NILE BASIN INITIATIVE
APPLIED TRAINING PROJECT (ATP)

Integrated Water Resources Management (IWRM) MSc Program and Short Courses

CURRICULUM

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Preface

The Nile Basin Initiative (NBI) was formed in 1999 by the nine countries which border the river and developed their vision, " *to achieve sustainable socio- economic development through the equitable utilization of , and benefit from, the common Nile Basin water resources"* The NBI formed seven Shared Vision Projects (SVP) to prepare the groundwork for investment in the Subsidiary Action Program projects (Eastern Nile Subsidiary Action Program and Nile Equatorial Lakes Subsidiary Action Program). Among the SVP projects there is the Applied Training Project (ATP) whose mandate is capacity building in the water resources sector. All these initiatives were done in order to realize the vision of the basin. As the projects are closing at the end of 2009, there is a need to put in place mechanisms for the sustenance of the initiatives of the capacity building activities. The ATP therefore, facilitated the development of an Msc curriculum in IWRM and short courses. The curriculum is meant to be adopted in full or in part by the Nile Basin Universities. With the evolvement of the Nile Basin University Forum the program will form a good link for collaboration, delivery of joint programs and exchange of staff and students. The curriculum is modular with a core program area in IWRM and specialization clusters. This was done in order to enable the Universities to choose their more appropriate specializations according to the needs of their countries.

Executive Summary

This document is the curricula for the Masters program in IWRM and short courses. It is a modular Masters program proposed with major module termed Core Program Area. This is proposed to be an area where all students attending the program should take (compulsory courses). There are eight specialized cluster areas covering a very wide spectrum of topics related to IWRM are proposed. Each cluster area has 3 courses as compulsory and 5-7 courses for elective courses. The proposed Masters program in IWRM is composed of 36 credit hours (or units) with 30 credit hours of course work and 6 hours of a Masters thesis. The course work is composed of 18 credit hours of mandatory courses in a Core Program Area to provide basic knowledge to the participants, covering the basic principles of IWRM (Core Program Area), and 12 credit hours from selected specialized cluster area. After successful completion of the 30-credit-hour course work, each student will undertake a research project and prepare a Thesis with the IWRM theme being highlighted in the research project. To graduate, a student has to accumulate 36 credit hours with 18 mandatory credit hours of course work, 12 credit hours of elective courses, and 6 credit hours of a Masters thesis.

The core program area contains all basic courses that water resources and related professionals must know and have as a pre-requisite for the IWRM courses. It introduces the students to the IWRM concepts and provides the necessary background and knowledge related to the integrated management of water resources. The courses in this core program area include, but may not be limited to, principles of IWRM, basic hydrology and hydrogeology, aquatic ecology, introduction to GIS and RS in water resources, statistical analysis, the basic theory for social and economic aspects of IWRM, and the legal and political issues related to water resources, environment and their management. This assumes that students have a basic knowledge of mathematics, physics and chemistry. In addition, the students will learn how to use appropriate scientific methods and research tools in carrying out water project tasks in general and management tasks in particular.

The program requires students to have a Bachelor's degree in a field related to water resources or natural resources. It is assumed that students in this Masters program have a diverse background and thus the program assumes little knowledge regarding water resources in general and water resources management in particular. The program can thus accommodate students with undergraduate degrees in Civil Engineering, Environmental Engineering, Water Resources Engineering, Geological Sciences, Physical Sciences, Biological Sciences, Agriculture, Mathematics, Statistics, and any other relevant field.

1.0 Objectives of the Masters Program

As stated earlier there were three gaps identified in the Nile basin countries regarding IWRM. These gaps are:

- Lack of capacity to manage water in an integrated manner;
- Uneven distribution of capacity within the basin; and
- Little interaction among water professionals in the basin.

The courses of the master program are designed to overcome the lack of capacity to manage water in an integrated manner. The program is anticipated to strengthen the research and learning institutions in the region throughout the joint courses and professor/student exchange. The success of this program will help capacity building in IWRM in the Nile Basin region. The proposed Masters program has the merit that it is the first degree program that will be offered by the universities of the Nile Basin region. The program mission infers the following set of educational objectives:

- Allow present and future water managers to effectively communicate with experts from other disciplines, such as resource economists, environmentalists, lawyers, planners, community representatives, scientists, health professionals, engineers etc.
- Coin a common language of the central concepts in Integrated Water Resources Management;
- Enhance, regionalize and strengthen research in the fields of IWRM in the Nile Basin countries
- Raise awareness with regard to the regional scale of IWRM among future water resources professionals
- Prepare graduates capable of applying science, fundamentals, and logical thinking to manage water problems in an integrated manner;
- Provide water resources professionals with the ability to discover, apply, and disseminate the knowledge required to solve increasingly complex water and environmental problems
- Stimulate regional cooperation between the universities of NB countries in the field of education in IWRM;
- Prepare graduates capable of operating and managing water projects through well understanding of the available water resources, appropriate technology, and the socioeconomic and environmental aspects of the water projects;
- Produce graduates who understand ethical issues associated with their profession
- Build the leadership skills, teamwork, life-long learning, career advancement and engineering capabilities
- Instill in students a respect for the educational process that is manifested by a lifelong pursuit of learning

2.0 Structure of the Masters Program

The proposed Masters program relies on the premise that the integrated water resources management practice is a group and a teamwork not an individual's task. No one individual can be proficient in all aspects of IWRM. Therefore, the program is designed with a wide spectrum of cluster areas in which participants may wish to be proficient. When a number of these cluster area graduates work together, it is anticipated that their ability to manage water resources in an integrated manner will be much better than if all of them went through the same exact program with the same exact course work and professional preparation. The proposed program has a mandatory core program area through which all students will have to go and finish all course work. Many cluster areas are proposed from which students will select a cluster area of interest in which they have to attend compulsory course and select few other courses from the same area of research. The details of the proposed Masters program are described in the following subsection.

2.1 Composition of the program

The proposed Masters program in IWRM is composed of 36 credit hours (or units) with 30 credit hours of course work and 6 hours of a Masters thesis. A credit hour is equivalent to a course having a one-hour lecture per week for a semester composed of 16 weeks. Accordingly, a 2-credit-hour course will have 2 hours of contact lecture time per week for a 16-week semester excluding the week of the final examination. The general structure of the program is shown in Figure 1. The course work is composed of 18 credit hours of mandatory courses in a Core Program Area assumed to provide basic knowledge of water issues to the participants and covering the basic principles of IWRM (Core Program Area), and 12 credit hours to be collected from the specialized cluster area of research in which 6 credit hours are compulsory and 6 others are elective courses selected from the same cluster area. After successful completion of the 30-credit-hour course work, each student will undertake a research project and prepare a Thesis with the IWRM theme being highlighted in the research problem and should be related to the specialized area they selected. To graduate, a student has to accumulate 36 credit hours with 24 mandatory credit hours of course work – including the specialized courses, 6 credit hours of elective courses from the specialized area, and 6 credit hours of a Masters thesis.

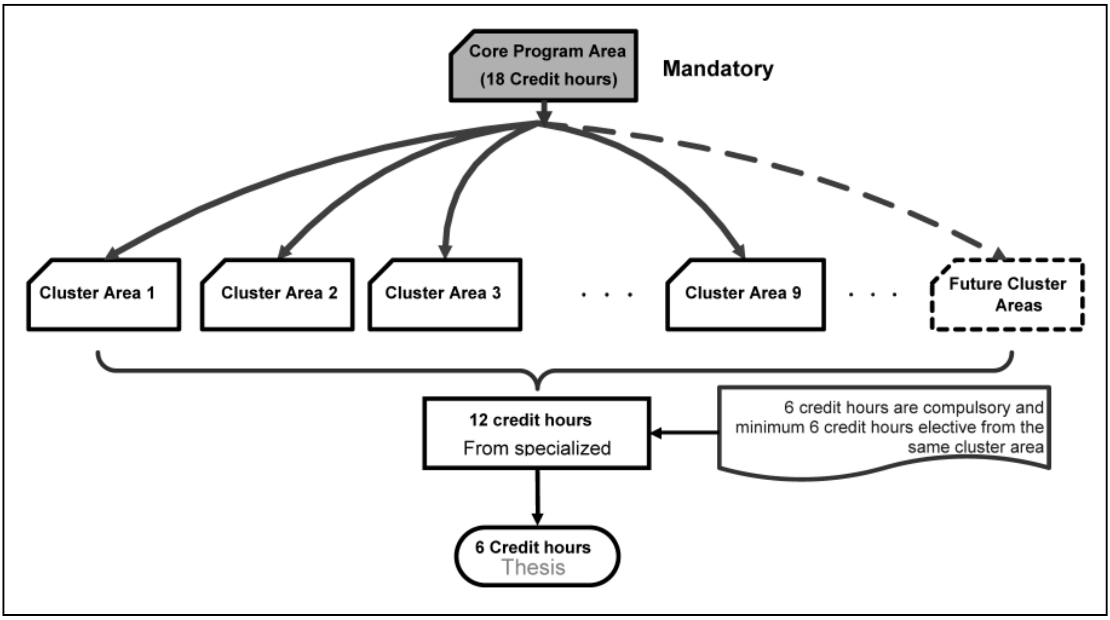

Figure 1 General structure of the proposed Masters program in IWRM.

2.2 Prerequisites

The program requires participants to have a Bachelor's degree in a field related to water resources. It is assumed that participants in this Masters program have a diverse background and thus the program assumes little knowledge regarding water resources in general and water resources management in particular. The program can thus accommodate students with undergraduate degrees in Civil Engineering, Environmental Engineering, Water Resources Engineering, Geological Sciences, Physical Sciences, Biological Sciences, Agriculture, Mathematics, Statistics, and any other relevant field.

Some very basic knowledge (e.g., Fluid Mechanics, Hydraulics, Irrigation and Drainage, Water Resources Systems) may be necessary for participants to be able to keep up with the water-related topics. For participants where this basic knowledge does not exist, additional pre-requisites should be placed such as completing full or short introductory courses which cover this necessary background. In addition, all applicants must have at least one undergraduate course in chemistry, physics, calculus, and technical writing.

2.3 Admission Requirements: (This will be as per the regulations of the host University)

2.4 Detailed Description of the Masters Program

The proposed Masters program has a hierarchical structure which is summarized in Figure 1 and detailed in Figure 2. The structure has a Core Program Area and many Cluster Areas. The core program area should contain all core courses that water resources professionals must know and be acquainted with, introduce the students to the IWRM concepts and provide the necessary background and knowledge related to the integrated management. The courses in this area include, but may not be limited to, the basic principles of IWRM, the social and economic aspects of IWRM, basic hydrology and hydrogeology, statistical analysis, numerical analysis and the legal and political issues related to water resources and their management. In addition, the students will learn how to use appropriate scientific methods and research tools in carrying out water project tasks in general and management tasks in particular.

With this knowledge present and considered as a prerequisite for the program, the core courses will provide the foundation for the program courses that are focused on Integrated Water Resources Management. The courses in the core program area will be mandatory for all students and there will be no elective core courses. The total credit hours for the core area are proposed to be 18 hours.

Following the completion of the Core Program Area, the student will have completed course work equivalent to 18 credit hours. Each student will then select a Focus Area where courses equating to a minimum of 6 credit hours will be selected from a range of courses proposed in each focus area. A minimum of 3 credits is to be selected from focus areas other than the student's main focus area. Then 3 more credit hours are to be selected from any focus area including the main focus area. In addition to selecting the courses of a particular focus area, the student will do a Masters thesis (equating to 6 credit hours) in this area and thus the selection of the focus area should essentially be tied to the thesis topic for each student. A large number of focus areas is proposed to cover the spectrum of topics related to IWRM as shown in **Figure 1.**

Eight cluster areas are proposed and more areas can be added to the program at any point in the future. The proposed areas include ecological system management, groundwater system management, Decision Support System and Data management, GIS and, water quality management, irrigation and drainage management, river engineering and hydropower management, integrated environmental management, and others. Under each of these cluster areas, three courses are compulsory and five to seven courses are proposed from which the student will select few courses to meet the minimum credit hours needed for the degree requirement.

2.4.1. Core Program Area

The core program area contains eight courses, see table 1: Principles of IWRM, Principles of Hydrology, Aquatic Ecology, GIS and RS in Water Resources Management, Socio-Economic Aspects of IWRM, Water and Environmental Policies and Laws, Statistical Analysis of Hydrologic Data & Computer Applications in WR. Research Methods, and Technical Writing, Projects and Team Work

The courses in this area introduce students to the basic concepts of water resources management in general and IWRM in particular. The courses cover the basic principles of IWRM, the political aspects of IWRM through water laws and policies, the social and economic aspects of IWRM, and research methods, technical writing, and teamwork.

The principle of hydrology concepts pertaining to surface water and groundwater and their interaction will be covered in other courses. This course will assume no previous exposure and concepts will be fairly simple early on and will increase in complexity as time progresses in the semester. Some students will find this course fairly easy and others will not. It will be up to the instructor to balance the course contents to meet the needs of the two groups: the group with good hydrology knowledge and the group with no previous exposure to the hydrology concepts. This balance will change from year to year depending on the background mix of the student group attending the course.

The course of Aquatic ecology covers basic ecology, ecology of aquatic ecosystems and interaction between human activities and aquatic ecosystems which is a new subject for some participants and should be treated in developing the materials and delivery as the principle of hydrology.

The basic principles of IWRM will most likely be a new topic for most of the students except those with professional experience in the water sector. Thus the course will be designed to introduce these basic concepts from the beginning under the assumption that all students have not dealt with such topics before. Therefore, students with undergraduate degrees in areas with little exposure to water resources topics will not find difficulties following these concepts.

The course covering the political, social, and economic and the course covering water and environmental policies and laws aspects will generally be descriptive in nature and will not be requiring significant previous knowledge on policy or socio-economic topics. Therefore, all students will be on equal footings regarding these courses except those with political or socio-economic background, if any.

The course of Geographic Information Systems (GIS) and Remote Sensing (RS) in Water Resources aims to give an introduction to GIS which covers the basic concepts of a GIS and principles of cartography and spatial analysis. The intent of this class is to prepare the student for advanced researching using specific GIS software packages. Moreover, introduction to RS will be carried out. In this course students acquire a base of geographic knowledge and data collection methods used in subsequent courses in GIS. Introductory raster and vector GIS operations are discussed and reinforced in computer lab work. Subjects include the acquisition and compilation of data from maps, field surveys, air photographs and satellite images. The use of remotely sensed imagery for change detection, calculation, and analysis is explored. Image processing and remote sensing capabilities of raster GIS are used to introduce remote sensing concepts such as image classification.

Each of these courses will be designed under the assumptions that students may not have any previous exposure to such topics. Thus the courses will start with very basic and simple concepts, move slowly early on. Later in the course, the complexity of the topics will be rapidly elevated. For example, it will be assumed that students have not been exposed to statistics or probability concepts before joining the program. Thus the course will start with very basic statistical concepts like data presentations, graphs, histograms, and numerical descriptive measures. Once these issues are covered and digested, more advanced topics such as probability theory, random variables and their distributions, frequency analysis for water-related data, and time series analysis will be covered with a faster pace than in the beginning. This makes it easy for participants with such background as agriculture, biology, ecology, geography, etc. to gradually grasp the statistical concepts necessary for water resources management.

With the need for undertaking a research project and writing a scientific thesis, the third course in the core area plays a very important role in this program. The course will be designed to cover how different numerical methods and computer applications are used in addressing water resources issues. Different software packages should be considered that belong to two categories: auxiliary analysis tools and water-related software packages. Software packages such as Microsoft Excel, Matlab, and Surfer belong to the first category and programs like HEC-RAS, MODFLOW, PumpTest, etc. belong to the second category.

Given the fact that IWRM encounters difficult (research) problems that need to be solved and requires significant cooperation and teamwork, the last course in the program area provides necessary background on research methods, teamwork and technical writing. Students will get acquainted with the basic research methods in hydrology and water resources including measurements of basic hydrological parameters, mapping, calculating hydrological parameters, statistical methods, and modeling techniques for hydrologic and water resources systems.

In addition some lectures on the basics of technical and scientific writing and report preparation are necessary. This allows the students to learn how to properly prepare their theses and how to professionally write project reports, research papers, and any scientific documents. This makes this course one of the very important courses for the program. It instills in the students the necessary talents and skills for conducting research in water-related projects and properly documenting and presenting their study analysis and results.

Large ambitious goals, such as achieving holistic water resources management, usually require that people work together, so teamwork has become an important concept in water sectors and for IWRM. Effective teams are an intermediary goal towards getting good, sustainable results. In this last course, lecturing and hands-on training through assigned team projects will instill in the students the ability to work with others more effectively and to accomplish shared goals. This aspect of team work should also be strengthened through the other program courses through group assignments and group projects, so students can appreciate the value of successful teamwork.

2.4.2. Module Areas

Many cluster areas are proposed and additional areas can be added to the program when needed. These cluster areas provide both compulsory and elective components of the program. Each student will choose a cluster area from which to select courses amounting to at least 12 credit hours. Each cluster is divided into two groups of courses. The First group is composed of three compulsory courses equivalent to 6 credit hours. While the second group has several courses, from which the student has to collect a minimum of another 6 credit hours among them. The advisor of the research thesis should be consulted to advise the student which courses to select to complete the required credit hours from the specialized cluster area.

The elective areas cover a very wide spectrum of topics that may be involved in IWRM in one way or another. As stated earlier, the philosophy here is that by selecting different cluster areas, graduates working in a certain water authority can efficiently work together and apply a holistic approach to water resources management. Detailed description of all courses for different cluster areas are given in Appendix A. For each cluster area general summary and specific objectives of the specialization are also given.

3.0 Guidelines for development of teaching materials

1. The teaching materials should be presented in a hard copy form (handouts/notes). That will help the student to keep in files; such materials might be used in his/her future career.
2. There should be Application of computer software regarding the IWRM this could be done as exercise covering different aspects of simulation
3. Selective case studies reflecting Nile Basin condition to be demonstrated for clear understanding of real problems should be developed.
4. Manuals describing laboratory experimental work for different subjects and field experiments associated with water resources activities, e.g. pumping test, rainfall distribution, river flow measurements, etc should be budgeted.
5. Problem sheets covering different aspects of the given subject should be prepared. The Majority of these problems should be solved by the students as assignments. Corner stone problems must be demonstrated as model answers (solved examples).

4.0 Vision for Implementation and Recommendations

In the implementation stage of such program, it is assumed that any participating country/university should be able to offer the courses in the Core Program Area. Module areas will be specific to specific universities. Therefore, students are assumed to be able to transfer from one university to another. For example, they would finish the core and program area courses in their home university (or another one) and then select the cluster area and see which universities offer the courses in this cluster area. Alternatively, instructors may move within the Nile Basin Countries to offer certain courses that belong to a cluster area that is not available in the host institutions. The logistical framework for implementing this program should be flexible enough to allow easy and simple transfer of credits across participating universities and also allow any of the attended universities to grant the Masters degree.

This approach will enforce the desired collaboration between the water resources professionals and students in the basin; an objective that was one of the most important drives for establishing the NBI.

5.0 Objectives of the graduate short courses

One of the components of in the Nile basin initiative activities is the ATP. It aims at coordinating the delivery of short graduate courses in IWRM for technician and professionals working in the water sector in the Nile basin countries. The major objectives are to support training and strengthen the capacity of the basin institutions in delivering educational and training program focused in IWRM in the Nile basin countries.

In this context a set of short courses on IWRM are proposed and designed in such a way that meets the differing country needs.

