems and**	4		2					6	14	R. Price, A. Mynett, Z. Vojinovic
2	**Environmental processes and water quality**	6		4					10	22	H.J. Lubberding
3	**Climate change and its impact on hydrology**	4		2					6	14	P.D.A. Pathirana
4	**Spatial Modelling using PCRaster**	2		4					6	14	W. van Deursen
5	**Land use modelling using CLUE**	4		4					8	20	P. Verburg
6	**Downscaling of climate change scenarios**	4		4					8	20	Y. Xuan
7	**Climate change and uncertainty**	4		2					6	16	A. van Griensven
8	**Probabilistic assessment of environmental risks**	4		4					8	20	G. Di Baldassarre
	Total	**32**		**26**					**58**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: HWR
Module Coordinator: J.W.A. Foppen, PhD, MSc

Module Sheet

Module Name Tracer Hydrology and Flow Systems Analysis	Module Code WSE/HWR/08/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: Tothâ€™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 Strijbeekse Beek (a small brook) on the border between the Netherlands and Belgium.

Lecturing Material

- Hand-outs
- Lecture Notes

Assessment

- **50%: Written Exam (closed book)**
- **50%: Written exam (closed book)**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/08/e: Tracer Hydrology and Flow Systems Analysis											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Tracer Hydrology**	16	4			2			22	60	Wenninger
2	**Tracer Hydrology**	4							4	12	Araguas (IAEA)
3	**Flow Systems Analysis**	12	4	8		6			30	70	Foppen
	Total	**32**	**8**	**8**		**8**			**56**	**142**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: WSE-HELWD, WSE-HWR, WSE-HECEPD, WSE-HERBD, WSE-HI
Module Coordinator:

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..

- Have a multidisciplinary overview of actual technical, research and organizational activities in the field of water management, hydraulic engineering, hydrology and the aquatic environment.
- Report detailed technical information received.
- Relect 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 or two 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.
The students take part in the compilation of a full report presenting an account of each visit. After completion, each student receives a printed copy of the report.
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" expalnation 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 prepare a fieldwork report

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, 2008. Manual Field Experiments in Irrigation.

Assessment

- **100%: Homework**

UNESCO-IHE/MSc 2011/2013-WSE/09/c: Fieldtrip and Fieldwork WSE											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Fieldtrip and Fieldwork**									140	
	Total									**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: M. van der Wegen, PhD, MSc

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 geotecnical 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

Geoâ€•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 Prandtlâ€•Buismanâ€™s and Meyerhofâ€™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 shallowâ€• 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.

Learning Activities:

Lectures and exercise

Sheetpile design

For the design of quay walls the knowledge of sheet piling gained in Geoâ€•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 MSHEET) are used.

Learning Activities:

Exercise

Marine Geotecnical Investigations

Characteristics of marine geotechnical investigations, geotechnical requirements, criticalâ€•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 inâ€•situ testing techniques, downhole inâ€•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 (contractorâ€™s logistics).

Learning Activities:

Lectures and workshop

Lecturing Material

- Lubking, 2004. Soil mechanics â€“ 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

- **70%: Oral Exam**
- **30%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/10/e: Geotechnical Engineering and Dredging											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Geo-Engineering and Sheet Pile Design**	20	16						36	92	Dr M. Rajabalinejad. Ing W.F. Heins
2	**Marine Geotechnical Investigations**			6					6	6	J. Molle, MSc
3	**Dredging Seminar**			32			8	8	40	40	IADC lecturers
	Total	**20**	**16**	**38**			**8**		**82**	**138**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: HELWD
Module Coordinator: L.G. Hayde, PhD, MSc

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;
- Understand and analyse environmental aspects of land and water development projects, identify environmental impacts, and to identify measures to alleviate or mitigate the negative impacts;
- 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

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

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.
• 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.
• Kay, Pumps and Lifting Devices (Hand-out)

Assessment

- **45%: Assignment**
- **30%: Assignment**
- **25%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/10/e: Irrigation and Drainage Structures											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Irrigation Structures**	18	10						28	60	L.G. Hayde, PhD, MSc
2	**Environmental Impact Assessment of Irrigation and Drainage**	10	8						18	44	W.J.R. Buydens, PhD, MSc
3	**Pumps and Lifting Devices**	8	6						14	36	M. Kay, MSc
	Total	**36**	**24**						**60**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: M. Marence, PhD, MSc