The courses curricula address the lack of capacity to manage water in an integral manner.

The short graduate courses cover a wide spectrum of IWRM subject areas. They address all the needs of the Nile basin countries. The proposed short courses modules are listed in appendix A.

The programs are also meant to build a critical mass of water professionals for water resources management.

Table 1 Structure of the Master Degree in Integrated Water Resources |Management (IWRM) for the Nile Basin

	Module Code	Module Title	Credit Hrs	Notes
Core Program area (Compulsory)	NBI-IWRM 101 NBI-IWRM 102 NBI-IWRM 103 NBI-IWRM 104 NBI-IWRM 105 NBI-IWRM 106 NBI-IWRM 107 NBI-IWRM 108	- Principles of IWRM - Principles of Hydrology - Aquatic Ecology - GIS and RS in Water Resources Management - Socio-Economic Aspects of IWRM - Water and Environmental Policies and Laws - Statistical Analysis of Hydrologic Data & Computer Applications in WR - Research Methods, Technical Writing, Projects and Team Work	2 3 2 2 2 2 3 2	

	Module Code	Module Title	Credit Hrs	Notes
MSc Thesis	NBI-IWRM 110		6	
Specialized Areas				
Cluster 1 Groundwater Development	NBI-IWRM 111 NBI-IWRM 112 NBI-IWRM 113	- Advance Hydrogeology - Groundwater Modeling - Groundwater exploration/investigations and assessment techniques	2 2 2	6 C.H. Comp.
	NBI-IWRM 114 NBI-IWRM 115 NBI-IWRM 116 NBI-IWRM 117 NBI-IWRM 118 NBI-IWRM 109	- Groundwater Management - Surface Water/Groundwater Interaction - Groundwater Pollution and Transport Process - Site Remediation - Soil Physics - Numerical Methods for Water Resources	2 2 2 2 2 2	Min. 6 C.H. Elective
Cluster 2 Water Quality and Sanitation Management	NBI-IWRM 121 NBI-IWRM 122 NBI-IWRM 123	- Water Supply and Sanitation - Water Quality Modelling, design, Operation & Monitoring - Freshwater Stream Pollution and Control	2 2 2	6 C.H. Comp.
	NBI-IWRM 124 NBI-IWRM 125 NBI-IWRM 126 NBI-IWRM 127 NBI-IWRM 128 NBI-IWRM 129 NBI-IWRM 1201 NBI-IWRM 1202 NBI-IWRM 1203 NBI-IWRM 1204	- Environmental Hydraulics - Hydro-geochemistry - Types and Sources of Groundwater Pollution - Bio-Treatment of Potable Water/ Wastewater - Water Treatment Processes and Plants - Wastewater Management - Community Water Quality Monitoring Program - Communities and Hazardous Wastes - Water Quality Mapping and Data Management - Management of Solid and Hazardous Wastes	2 2 2 2 2 2 2 2 2 2	Min. 6 C.H. Elective
Cluster 3 Irrigation Engineering Management	NBI-IWRM 131 NBI-IWRM 132 NBI-IWRM 133	- Advances in Irrigation Engineering - Advances in Agriculture Lands - Management and Distribution of Irrigation water	2 2 2	6 C.H. Comp.
	NBI-IWRM 134 NBI-IWRM 135 NBI-IWRM 136 NBI-IWRM 137 NBI-IWRM 138 NBI-IWRM 109	- Land Reclamation and topography - Soil – Plant – Water Relationship - Soil, water and Agriculture conservation - Sustainable agriculture - Agro fisheries - Numerical Methods for Water Resources	2 2 2 2 2 2	Min. 6 C.H. Elective

	Module Code	Module Title	Credit Hrs	Notes
Cluster 4 River Engineering and Drainage Management	NBI-IWRM 141 NBI-IWRM 142 NBI-IWRM 143	- River Basin Management - Open Channel and Alluvial Hydraulics - Surface Water Hydrology	2 2 2	6 C.H. Comp.
	NBI-IWRM 144 NBI-IWRM 145 NBI-IWRM 146 NBI-IWRM 147 NBI-IWRM 154 NBI-IWRM 186 NBI-IWRM 109	- Surface water Hydraulic modeling - Storm water and mine Drainage - Reservoir and Wetlands Storage - Hydraulic Transients in Hydropower Systems - Watershed Modelling and Management - Application of GIS and RS in WRM - Numerical Methods for Water Resources	2 2 2 2 2 2 2	Min. 6 C.H. Elective
Cluster 5 Watershed Management and Society	NBI-IWRM 151 NBI-IWRM 152 NBI-IWRM 153	- Watershed Hydrology - Participatory Watershed management - Environmental Impact Assessment and Auditing	2 2 2	6 C.H. Comp.
	NBI-IWRM 154 NBI-IWRM 155 NBI-IWRM 156 NBI-IWRM 157 NBI-IWRM 158 NBI-IWRM 159 NBI-IWRM 160 NBI-IWRM 1601 NBI-IWRM 1602 NBI-IWRM 1603 NBI-IWRM 1604 NBI-IWRM 186 NBI-IWRM 109	- Hydrology of the Nile River - Watershed Modeling and Management - Gender mainstreaming in IWRM - Mediation, Negotiation Skills and Conflict Management of water recourses issues - Soil and Water Conservation - Water Rights and Governance - Management of Hydrologic. Extremes - Water Harvesting - Environmental Components and Interaction - Environmental Management System - Wetlands hydrology - Application of GIS and RS in WRM - Numerical Methods for Water Resources	2 2 2 2 2 2 2 2 2 2 2 2 2	Min. 6 C.H. Elective
Cluster 6 Ecology Management	NBI-IWRM 161 NBI-IWRM 162 NBI-IWRM 163	- Wetlands Ecology - Limnology - Ecological Eng. and Industrial Ecology	2 2 2	6 C.H. Comp.
	NBI-IWRM 164 NBI-IWRM 165 NBI-IWRM 166 NBI-IWRM 167 NBI-IWRM 168	- Issues of Tropical Biology - Wildlife Ecology - Political Ecology - Ecology of Lakes – Function conservation & management - Wetland & River Floodplain Ecology	2 2 2 2 2	Min. 6 C.H. Elective

	Module Code	Module Title	Credit Hrs	Notes
Cluster 7 Climate and Water	NBI-IWRM 171 NBI-IWRM 172 NBI-IWRM 173	- Introduction to Meteorology and Climate - Impact of Climate Change on Water Resources - Introduction to Hydroclimatology	2 2 2	6 C.H. Comp
	NBI-IWRM 174 NBI-IWRM 175 NBI-IWRM 176 NBI-IWRM 177 NBI-IWRM 178 NBI-IWRM 179 NBI-IWRM 180 NBI-IWRM 189 NBI-IWRM 186 NBI-IWRM 109	- Climate Variability and Change - Hydrological Risks and Climate Change - Climate Vulnerability and Adaptation - Introduction to Agricultural meteorology - Climate Analysis and Modelling - Dynamical Climatology - Applied Hydroclimatology - Risk Assessment and Management - Applications of GIS & RS in WRM - Numerical Methods for Water Resources	2 2 2 2 2 2 2 2 2 2	Min. 6 C.H. Elective
Cluster 8 DSS – Data collection and Hydro-Informatics	NBI-IWRM 181 NBI-IWRM 182 NBI-IWRM 183	- GIS and database management - Principles and components of DSS for IWRM - Hydro-Informatics	2 2 2	6 C.H. Comp.
	NBI-IWRM 184 NBI-IWRM 185 NBI-IWRM 186 NBI-IWRM 187 NBI-IWRM 188 NBI-IWRM 189 NBI-IWRM 109	- DSS & Methods of data collection and management - Integrated Water Information System - Applications of GIS & RS in WRM - Managing Strategies - Knowledge Man.. for Decision makers in WS - Risk Assessment and Management - Numerical Methods for Water Resources	2 2 2 2 2 2 2	Min. 6 C.H. Elective
Cluster 9 Hydropower Development	NBI-IWRM 191 NBI-IWRM 192 NBI-IWRM 193	- River Basin Management - Open Channel hydraulics - Hydropower Engineering and Management	2 2 2	6 C.H. Comp.
	NBI-IWRM 194 NBI-IWRM 195 NBI-IWRM 196 NBI-IWRM 197 NBI-IWRM 198 NBI-IWRM 199 NBI-IWRM 153 NBI-IWRM 186 NBI-IWRM 109	- Dam Construction and Rehabilitation - Reservoir Storage and Hydropower - Hydropower Electro-mechanical equipments - Small Hydropower Plants and Alternate Energy Sources - Design of Components of Hydropower Systems - Hydraulic Transients in Hydropower Systems - Participatory Watershed Management - Application of GIS and RS in WRM - Numerical Methods for Water Resources	2 2 2 2 2 2 2 2 2	Min. 6 C.H. Elective

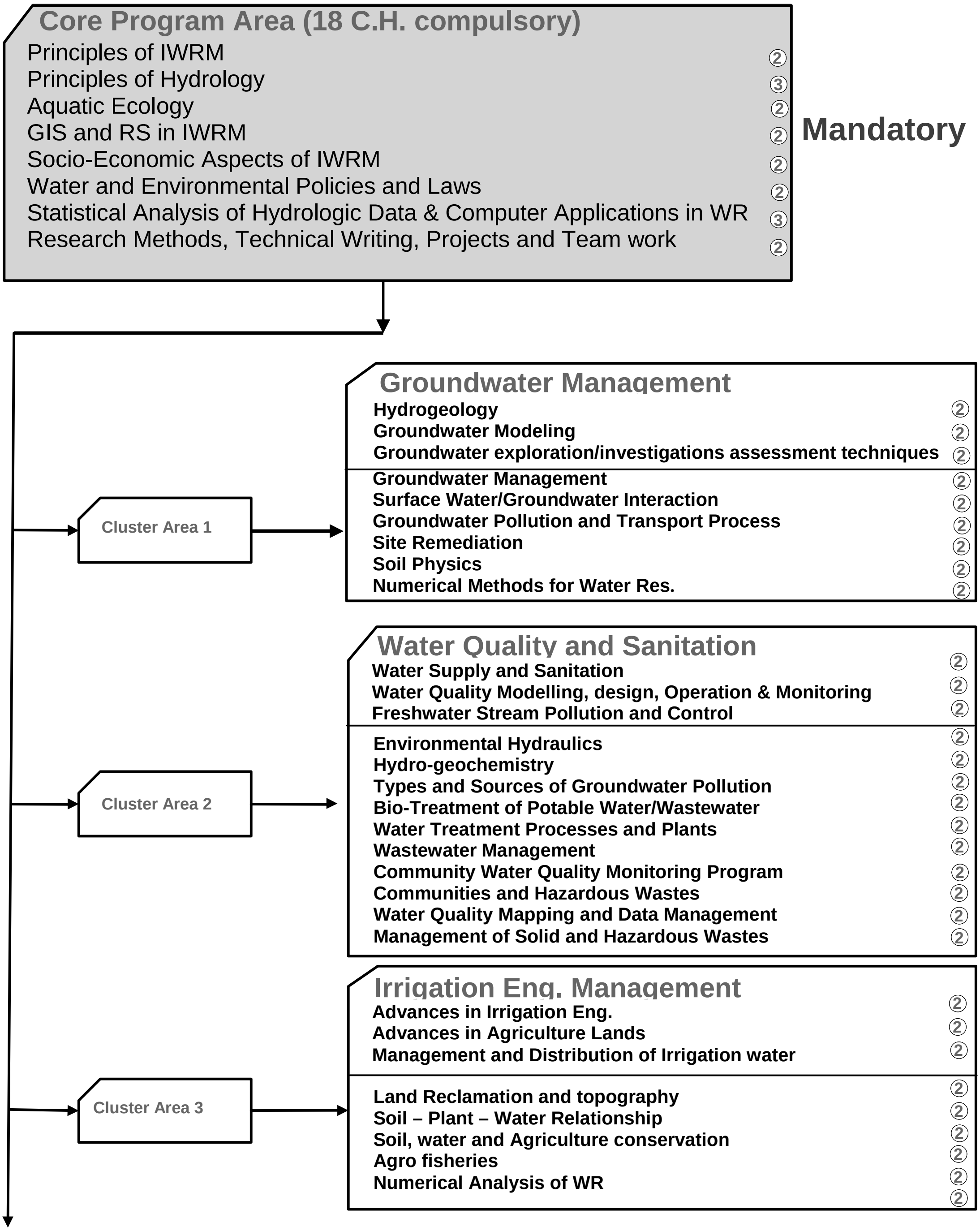

Figure 2. Detailed structure of the proposed Masters program in IWRM with the description of each cluster area.

Core Program Area (18 C.H.

- Principles of IWRM (2)
- Principles of Hydrology (3)
- Aquatic Ecology (2)
- GIS and RS in IWRM (2)
- Socio-Economic Aspects of IWRM (2)
- Water and Environmental Policies and Laws (2)
- Statistical Analysis of Hydrologic Data & Computer Applications in WR (3)
- Research Methods, Technical Writing, Projects and Team work (2)

Mandatory

Cluster Area 4

River Engineering and Drainage Development

- **River Basin Management** (2)
- **Open Channel and Alluvial Hydraulics** (2)
- **Surface Water Hydrology** (2)

- **Surface water Hydraulic modeling** (2)
- **Storm water Drainage** (2)
- **Reservoir and Wetlands Storage** (2)
- **Drainage of Mine Sites** (2)
- **Hydraulic Transients in Hydropower Systems** (2)
- **Watershed Modelling and Management** (2)
- **Application of GIS and RS in WRM** (2)
- **Numerical Methods for Water Res.** (2)

Cluster Area 5

Watershed Management and

- **Watershed Hydrology** (2)
- **Hydrology of the Nile River** (2)
- **Participatory Watershed management** (2)

- **Watershed Modeling and Management** (2)
- **Gender mainstreaming in IWRM** (2)
- **Mediation, Negotiation Skills and Conflict Managt of WR issues** (2)
- **Soil and Water Conservation** (2)
- **Water Rights and Governance** (2)
- **Flood Forecasting** (2)
- **Water Harvesting** (2)
- **Numerical Methods for Water Res.** (2)

Cluster Area 6

Ecological Management

- **Wetlands Ecology** (2)
- **Limnology** (2)
- **Ecological Eng. and Industrial Ecology** (2)

- **Issues of Tropical Biology** (2)
- **Wildlife Ecology** (2)
- **Fish Ecology** (2)
- **Lake Ecology** (2)
- **Wetland river flood plain Ecology** (2)
- (2)

Core Program Area (18 C.H. compulsory)

Mandatory

Course	C.H
Principles of IWRM	2
Principles of Hydrology	3
Aquatic Ecology	2
GIS and RS in IWRM	2
Socio-Economic Aspects of IWRM	2
Water and Environmental Policies and Laws	2
Statistical Analysis of Hydrologic Data & Computer Applications in WR	3
Research Methods, Technical Writing, Projects and Team work	2

Cluster Area 7 — Climate and Water

Course	C.H
Introduction to Meteorology and Climate	2
Impact of Climate Change on Water Resources	2
Introduction to Hydroclimatology	2
Climate Variability and Change	2
Climate and Water Resources	2
Vulnerability and Adaptation	2
Introduction to Agricultural meteorology	2
Climate Analysis and Modelling	2
Dynamical Climatology	2
Applied Hydroclimatology	2
Applications of GIS & RS in WRM	2
Numerical Methods for Water Res.	2
	2

Cluster Area 8 — DSS, Data Collection and Hydro-Informatics

Course	C.H
GIS and database management	2
Principles and components of DSS for IWRM	2
Hydro-Informatics	2
Methods of data collection and management	2
Water Information System	2
Applications of GIS & RS in WRM	2
Managing Strategies	2
Knowledge Manag. For Decision makers in WS	2
Risk Assessment and Management	2

Cluster Area 9 — Hydropower Development

Course	C.H
River Basin Management	2
Open Channel hydraulics	2
Hydropower Engineering and Management	2
Dam Construction and Rehabilitation	2
Reservoir Storage and Hydropower	2
Hydropower Electro-mechanical equipment	2
Small Hydropower Plants and Alternate Energy Sources	2
Design of Components of Hydropower Systems	2
Hydraulic Transients in Hydropower Systems	2
Participatory Watershed Management	2
Application of GIS and RS in WRM	2
Numerical Methods for Water Res.	2

Table 2. Proposed timetables for MSc degree, 2 years duration

Semester		Courses	Credit hours	Notes
First (1st year)	Core Program courses	- Principles of IWRM - Principles of Hydrology - Aquatic Ecology - GIS and RS in Water Res. Management	9	It is possible to finish all 30 credits in two semesters and allow more time for research thesis
Second* (1st year)		- Socio-Economic Aspects of IWRM - Water and Environmental Policies and Laws - Statistical Analysis of Hydrologic Data & Computer Applications in WR - Research Methods, Technical Writing, Projects and Team Work	9	
Third* (2nd year)	Specialized Cluster Courses	- Compulsory courses - Elective Courses	12	
Forth (2nd year)	Research Thesis		6	
Total Credit hours			36	

Appendix A

Structure of the Masters Program

A.1. Modules of Core Program Area (Compulsory)

NBI-IWRM 101	-	Principles of IWRM
NBI-IWRM 102	-	Principles of Hydrology
NBI-IWRM 103	-	Aquatic Ecology
NBI-IWRM 104	-	GIS and Remote Sensing in Water Resources Management
NBI-IWRM 105	-	Socio-Economic Aspects of IWRM
NBI-IWRM 106	-	Water and Environmental Policies and Laws
NBI-IWRM 107	-	Statistical Analysis of Hydrologic Data & Computer Applications in WR
NBI-IWRM 108	-	Research Methods, Technical Writing, Projects and Team Work

Course Code: NBI-IWRM 101

Course Title: Principles of IWRM

Credit Hours: 2

Prerequisites: Basic knowledge of water resources and social sciences

Summary and General Objective:

To enable the students to discover what is IWRM, and the implied multidisciplinary approach to water resources management.

Specific Objectives:

- To get familiarity with the definition of IWRM
- To get knowledge of water concepts relevant to and consistent with IWRM
- To get familiarity with water demand per sector
- To get familiarity with systems thinking and problem analysis

Course Outline:

- Introduction to IWRM
- Enabling Environment and Institutions
- Demand Management
- River Basin Planning and Management
- Sanitation and Health
- Financing and Economic dimensions
- Ground water management
- IWRM and Agriculture
- Conflict Resolution
- Sustainability of Ecosystems
- Gender Mainstreaming in IWRM
- Stakeholder Participation/Involvement
- Local Water Management
- Public-Private-Partnerships in Water Management
- Water Policy
- Preparation of national IWRM plans

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	N/A
Course Computer Hours:	12
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	20
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications – laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	10%

References:

- **Grigg, N S, 1996**, Water Resources Management: Principles, Regulations and Cases, 1st Edition, McGraw-Hill Professional, 540p
- **Gido, J and Clements, J P, 1999**. Successful Project Managements: A Practical Guide for Managers, 1st Edition, South-Western Educational Publishing, 355p
- **Knuston, J and Bitz, I, 1991**. Project Management: How to Plan and Manage Successful Projects, AMACOM/American Management Association, 198p
- **Brown, M., 1992**, Successful Project Managements Hoddle and Strongton, kent, 111p
- **Richmond, B. Peterson, S. Charyk, C, 1994**, Introduction to Systems Thinking and High Performance Systems Hannover

Additional Information:

- **CapNet and Global Water Partnership (GWP) toolkits in IWRM** Capacity Building for Integrated Water Resources Management. http://www.cap-net.org//

Course Code: NBI-IWRM 102

Course Title: Principles of Hydrology

Credit Hours: 3

Prerequisites: Basic knowledge of mathematics and familiarity of statistical knowledge.

Summary and General Objective:

To enable the participant to have a general knowledge in hydrology and the interaction between climatological factors and land resources.

Specific Objectives:

- To get familiarity with different precipitation analysis
- To get familiarity with evaporation calculations
- To get familiarity with river flow analysis and the hydrograph
- To get familiarity with reservoir yield analysis

Course Outline:

- An introduction to the importance of hydrology analysis
- Precipitation analysis and determination of aerial rainfall; rainfall frequency; intensity duration frequency analysis and extreme values of precipitation.
- Evaporation and transpiration and evaporation from a reservoir using climatological data
- Land and water interaction including infiltration and soil moisture in the unsaturated zone
- River flow analysis including flood frequency analysis by getting the analysis of annual maximum series, flow duration curves and draught frequency analysis
- Rainfall-runoff relationships including the rational method, the time area method, unit hydrograph analysis, instantaneous unit hydrograph, the Nash model, Muskingum routing and the Pul's reservoir routing.
- Reservoir yield analysis including the mass curve analysis; conjunctive use of ground water and surface water; operation of reservoirs and management principles.
- Data analysis using spreadsheets; statistics and probability in hydrology
- Case study for Nile River Hydrology
- Fundamentals of Groundwater hydrology

- Darcy's law
- Hydraulic conductivity, transmessivity, storativity
- Types of aquifers
- Different equations governing GW flow
- Boundary Conditions

- Hydraulics of Wells
- Steady
- Unsteady (pumping tests)
- Groundwater Recharge
- Groundwater contamination, sea-water intrusion
- Well technology

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	36
Course Laboratory Hours:	6
Course Computer Hours:	12
Course Field Hours:	6
Total Course Hours:	54
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications – laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	10%

References:

- **Hornberger, G.M., Raffensberger, J.P., Wiberg, P.L., and Eshleman, K.N, 1998,** Elements of physical hydrology. Johns Hopkins University Press, Baltimore, 302p
- **Linsley, R.K. et al., 2000,** Hydrology for Engineers –McGraw Hill So.
- **Linsley, R.K. et al., 2000,** Water Resources Engineering Engineers –McGraw Hill So.
- **Freeze, A. and Cherry, 1979,** Groundwater hydraulics, Academic Press.

Course Code: NBI-IWRM 103

Course Title: Aquatic Ecology

Credit Hours: 2

Prerequisites: Basic knowledge of integrated water resources management and principles of hydrology

Summary and General Objective:

To provide students with ecology and management of inland water, and managing environmental problems

Specific Objectives:

- To get familiarity with ecology and management of inland waters from an environmental point of view
- To get familiarity with the linkages between water resources and other environmental systems
- To get familiarity with the principles of managing environmental problems associated with water resources

Course Outline:

- Basic ecology: ecosystems, communities, populations; biodiversity and biogeography; and natural selection and evolution
- Ecology of aquatic ecosystems: systems, e.g. rivers, lakes, wetlands; water chemistry; and physical aspects.
- Interaction between human activities and aquatic ecosystems: physical disturbance, pollution, exploitation of natural resources.
- An introduction to environmental management: the concept of sustainable development; its various meanings; historical background; and environmental management tools.
- Practical work: field trips; introduction to types of ecosystems and habitats; degradation; bio monitoring, and practical; introduction to plants and animals; analysis of data.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	6
Course Field Hours:	6
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- Chatterjee, A.K., 1998, Water Supply, Waste Disposal and Environmental Engineering. 6th edition, Khanna publishers, Delhi,
- Simon Jennings, 2001, Marine Fisheries Ecology, Blackwell Science, UK
- Rivas-Martinez S., A. Penas, M.A. Luengo & S.Rivas-Saenz; H. Lieth (Ed.), 2003 Worldwide Bioclimatic Classification System. CD-Series: Climate and Biosphere II. CD-ROM.
- Streams and Ground Waters (Aquatic Ecology) Array Academic Press
- R. S. Barnes, K. H. Mann, 2002, Fundamentals of Aquatic Ecology Blackwell Publishing Limited

Course Code: NBI-IWRM 104

Course Title: GIS and Remote Sensing in Water Resources Management

Credit Hours: 2

Prerequisites: This course is designed for: hydrologists, agricultural – civil engineers, physical geographers or environmental scientists (BSc or MSc level), with by preference some years of professional experience in the land and water resources, watershed management or natural resources sector.

Summary and General Objective:

New developments in the field of GIS, Remote Sensing and modeling have let to various new and better tools for Integrated Catchments and Water Management (ICWM). In many cases spatial components have been added to computer models for water quality and quantity. Remote sensing images are used for obtaining spatial information on the hydrological behavior of catchments. This course will address both the new developments in modelling as the contribution of GIS and RS to integrated water management

Specific Objectives:

At the end of the course student will be able to use GIS – RS software and various modelling tools in ICWM. Students have been exposed to applications of earth observation techniques and geographic information systems in the field of water resource development projects, irrigation management, flooding, erosion and surface and groundwater water pollution control. Students will get exposure to advanced data acquisition systems (data loggers, sensors etc.) and learn how to analyse and environmental and water data for elaborating environmental impact studies and reports.

Course Outline:

- Spatial analysis & interpretation of hydro geochemical and water quality data; introduction to geostatistics; optical remote sensing of water quality.
- Water resource modelling: concepts of hydrologic & environmental system analysis, use of watershed models incl. GIS interfaces, numerical water quality & non point source pollution models.
- Geographic analysis & modelling of erosion – sedimentation processes; analysis & interpretation of remote sensing data; design and performance evaluation of engineering control methods.

- Hydrologic & environmental monitoring methods; automated data acquisition systems (hydrologic, meteorological
- data, use of geo positioning systems); hydrometrics and field measurement of water flows and water quality parameters; laboratory methods for soil and water analysis; environmental reporting on water resource projects

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	20
Course Laboratory Hours:	6
Course Computer Hours:	12
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications – laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	10%

References:

- **Clarke, K.C., 2003,** Getting Started with Geographic Information Systems, 4th Edition. Upper Saddle River, NJ: Prentice Hall.
- **DeMers, M.N., 2000,** Fundamentals of Geographic Information Systems, 2°d Edition. New York: John Willy & Sons Inc.
- **Longley, P.A. et al, 2001,** Geographic Information Systems and Science. New York: John Willy & Sons Inc.

Course Code:	NBI-IWRM 105
Course Title:	Socio-Economic Aspects of IWRM
Credit Hours:	2
Prerequisites:	Basic knowledge of integrated water resources management and principles of hydrology

Summary and General Objective:

To introduce students to key socio-economic issues related to water resources management and development

Specific Objectives:

- To get familiarity with Socio-Economic aspects and issues
- To get familiarity with disciplinary focus
- To get familiarity with other Socio-Economic Issues

Course Outline:

- An introduction about the key socio-economic aspects and issues, and context of water use in developing countries and linkages with different environmental issues
- Disciplinary focus: Socio-cultural aspects of water use, e.g. attitudes, perceptions, values, and indigenous systems of knowledge, and economic aspects of water use, e.g. resource valuation and pricing, cost recovery and pricing, economic rights to water, optimal water use and efficiency, cost benefit analysis; resource/ environmental/ ecological economics; national resource accounts.
- Other socio-economic issues: gender and equity, e.g. access, control, power and affordability; water users, water contestations and resolution; access to water; security versus water independence; demographic and spatial issues, urbanization, natural disasters, rural marginalization, effects of technology; and institutional development, stakeholder involvement, role of government and NGOs; water user groups; CBNRM approaches, participatory methodology

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Boelens, R. Daila, G.,1998,** Searching for Equity in Peasant Irrigation Holland von Gorain
- **Sharma, N.P., 1996,** African Water Resources: Challenges and Opportunities World Bank Technical Paper No. 331

Course Code: NBI-IWRM 106

Course Title: Water and Environment Policies and Laws

Credit Hours: 2

Prerequisites: Basic knowledge of integrated water resources management and principles of hydrology

Summary and General Objective:

To provide the students with a critical understanding of the interrelations between institutions, polices and laws related to water, at local, national and transnational level.

Specific Objectives:

- To get familiarity with the local water laws
- To get familiarity with national water law and institutions
- To get familiarity with environmental law and water quality

Course Outline:

- An overview in institutions, policies and the law
- Local water law and institutions, incl. common pool resources
- National water law and institutions
- An overview of water quality and environmental law
- Legislation of international water courses, role play: negotiation between riparian countries; assignment comparing protocol with a national water law; or protocol with UN Convention, dispute / conflict resolution

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **F.R. Mandelkor D.R., 1984,** Environmental Protection: Law and Policy, Anderson, Little Brown and Co.
- **Abernety Charles, 1997,** Water Management in the 21st Century: Development and Cooperation, Frankfurt.

Course Code:	NBI-IWRM 107
Course Title:	Statistical Analysis of Hydrologic Data & Computer Applications in WR
Credit Hours:	2
Prerequisites:	Basic knowledge of mathematics, calculus, and familiarity of different sets of hydrologic data

Summary and General Objective:

To provide students with the necessary statistical knowledge for dealing with water resources management issues and decision making issues.

Specific Objectives:

- To get familiarity with different statistical terminology as applied to water resources and hydrologic data analysis
- To get familiarity with basic probability concepts and the notion of randomness and uncertainty as applied to hydrologic data
- To understand the differences between different probability distributions and the situations each distribution can be used in
- To understand and learn how to conduct frequency analysis to study extreme event and predict their frequency of occurrence
- To understand and learn how to conduct times series analysis and how to model time series and use the model for future prediction

Course Outline:

- An introduction about the importance of statistics in water resources management
- Basic concepts of sampling and data presentation methods and how to summarize the main features of data sets with visually appealing aids
- Numerical descriptive measures of data sets that deal with central tendency in the data, dispersion in the data, and the shape of the data distribution
- Elementary probability theory including conditional probability, joint and marginal probabilities, Baye's theorem, addition rule, and multiplication rule
- Discrete probability distributions including Bernoulli's distribution, Binomial distribution, Poisson distribution, and Hypergeometric distribution
- Normal distribution and sampling distributions and how to use the standard normal tables to obtain probability values

- Basics of frequency analysis, the direct method for conducting frequency analysis and the frequency factor method for conducting frequency analysis using a few distributions
- Basic concepts of time series analysis and how to conduct a time series modeling process including identification of model type, order, parameters estimation, model diagnostic checks, model refinement, and model use in prediction.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Charles T. Haan, 2002,** Statistical methods in Hydrology –, Iowa State Press, Second Edition,
- **Mamdouh Shahin, H.J.L. Van Oorschot, and S.J. De Lange, 1993,** .Statistical Analysis in Water Resources Engineering –Balkema Publishers – Applied Hydrology Monographs 1.

Course Code: NBI-IWRM 108

Course Title: Research Methods, Technical Writing, Projects and Team Work

Credit Hours: 2

Prerequisites: Basic knowledge of statistics

Summary and General Objective:

To provide students with the techniques of planning and executing research, and writing a technical report

Specific Objectives:

- To get familiarity with techniques of planning and executing research
- To get familiarity with applications of computers in experimental data collection and data handing
- To get familiarity with data interpretation
- To get familiarity with technical report writing

Course Outline:

- An introduction to research methodologies: meaning; objectives, types and significance of research. Methods versus methodology.
- How to define the research problem: selecting the problem, necessity of defining the problem.
- Research design: meaning of research design features and concepts relating to research design. Basic principles of experimental design. Computer application of software support for experimental design.
- Sampling fundamentals, sampling design: census and sample survey; implications of a sample design; steps in sampling design; criteria for selecting a sampling procedure.
- Measurement and scaling techniques, methods of data collection, processing and analysis of data; statistical methods.
- Testing hypothesis. Interpretation and report writing. Research proposal writing.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Alred, G J, Brusaw, C T and Oliu, W E, 2003**. Handbook of Technical Writing, 7th Edition, St. Martin's Press, 768p
- **Zaleznik, J M and Benson, Ph P, 1999.** Technical Writing, 1st Edition, Learning Express, 256p
- **Markel, M, 2002. Technical Communication: Updates 2002,** 6th edition, St. Martin's Press, 764p
- **Anderson, P V, 1998.** Technical Communications: A Reader-Centered Approach, 4th Edition, Harcourt Brace College Publishers, 643p
- **Goodwin, G.C. and R. L. Payne. 1977,** Process System Identification and Experiment Design and Data Analysis, Academic Press.
- **Fisher, R. A. 1990,** Statistical Methods, Experimental Design and Scientific Inference. Oxford University Press

A.2. Cluster Area Modules

A.2.1 Cluster Area 1

Groundwater Development

NBI-IWRM 111	-	Advanced Hydrogeology
NBI-IWRM 112	-	Groundwater Modeling
NBI-IWRM 113	-	Groundwater exploration/investigations and assessment techniques
NBI-IWRM 114	-	Groundwater Management
NBI-IWRM 115	-	Surface Water/Groundwater Interaction
NBI-IWRM 116	-	Groundwater Pollution and Transport Process
NBI-IWRM 117	-	Site Remediation
NBI-IWRM 118	-	Soil Physics
NBI-IWRM 109	-	Numerical Methods for Water Resources

Master of Science Specialized in Ground Water Development

This M.Sc programme will provide the students with the knowledge and skills to the study of Groundwater development. All Graduate students must have 36 credit points, 18 credit points by having successfully completed the core programme (compulsory course of IWRM), 6 credit points for M.Sc thesis.

For graduates who wish to be specialized in Groundwater development he must have 6 credit points by successfully completing 3 specialized compulsory courses of Hydrogeology, Groundwater Modeling and Groundwater exploration/investigations assessment techniques.

Furthermore, he must have 6 credit points by choosing at least 3 courses from the specialized elective courses which are : Groundwater Management, Surface Water/ Groundwater Interaction, Groundwater Pollution and Transport Process, Site Remediation, Soil Physics, Numerical Methods for Water Resources.

Graduate students, who successfully complete the master degree programme, are awarded the title **Master of Science in Civil Engineering**.

The graduate students who wish to have certificate of master degree programme specialized in Groundwater development must have complete the following **compulsory** courses:

- The course in **Hydrogeology** conducted through a combination of classroom and laboratory sessions (where necessary), provides knowledge of geological occurrences and hydraulics of groundwater flow, exploration techniques, extraction engineering and borefield management.
- The course in **Groundwater Modeling** which is directed towards understanding the Principles of modeling, Mathematical description of groundwater Governing equations, numerical methods, Model simulation, calibration, validation and applying scenarios to solve practical problems of by using different models such as GMS and Modflow.
- The course in **Groundwater exploration/investigations assessment techniques** comprises, Data collection and monitoring, Management and planning of surveys and networks; Exploration drilling:; Pumping tests; Monitoring of diffuse pollution, Monitoring of waste disposal sites, Network density graph, Determination of sampling frequency; Preparation of hydro-geological maps, Interpretation of a Schlumberger measurement (GEWIN), Preparation of a well log, Analytical analysis of a step-drawdown test, Analytical interpretation of constant yield tests (AQUITEST), Designing an adequate network (NETGRAPH),

In addition to the above courses, it also required from the graduate students specialized in Groundwater development to choose at least 3 courses from the following **electives** available courses:

- The course in **Groundwater Management** comprises introduction on Groundwater Resources of the world, their use, global groundwater situation, covers the Basic concept of groundwater hydrology, Economic aspects of groundwater use, Principles of the regional assessment of groundwater resources, Groundwater monitoring, Local regulation.
- The course in **Surface Water/Groundwater Interaction** which covers the following topics; Basic concept of surface /groundwater water interaction, impact of Groundwater withdrawal on surface water, Conjunctive use of groundwater and surface water River basin management and planning Aquifer vulnerability mapping with dynamic recharge and surface water boundaries Flood plain and interaction with groundwater Impact studies for changes in land use and climate Impact studies of agricultural practices including irrigation, drainage and nutrient and pesticide management
- The course in **Groundwater Pollution and Transport Process** covers Overview and introduction to groundwater pollution and hydrology, Principles and fundamental concepts of groundwater flow, Contamination, fate and transport and natural attenuation, Advective flow; diffusion transport; diffusion and dispersion coefficients; partition coefficients; adsorption isotherms; Spatial and temporal variability of transport phenomena and coefficients; Derivation of advection dispersion equation and its use, Introduction to contaminant transport modeling
- The course in **Site Remediation** involves Field investigations; geotechnical and geophysical techniques; hydro geological conditions; risk assessment; contaminant transport; remedial action plan; containment systems on-site and off-site treatment);In-situ treatment techniques ,Technologies for cleaning sites with subsurface contamination. Comprehensive design project involving design and evaluation of site remediation activities required
- The course in **Soil Physics** covers the following: Overview to the composition of soil General physical characteristics of soils Interaction between soil and water Properties of water relation to porous media Soil structure and aggregation Content and potential of soil water Flow of water in saturated / unsaturated soil.

- The course in **Numerical Methods for Water Resources** covers the following topics: introduction to numerical methods, Difference equation, Systems of simultaneous linear equations, Special iterative methods, Partial differential equations and its solving by different numerical methods (Finite difference, Finite element and Boundary element).

Summary and General Objective:

Groundwater represents the world's largest and most important fresh water resource.

The primary aim of this Master of Science programme is to provide opportunities for Graduates with first degrees in a range of scientific and engineering disciplines to Enhance their knowledge of Ground Water Development.

Students taking this M.Sc course will be able to protect in a sustainable way, the Ground water by understanding the fundamental of groundwater pollution, the Interaction between surface water and groundwater and use the different techniques Adopted for aquifer remediation. Also they will be able to manage the ground water Resources and to develop groundwater models.

Specific Objectives:

Upon completion of this program, students will be able to:

- Understand the mechanisms used to couple the hydrologic processes, familiar by using integrated water resource approach, the river management and its relation to the groundwater system and the effect of land use on the groundwater resource.
- Understand the physical characteristics of soils, the interaction between soil and water, the principles of water movement in soil and soil structure.
- Understand different mechanisms for groundwater recharge, be familiar and advanced in hydrologic field methods and groundwater principles for saturated and unsaturated media, contaminant transport and numerical simulation of fluid flows.
- Understand the fundamentals of contamination, fate and transport, know the sources of groundwater pollution, learn the main processes governing the contaminant movement and learn how to simulate and model contaminate transport.

- Be familiar with field investigation and in-situ treatment techniques to formulate the pollution problem, access technical and economical feasibility of applied techniques and put an action plan for mitigation or remediation.
- Carry out groundwater data collection and analyses procedures relating to hydro-geological mapping and well inventories, surface geophysics, exploration drilling, well design, pumping tests and groundwater monitoring, be familiar with the most popular groundwater codes: GEWIN, AQUIFERTEST, FREQ and NETGRAPH, Be able to visualize the application of data collection and monitoring techniques within the wider framework of groundwater studies.
- Understand the basic concepts of groundwater management, know the global distribution of groundwater resources, put an action plan for mitigation or remediation, get familiar with field investigation to formulate the pollution problem, the economical aspects of groundwater, design groundwater monitoring networks, access technical and economical feasibility of applied techniques.
- Understand how to formulate a conceptual model of a system, translate conceptual model into a numerical model, and develop expertise in solving practical groundwater flow and solute transport problems using numerical methods, be familiar with the model calibration, verification, and validation and learn groundwater modeling program GMS-MODFLOW.