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 â€“ 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
- **40%: Written Exam (open book)**
- **40%: Written Exam (closed book)**
- **20%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/10/e: Storage and Hydropower											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Dams and reservoirs - Introduction**	2								6	
2	**Embankment dams**	2	2							10	
3	**Gravity dams**	2	2							10	
4	**Dam design considerations and modelling**	2	4							14	
5	**Arch dams**	2								6	
6	**Dam foundation treatment and grout curtain**	2								6	
7	**Diversion, spillways and bottom outlets**	2								6	
8	**Dam safety management**	2								6	
9	**Reservoir design and environmental impact**	2								6	
10	**Hydropower - Introduction**	2								6	
11	**Hydropower schemes - Layouts and design requirements**	2	2							10	
12	**Open power waterways**	2	2							10	
13	**Power waterways**	3	2							13	
14	**Powerhouse**	2								6	
15	**Electromechanical equipment**	2	2							10	
16	**Small hydropower**	2								6	
17	**Cost control and financial analyses**	2								6	
18	**Future developments and perspectives**	1								3	
	Total	**36**	**16**							**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: B. Bhattacharya, PhD, MSc

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;
- Familiarise with the different flood forecasting models;
- Utilise their hands-on experience in the step-by-step modelling procedure to build flood inundation models.

Topics and Learning Activities

Flood risk management, B. Bhattacharya (IHE), P. Samuels (HR Wallingford), F. Klijn (Deltares), M. Werner (IHE)

Introduction to flood risk management. Quantifying flood risk â€“ probabilistic and statistical approaches. Risk-based decision making. Case studies. Introduction to risk analysis of flood defence structures. Case studies. Flood vulnerability and resilience.
European experience in managing floods. EU framework directive on floods. Other national (eg UK) flood directives.
Flood disaster management (Pre-, post- and during flood). Flood emergency response and flood preparedness. Flood fighting, recovery and insurance. Evacuation management.
Flood forecasting and warning. Objectives. Lead time considerations. Data requirements. Flood forecasting models. Issuance of flood warning and response.
Uncertainty issues in flood forecasting. Modelling uncertainty and its benefits.
Social issues.

Where possible lectures and exercises will be given in conjunction with Module 10 of the Hydraulic Engineering and River Basin Development Specialisation.

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)

2D, 1D2D river flood modelling. Dam break modelling. Flood modelling, in 2D, in support of flood mitigation strategies (including flood risk maps. Structural and non-structural approaches in flood mitigation. Engineering solutions - flood routing and flood alleviation: channel & reservoir routing, flood banks, channel improvements, diversion schemes, flood storage on-stream and off-stream ; and non-structural issues - approaches to the reduction of flood impacts, flood risk maps.

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

- **60%: Written Exam (open book)**
- **40%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HI/10A/e: Flood Risk Management											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Flood risk management**	8		2					10	26	B. Bhattacharya
2	**Flood risk management**	10	2						12	34	P. Samuels
3	**Flood risk management**			4					4	4	F. Klijn
4	**Flood risk management**	4	2	2					8	18	M. Werner
5	**River flood modelling**		12						12	24	G. Di Baldassarre, S van Andel & I. Popescu
6	**Inundation modelling**		6	2					8	14	I. Popescu
7	**Flood risk mapping**		10						10	20	B. Bhattacharya
	Total	**22**	**32**	**10**					**64**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: Z. Vojinovic, PhD, MSc

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..

- 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, R.K. Price (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), 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**
- **30%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HI/10B/e: Urban Water Systems											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Introduction to urban water systems	4							4	12	Prof. R.K. Price, PhD
	Water distribution modelling	10	6						16	42	N. Trifunovic, MSc, Prof. D.A. Savic
	Wastewater and stormwater systems modelling	8	8	4					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		4					8	16	A.B.K. van Griensven, PhD, MSc, Z. Vojinovic, PhD, MSc
	Total	**32**	**14**	**16**					**62**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: A.B.K. van Griensven, PhD, MSc

Module Sheet

Module Name Environmental Systems Modelling	Module Code WSE/HI/10C/e	Credits 5

Target Group	Prerequisites
Participants in WSE programmme; Participants in short course "Environmental Systems Modelling"	Basic knowledge of hydrology and hydraulics

Learning Objectives

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

- understand and explain the chemical and biological processes affecting water quality in the natural environment
- select and combine the appropriate mathematical modelling tools for a water quality problem in natural open channels
- support integrated water management with analytical tools

Topics and Learning Activities

Introduction to Environmental Systems Modelling, A. Mynett (UNESCO-IHE)

Getting experience in several modelling paradigms (physically based modelling, cellular automata, fuzzy logic,..) to represent the environmental and ecological processes.