Course Code: NBI-IWRM 111

Course Title: Advanced Hydrogeology

Credit Hours: 2

Prerequisites: Basic hydrology, geology, water resources and related issues

Summary and General Objective:

To get in depth study of groundwater, emphasizing the geologic aspects of groundwater flow and chemistry principles for saturated and unsaturated media, contaminant transport and numerical simulation of fluid flow. This course covers the occurrence and movement of water beneath the Earth's surface, both in the unsaturated and saturated zones

Specific Objectives:

Participants should be able to;

- Explain movement of water through many geologic settings
- Advance in hydrologic field methods and groundwater principles for saturated and unsaturated media, contaminant transport and numerical simulation of fluid flows.
- Understand different mechanisms for groundwater recharge

Course Outline:

- Groundwater principles for saturated and unsaturated media, contaminant transport and numerical simulation of fluid flow
- The mathematical equations used to described groundwater flow are developed
- Groundwater Geology, Geochemistry, and the modeling classes
- Aquifer Systems, specific geologic settings, units, physical properties (hydraulic conductivity, storability, porosity, etc.),
- current and future rates of extraction, groundwater quality, chemistry, and contamination
- How the rocks control water chemistry
- The mathematical equations governing solute transport are developed. Other topics include hydrodynamic dispersion, homogeneous and redox reactions,

adsorption, liquid/vapor partitioning, biodegradation, and groundwater dating

- aquifer contamination, and aquifer management
- methods for measuring aquifer properties
- Reservoir characterization using geophysical methods, including time-lapse seismic and permanently-instrumented reservoirs
- Groundwater Recharge, natural and artificial

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)
Teaching Method:	Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	**15%**
Class Participation:	**15%**
Mid-term:	**20%**
Final Exam:	**50%**
Course Project:	**NA**

References:

- **Chow, Maidment and Mays, 1988,** Applied Hydrology, McGraw-Hill
- **Deming, D, 2001.** Introduction to Hydrogeology, 1st Edition, McGraw-Hill Science/Engineering/Math, 480p
- **Hudak, P F, 2000.** Principles of Hydrogeology, 2nd Edition, Lewis Publishers, 202p

Code: NBI-IWRM 112

Course Title: Groundwater Modeling

Credit Hours: 2

Prerequisites: Basic principle of surface and subsurface hydrology

Summary and General Objective:

To provide students with the basic knowledge and skills for developing groundwater models and provide the computer modeling tools required for practical groundwater resource management.

Specific Objectives:

- To understand how to formulate a conceptual model of a system.
- To understand how to translate conceptual model into a numerical model.
- To develop expertise in solving practical groundwater flow and solute transport problems using numerical methods.
- To get familiarity with the model calibration, verification, and validation.
- To learn the different types of boundary conditions and how to simulate it.
- To learn groundwater modeling program GMS-MODFLOW.

Course Outline:

- Principles of modeling: Introduction and Overview.
- Mathematical theory of groundwater modeling: Governing equations and numerical method, the conceptual model, types of model.
- Boundary conditions and their types: simulation of boundary conditions and the source and sink.
- General purpose of modeling programs such as GMS and Modflow: Model calibration, verification, Sensitivity analysis and Advective transport.
- Project that allows students to apply concepts and skills from the lectures to a particular problem of interest.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	12
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	10%
Final Exam:	50%
Course Project:	20%

References:

- **Anderson and Woessner, 1992,** Applied Groundwater Modeling: Simulation of Flow and Advective Transport, Academic Press.
- **Sonderegger, and Willis D. Weight, Manual, 2001,** of Applied Field Hydrogeology - John L. McGraw-Hill
- **Fetter, C.W.** 1994. Applied hydrogeology, 3rd edition, Prentice-Hall, Inc.

Code: NBI-IWRM 113

Course Title: Groundwater Exploration/Investigation and Monitoring Techniques

Credit Hours: 2

Prerequisites:

Summary and General Objective:

The course will teach the participants the principles of groundwater data collection and monitoring and the use of software to process and analyzed the information. The experiences of data collection and monitoring will be obtained through a series of lectures, hands-on training in class exercises and computer workshops

Specific Objectives:

- Know how to carry out groundwater data collection and analyses procedures relating to hydro- geological mapping and well inventories, surface geophysics, exploration drilling, well design, pumping tests and groundwater monitoring.
- Be familiar with the most popular groundwater codes: GEWIN, AQUIFERTEST, FREQ and NETGRAPH.
- Be able to visualize the application of data collection and monitoring techniques within the wider framework of groundwater studies.

Course Outline:

- Introduction: data collection and monitoring, Management and planning of surveys and networks.
- Available data and basic surveys: How to handle available data?, Hydro geological interpretation of remote sensing data, Hydro- geological mapping and well inventories.
- Surface geophysical methods: Principles of geo-electrical surveying, Variable electrode distance techniques, horizontal profiling, Hydro-geological interpretations.

- Exploration drilling: Selection of well sites, Drilling methods and their applicability, Geological and geophysical well logging; water quality sampling, Well design criteria and design methods, Well development
- Pumping tests: Principles of pumping tests, Field guidelines and data processing, Preliminary interpretation, Analyses of constant yield tests
- Design of networks: Network density for estimating global mean, Monitoring of diffuse pollution, Monitoring of waste disposal sites, Network density graph, Determination of network density with Kriging, Determination of sampling frequency.
- Instructional problems: Preparation of hydro-geological maps and sections, Interpretation of a Schlumberger measurement (GEWIN), Preparation of a well log, Analytical analysis of a step-drawdown test, Analytical interpretation of constant yield tests (AQUITEST), Error analysis using Kriging (GEO-EASE)
- Designing an adequate network (NETGRAPH), Interpretation of time series and assessing sampling frequency (FREQ)

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	20
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	12
Total Course Hours:	35
Required Self Reading Hours:	24
Required Assignment Hours:	18
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Bisson, R A and Lehr, J H, 2004.** Modern Groundwater Exploration: Discovering new water resources in consolidated rocks using innovative hydrogeologic concepts, exploration, drilling, aquifer testing and management methods, Willey-Interscience, 328p.
- **Kearey, P, Brooks, M and Hill, I, 2002.** An introduction to Geophysical Exploration, 3rd Edition, Blackwell Science, 262p
- **Kruseman, G P and de Ridder, N A, 1990.** Analysis and Evaluation of Pumping Test Data, Intl Inst for Land Reclamation, 377p

Code: NBI-IWRM 114

Course Title: Groundwater Management

Credit Hours: 2

Prerequisites: Principle of surface and subsurface hydrology

Summary and General Objective:

To provide students with the basic knowledge and skills for groundwater management

Specific Objectives:

- To know the global distribution of groundwater resources.
- To understand the basic concepts of groundwater management.
- To get familiarity with the economical aspects of groundwater.
- To learn how to design groundwater monitoring networks.

Course Outline:

- Groundwater Resources of the world: their use, global groundwater situation.
- Basic concept of groundwater hydrology
- Economic aspects of groundwater use.
- Principles of the regional assessment of groundwater resources
- Safe yield, GW depletion
- Groundwater/seawater boundary dynamics, Sea water intrusion, saltwater upcoming
- Management of coastal aquifers
- Groundwater monitoring,
- Groundwater conservation and demand management
- Local regulation, Wise use, Micro planning, Using laws and awareness.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	12
Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	10%
Final Exam:	50%
Course Project:	20%

References:

- **El-Kadi, A. I, 1995.,** Groundwater Models for Resources Analysis and Management - CRC,.
- **John L. Sonderegger and Willis D. Weight, 2001,** Manual of Applied Field Hydrogeology - McGraw-Hill.
- **Fetter, C.W. 1994,** Applied hydrogeology, 3rd edition, Prentice-Hall, Inc.

Code: NBI-IWRM 115

Course Title: Surface Water/Groundwater Interaction

Credit Hours: 2

Prerequisites: Principle of surface and subsurface hydrology

Summary and General Objective:

To provide students with the basic knowledge of the interaction Between surface water and groundwater

Specific Objectives:

- To understand the mechanisms used to couple the hydrologic processes
- To get familiarity with the river management and its relation to the groundwater system
- To understand the effect of land use on the groundwater resource
- To get the familiarity with using integrated water resource approach

Course Outline:

- Basic concept of surface water groundwater interaction
- Groundwater withdrawal impact on surface water
- Conjunctive use of groundwater and surface water
- River basin management and planning
- Aquifer vulnerability mapping with dynamic recharge and surface water boundaries
- Flood plain and interaction with groundwater
- groundwater/seawater boundary dynamics
- Impact studies for changes in land use and climate
- Impact studies of agricultural practices including irrigation, drainage and nutrient and pesticide management

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Janine Gibert, Jacques Mathieu, and Fred Fournie, 1997**, Groundwater/Surface Water Ecotones: Biological and Hydrological Interactions and Management Options - Cambridge University Press.
- **John L. Sonderegger, and Willis D. Weight, 2001,** Manual of Applied Field Hydrogeology - McGraw-Hill

Code: NBI-IWRM 116 (126)

Course Title: Groundwater Pollution and Transport Process

Credit Hours: 2

Prerequisites: Principle of surface and subsurface hydrology

Summary and General Objective:

To provide students with the basic knowledge and fundamental of groundwater pollution and the main transport mechanisms

Specific Objectives:

- To know the sources of groundwater pollution
- To understand the fundamentals of contamination, fate and transport
- To learn the main processes governing the contaminant movement
- To learn how to simulate and model contaminate transport

Course Outline:

- Overview and introduction to hydrology and groundwater pollution.
- Principles and fundamental concepts of groundwater flow.
- Contamination, fate transport and natural attenuation.
- Adjective flow; diffusion transport; diffusion and dispersion coefficients; partition coefficients; adsorption isotherms.
- Spatial and temporal variability of transport phenomena and coefficients.
- Derivation of advection dispersion equation and its use.
- Introduction to contaminant transport modeling.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Fetter, C.W, 1998** Contaminant Hydrogeology -. Prentice Hall.
- **Chunmiao Zheng and Gordon D. Bennett, 2002,** Applied Contaminant Transport Modeling - Wiley-Interscience
- **Domenico, Schwartz, 2002,** Physical and Chemical Hydrogeology - Wiley-Interscience

Code: NBI-IWRM 117

Course Title: Site Remediation

Credit Hours: 2

Prerequisites: Principle of surface and subsurface hydrology

Summary and General Objective:

To provide students with different techniques adopted for aquifer remediation subject to pollution from different sources

Specific Objectives:

- To get familiar with field investigation to formulate the pollution problem
- To put an action plan for mitigation or remediation
- To access technical and economical feasibility of applied techniques
- To get familiar with in-situ treatment techniques

Course Outline:

- Field investigations.
- Geotechnical and geophysical techniques.
- hydro geological conditions; risk assessment; contaminant transport.
- remedial action plan: containment systems (gas, surface water, and
- ground water).
- On-site and off-site treatment techniques (solidification, stabilization, land filling, and soil washing).
- In-situ treatment techniques (physical, biological, chemical and non-aqueous).
- Technologies for cleaning sites with subsurface contamination.
- Comprehensive design project involving design and evaluation of site remediation activities required.

Maximum Number of Participants: 20
Course Duration: 1 Semester
Course Lecture Hours: 21
Course Laboratory Hours: 6
Course Computer Hours: 6
Course Field Hours: 10
Total Course Hours: 32
Required Self Reading Hours: 24
Required Assignment Hours: 12

Teaching Method: Multimedia – computer applications- Field instruments.

Course Examination Method (Grading System):

Assignments: 10%
Class Participation: 10%
Mid-term: 20%
Final Exam: 40%
Course Project: 20%

References:

- **Genske, D.D., (2006),** Investigation, Remediation and Protection of Land Resources, Whittles Smith Publication, ISBN 1870325877.
- **Moyer, E. and Kostecki, P.K (Eds), (2002),** Remediation Handbook Amherst Publ. ISBN 1884940293

Code: NBI-IWRM 118

Course Title: Soil Physics

Credit Hours: 2

Prerequisites: Principle of surface and subsurface hydrology

Summary and General Objective:

To provide students with the basic knowledge and the main concepts of soil physics related to groundwater

Specific Objectives:

- To understand the physical characteristics of soils
- To get familiarity with the interaction between soil and water
- To know how to measure water content and potential
- To learn the principles of water movement in soil
- To learn soil structure
- To get basic knowledge of the vadose zone

Course Outline:

- Overview to the composition of soil
- General physical characteristics of soils
- Interaction between soil and water
- Properties of water relation to porous media
- Soil structure and aggregation
- Content and potential of soil water
- Flow of water in saturated / unsaturated soil
- Introduction to vadose zone hydrology

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	12
Course Computer Hours:	NA
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	12
Required Assignment Hours:	12

Teaching Method:	Multimedia – lab work

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Daniel Hillel, 1998,** Environmental Soil Physics: Fundamentals, Applications, and Environmental Considerations - Academic Press.
- **William A. Jury and Robert Horton, 2004** Soil Physics- Wiley
- **T. J. Marshall, J. W. Holmes, and C. W. Rose, 1996**, Soil Physics - Cambridge University Press

A.2.2 Cluster Area 2

A.2.2 Cluster Area 2

Water Quality and Sanitation Management

NBI-IWRM 121	-	Water Supply and Sanitation
NBI-IWRM 122	-	Water Quality Modeling, design, Operation &
NBI-IWRM 123		Monitoring
	-	Freshwater Stream Pollution and Control
NBI-IWRM 124	-	Environmental Hydraulics
NBI-IWRM 125	-	Hydro-geochemistry
NBI-IWRM 126	-	Types and Sources of Groundwater Pollution
NBI-IWRM 127	-	Bio-Treatment of Potable Water/Wastewater
NBI-IWRM 128	-	Water Treatment Processes and Plants
NBI-IWRM 129	-	Wastewater Management
NBI-IWRM 1201	-	Community Water Quality Monitoring Program
NBI-IWRM 1202	-	Communities and Hazardous Wastes
NBI-IWRM 1203	-	Water Quality Mapping and Data Management
NBI-IWRM 1204	-	Management of Solid and Hazardous Wastes

Master Title: Master Degree in Water Quality and Sanitation Management

Summary and General Objective:

By successful completion of the master degree, the participant should be able to;

- Analyse sanitation needs technologies and domestic water supply issues for rural peri-urban and urban areas within the context of IWRM and of groundwater management.
- The biological techniques applied for potable water and wastewater treatment and types and sources of pollution and means of its stoppage and treatment.
- Offers participants the opportunity to creatively apply their knowledge and experience in water quality and water treatment methods in design and engineering, operation & maintenance and rehabilitation of convention water treatment processes and plants.
- Using the mathematical models to understand surface water quality and water pollution dispersion models.
- Providing the Participant with the theoretical framework of the subsurface chemical processes that affect groundwater composition and the application of hydraulic engineering principles to problems of environmental concern.

Specific Objective:

The Students are knowledgeable on:

- Techniques of potable water and wastewater treatments, in particular the biological techniques and applying soft technologies in water and wastewater treatment compared to mechanical treatment systems.
- Explain types of pollution and sources and its impacts of stream fresh water pollution and identifying ways to mitigate and control the pollution effect.
- Design and execute the performance studies of the surface water intake for the water treatment plant and know-how for operating (process & quality control, trouble shooting) and maintaining of manually and semi-automated water treatment plants.
- Providing the participants with the main concepts of geochemistry, calculate solubility of minerals, the basic concepts of thermodynamics, know ion exchange equation, learn how to conduct hydro-geochemical transport models.
- Understanding the participant the main concepts of wastewater management, water quality and the design criteria and approaches to wastewater estimation.

Course Code: NBI-IWRM 121

Course Title: Water Supply and Sanitation

Credit Hours: 2

Prerequisites: Basic hydraulics and sciences

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Summary and General Objective:

By successful completion of the course participants should be able to;

- Analyze domestic water supply issues for rural peri-urban and urban areas within the context of IWRM
- Analyze sanitation needs technologies and uses for rural, peri-urban and urban situations within the context of IWRM

Course Outline:

- Domestic water supply sources
- Domestic water supply uses, and relative values
- Abstraction, transfer and storage systems and technologies
- Treatment systems (household, slow sand filters, rapid gravity filters)
- Sanitation systems (on site and off-site; dry and wet), waste valuation and ecological sanitation
- Community participation, institutional arrangements, Operation and Maintenance and gender
- Health and hygiene education
- Practical Case Studies

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Computer/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Feachem, R, McGarry, M and Mara D (Eds), 1978.** Water, wastes and health in hot climates, Vol 2, Wiley and Sons, 399p
- **Twort, A C, Hoather, R C and Law, F M, 1974.** Water supply, 2nd Edition, Edward Arnold (Publishers) Ltd, 478p
- **Pacey, A (Ed), 1978.** Sanitation in developing countries, Wiley and Sons, 238p
- **Gordon, M. John G** Water and Wastewater Engineering, Vol 2. John Wiley and sons.
- **Ray K . Linsley, Joseph Franzini Tchobanoglons ed** Water Resources Engineering McGraw Hill int. Edition

Course Code: NBI-IWRM 122

Course Title: Water Quality Modelling, Design, Operation & Monitoring

Credit Hours: 2

Prerequisites: Basic knowledge of hydrology and computer

Summary and General Objective:

After successful completion of the course, students are able to:

- Use mathematical models to understand surface water quality and processes influencing the same
- Understand water pollution dispersion models

Course Outline:

- Introduction to: Basic modelling concepts:
  - time series analysis;
  - control theory; modelling river systems;
  - modelling acidification processes;
  - modelling lakes and eutrophication;
  - modelling biological systems.
- Transport processes:
  - Concentration, advection and bulk transport;
  - Diffusion processes;
  - Solutions to Advection-Diffusion;
- Introduction to turbulent diffusion;
  - Time-averaged equations of motion;
  - Dispersion in un-directional flows; Jet dynamics.
- Thermal Effects.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	24
Course Computer/lab Hours:	20
Total Course Hours:	34
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Computer/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Wu-Seng Lung, 2001,** Water Quality Modelling for Wasteload Allocations and TMDLs, John Wiley & Sons
- **Michael L. Deaton, James J. Winebrake, 1999**, Dynamic Modeling of Environmental Systems (Modeling Dynamic Systems. Springer Verlag
- **Kolditz. Olaf, 2002**, Computational Methods in Environmental Fluid Mechanic. Springer-Verlag Berlin and Heidelberg GmbH & Co. KGs
- **G.P. Karatzas, A.C. Payatakes, V.N. Burganos, 1998,** Computational Methods in Water Resources: Computational Methods in Contamination and Remediation of Water Resources 12th (Water Studies) WIT Press

Course Code: NBI-IWRM 123

Course Title: Freshwater Stream Pollution and Control

Credit Hours: 2

Prerequisites: Basic knowledge of sciences and environmental engineering

Summary and General Objective:

This course deals with environmental pollution hazards. It covers the assessment of types and sources of pollution and means of its stoppage and treatment.

Specific Objectives:

Participants should be able to;

- Explain types of pollution and sources of stream fresh water pollution
- Learn ecologic Impacts of polluted fresh water stream
- To identify ways to mitigate the pollution effect
- Study methods and techniques used to prevent and control freshwater stream pollution
- Appreciate the difference between pollution control and prevention

Course Outline:

- Overview of Environmental Pollution and Climate Change.
- Pollution and the environment; Types and Sources of pollution (air, water, solid); Environmental Standards: national and international,
- Pollution assessment and analysis.
- Industrial Product Life Cycle Assessment, Clean technology, Environmental Conscious
- Design and Manufacturing. Practicals covering chemical, physical and biological analyses
- Water Quality: physical, chemical & biological water quality parameters.
- Application of cleaner technology to minimization of water pollution.
- Elements of water treatment.

- Physical, Chemical, Biological treatment processes and operations.
- Concept in treatment plants design.
- Sludge handling and treatment.
- Environmental impact of water and wastewater treatment plants.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Smol, J.P., 2002,**. Pollution of Lakes and Rivers: A Paleoenvironmental Perspective. Arnold Publ., London, 280p.
- **A.K. Chatterjee, 1998.** Water Supply, Waste Disposal and Environmental Engineering. 6th edition, Khanna publishers, Delhi,
- **Bradshaw, A.D.; Southwood, R. and F. Warner (Eds.), 1992,**. The treatment and handling of wastes. Chapman & Hall. London.
- **Forster, C.F. and D.A.J. Wase (Eds.), 1987**,. Environmental Biotechnology. Ellis Horwood Limited. Chichester.
- **Enger, Bredley F. Smith, 2000**, Environmental science. McGraw Hill publishers. Boston.

Course Code: NBI-IWRM 124

Course Title: Environmental Hydraulics

Credit Hours: 2

Prerequisites: Basic fluid mechanics, hydraulics and environmental engineering.

Summary and General Objective:

To provide students with the knowledge of application of hydraulic engineering principles to problems of environmental concern.

Specific Objectives:

- To learn the different pollution sources
- To understand scientific literature on environmental hydraulics
- To develop approximate solutions to real world problems in environmental hydraulics
- To evaluate the hazardous effects of pollutants
- To know how to predict the dispersal of nutrients and pollutants in aquatic systems.

Course Outline:

- Introduction, Hydraulics and the environment, Water quality and pollution sources, sources of pollution of surface and groundwater, Types and properties of pollutants.
- Diffusion and Dispersion, Derivation of the Diffusion Equation, Solutions of Diffusion Equation, Advective Diffusion, Turbulent Diffusion, Shear Flow Dispersion.
- Transport processes in Rivers, Mixing in Rivers, Continuous Point Discharges, Two Rivers Mixing, Dispersion in Rivers.
- Transport processes in Lakes and Reservoirs, Reservoir Classification, External Energy Sources, The Surface Layer, Mixing in the Hypolimnion, Inflows and Outflows.
- Transport processes in Estuaries Classification, Forcing – wind, tides, rivers, Trapping and Pumping, Estuarine Circulation, Jets and Plumes

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- Mixing in Inland and Coastal Waters - Hugo B. Fischer, John E. List, C. Robert Koh, and Jorg Imberger, Academic Press, 1979
- Environmental Hydraulics For Open Channel Flows - Butterworth-Heinemann -, 2004
- Surface Water Quality Modeling - Thomann and Muller, Prentice Hall, 1994.

Course Code: NBI-IWRM 125

Course Title: Hydro-geochemistry

Credit Hours: 3

Prerequisites: Basic knowledge of chemistry and groundwater hydrology

Summary and General Objective:

To provide the student with the theoretical framework of the subsurface chemical processes that affect groundwater composition

Specific Objectives:

- To get familiarity with the main concepts of geochemistry
- To learn how to analyze groundwater samples
- To calculate solubility of minerals
- To learn the basic concepts of thermodynamics
- To know ion exchange equation
- To learn how to conduct hydro-geochemical transport models

Course Outline:

- Introduction to groundwater geochemistry;
- why are we interested in groundwater geochemistry,
- groundwater quality, sampling of groundwater,
- analysis of samples; aqueous geochemistry;
- Field hydrochemistry; Solutions and minerals; ion exchange and sorption, weathering;
- Data presentation and interpretation; reactive solute transport. Environmental monitoring; hydro-geochemical transport modeling.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	5
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Appelo, C and Postma, D, AA, 1996,** Geochemistry, Groundwater and Pollution-Balkema,
- **Domenico, PA and Schwartz, FW, 1998,** Physical and Chemical Hydrogeology - Wiley, 2nd ed
- **Ramanathan et al. (Eds), 2005.** Mathematical models in Hydrogeochemistry: Assessment of groundwater quality and management, 358p
- **Kehew, A E, 2000.** Applied chemical hydrogeology, 1st Edition, Prentice Hall, 368p

Course Code: NBI-IWRM 126

Course Title: Types and Sources of Groundwater Pollution

Credit Hours: 2

Prerequisites: Basic knowledge of hydrology and computer

Summary and General Objective:.

Participants should be able to;

- Analyse types of pollution issues for rural peri-urban and urban areas within the context of groundwater management
- Analyse sources of pollution for rural, peri-urban and urban situations within the context of groundwater management

Course Outline:

- Sources of soil and groundwater pollution:
  - Agriculture, Aquaculture.
  - Industrial, Mining, Hydrocarbons spill (oil)
  - Domestic wastewater
  - Sea water intrusion, saltsater upcoming
- Soil sciences and groundwater hydrology;
  - the water cycle;
  - Soil Classification.
- Impact of chemicals and low qualitywater on groundwater; Role of vadios zone; Health aspects of groundwater pollution.
- Monitoring and control of groundwater pollution, monitoring the saturated and unsaturated zone (soil sampling, lysimeters, tensiometers), data acquisition and processing, control of pollution sources (non-point sources)
- Introduction of groundwater quality modelling
- Practical Case Studies

Maximum Number of Participants: 20
Course Duration: 1 Semester
Course Lecture Hours: 24
Course Computer/lab Hours: 20
Total Course Hours: 34
Required Self Reading Hours: 15
Required Assignment Hours: 10 (in class)

Teaching Method: Presentation/Computer/Lab/Field work.

Course Examination Method (Grading System):

Assignments: 15%
Class Participation: 15%
Mid-term: 20%
Final Exam: 40%
Course Project: 10%

References:

- **Walle, B. De & Sevenster, J., 1998,** Soil and Groundwater Pollution", Kluwer Academic Publishers.
- Zehnder, Alexander J. B, 1995, Soil and Groundwater Pollution", Kluwer Academic Publishers.
- **Cunnigham, W. P. and Saigo, B. W., 2001,** Environmental Science: A Global Concern. McGraw Hill, Sixth Edition, Boston.
- **Enger, E.G. and Smith B. F., 2000,** Environmental Science: A study of Interrelationship. Seventh Edition, McGraw-Hill Companies, Boston.
- **David Ahlfeld, Ann Mulligan, 2000,** Optimal Management of Flow in Groundwater Systems. Academic Press

Course Code: NBI-IWRM 127

Course Title: Bio-Treatment of Potable Water/Wastewater

Credit Hours: 2

Prerequisites: Basic knowledge of sciences and engineering fields

Summary and General Objective:

This course covers the biological techniques applied for potable water and wastewater treatment.

Specific Objectives:

Students are knowledgeable on:

- Techniques of potable water and wastewater treatments, in particular the biological techniques.
- Advantages of applying soft technologies in water and wastewater treatment compared to mechanical treatment systems.

Course Outline:

- Potable water treatment and associated problems (Algae, biological pollution, etc.)
- Biological characteristics of wastewater;
- principles of microbial metabolism; bacterial growth kinetics.
- Aerobic and anaerobic treatment systems, attached and suspended growth processes.
- Theory and principles of activated sludge, trickling filters, rotating biological contactors, lagoons and stabilization pond processes.
- Biological nutrient removal (Constructed wetlands).
- Toxicity screening of wastewater systems by microbial testing methods.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	20
Course Laboratory Hours:	6
Course Computer Hours:	12
Course Field Hours:	6
Total Course Hours:	35
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **MWH Soft Inc, 1998,** Pub Water Treatment Principles and Design, McGraw Hill
- **Letterman, R.D ,1999,**. Water quality and treatment a Handbook McGraw Hill
- **Peirce, J.J.; Weiner, R.F. and P.A Vesilind, 1998,**. Environmental Pollution and Control. Fourth Edition. Butterworth-Heinemann. Boston.
- **Miller, G.T. Jr., 2000,.** Living in the Environment: Principles, Connections, and Solutions. Brooks/Cole Publishing Company. London.
- **Forster, C.F. and D.A.J. Wase (Eds.), 1987**, Environmental Biotechnology. Ellis Horwood Limited. Chichester.
- **Enger, Bredley F. Smith., 2000,** Environmental science. McGraw Hill publishers. Boston.

Course Code: NBI-IWRM 128

Course Title: Water Treatment Processes and Plants

Credit Hours: 2

Prerequisites: Basic knowledge of sciences and environmental engineering

Summary and General Objective:.

This course offers participants the opportunity to creatively apply their knowledge and experience in water quality and water treatment methods in design and engineering, operation & maintenance and rehabilitation of convention water treatment processes and plants.

Summary and General Objective:.

On the conclusion of this course, the participant should be able to:

- Critically analyse water quality data and to select the most attractive raw water resource;
- Design and engineer a surface water intake and a water treatment plant;
- Execute plant performance studies and proposing improvements in order to rehabilitate the malfunctioning parts of the plant;
- Show professional know-how for operating (process & quality control, trouble shooting) and maintaining of manually and semi-automated water treatment plants.

Course Outline:

- Surface Water Collection & Storage: Direct intake: surface water resources, types of intake systems and structures, design and operational aspects, cost. Raw water reservoirs: functions, quality change, operation modes and design aspects, selective intake.
- Bank infiltration: types, quality aspects, treatment and cost. Artificial recharge. Design exercise: Raw water intake system.
- Water Treatment Processes and Plants: Raw and drinking water aspects, processes for groundwater and surface water, pre- and post treatment, Introduction to process/plant design. Design exercise: Identification of water resources, comparison and evaluation of various treatment methods and processes for

ground and surface water, calculation water demand, process design, calculation achieved drinking water quality, calculation of cost, engineering details.

- Operation & Maintenance of Water Treatment Plants: Basic aspects of O&M, writing an operating annual and drafting a programme for preventive maintenance.
- Process & Quality Control: Basics of process control, examples of process control in water supply, designing of a measuring programme supporting the (daily) process- and quality control.
- Rehabilitation of Conventional Water Treatment Plants: Reasons for process/ plant improvement, methods to evaluate the performance of existing conventional treatment plants, examples of technical solutions.
- Sludge Treatment & Disposal: Treatment of backwash water and sludge from coagulation units. Alternatives for disposal and re-use. Design of a sludge treatment process line.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	28
Course Computer/lab Hours:	10
Total Course Hours:	38
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/Computer/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Gordon, M. John G** Water and Wastewater Engineering, Vol 2. John Wiley and sons.
- **Ray K . Linsley, Joseph Franzini Tchobanoglons ed** Water Resources Engineering McGraw Hill int. Edition.

Course Code: NBI-IWRM 129

Course Title: Wastewater Management

Credit Hours: 2

Prerequisites: Basic environmental engineering background

Summary and General Objective:

This course covers the main concepts and criteria of wastewater management. It aims at providing the participants with principles, systems and processes in wastewater management.

Specific Objectives:

- To understand the main concepts of wastewater management
- To learn the principles of water quality
- To provide the students with the design criteria and approaches to wastewater estimation
- To learn the theory and construction details of treatment systems

Course Outline:

- Introduction to wastewater management: Overview of wastewater management; waste and water utilities management; private sector participation and commercialization; community- based management of wastewater and sanitation; ethical considerations.
- Principles and objectives of wastewater management: Water pollution control philosophy; legal and institutional frameworks; standards and regulations; public health and environmental impacts of water pollution.
- Principles of water quality: Introduction to water quality management; concepts and practices; classification and characterization of pollutants; discharge standards and the receiving environment.
- Systems and processes in wastewater management: Planning, design criteria and approaches to wastewater estimation, collection, conveyance and treatment systems; operation and maintenance of systems; Theory and design criteria and construction details of treatment systems.

- Overview of unit processes and operations in wastewater treatment.
- Industrial wastewater management and cleaner production.
- Wastewater disposal, effluent reuse and recycling.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	46
Required Self Reading Hours:	12
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Ronald W. Crites, George Tchobanoglous Small & Decentralized, 1998**, Wastewater Management Systems, - - McGraw-Hill Science.
- **Metcalf and Eddy, 1998.** Wastewater Engineering: Treatment, Disposal and Reuse, 3rd Edition, Tata McGraw-Hill Publishing Company, 1334p
- **Dahi, E (Ed), 1990.** Environmental Engineering in Developing Countries, Polyteknisk Forlag, 416p

Course Code: NBI-IWRM 1201

Course Title: Community Water Quality Monitoring Program

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide capacity for enhancing community understanding of their environment, water quality and the need to monitor water quality for their protection

Specific Objectives:

Participants should be able to;

- Identifying elements of environment
- Understanding Water quality parameters and their implications.
- Understand the monitoring of water quality and their protection
- The rule of community in water quality issues

Course Outline:

- Introduction to environmental and water quality protection
- Water quality aspects (physical, chemical and microbiological)
- Community activities and water quality pollution
- Water quality monitoring: Importance of macro-invertebrates and fish as indicators of water pollution
- Water quality monitoring: Simple methods for water quality testing
- Water quality data analysis, interpretation and reporting
- Designing community water quality monitoring programmes

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **David A Wardle 2002,** Communities and Ecosystem, Princeton UP
- **Wu-Seng Lung 2001,** Water Quality Modelling for Waste load Allocations and TMDLs, John Wiley & Sons

Course Code: NBI-IWRM 1202

Course Title: Communities and Hazardous Wastes

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide better understanding of the roles of communities on the generation, spread, storage, treatment and disposal of hazardous wastes

Specific Objectives:

Participants should be able to;

- Identifying hazardous wastes and their characteristics
- Identification of hazardous wastes.
- Management of hazardous wastes and recycling
- Management of hazardous wastes: Community treatment and disposal technologies

Course Outline:

- Introduction to hazardous wastes
- Hazardous waste characteristics
- Identification of hazardous wastes
- Management of hazardous wastes: Reduced consumption
- Management of hazardous wastes: Community recycling
- Management of hazardous wastes: Community treatment and disposal technologies

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **David A Wardle, 2002,** Communities and Ecosystem, Princeton UP
- **Wu-Seng Lung, 2001,** Water Quality Modelling for Waste load Allocations and TMDLs, John Wiley & Sons
- **Kreith, F., 1994,** Handbook of Solid Waste Management. McGraw Hill.
- **Tchobanoglous, G, 1993,**. Integrated Solid Waste Management", McGraw Hill.
- **Tchobanoglous, G.**, Theisen H. and S. Vigil, 1993, Integrated Solid Waste Management; Engineering Principles and Management Issues. McGraw Hill.
- **Enger, Bredley F. Smith, 2000,** Environmental science. McGraw Hill publishers. Boston.
- **Cheremisnoff, N.P, 2003,** Handbook of Solid Waste Management and Waste Minimization Technologies. Butterworth-Heinemann

Course Code: NBI-IWRM 1203

Course Title: Water Quality Monitoring and Data Management

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide relevant techniques for mapping WQ parameters to promote spatial analysis of the health of water resources for WQ monitoring

Specific Objectives:

Participants should be able to;

- Identifying Water Quality parameters
- Identification of hazardous wastes.
- Management of hazardous wastes and recycling
- Management of hazardous wastes: Community treatment and disposal technologies
- Chemical water quality issues: drinking water quality (e.g. impacts on human health; aesthetics), environmental water quality (e.g. eutrophication, eco-toxicity), agricultural water quality (e.g. salinity).
- Microbiological water quality issues: drinking water quality (e.g. impacts on human health), recreational water quality (human health); water quality in distribution.
- Biotic indicators of water quality.
- Water quality guidelines, standards and legislation. Role of WHO and EU
- Sampling strategies. Sampling methods: surface and groundwater. Quality assurance. Data handling and interpretation
- Methods of chemical analysis (probes, titrations, preservation of samples): visual methods; chromatography, spectophotometry, stoichiometry
- Microbiological testing (plate counts, membrane filtration, MPN)
- Biological sampling and analysis (BMWP system)

Course Outline:

- Introduction to GIS
- Database management
- Application of GIS in water quality spatial analysis
- Water quality parameters
- Hazard wastes
- Recycle of Hazardous wastes
- Management of hazardous wastes
- Introduction to waste disposal treatments
- Technology for waste treatment

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **David A Wardle, 2002,** Communities and Ecosystem, Princeton UP
- **Wu-Seng Lung, 2001,** Water Quality Modelling for Waste load Allocations and TMDLs, John Wiley & Sons

Course Code: NBI-IWRM 1204

Course Title: Management of Solid and Hazardous Wastes

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide knowledge of various aspects of solid and hazardous waste management including engineering principles of handling them

Specific Objectives:

Participants should be able to;

- Identifying solid wastes
- Identification refuses transfer and transport.
- Management of hazardous wastes

Course Outline:

- Management of solid wastes
  - Collection and storage of refuse
  - Refuse transfer and transport
  - Refuse disposal
- Management of hazardous wastes
  - Characterization of hazardous wastes
  - Waste minimization and recovery

  Hazardous waste management technologies

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Kreith, F. 1994,** Handbook of Solid Waste Management. McGraw Hill.
- **Tchobanoglous, G. 1993,** Integrated Solid Waste Management, McGraw Hill.
- **Tchobanoglous, G., Theisen H. and S. Vigil, 1993,** Integrated Solid Waste Management; Engineering Principles and Management Issues. McGraw Hill
- **Enger, Bredley F. Smith, 2000,** Environmental science. McGraw Hill publishers. Boston.
- **Cheremisnoff, N.P. 2003,** Handbook of Solid Waste Management and Waste Minimization Technologies. Butterworth-Heinemann

A.2.3 Cluster Area 3

A.2.3 Cluster Area 3
Irrigation Engineering Management

NBI-IWRM 131	-	Advances in Irrigation Engineering
NBI-IWRM 132	-	Advances in Agriculture Lands
NBI-IWRM 133	-	Management and Distribution of Irrigation water
NBI-IWRM 134	-	Land Reclamation and topography
NBI-IWRM 135	-	Soil – Plant – Water Relationship
NBI-IWRM 136	-	Soil, water and Agriculture conservation
NBI-IWRM 137	-	Sustainable agriculture
NBI-IWRM 138	-	Agro fisheries
NBI-IWRM 109	-	Numerical Methods for Water Resources

Master Title: Master Degree in Irrigation Engineering Management

Summary and General Objective:

- Providing the participants with principles of irrigation engineering and management.
- Teaching the participants the efficient ways of using water for irrigation to produce best yield. It provides the students with related aspects to deal with irrigation programs, economics, water conservation and minimum losses.
- Providing the participants with the necessary statistical knowledge for dealing with land reclamation and salinity control.
- Providing the participants with the Principles of Soil and Plant Water Relations and to know how water moves through the soil-plant-atmosphere continuum.

Specific Objective:

- Getting familiarity with water resources and use in different sectors, the relationship between soil-water-plant, study different methods of irrigation, know how to design subsurface and vertical drains and get familiarity with the environmental impacts of irrigation and drainage projects.
- Discuss and recommend an economically optimum irrigation management strategy for a given situation and appropriate methods for improving water use efficiency and select appropriate instrumentation for irrigation scheduling.
- Design of regional drainage systems, stability of ditches, subsurface drainage systems, wells and water table control and the drainage for salinity control of irrigated land. Institutional, management and maintenance aspects.
- Getting familiarity with significance of salinity, learn how to manage salinity problems and know different salinity management techniques.
- Getting the basic knowledge of Soil-Plant-Water relationship, soil water terminology, different types of Tensiometers and how they work, how to measure water content and potential and calculate evapotranspiration.