Learning Activities:

Lectures

Introduction to water quality policy and processes, A. van Griensven (UNESCO-IHE)

Lectures on water policies in Europe and the US, and an introduction to the aquatic systems and their governing chemical and biological processes

Learning Activities:

Lectures

Water quality modelling, J. Smits (Deltares)

Mathematical formulation of chemical and biological processes in water quality models, bacterial processes, primary production and nutrient cycles, heavy metals and organic micro-pollutants in relation to suspended sediment; The role of bottom water and its formulation in models, processes, time scales, re-mobilisation of nutrients; The food chain, ecosystem productivity, bio-accumulation, limitations in traditional predator-prey models, examples from modelling practice.

Learning Activities:

Lectures
Exercise

Ecohydraulics, Li Hong (IWA) and Arthur Mynett (UNESCO-IHE)

Introduction to ecohydraulic modelling paradigma using e.g. cellular automata, fuzzy logic.

Learning Activities:

Lectures

Ecological modelling using HABITAT (Valesca Hareslac, Deltares)

HABITAT is spatial analysis tool to support the development of management plans. The tool is especially designed for ecological assessment to analyse the availability and quality of habitats for individual or groups of species, but it is also usefull for other spatial analysis where grid operations are needed like flood risk maps or damages to agriculture or urban areas in case of floods and droughts.

Learning Activities:

Lectures
Exercise

Wastewater treatment modelling, I. Nopens (University of Ghent, Belgium), P. Vanrolleghem (University of

Laval, Canada)

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,

Exercise computer lab

Integrated water quality modelling, A. van Griensven (IHE), L. Benedetti (Most for Water, Belgium)

Integrated modelling; sequential and parallel simulations of integrated models, receiving water impact modelling; using WEST++ for water quality modelling in a stream polluted by sewer discharges (point sources), exercise on the Nete catchment

Learning Activities:

Fieldtrip to Belgium, Prof. JJ Peters (Flanders Hydraulics), A. van Griensven (IHE)

The trip includes a visit to Flanders Hydraulics (Antwerp) and a trip on the Scheldt river under guidance of the sediment transport expert Prof. JJ Peters (University of Brussels, Belgium).

Lecturing Material

- Van Griensven: Lecture notes on Environmental policy and processes, and integrated water quality modelling
- Vanrolleghem/Nopens: Lecture notes on Wastewater treatment modelling
- Minns: handouts on ecohydraulics
- Modelling software WEST++,Exercise
- Modelling software DELWAQ, Exercise

Assessment

- **100%: Written Exam (closed book)**

UNESCO-IHE/MSc 2011/2013-WSE/HI/10C/e: Environmental Systems Modelling											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Introduction to Environmental Systems Modelling	2		4					6	10	Prof. A.E. Mynett
	Â Introduction to water quality policy and processes	2		4					6	10	A.B.K. van Griensven, PhD, MSc
	Water quality modelling	8	8						16	40	Ir J.G.C. Smits
	Ecohydraulics	4		4					8	16	Prof. A.E. Mynett
	Ecological modelling using HABITAT	2		4					6	10	Dr Ir I. Nopens
	Waste water treatment modelling (together with HUS)	6		8					14	26	A.B.K. van Griensven, PhD, MSc
	Integrated water quality modelling	6		4					10	22	A.B.K. van Griensven, PhD, MSc
	Field trip to Belgium			8					8	8	V. Harezlak, MSc
	Total	**30**	**8**	**36**					**74**	**142**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: WSE-HWR, WSE-HECEPD, WSE-HELWD, WSE-HERBD, WSE-HI, WSE-HECEPD Hohai, WSE-HE
Module Coordinator: S. Maskey, PhD, MSc

Module Sheet

Module Name Hydrological Modelling	Module Code WSE/HWR/10A/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):

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**
- **50%: Assignment**
- **35%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/10A/e: Hydrological Modelling											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Introduction to Hydrological/Catchment Modelling**	2	6						14	24	S. Maskey
2	**River Flow and Water Quality Modelling**										S. Maskey
2.1	River flow hydrodynamic modelling	4	12						16	36	
2.2	River water quality modelling	4	10						14	32	
3	**Catchment Modelling**	4	18						22	48	R. Venneker
	Total	**14**	**46**					**6**	**66**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: **2011-2013**
Specialization: **Hydrology and Water Resources**
Module Coordinator: **Y. Zhou, PhD**

Module Sheet

Module Name 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**
- **30%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HWR/10B/e: Groundwater Modelling											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Groundwater modelling	16	24						40	98	
	Saline groundwater modelling	10	6						16	42	
	Total	**26**	**30**						**56**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Water engineering and river basin development
Module Coordinator: Berry Gersonius

Module Sheet

Module Name Water Resilient Cities	Module Code WSE/11	Credits 5

Target Group	Prerequisites
All WSE 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 similar technical background; basic knowledge of hydrology and hydraulics; good command of English.

Learning Objectives

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

- understand the different approaches to flood and drought resilience, together with their key aspects.
- develop and analyse water and flood risk management strategies for the context of urban areas.
- understand the role of emerging approaches/technologies in urban water and flood risk management.
- understand the need for and the place of adaptive management and governance in delivering increased flood and drought resilience.

Topics and Learning Activities

Water and flood risk management strategies

The module will introduce different approaches to understand and assess flood and drought resilience. It goes on to discuss key aspects of resilience, including the system's resistive, coping, recovery, adaptive and transformative capacity. A framework (so-called 3-Points approach) for developing and analysing water and flood risk management strategies will be presented and applied (within a workshop) to the context of an urban area (Porto Alegre, Brazil / Dhaka, Bangladesh). Experiences from different cities worldwide with the development of urban water and flood risk management strategies will be addresses through formal and guest lectures (including a field trip).

Learning Activities:

Lecture, workshop, fieldtrip, self study.

Emerging approaches and technologies

Introduction to emerging approaches and technologies in urban water and flood risk management. Regional-scale approaches/technologies include: Room for River and Building with Nature. Urban-scale approaches/technologies include: Multi-functional Flood Defences, Flood-proofing (critical) infrastructures, Green Infrastructure (including Sustainable Drainage Systems and Low Impact Development ideas), and Water Sensitive Urban Design. Building-scale approaches include: Flood-proofing (hotspot and normal) buildings, Floating and Amphibious buildings, and Smart Shelters.

Learning Activities:

Lecture, self study.

Adaptive management and governance

Explanation of the need for and place of adaptive management and governance in delivering increased flood and drought resilience. Diverse topics will be addressed in a series of formal lectures, such as social/active learning, networks, organizations, institutions, and governance structures. A a result from discussions in a workshop, a strategic plan will be made how how flood risk management strategies can be applied and made to a success in the (institutional) context of an urban area (Porto Alegre, Brazil).

Learning Activities:

Lecture, workshop, self study.

Lecturing Material

- Urban Flood Management Textbook
- Reader with powerpoint presentations

Assessment
- **50%: Oral Exam**
- **50%: Presentation**

UNESCO-IHE/MSc 2011/2013-WSE/11: Water Resilient Cities											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Water and flood risk management strategies**	10		20			8	8		68	Gersonius, Veerbeek, Bachhin, De Bruijn,
2	**Emerging approaches and technologies**	10								30	Zevenbergen, Ashley, Olthuis, Van de Meulen, De
3	**Adaptive management and governance**	10		10						40	Rijke, Anema, Ashley, Van Herk
	Total	**30**		**30**			**8**	**20**		**138**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: R.W.M.R.J. Ranasinghe, PhD

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..