Course Code: NBI-IWRM 131

Course Title: Advances in Irrigation Engineering

Credit Hours: 2

Prerequisites: Knowledge of Basic hydraulics and agriculture land planning

Summary and General Objective:

To provide the participants with principles of irrigation and drainage engineering

Specific Objectives:

- To get familiarity with water resources and use in different sectors.
- To learn the relationship between soil-water-plant
- To study different methods of irrigation
- To know how to design subsurface and vertical drains
- To get familiarity with the environmental impacts of irrigation and drainage projects

Course Outline:

- Definitions
- Water resources and use in different sectors.
- Irrigation water quality - soil-water-plant relationships
- Estimation of water requirements
- Different types of field water application: Surface irrigation methods, Sprinkler and drip irrigation, subsurface irrigation;
- Planning, design, management, operation and maintenance for different irrigation methods;
- Canal lining.
- Introduction to drainage, types, Factors influencing selection and design; subsurface drainage - Vertical drainage
- Planning of irrigation and drainage networks.
- Design of open, Subsurface and vertical drains.

- Disposal of drainage water and drainage water reuse and precautions.
- Environmental impacts of irrigation and drainage projects.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	8
Total Course Hours:	34
Required Self Reading Hours:	24
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Santosh Garg, 2005,** Irrigation Engineering and hydraulic structure –Khanna Publishers, Delhi
- **M. E. Jensen, 1980,** Design and operation of farm irrigation system-

Course Code: NBI-IWRM 132

Course Title: Advances in Agriculture Lands

Credit Hours: 2

Prerequisites: Knowledge of basic hydraulics and flow through porous media

Summary and General Objective:

To provide students with the Principles of drainage management

Specific Objectives:

- To understand the theories of water movement and drainage systems
- To design regional drainage systems
- To design subsurface drainage system

Course Outline:

- Land drainage in relation to soils and crops.
- Design of regional drainage systems, stability of ditches.
- Design of subsurface drainage systems.
- Theories of flow into drain tubes.
- Hydraulics of wells.
- Drainage of irrigated lands.
- Water table control.
- Drainage for salinity control of irrigated land. Institutional, management and maintenance aspects

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	8
Total Course Hours:	34
Required Self Reading Hours:	24
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%

References:

- **Malano, H M and van Hofwegen, P, 1999.** Management of irrigation and drainage systems, 160p
- **Smedema, L. K. and D.W. Rycroft., 1983,** Land Drainage: Planning and Design of Agricultural Drainage Systems Cornell University Press, Ithaca, New York
- **Lambert K. Smedema, Wilhelm F. Vlotman, David W. Rycroft, Taylor & Francis, 2004,** Modern Land Drainage.
- **Cuenca, R.H. , 1989,** Irrigation System Design: An Engineering Approach - Prentice Hall, NJ

Course Code: NBI-IWRM 133

Course Title: Management and Distribution of Irrigation water

Credit Hours: 2

Prerequisites: Basic hydraulics, agriculture eng. and water resources

Summary and General Objective:

This course covers the details of the efficient ways of using water for irrigation to produce best yield. It provides the students with related aspects to deal with irrigation programs, economics, water conservation and minimum losses

Specific Objectives:

On successful completion of this study, the participant should be able to:

- Discuss potential criteria for evaluating and optimising irrigation management
- Evaluate and use a range of methods for quantifying the benefits of irrigation, with a focus on yield and quality
- Evaluate a range of methods for quantifying the costs of irrigation
- Discuss and recommend an economically optimum irrigation management strategy for a given situation, and appropriate methods for improving water use efficiency.
- Determine the net irrigation requirement for a given soil / vegetation / climatic environment.
- Schedule irrigation on the basis of plant water status, soil water status and water balance methods.
- Select appropriate instrumentation for irrigation scheduling

Course Outline:

- Objectives of irrigation management: optimisation of resource use; environmental responsibility
- Quantifying irrigation requirements and benefits: climate and potential crop production, evaporation under standard and drought stress conditions; critical deficits; responses (yield and quality) to drought stress; case study of an irrigation program for a selected crop

- Quantifying water supply and costs: water resources management; capital and operating cost components; economics of irrigation; cost-benefit analysis.
- Maximising water supply; minimising unproductive water use: use of audits and the need to monitor; water use efficiency; water conservation; water storage;
- Minimising irrigation losses; minimising evapotranspiration, deficit irrigation, uniformity and accuracy of applications. Effects of climate change.
- Real-time irrigation scheduling: the need for good scheduling, scheduling by plant or soil water status, scheduling by water balance methods. Case studies in agriculture, horticulture or turf-grass irrigation.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	6
Total Course Hours:	34
Required Self Reading Hours:	24
Required Assignment Hours:	12

Teaching Method:	Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Santosh Garg, 2005,** Irrigation Engineering and hydraulic structure –Khanna Publishers, Delhi
- **M. E. Jensen, 1980,** Design and operation of farm irrigation system-

Code: NBI-IWRM 134

Course Title: Land Reclamation and topography

Credit Hours: 2

Prerequisites: Agriculture, civil engineering and related specialties

Summary and General Objective:

To provide students with the necessary statistical knowledge for dealing with land reclamation and salinity control.

Specific Objectives:

- To get familiarity with significance of salinity.
- To learn how to manage salinity problems
- To know different salinity management techniques
- To get familiarity with the procedures for reclamation of salt-affected soil
- To get familiarity with modern surveying techniques related to land topography

Course Outline:

- Salinity in irrigated agriculture,
- Salinity effects on crops,
- Crop salt tolerance,
- Salinity management,
- Drainage,
- Salinity control by leaching,
- Land development for salinity control, Irrigation Water Quality,
- Salinity Management Techniques,
- Reclamation of Salt-Affected Soil,
- Water requirement,
- Land shaping,
- Farm water distribution system and management

- Land topography
- Advanced surveying
- Computer applications

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	28
Course Laboratory Hours:	NA
Course Computer Hours:	NA
Course Field Hours:	12
Total Course Hours:	34
Required Self Reading Hours:	12
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Sharma, R D, 2001.** Impacts of subsurface drainage on reclamation of saline land in Chambal Command Area (1993-1998), Rajasthan Agricultural Drainage Research Project
- **Moore, H M, Fox, H R and Elliott, S, 2003.** Land reclamation: Extending boundaries, 404p
- **Hester, R E and Harrison, R M, 2001.** Assessment and reclamation of contaminated land, British Nuclear Energy Society, 164p
- **M. E. Jensen,** 1980 Design and operation of farm irrigation system-
- **R.S. Ayers, and D.W. Westcot , 1989,** Water quality for agriculture-, FAO Irrigation and Drainage Paper

Code: NBI-IWRM 135

Course Title: Soil – Plant – Water Relationship

Credit Hours: 2

Prerequisites: Basic knowledge of soil physics and water properties

Summary and General Objective:

To provide students with the Principles of Soil and Plant Water Relations and to know how water moves through the soil-plant-atmosphere continuum

Specific Objectives:

- To gain the basic knowledge of Soil-Plant-Water relationship
- To get familiarity with the Soil water terminology
- To learn the different types of Tensiometers and how they work
- To know how to measure water content and potential
- To learn Poiseuille's law for water flow in roots
- To calculate evapotranspiration

Course Outline:

- Introduction, why study Soil-Plant-Water relations, the soil-plant atmosphere continuum,
- Water relations of plant cells and tissues,
- Structure and properties of water. Tensiometers, description and types of Tensiometers.
- Soil water terminology and application: water content, water potential, movement of water between Tensiometers.
- Static water in soil: surface tension, rise and fall of water in soil pore, field capacity, wilting point.
- Penetrometer measurement.
- Infiltration.
- Uptake of soil moisture by plants; Root anatomy, hydraulic process of roots.

- Poiseuille's law for water flow in roots.
- Gardner's Equation for water movement to plant root.
- Evapotranspiration

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	18
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%

References:

- **M.B. Kirkham, 2004,** Principles of Soil and Plant Water Relations - Academic Press.
- **Daniel Hillel, 1998,** Environmental Soil Physics: Fundamentals, Applications, and Environmental Considerations - Academic Press.

Code: NBI-IWRM 136

Course Title: Soil, Water and agriculture Conservation

Credit Hours: 2

Prerequisites: Agricultural and rural development personals

Summary and General Objective:

The course introduces the problem of soil erosion and land degradation and the climatic effect of the problem. How to model soil erosion, and classification of land and soil. Also it Introduce the concept of water harvesting.

Specific Objectives:

- Describe the main kinds of soil erosion and land degradation.
- Demonstrate an understanding of the climatic and edaphic factors contributing to land degradation
- Use simple methods to model soil erosion
- Assess land degradation using simple classification methods
- Use a simple land classification system
- Describe a range of appropriate agronomic and physical measures to ameliorate land degradation in a drought prone area.
- Design a simple water harvesting scheme
- Discuss the main social, political and economic contributor factors influencing land degradation
- Lay out contours and small gradients using simple surveying implements
- Demonstrate an understanding of the operation of advanced surveying tools

Course Outline:

- Soil and water conservation, and soil improvement, one of the greatest challenges of our time
  . Some of the wrong ideas and practices concerning soil conservation
  . Soil
  . A closer look at better plant nutrition
  . Improving the soil management
  . Erosion

. Soil conservation theory
. Soil and fertility conservation
. Water conservation
. Forestry and agroforestry
. Bamboo: An undervalued crop plant
. Livestock
. Some grasses and legumes for use in soil conservation
. Practical surveying of land for soil conservation
. Appropriate field trials
. Weed control
. What are the needs for research and development for genuine sustainable soil conservation and improvement; particularly that appropriate for normal third world situations?
Extension policy and methods

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	28
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	34
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **A Manual of Soil and Water Conservation and Soil Improvement on Sloping Lands,** The Conservation and Improvement of Sloping Land Volume 1: Practical Understanding, P.J ISBN 978-1-57808-201-8; 2002. Storey

Course Code: NBI-IWRM 137

Course Title: Sustainable agriculture

Credit Hours: 2

Prerequisites: Basic knowledge of water, agriculture and other sciences

Summary and General Objective:

To provide students with importance of sustainability for agriculture issues, water for food..

Specific Objectives:

- Identifying challenges for sustainability
- Need for integrated agricultural system

Course Outline:

- The growing demand for food and fiber
- The challenges to reduce poverty
- Resource depletion and degradation
- Land, water and the environment
- Loss of animal and plant species
- Challenges to sustainable forestry
- Challenges to sustainable fisheries
- The challenge in developing human capital
- The need for a long-term global perspective
- Harmonizing general and sectoral policies
- Integrating action within the agricultural sector
- Building an appropriate legal and institutional structure
- Policy making that accounts for imperfect knowledge
- Risk, risk aversion and downside risk
- Precautionary principles and adaptive planning

- The need for a systems approach to policy making
- Policies relating to agricultural and rural development
- Rural infrastructure,
  - Building human capital for the rural sector
    Agricultural research and technology development
    Agricultural prices
    Stabilization and risk in agriculture
    Direct government involvement
    Sustainable rural livelihoods
    Food and nutrition
- Integrated approaches
- Improving the efficiency and sustainability of rural resource use
- Improving the efficiency and sustainability of farm production
  - Forestry
  - Fisheries
  - Rural development
- Implementing the guidelines
- Improving information
- Education and training needs
- International cooperation, Extended cost-benefit analysis, Cost- effectiveness analysis, Multi-criteria analysis
- Impact assessment, Appraisal,
- Decision making, Implementation, Monitoring and evaluation

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	22
Course Laboratory Hours:	NA
Course Computer Hours:	8
Course Field Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Reijntjes, C, Haverkort, B and Baye, A W, 1992**. Farming for future: An Introduction to Low-External In-put and Sustainable Agriculture
- **J. Bunders, J, Haverkort, B and Hiemstra, W, 1996.** Biotechnology: Building on Farmers' Knowledge, Diane Publishing Company
- **Peterson, G A, Unger, P W and Payne, W A (Eds), 2006.** Dryland Agriculture, Agronomy monograph No.23, 2nd edition, American Society of Agronomy, 1026p
- **Guidelines for the integration of sustainable agriculture and rural development into agricultural policies. 1997** (FAO agricultural policy and economic development series 4) ISBN 92-5-104104-0

Code: NBI-IWRM 138

Course Title: Agro-Fisheries

Credit Hours: 2

Prerequisites: Agricultural and rural development personals

Summary and General Objective:

The course introduces the integration between fish farming and agriculture.

Specific Objectives:

- Explain and discuss quantitative and qualitative indicators of sustainability in conventional and fish, agriculture in order to assess the direction and degree of sustainability of a farm or a farming system;
- Examine and appraise indicators of sustainable soil, water, and biodiversity management in agroecosystems
- IWRM through fisheries and agriculture
- agro fisheries management and relate it to social, economic, and political indicators of sustainability, including equity and community development Suitable plants and fisheries for agro fisheries

Course Outline:

- Relation between fishery and agriculture
- Social and economic benefits of agro fisheries
- IWRM and fisheries, agriculture
- biodiversity management in agroecosystems
- Sustainability of a farm or a farming system;

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	28
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	10
Required Assignment Hours:	10

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Hoboken, N.J. 2006,** Agriculture: Aquaculture and Fisheries: John Wiley & Sons

A.2.4 Cluster Area 4

A.2.4 Cluster Area 4

River Engineering and Drainage Management

NBI-IWRM 141	-	River Basin Management
NBI-IWRM 142	-	Open Channel and Alluvial Hydraulics
NBI-IWRM 143	-	Surface Water Hydrology
NBI-IWRM 144	-	Surface water Hydraulic modeling
NBI-IWRM 145	-	Storm water and mine Drainage
NBI-IWRM 146	-	Reservoir and Wetlands Storage
NBI-IWRM 147	-	Hydraulic Transients in Hydropower Systems
NBI-IWRM 154	-	Watershed Modelling and Management
NBI-IWRM 186	-	Application of GIS and RS in WRM
NBI-IWRM 109	-	Numerical Methods for Water Resources

M.Sc. Title: River Engineering and Drainage management

Summary and General Objective:

This course provides the participant with basic knowledge about fluid mechanics, hydraulics in open channel & modeling technique, sediment transport and river morphology in addition to River management and hydrological cycle of the whole Nile basin. Understanding principles of dam design, construction, operation, regulation and rehabilitation. This course enables students to plan, design and analyze various components of hydropower schemes such as types of turbines, their characteristic and performance along with the associated equipments. It covers structural and mechanical components from water intake through water conveyances and powerhouse up to return flow to Original River

Specific Objectives:

- Development of hydrodynamic equations and their applications to the open channel flow. Applications for transient regime in channels: kinematic and diffusive waves Applications for hydraulic design of prismatic channels and stilling basins. Various types of measuring equipments. Flow over broad crested weir, through a contraction, underneath a gate.
- Physical and mathematical model design techniques. Selection the suitable model: Physical or mathematical, distorted or undistorted, fixed or movable, 1D, 2D or 3D.
- Implement finite difference schemes to solve ordinary and partial differential equations and build a river flood model using SOBEK 1D and 2D, including specification of geometry and boundary conditions
- Sediment transport Phenomena, properties of the sediment, initiation of motion, bed forms & roughness, sampling techniques, elaboration of the sediment, prediction of sediment transport.
- Understanding the hydrological cycle of the whole Nile basin, dealing with each tributary in turn but drawing attention to links between reaches. The relationship between hydrology and vegetation affects the important wetlands of the White Nile basin, and discussion of this relationship includes the effect of increased lake outflows. The extensive records collected throughout the basin to help paint a detailed hydrological picture of the regime of the Nile.
- Familiarity with type of dams and their functions, how to select a suitable dam type

for give conditions, field investigation for construction (structural and geotechnical), How to propose a dam design based on long-term hydrologic analysis, familiarity with aspects related to dam operation, safety and rehabilitation

- Describing forms of energy focusing on water energy, the status of global energy supply and sources as well as the situation in the Nile basin. Emphases are on hydropower projects and development including feasibility, implementation and maintenance along with economic.
- To get familiar with different types of turbines, features, arrangement and performance, main components, equipments and instrumentation of hydropower plants.
- Advanced understanding and working knowledge on main principles and practices used in the analysis and hydraulic design of dams for storage, regulation and hydropower development. Principles and operation of the sediment in reservoirs and operation rules. Evaluating the impacts of in-stream flow works over the appropriate timescales. Understanding steady and unsteady flow, transient flow and periodic flow (oscillatory), column separation and water hammer
- Advanced knowledge on use of the surface and underground storage for water harvesting. Systems for rain and floodwater harvesting.
- Familiarize participants with recent advances and updated framework of integrated river management, planning, monitoring and surveying (remote sensing) and operation and maintenance of riverine (sub-) systems, including the treatment of hydraulic infrastructure works, watercourses and riparian land areas (floodplains).
- To understand the relationships between natural water resources and socio-economic systems, concepts and measures to improve the performance of water resources systems and principles and advances in planning and implementation of hydraulic engineering and water resources development schemes in river basins.
- Understanding the various aspects in analyzing data and developing strategies, including planning and implementation of hydraulic infrastructure works for different geographical and time scales, for the purpose of establishing river basin development schemes

- This module develops specialist scientific knowledge and understanding of how rivers function at the basin, reach and channel levels and to use this knowledge of the 'natural' process system as a basis for managing rivers and wetlands effectively. The emphasis is on Nile river environments, within a global context. The module identifies the main controls and areas of leverage (human intervention) within fluvial systems at different spatial and temporal scales. It apprises the specialist skills required for efficient investigation of rivers and wetlands from hydrological, geomorphological and ecological perspectives and evaluate critically the inter-relationships between pure and applied fluvial research. The module allows debate about current issues involved in river/ wetland management and conservation within a framework of European and International policy. There is critical evaluation of the role of different specialists within multi- and inter-disciplinary river management teams

Code: NBI – IWRM 141

Course Title: River Basin Management

Credit Hours: 2

Prerequisites: Basic hydraulics and Water Resources

Summary and General Objective:

- This course covers the broad spectrum of river management including planning, monitoring, developing strategies and infrastructure works. It provides the students with the state of the art of the related topics.

Specific Objectives:

- Familiarize participants with recent advances and updated framework of integrated river management, planning, monitoring and surveying (remote sensing) and operation and maintenance of riverine (sub-) systems, including the treatment of hydraulic infrastructure works, watercourses and riparian land areas (floodplains).
- Familiarize participants with relationships between natural water resources and socio-economic systems, concepts and measures to improve the performance of water resources systems and principles and advances in planning and implementation of hydraulic engineering and water resources development schemes in river basins.
- Familiarize participants with various aspects in analyzing data and developing strategies, including planning and implementation of hydraulic infrastructure works for different geographical and time scales, for the purpose of establishing river basin development schemes
- This module develops specialist scientific knowledge and understanding of how rivers function at the basin, reach and channel levels and to use this knowledge of the 'natural' process system as a basis for managing rivers and wetlands effectively. The emphasis is on Nile river environments, within a global context. The module identifies the main controls and areas of leverage (human intervention) within fluvial systems at different spatial and temporal scales. It apprises the specialist skills required for efficient investigation of rivers and wetlands from hydrological, geomorphological and ecological perspectives and evaluate critically the inter-relationships between pure and applied fluvial

research. The module allows debate about current issues involved in river/ wetland management and conservation within a framework of European and International policy. There is critical evaluation of the role of different specialists within multi- and inter-disciplinary river management teams.

Course Outline:

- River System Management;
- Principles of integrated management of riverine systems, including the role of monitoring and modelling forecasting and the use of decision support systems.
- Water Resources Development; potentials and uses of water resources and factors affecting these, including the scope and role of hydraulic engineering in WRM/WRD projects.
- Workshop on River Basin Development; problem analysis, policy making, planning and engineering aspects; integration of scales in time and space; exercises and computer simulations on water supply and demand and floodplain management.
- Computational Hydraulics; linking physical processes and mathematical descriptions and comparison of traditional methods with modern mathematical modeling techniques; hands on experience with mathematical models; physical Models; physical laws and modeling; reproduction of various hydraulic phenomena like 2D and 3D flows in rivers, over and through the hydraulic structures, sediment transport, morphology, air entrainment and local scour.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Laboratory Hours:	-
Course Computer Hours:	4
Course Field Hours:	10
Total Course Hours:	32
Required Self Reading Hours:	20
Required Assignment Hours:	10 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	20%
Mid-term:	-
Final Exam:	60%
Course Project:	-

References:

- **Beek, E. van & D.P. Loucks, 2005.** Water Resources Systems Planning and Management - an introduction to methods, models and applications. UNESCO. Paris, France.
- **Anderson, M. G., Walling, D. E. and Bates, P. D. (eds)m 1996,** Floodplain Processes (Wiley, Chichester)
- **Best, J. L. and Bristow, C. S, 1993,** Braided Rivers Geological Society Special Publication No. 75
- **Billi, P., R.D. Hey, C.R. Thorne and P. Tacconi, 1992,** Dynamics of Gravel-bed Rivers (Wiley, Chichester)
- **Boon, P. J. and Calow, P., 1992,** River Conservation and Management (Wiley, Chichester)
- **Brookes, A., 1988,** Channelised Rivers: perspectives for environmental management (Wiley, Chichester)
- **Brown, A. and Quine, T., 1999,** Fluvial Processes and Environmental Change (Wiley, Chichester)
- **Carling, P. and Beven, K., 1989,** Floods: hydrological, sedimentological and geomorphological implications (Wiley, Chichester)

Course Code: NBI – IWRM 142

Course Title: Open Channel and Alluvial Hydraulics

Credit Hours: 2

Prerequisites:

Summary and General Objective:

To provide the participants with a basic knowledge of:
Uniform and non-uniform steady and unsteady flow in rivers and hydraulics of control structures. Emphasis is put onto the hydraulic concepts. Sediment transport in rivers and hydraulic roughness; floodplain roughness. River systems as process-response systems; river morphology, river characteristics and impacts of anthropogenic interventions in river systems. riverine ecosystems in floodplains; water quality and impact of hydraulic structures

Specific Objectives:

- Development of hydrodynamic equations and their applications to uniform and non-uniform flow
- Experimental results as support to the theory such as velocity distribution, characteristics of turbulence and friction coefficients for fixed and mobile channel beds, composite roughness, flow in curves and instabilities at the free water surface
- Gradually and rapidly varied flow, equations of water surface profiles
- Hydrodynamic equations and different methods of solution
- Applications for transient regime in channels: kinematic and diffusive waves Applications for hydraulic design of prismatic channels and stilling basins
- Various types of measuring equipments.
- Flow over a broad crested weir, through a contraction, underneath a gate
- sediment transport phenomena
- Properties of the sediment, Initiation of particle motion,
- Transportation mechanics bed forms, alluvial roughness, Floodplain roughness
- Prediction of sediment transport. Sampling techniques. Elaboration of sediment data.

Course Outline:

- River systems and river hydraulics; types of flow and hydraulics of control structures;
- Transient regime in channels: kinematic and diffusive waves, sudden failure of a dam,
- Hydraulic design of prismatic channels and stilling basins.
- Hydraulic laboratory tests
- Sediment Transport in Rivers and River Dynamics.
- riverine, hydraulic and morphological impacts of anthropogenic interventions.
- Computational methods for river engineering.
- Riverine ecosystems and water quality.
- Relation between riverine ecosystems and environmental factors in floodplains.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	20
Course Laboratory Hours:	10
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	35
Required Self-Reading Hours:	10
Required Assignment Hours:	10 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System): NA

Assignments:	20%
Class Participation:	20%
Mid-term:	20%
Final Exam:	40%
Course Project:	-

References:

- **Chang, H.H., 2001,** Fluvial processes in river engineering, Krieger Pub Co [ISBN: 1575242125]
- **Jansen, P.Ph., L. van Bendegom, J. van den Berg, M. de Vries & A. Zanen, 1979,** Principles of River Engineering; The Non-Tidal Alluvial River. Pitman, London [ISBN 0-273-01139-1]
- **Rijn, L.C. van, 1993,.** Principles of Sediment Transport in Rivers, Estuaries and Coastal Seas. Aqua Publications, Amsterdam [ISBN 90-800356-2-9]
- **Thorne, C.R., Hey, R.D., Newson, M.D. eds., 1997,** Applied Fluvial Geomorphology for River Engineering and Management. John Wiley and Sons, England, 376 pages [ISBN 0-471-96968-0]
- **Chow, V.T. , 1983** Open Channel Hydraulics, McGraw-Hill
- **Petersen, M., 1985,** River Engineering, Prentice Hall [ISBN: 013781352X]

Course Code: NBI-IWRM 143

Course Title: Surface Water Hydrology

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

This subject concentrates on the quantification of surface hydrological processes. An understanding of rainfall, evapotranspiration, runoff, groundwater recharge, is essential for those involved in the science, engineering or management of the water environment. This module provides a conceptual and quantitative understanding of hydrology and the basic principles of hydraulics as a basis for later applied studies of water quality, water engineering, and water management.

Specific Objectives:

On successful completion of this module the student will be able to:

- Understand the basic hydraulic principles of static and moving water.
- Measure point and estimate areal rainfall. Estimate potential evapotranspiration from weather data and understand the relationship between actual and potential evapotranspiration.
- Differentiate between various runoff processes and identify the conditions under which each are important.
- Choose the appropriate flow measurement technique for different types of watercourses.
- Calculate the discharge of a watercourse by the velocity area method and by use of weirs and flumes.

Course Outline:

- The hydrological cycle and the influence of man.
- Basics of hydraulics: SI Units, properties of fluids, basic mechanics.
- Hydrostatics: Pressure, pressure measurement, pressure and forces on submerged surfaces.

- Fluids in motion: Types of flow. Continuity, energy and momentum equations and their applications. Behaviour of a real fluid.
- Precipitation, measurement of precipitation amount and intensity, spatial analysis. Interception and depression storage. Evapotranspiration, Penman approach, actual evapotranspiration. Runoff processes; overland flow, interflow, base flow.
- Runoff measurement; velocity area methods. Structures; hydraulic principles of weirs & flumes. Stage measurement. Rating curves and other methods

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Hornberger, G.M., Raffensberger, J.P., Wiberg, P.L., and Eshleman, K.N, 1998**, Elements of physical hydrology. Johns Hopkins University Press, Baltimore, 302p
- **Linsley, R.K. et al., 2000,** Hydrology for Engineers –McGraw Hill So.
- **Linsley, R.K. et al., 2000,** Water Resources Engineering Engineers –McGraw Hill So.
- **Freeze, A. and Cherry, 1979,** Groundwater hydraulics, Academic Press.

Course Code: NBI – IWRM 144

Course Title: Surface water hydraulic modeling

Credit Hours: 2

Prerequisites: Basic Mathematics, Hydraulics, Computational fluid dynamics

Summary and General Objective:

This course aims at providing the participants with the state of the art of surface water modeling. They will be familiarized with structure of equation systems, numerical solution techniques and their representation in modelling systems and practical. They will get practical experience with standard models and develop an understanding of steady flow modeling in rivers. Introduce of the use and design of hydraulic model studies as a tool for improving hydraulic engineering solutions.

On completion of this course the participants are able to

- Programs a computer code for calculating free-surface flow in canals and provide interpretation of a series of test involving various initial and boundary conditions
- Build a river flood model using SOBEK 1D and 2D, including specification of geometry and boundary conditions
- Understand and explain the foundations of mathematical modelling
- Explain how modelling software is developed, how to identify the type of model to use for a given application, how to select the modelling software, what modelling software is available, and how to instantiate and use a model safely in the context of a project
- Describe the application of modelling in different situations involving rivers and coastal waters
- Specify, design and build a simple modelling system

Specific Objectives:

On completion of this module the participants are 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

- Explain how to model the concentration of substances in the flow
- 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 and indicate if the scheme is likely to exhibit numerical diffusion, dispersion and/or instability and Implement different numerical schemes for water related problems
- Know about the main notions and types of information and knowledge systems and implement information systems using database technology using the Borland Delphi application development environment and MS-Access

Course Outline:

- Introduction of primary features, how to set up branch geometry, cross sections, roughness, structures, boundary conditions, running a model.
- Exercise on the various free surface profiles (backwater, drawdown), etc. Use of commercially available packages.
- Exercise on hydraulic jump, mass, momentum and energy balance.
- Exercises on sudden changes in geometry.
- Hands on experience with mathematical models
- Physical laws and modeling. Application area of physical models. Application of dimensional analysis in theory of similarity. Derivation and use of scale laws, and conditions.
- Scale effects, accuracy of measurements and costs as determining factors for scale selection.

- Design, calibration and verification of hydraulic scale models. Reproduction of various hydraulic phenomena like 2D and 3D flows in rivers, over and through the hydraulic structures, sediment transport, morphology, air entrainment and local scour.
- Physics of flood generation; flood wave propagation in natural rivers; introduction to SOBEK 1D or HAC-RAS; exercises on flood waves in regular channels; exercise and workshop on modelling floods in a real 1D system
- Context of modelling; nature of modelling; conceptualisation; physically-based modelling software; modelling in the context of projects; building a model, calibration and verification, confirmation, verifying the structural integrity of the model domain, working with model uncertainty, applying a confirmed model including base line performance; mathematical modelling in practice.
- Developing modelling and graphical components of water-based system using standard numerical and computer graphics toolboxes

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Laboratory Hours:	6
Course Computer Hours:	6
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	10
Required Assignment Hours:	10 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System): NA

Assignments:	20%
Class Participation:	20%
Mid-term:	20%
Final Exam:	40%
Course Project:	-

References:

- **Hornberger, G.M., Raffensperger, J.P., Wiberg, P.L. and Eshleman, 1998,** K.N. Elements of physical hydrology. John Hopkins Univ. Press
- **Chow, V.T. , 1983,** Open Channel Hydraulics, McGraw-Hill

Course Code: NBI-IWRM 145

Course Title: Storm Water and mine Drainage

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

An overview of stormwater management. Topics include stormwater management history and regulations, urban hydrology and hydraulics, stormwater quality and receiving-water impacts, design of drainage systems, mine drainage and best management practices, and computer modeling techniques.

Specific Objectives:

Participants should be able to;

- Describe and explain the local and federal stormwater regulations.
- Appraise municipal stormwater management program elements and recommend modifications to meet local and federal regulations.
- Discuss stormwater runoff quantity and quality characteristics and interpret their impacts on receiving water systems.
- Predict stormwater runoff flow rates, volumes, hydrographs, pollutant loads, and pollutant concentrations.
- Plan construction site erosion and sediment control.
- Analyze stormwater drainage systems using state-of-the-practice computer modeling techniques.
- Design stormwater best management practices for mine drainage, control structures, and conveyance systems

Course Outline:

- History of Stormwater Management
- Stormwater Management Paradigms
- Small Storm Urban Hydrology
- Stormwater Regulations

- Pollutants/Stressors – Receiving Water Effects
- Pollutant Loading
- Stormwater Modeling
- Site Design / Better Site Design
- Construction Site Erosion and Sediment Control
- Preparing an Erosion and Sediment Control Plan
- Gutter Flow, Inlet Design, Source Controls, and Water Quality Inlets
- Hydraulics of Storm Drains
- Design of Storm Drains
- Bioretention Areas, Vegetated Swales, Filter Strips
- Design of Bioretention Areas
- Design of Vegetated Swales (Biofilters)
- Stormwater Infiltration; Infiltration Basin Design
- Infiltration Trench Design
- Sand Filters
- Detention Basin Design Overview
- Design of Dry Detention Basins
- Extended Detention Basins
- Design of Extended Detention Basins
- Wet Detention Basins
- Design of Wet Detention Basins
- Mine drainage

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Debo, T.N. and Reese, A.J., 2003**, Municipal Stormwater Management, Second Edition. Lewis Publishers, Boca Raton, FL

Course Code: NBI – IWRM 146

Course Title: Reservoir and wetland Storage

Credit Hours: 3

Prerequisites: Civil engineering, hydrology

Summary and General Objective:.

Advanced understanding and 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 construction and operation. Principles and operation of the sediment in reservoirs and operation rules. Evaluating the impacts of in-stream flow works over the appropriate timescales. Advanced knowledge on use of the surface and underground storage for water harvesting. Systems for rain and floodwater harvesting.

Specific Objectives:

- To learn river hydrology analysis and reservoir storage for power generation
- To study static and dynamic analysis of dams
- To be familiar with works associated with dam construction, operation and maintenance to secure hydropower generator.

Course Outline:

- Dams; importance; historical development & trends; examples; failures & lessons.
- 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.
- Case studies and exercises on dam analyse and design.
- Reservoir sedimentation; flushing schemes and sedimentation process. Operation rules.
- Typical arrangements & layouts.

- Principles and experiences in analyse and design of headrace works, canals, tunnels, surge tanks, penstocks.
- Small-scale schemes; design and operation principles.

Maximum Number of Participants:	
Course Duration:	14 days
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/software in modeling – case studies

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Moris, G L and Fan, J, 1997.** Reservoir Sedimentation Handbook, 1st Edition, McGraw-Hill Professional, 848p
- **Robert B. Jansen (Editor), 1988,** Advanced Dam Engineering for Design, Construction, and Rehabilitation, , Publisher: Van Nostrand Reinhold, [ISBN: 0442243979]
- **Ronald C. Hirschfeld, Steve J. Poulos (Eds) 1987,** Embankment Dam Engineering; Casagrande Volume, Publisher: Krieger Pub Co [ISBN: 0898749972]
- **Alfred R. Golze, 1977,** Handbook of Dam Engineering, , Publication Date: January [ISBN: 0442227523]

Course Code: NBI – IWRM 147

Course Title: Hydraulic Transients in Hydropower Systems

Credit Hours: 2

Prerequisites: Fluid mechanics, Hydraulic Engineering and computer skills

Summary and General Objective:

Closing a value at the downstream end of a single pipe, produces propagation and reflection of waves. Classification and causes of hydraulic transient are discussed in this course.

Specific Objectives:

- In relation with hydropower, to get familiar with:
- Steady and unsteady flow
- Transient flow and periodic flow (oscillatory)
- Column separation and water hammer

Course Outline:

- Fundamentals of steady flow in closed conduits.
- Causes of hydraulic transients in conduits and in open channels.
- Basic equations of unsteady flow in closed conduits.
- Methods of characteristics for numerical computation of unsteady flow in pipes. Boundary conditions in pipe systems – reservoirs with constant and variable water level, closed and open valves of various types, pipe junctions, pipe network systems, surge tanks, pumps, turbines, etc.
- Hydraulic transients in hydroelectric power plants.
- Transient cavitations and column separation methods for controlling hydraulic transients.

Maximum Number of Participants: 20
Course Duration: 1 semester
Course Lecture Hours: 26
Course Computer/lab Hours: 12
Total Course Hours: 32

Required Self Reading Hours: 15
Required Assignment Hours: 10 (in class)

Teaching Method: Presentation/software in modeling – case studies

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Zipparro, V J and Hans Hasen, H, 1992.** Davis' Handbook of Applied Hydraulics, 4th edition, Mcgraw-Hill (Tx), 1056p
- **Hauser, B, 1995.** Practical Hydraulics Handbook, 2nd edition, CRC, 359p
- **M. Hadif Chaudhry, 1979,** Applied Hydraulic Transients, VanNostrand Reinhdd Comp. New York, and London.

Code: NBI-IWRM 155

Course Title: Watershed Modeling and Management

Credit Hours: 2

Prerequisites: Basic hydrology and computer skills

Summary and General Objective:

This course will introduce students to process-based modeling of Watershed with emphasis on current concepts and model applications. The general objective is to provide students with the basic knowledge and skills for developing watershed models and provide the computer modeling tools required for watershed management.

Specific Objectives:

- To select among alternative approaches to watershed modeling.
- To critically evaluate the usefulness of a model.
- To apply a model to meet stated objectives and a particular situation.
- To know and learn the most common software and their application to real life problems.
- To become proficient with standard hydrologic modeling software tools.

Course Outline:

- Introduction.
- Modeling concepts and objectives.
- Model Classification: Choice of model complexity.
- Descriptive watershed modeling: Sensitivity analysis, Parameter identification, Parameter estimation, Model evaluation
- Mathematical model verification, Operational model verification.
- Model Overviews: overviewed and used extensively AnnAGNPS, SWAT 2000, WMS, Model Application and Selection
- User Interfaces, GIS, and Decision Support Systems.
- Model Calibration and Testing, Course project.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	N/A
Course Computer Hours:	18
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	18
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	10%
Final Exam:	40%
Course Project:	30%

References:

- **Vijay P. Singh 1989,** Hydrologic Systems: Watershed Modeling - Prentice Hall College Div,
- **James Westervelt, 2001** Simulation Modeling for Watershed Management, - Springer publication,
- **User Manuals and Technical Reference Guides for HEC-HMS,** HEC-RAS and HEC-GeoHMS and GeoRAS (Public Domain, available online)

A.2.5 Cluster Area 5

A.2.5 Cluster Area 5

Watershed Management and Society

NBI-IWRM 151	-	Watershed Hydrology
NBI-IWRM 152	-	Participatory Watershed management
NBI-IWRM 153	-	Environmental Impact Assessment and Auditing
NBI-IWRM 154	-	Hydrology of the Nile River
NBI-IWRM 155	-	Watershed Modeling and Management
NBI-IWRM 156	-	Gender mainstreaming in IWRM
NBI-IWRM 157	-	Mediation, Negotiation Skills and Conflict Management of water recourses issues
NBI-IWRM 158	-	Soil and Water Conservation
NBI-IWRM 159	-	Water Rights and Governance
NBI-IWRM 160	-	Management of Hydrologic. Extremes
NBI-IWRM 1601	-	Water Harvesting
NBI-IWRM 1602	-	Environmental Components and Interaction
NBI-IWRM 1603	-	Environmental Management System
NBI-IWRM 1604	-	Wetlands hydrology
NBI-IWRM 186	-	Application of GIS and RS in WRM
NBI-IWRM 109	-	Numerical Methods for Water Resources

Master of Science Specialized in Watershed-Society

This M.Sc programme will provide the students with the knowledge and skills to the study of Watershed-Society. All Graduate students must have 36 credit points, 18 credit points by having successfully completed the core programme (compulsory course of IWRM), 6 credit points for M.Sc thesis.

For graduates who wish to be specialized in **Watershed-Society** he must have 6 credit points by successfully completing 3 specialized compulsory courses of **Watershed Hydrology, Hydrology of the Nile River and Participatory Watershed management.**

Furthermore, he must have 6 credit points by choosing at least 3 courses from the specialized elective courses which are : **Watershed Modeling and Management, Gender mainstreaming in IWRM, Mediation, Negotiation Skills and Conflict Management of water recourses issues, Soil and Water Conservation, Water Rights and Governance, Flood Forecasting, Water Harvesting and Numerical Methods for Water Resources.**

Graduate students, who successfully complete the master degree programme, are awarded the title Master of Science in Civil Engineering.