- Learn to design dikes, revetments and closure dams
- Familiarise participants with concepts and advances of flood risk management in relation to societal aspects, including flooding issues in the floodplain and coastal zone, management of flood risk, planning aspects and a variety of non-structural measures
- Familiarise participants with concepts and advances in tools used for flood modelling and flood forecasting
- Introduction of the principles of flood frequency analysis and risk based approaches to design of hydraulic works
- Learn about (the practical application of) probabilistic design theory

Topics and Learning Activities

Dikes and Revetments (M. Rajabalinejad, 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. Vatvani, van Ormond, D. Roelvink)

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/

Assessment
- **40%: Oral Exam**
- **40%: Assignment**
- **20%: Written Exam (closed book)**

UNESCO-IHE/MSc 2011/2013-WSE/HECEPD/11/e: Flood Protection in Lowland Areas											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Dikes and Revetments**	8	4						12	20	Ir. C. Dorst
2	**Dikes and Revetments**	12							12	36	Dr. M. Rajabalinejad
3	**Probabilistic design**	6	6						12	30	Dr. Ir. P. van Gelder
4	**Storm Impact modelling**	2							2	6	Prof. J. A. Roelvink
5	**Storm Impact modelling**	2	9						11	24	Ir. M. van Ormondt
6	**Storm Impact modelling**	2	9						11	24	Ir. D. K. Vatvani
	Total	**32**	**28**						**60**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: F.X. Suryadi, PhD, MSc

Module Sheet

Module Name Advanced Methods and Equipment	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, B. Schultz (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. Future outlook.

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 AzÃºcar.
- 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 â€“ 11 July 2008, Helsinki University of Technology, Helsinki, Finland.
- Schultz, 2010. Land use and water in flood prone areas.

Assessment

- **40%: Assignment**
- **60%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HELWD/11/e: Advanced Methods and Equipment											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Sprinkler and Drip**	8	12						20	38	F.B. Reinders
2	**Subsurface Drainage**	12	10						22	56	Dr Ir H.P. Ritzema
3	**Remote Sensing for Irrigation and DrainageÂ**	6	6						12	18	Dr. Z. Vekerdy
4	**Reuse of Low Water Quality**	8							8	16	N.P. van der Steen, PhD, MSc
5	**Land Use and Water in Flood Prone Areas**	6							6	12	Prof. E. Schultz, PhD, MSc
	Total	**40**	**28**						**68**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: HERBD
Module Coordinator: I.I. Popescu, PhD, MSc

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)

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)

Development and design of reservoir operation rules including hedging rules, linear & dynamic programming techniques, long term versus short term reservoir operation. Multi-purpose reservoir operation, tandem operation of multiple reservoirs. Planning and implementation of environmental flows. Case studies.

The topic will also provide the participants the oportunity to solve an exercise on reservoir operation.

Learning Activities:

Formal lectures, home assignments, exercises and workshops in computer lab

Modelling Exercise (I. Popescu, IHE; F. Martins, U. of Algarve)

Practical experience with computational numerical models will be gained by students. This will take the form of either lake or river 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

Assessment

- **30%: Written Exam (open book)**
- **30%: Written Exam (open book)**
- **40%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/HERBD/11/e: Modelling and Operation of River Systems											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Computational Hydraulics**	16							16	48	I. Popescu, PhD, MSc
2	**Model quality assessment & uncertainty**	4		2					6	14	M. Werner, PhD, MSc
3	**Reservoir control and Optimisation**	10	6						16	42	M. Werner, PhD, MSc
4	**Modelling Applications**		10						10	20	I. Popescu, PhD, MSc and F. Martins, PhD, MSc
	Total	**30**	**16**	**2**				**10**	**48**	**124**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Hydroinformatics: modelling and information systems for water management
Module Coordinator: A. Jonoski, PhD, MSc

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, both as stand-alone and Internet-based
- 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), A. Almoradie (IHE)

Introduction to methods and tools for software integration of models and data: file conversions exercises. Object-oriented integration approaches.

Software integration across networks: Client-server programming, Web protocols, Technologies for integrating distributed resources: web-interfaces technologies; creating web-based applications with assignment exercise.

Learning Activities:
Attending lectures;
Computer exercises;
Home assignment;

Integration of weather prediction and water models, S.J. van Andel (IHE), A.H. Lobbrecht (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)
• L. Alfonso, A. Almoradie: Handouts Software integration exercises
• S.J van Andel: Integration of weather prediction and water models (PowerPoint Slides)
• Software:- LINGO, mDSS4, visual Basic editor (Excel), AlleyCode - web editor, Apache web server, Google maps API

Assessment

• 40%: Assignment
• 30%: Assignment
• 30%: Assignment

UNESCO-IHE/MSc 2011/2013-WSE/HI/11/e: Hydroinformatics for Decision Support											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Systems analysis in water resources**	8	6	6					20	42	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, L. Alfonso, A. Almoradie,
4	**Integration of weather prediction and water models**	8		2					10	26	S.J. van Andel, A. Lobbrecht
	Total	**26**	**20**	**22**				**16**	**68**	**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: R.G.W. Venneker, PhD

Module Sheet

Module Name Water Resources Management	Module Code WSE/HWR/11/e	Credits 5

Target Group	Prerequisites
describe here your target group.	describe prerequisites..

Learning Objectives

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

Topics and Learning Activities

Lecturing Material

Assessment

UNESCO-IHE/MSc 2011/2013-WSE/HWR/11/e: Water Resources Management											
Nr	Course/Topic	lecture	exercise	workshop	labwork	fieldwork	fieldtrip	selfstudy	contact hours	studyload hours	Lecturer(s)
	Total										

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: WSE-HWR, WSE-HERBD, WSE-HECEPD, WSE-HI, WSE-HELWD
Module Coordinator:

Module Sheet

Module Name Groupwork WSE	Module Code WSE/12/c	Credits 5
Target Group	**Prerequisites** All previous modules	

Learning Objectives

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

- Develop a Master Plan for Water Resources Management
- Do design projects in their own discipline as a part of the pre-feasibility study for the proposed Master Plan.
- Use an engineering approach based on suitable technical considerations.
- Develop multi-disciplinary project activities in integrated teams.

Topics and Learning Activities

Group work

The group work project consists of the multidisciplinary preparation of (alternatives for) a rough Master Plan for Water Resources Management in (parts of) a river basin, taking into account given and imaginable threats and opportunities. In multidisciplinary or monodisciplinary subgroups the group members will work out a technical research or design study to support the proposed Master Plan. Based on the results of the various technical supporting studies, the feasibility of the Master Plan will be reviewed.
The project involves:
data collection and analysis;
proposals to develop the water resources potential in the area;
proposals to decrease water-related risks like flooding, pollution or erosion;
development of engineering components in the areas of rivers and river basin development, coasts and ports and land and water development, including economic considerations.
The group work will be carried out within the framework of a team effort and includes:
showing a clear engineering approach within the frame work of a multidisciplinary project;
organizing the work flow efficiently an keeping to the time planning;
preparing readable well-structured reports of the required quality;
presentation of the results of a study or design work orally in a short period for a technical audience, making adequate use of presentation tools.
Learning Activities:
Exercise

Lecturing Material

- Handouts group work, information and data

Assessment

- **100%: Presentation**

UNESCO-IHE/MSc 2011/2013-WSE/12/c: Groupwork WSE											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
1	**Groupwork**	2		30					32	140	
	Total	**2**		**30**					**32**	**140**	

MUNICIPAL WATER AND INFRASTRUCTURE

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: E.A. de Jong, MA..

Module Sheet

Module Name Summer courses / Research methodology for WSE	Module Code WSE/13/c	Credits 3

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**

UNESCO-IHE/MSc 2011/2013-WSE/13/c: Summer courses / Research methodology for WSE											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	Research methodology									28	Various
	Summer Course									56	Various
	Total									**84**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME

Academic Year: 2011-2013
Specialization: Core Programme
Module Coordinator: E.A. de Jong, MA

Module Sheet

Module Name MSc research proposal development for WSE	Module Code WSE/14/c	Credits 7

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**

UNESCO-IHE/MSc 2011/2013-WSE/14/c: MSc research proposal development for WSE											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	MSc research proposal drafting									139	Mentor
	MSC research proposal presentation									1	Mentor and professor
	Total									**140**	

WATER SCIENCE AND ENGINEERING

MASTERS PROGRAMME
Academic Year: **2011-2013**
Specialization: **Core Programme**
Module Coordinator:

Module Sheet

Module Name MSc research	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..

- 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;
- 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;
- 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.

Topics and Learning Activities

Lecturing Material

Assessment

- **100%: Assignment**

UNESCO-IHE/MSc 2011/2013-WSE/15: MSc research											
Nr	**Course/Topic**	**lecture**	**exercise**	**workshop**	**labwork**	**fieldwork**	**fieldtrip**	**selfstudy**	**contact hours**	**studyload hours**	**Lecturer(s)**
	MSc Research									1008	
	Total									**1008**	