The graduate students who wish to have certificate of master degree programme specialized in **Watershed-Society** must have complete the following **compulsory courses:**

- The course in **Watershed Hydrology** conducted through a series of lectures on Components of hydrologic cycle, hydrologic transport; Statistical methods in hydrology: frequency analysis, time series analysis; Hydrologic technology: data collection, forecasting, hydrologic design, Infiltration, Tracers in hydrology, Isotopic and geochemical tools and biogeochemical budgets, Stream channels, riparian zones, and geomorphology, Hyporheic zone hydrology and groundwater surface water interactions
- The course in **Hydrology of the Nile River,** which covers the following topics: An Outline of the Nile Basin (Rainfall and runoff, Main tributaries,..) , Early Studies and Flow Measurement (Early investigations Establishment of the hydrological network,..) , The Lake Victoria Basin (Early studies of the water balance, Evaporation ,Rainfall over Lake Victoria,..) , The East African Lakes below Lake Victoria (Geography of the lake system, Water balance,..), The Bahr el Jebel and the Sudd (Early studies, Studies of the Jonglei Canal, ..) , The Bahr el Ghazal Basin (Early studies, The water balance model,..), The Sobat Basin and the Machar Marshes (Geography of the Sobat basin, General hydrology, Water balance,..), The White Nile below Malakal (Inflows and Outflows, Effect of water-saving projects,.), The Blue Nile and its Tributaries (Geography of

the basin, Rainfall and evaporation, Flow forecasting systems, Sedimentation, Operation of Blue Nile reservoirs,...), The Atbara and Main Nile to Wadi Halfa (Topography, Land use and climate, Available flow records,..), The Main Nile in Egypt (, Flow records at Aswan, The effects of the Aswan High Dam,..) and The Nile and Hydrological Aspects of Water Use (Summary of flow series , Water use in the Nile basin, , Projects to increase river flows,..)

- The course in **Participatory Watershed management,**, which is directed towards understanding Planning Tools and Techniques, Watershed Management, Overview of tropical watershed management, policy and legal frameworks, and-use zoning, bio-diversity conservation, forest rehabilitation, agro-forestry development, protected area management and conservation, Soil and Water Conservation, Case Studies and Study Visits, Field visits to successful and unsuccessful watershed management projects.

In addition to the above courses, it also required from the graduate students specialized in Groundwater development to choose at least 3 courses from the following electives available courses:

- The course in **Watershed Modeling and Management** comprises introduction on Modeling concepts and its objectives, Model Classification, Descriptive watershed modeling, Mathematical model Calibration - verification, Operational model, Model Overviews (AnnAGNPS, SWAT 2000, WMS), User Interfaces, GIS, and Decision Support Systems and course project.
- The course in **Mediation, Negotiation Skills and Conflict Management of water recourses issues** which covers the following topics; Mediation, Conflict and communication, Mediation Methods, Steps in Mediation, Advanced mediation concepts, Case-study and Role-play, Evaluation, Attitudes for Mediators, MANAGING EMOTIONS, Willingness to Resolve, Mapping the conflict, Designing Options, Negotiation skills, Third Party Mediation, Broadening Perspectives.
- The course in **Soil and Water Conservation** covers Overview and introduction to soil erosion and land degradation, climatic factors contributing to land degradation, methods to model soil erosion, Land degradation, Land classification system, Agronomic and physical measures to ameliorate land degradation in a drought prone area, Water harvesting techniques, social, political and economic contributor factors influencing land degradation, Soil topography and Advanced surveying tools.
- The course in **Water Rights and Governance** which covers the following

topics: An Overview 0n Water Resources and Water Rights(Water Resources and Its Utilizations, Evolution of Water Rights, Water Rights from the prospective of the Human, the Property and the Environment, The Influence of International Law, Comments and Observations on Water Rights Systems, Water resources governance.

- The course in **Flood Forecasting** covers the following topics: Introduction to stochastic hydrologic models and advanced stochastic models, Analysis and modeling of droughts, Hydrological forecasting concepts and methods, Operational flood forecasting, Methods for real-time runoff predictions, Flood warning systems and flood protection measures and Methods for flood risk mitigation. Agronomic Aspects of WH, Water Harvesting Techniques, Socio-Economic, Planning of WH Schemes and Project Management.
- The course in **Numerical Methods for Water Resources** covers the following topics: introduction to numerical methods, Difference equation, Systems of simultaneous linear equations, Special iterative methods, Partial differential equations and its solving by different numerical methods (Finite difference, Finite element and Boundary element)

Summary and General Objective:

The course will enable the students to get the knowledge and skills for developing watershed models. Also he will used the state-of-the-art methods of hydrological forecasting, with a major focus on stochastic methods. Be familiar with aspects related to rainwater and floodwater harvesting including techniques, planning, management and socio-economic. Develop gender-sensitive indicators for IWRM projects. Create a common understanding on the use and application of gender mainstreaming tools. Identify tools and methodologies for policy and organizational analysis and assessment. He will be able to contribute to regional water security and peace through strengthening water diplomacy. He will be able to examine the various methods that are available for conflict resolution. to develop and manage water resources and the delivery of water services, at different levels of society. Works with multiple thematic areas that range from integrated water resources management, transboundary water and water supply and sanitation to climate variability, gender and capacity building.

Specific Objectives:

Upon completion of this program, students will be able to have:

- an understanding of the circulation of water and its constituents through the hydrologic cycle , To learn hydrologic data collection , To analysis, forecast the hydrological data and learn the runoff generation mechanisms
- To select among alternative approaches to watershed modeling, To critically evaluate the usefulness of a model, To apply a model to meet stated objectives and a particular situation, To know and learn the most common software and their application to real life problems and To become proficient with standard hydrologic modeling software tools
- To be familiar with the principles and methods of stochastic hydrological modeling, environmental variables that are amenable to prediction and its relation to flood forecasting, the management forecasting framework, methods for long and mid term forecasting, and the specific case of flood and drought forecasting and To learn about real time, operational hydrological forecasting approaches, flood warning systems, and concepts of flood risk assessment.
- To train staff of national water resources, irrigation and agricultural services in the planning, design and implementation of water harvesting structures for improved rain fed production, supplementary irrigation and livestock watering, To make participants familiar with the associated socio-economic problems which go along with the implementation of Water Harvesting.
- Have acquired a basic understanding of participatory development theory in the context of gender mainstreaming , Understand the linkage between use of participatory tools and gender mainstreaming within the project cycle, Be able to identify and adapt tools for their specific needs and use, Analyze policies/ processes in order to facilitate the formulation and implementation of gender mainstreaming strategies at different levels of an organization, Understand how to use different tools for gender mainstreaming in policy processes.
- an understanding of conflict transformation and impart advanced mediation skills, To strengthen regional water diplomacy, Power-based mediation versus confidence building, Enhanced self-understanding with respect to conflict, Dynamics of communication, Process facilitation skills, Facilitating the mediation process, Mediated negotiations in practice

- an understanding the meaning of conflict, Explain the importance information gathering and personal threat assessments, Interpret the bodies responses to stress/conflict, Apply relevant legislation in relation to use of force, Demonstrate strategies and solutions to deal with a variety of conflict situations
- Water Rights and Water Resources, the formulation and adoption of sustainable legislation, policies and institutions, the way legislation, institutions and policies are being established, enforced and implemented , clarification of the roles and responsibilities of all involved stakeholders - local and national government, private sector, civil society - regarding ownership, administration and management of water resources

Course Code: NBI-IWRM 151

Course Title: Watershed Hydrology

Credit Hours: 2

Prerequisites: Basic knowledge in sciences and statistics

Summary and General Objective:

To provide a basic understanding of the various hydrologic processes and their importance in various physical environments

Specific Objectives:

- To provide an understanding of the circulation of water and its constituents through the hydrologic cycle.
- To learn hydrologic data collection.
- To analysis, forecast the hydrological data.
- To learn the runoff generation mechanisms.

Course Outline:

- Introduction.
- Components of hydrologic cycle, hydrologic transport.
- Statistical methods in hydrology: frequency analysis, time series analysis.
- Hydrologic technology: data collection, forecasting, hydrologic design.
- Infiltration and Vadose zone hydrology.
- Runoff Generation mechanisms.
- Hill slope and small watershed hydrology.
- Tracers in hydrology - Isotopic and geochemical tools and biogeochemical budgets.
- Stream channels, riparian zones, and geomorphology.
- Hyporheic zone hydrology and groundwater surface water interactions.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	N/A
Course Computer Hours:	12
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Hornberger *et al.*, 1998,** Elements of Physical Hydrology. Johns Hopkins University Press
- **Shaw, E. M, 1994** Applied Hydrology- - McGraw-Hill Book Company

Code: NBI-IWRM 152

Course Title: Participatory Watershed management

Credit Hours: 2

Prerequisites:. Basic knowledge in water sciences and related fields

Summary and General Objective:

To improve the knowledge and skills of participants in beneficiaries-oriented participatory planning and management of natural resources development, with a focus on the watershed areas, to achieve sustainable development.

Course Outline:

- Planning Tools and Techniques:(Integrated natural resources planning concepts; GIS and remote sensing for watershed management; watershed classification and land use; environmental impact assessment; agro-socio-economic development planning; strategic planning workshop).
- Watershed Management:(Overview of tropical watershed management; policy and legal frameworks; land-use zoning; bio-diversity conservation; forest rehabilitation; agro-forestry development; protected area management and conservation). Soil and Water Conservation:(Watershed hydrology; soil erodibility and erosion control; small-scale soil and water conservation structures; monitoring and evaluation of water yield and soil losses). Community Participation and Institutional Strengthening:(Participatory problem analysis and development planning; community participation in watershed management; community leadership an institutional strengthening; strategies and approaches for empowering the poor; participatory monitoring and evaluation). Case Studies and Study Visits:(Case studies on community forest, agro-forestry, soil and water conservation measures, integrated development programs in forest area, public campaign programs, natural resources degradation and environmental impact by various forms of exploitation and development, Field visits to successful and unsuccessful watershed management projects, integrated watershed management projects, community forests, agro-forestry project).

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	24
Course Computer/lab Hours:	18
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Computer/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Heathcote, I W, 1998.** Integrated Watershed Management: Principles and Practice, Wiley, 424p
- **DeBarry, P A, 2004.** Watersheds: Processes, Assessment and Management, Wiley, 720p
- **Hinchcliffe, F and Thompson, J, 1999.** Fertile Grounds: The Impacts of Participatory Watershed Management, Practical Action, 256p
- **Libor Jansky and Juha I. Uitto, January 2000 Ed., 1998**, Enhancing Participation and Governance in Water Resources Management: Conventional Approaches and Information Technology, Edited by United Nation Press,
- **Laki, S.L.,** Management of Water Resources of the Nile Basin, 6 Int'l J. Sustainable Dev. & World Ecology 288

Course Code: NBI-IWRM 153

Course Title: Environmental Impact Assessment and auditing

Credit Hours: 2

Prerequisites: Basic knowledge of sciences and engineering fields

Summary and General Objective:

This module examines how environmental impact assessment is undertaken in practice. It uses case studies to assist students in developing an understanding of the assessment process, its legal context, and specific methodologies that address different types of impacts. Students will undertake specific parts of an environmental impact assessment and be required to produce project reports. Group work will also be required, giving opportunities to enhance team working and project management skills.

Specific Objectives:

- Practice the integration of environmental concerns into the development process.
- Contribute to and assess the quality of environmental impact assessments.
- Apply the tools of EIA to facilitate wise IWRM.

Course Outline:

- The legal context of environmental impact assessment (EIA), tracking legal requirements from the European Directive through to the development of legislation in member states;
- The process of EIA in practice, in the context of the many different stakeholders involved (including the developer, the planning authorities or equivalent, the consultant, the regulators, the public, statutory and non-statutory consults);
- Different methods for the assessment of multi-disciplinary environmental impacts;
- Preparation of the Environmental Statement and requirements to communicate to technical and non-technical audiences, through report writing and delivery of presentations;

- Conducting a live EIA project with choice of application to different sectors (examples including water, waste, minerals & renewable energy);
- Strategic Environmental Assessment and other applications of EIA techniques.
- Professional practice experience in an area of high vocational relevance, requiring the development of skills in independent research, team work, and project management.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	21
Course Laboratory Hours:	6
Course Computer Hours:	10
Course Field Hours:	6
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	20%
Final Exam:	40%
Course Project:	20%

References:

- **Barrow, C. J., 1999,** Environmental Management — Principles and Practice (Routledge, London)
- **Byron, H., 2000,** Biodiversity and Environmental Impact Assessment: A Good Practice Guide for Road Schemes (The RSPB, WWF-UK, English Nature and the Wildlife Trusts, Sandy)
- **Carroll, B and Turpin, T, 2002,** Environmental Impact Assessment Handbook (Thomas Telford, London)

Course Code: NBI-IWRM 154

Course Title: Hydrology of the Nile River

Credit Hours: 2

Prerequisites: Basic hydrology and hydraulics

Summary and General Objective:

To draw the attention to links between reaches of the whole Nile basin, Recent changes to the basin will be discussed, in particular the dramatic change of regime of Lake Victoria and other lakes which occurred after 1961. The relationship between hydrology and vegetation affects the important wetlands of the White Nile basin, and discussion of this relationship includes the effect of increased lake outflows. The extensive records collected throughout the basin to help paint a detailed hydrological picture of the regime of the Nile.

Specific Objectives:

- Perceptions and Realities Initiatives and Challenges From Cooperation to Socioeconomic Development
- Geography Hydrology Climate Demography and Society
- Context History Development Contemporary Politics, Legal Issues, Socioeconomic, Development Information and Data Issues
- The Challenge Development, Building a Cooperative Framework (the 1990s)
- Institutionalizing Cooperation (the NBI)

Course Outline:

- An Outline of the Nile Basin: Extent of the Nile basin, Rainfall and runoff, Main tributaries.
- Early Studies and Flow Measurement: Early investigations Establishment of the hydrological network, Numbers of gauging stations, Collaboration with other hydrological services and Records available at key sites
- The Lake Victoria Basin: Early studies of the water balance, The Kagera basin, Lakes and swamps in lower Kagera, Contribution of other tributaries, Rainfall over Lake Victoria, Evaporation, Lake levels, Lake Victoria outflows, Water balance of Lake Victoria, The WMO/UNDP Hydro meteorological Survey, Reviews by the

Institute of Hydrology Long-term Lake Victoria balance, Downstream influence

- The East African Lakes below Lake Victoria, Geography of the lake system, Early water balance observations, General climate of Lake Kyoga and Lake Albert basins, Published flow records, Main Nile between Lake Kyoga and Lake Albert, Semliki at Bweramule, Lake Albert outflows, Review of river flows at key sites, Lake Kyoga outflows at Masindi Port, River flows at Kamdini, Comparison of flows at Masindi Port and Kamdini, Comparisons of inflows and outflows for Lake Kyoga, Water balance of Lake Kyoga, Lakes Edward and George, Lake Albert, Kyoga Nile inflows, Semliki and local inflows, Albert Nile outflows, Other components of Lake Albert balance, Water balance, The surroundings of Lake Albert, Potential of Lake Albert as a reservoir, Effect on flows of Lake Kyoga and Lake Albert basins
- The Bahr el Jebel and the Sudd, Early studies, Studies of the Jonglei Canal, Flows of the Bahr el Jebel, Available river flow records, Published river flow records, The Bahr el Jebel swamps, The influence of topography, The flooding regime, Study of a sample reach, Hydrological model of the Sudd, The hydrological model, Effect on areas of seasonal flooding, Hydrological control of flood-plain vegetation, Early observations and botanical studies, Botanical studies of the Jonglei Investigation Team, Juba–Bor survey, Description of flooding mechanism, Statistical analysis of vegetation distribution, Effect of rise in Lake Victoria, Importance of seasonal, flooding to grazing, Effects of the Jonglei Canal, Assessment of the effects of the Jonglei Canal
- The Bahr el Ghazal Basin, Early studies, Physical background, River profile, early water balance, Estimates of tributary inflow, Available flow records, Revised analysis of available river flow records, Derivation of total inflow series, Other water balance elements, Spill from Bahr el Jebel to Bahr el Ghazal, Area of Bahr el Ghazal swamps, The water balance model, Distribution of wetlands, Plans for reducing losses in the Bahr el Ghazal basin
- The Sobat Basin and the Machar Marshes, Geography of the Sobat basin, General hydrology, Spill from the Sobat tributaries, The Machar marshes, Contributions of the Pibor, Spill from Baro to Machar marshes, Balance of Sobat channel, Water balance of the Machar marshes, Analysis by Hurst (1950), Jonglei Investigation Team (1954), Analysis by MIT (1980), Analysis of years 1950–1955 (after Sutcliffe, 1993), General environment, Analysis of Sobat channel storage, Runoff from the eastern plain

- The White Nile below Malakal, Inflows to the White Nile, Outflows from the White Nile, Water balance of the White Nile from Malakal to Renk, Trends of losses on the White Nile, Vegetation of the White Nile flood plain, Effect of water-saving projects
- The Blue Nile and its Tributaries, Geography of the basin, Rainfall and evaporation, Availability of flow records, Flows at various sites on the Blue Nile, Losses between Roseires and Khartoum, Flood regime, Flow forecasting systems, Sedimentation, Operation of Blue Nile reservoirs
- The Atbara and Main Nile to Wadi Halfa, Topography, Land use and climate, Early account of the hydrology of the reach from Khartoum to Wadi Halfa, Available flow records, Flow measurements, Hydrology of individual components, Comparisons of inflows and outflows
- The Main Nile in Egypt, Flow records at Aswan, Comparison with upstream flows, The genesis of the Aswan High Dam, Elimination of flood reserve, The effects of the Aswan High Dam, Flows down the Nile below Aswan, Evidence of the Roda gauge
- The Nile and Hydrological Aspects of Water Use, Summary of flow series, Water use in the Nile basin, East Africa, Rwanda, Burundi and Congo, Uganda, Kenya and Tanzani, Ethiopia and Eritrea, Sudan, Egypt, Projects to increase river flows

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	NA
Course Field Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	18
Required Assignment Hours:	10 (in class)

Teaching Method: Multimedia – field work, lab work

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%

References:

- **J. V. Sutcliffe & Y. P. Parks (Published February 1999,** The Hydrology of the Nile, Wallingford, England: International Association of Hydrological Sciences, IAHS Special Publication No. 5, 179p. [ISBN 1-901502-75-9]
- **Rushdi Said, 1993,** The River Nile: Geology, Hydrology and Utilization, by, November Publisher: Pergamon Pr, [ISBN: 0080418864]

Additional Information:

Nile Basin Initiative (NBI) website http://www.nbi.org//

Course Code: NBI-IWRM 155

Course Title: Watershed Modeling and Management

Credit Hours: 2

Prerequisites: Basic hydrology and computer skills

Summary and General Objective:

This course will introduce students to process-based modeling of Watershed with emphasis on current concepts and model applications. The general objective is to provide students with the basic knowledge and skills for developing watershed models and provide the computer modeling tools required for watershed management.

Specific Objectives:

- To select among alternative approaches to watershed modeling.
- To critically evaluate the usefulness of a model.
- To apply a model to meet stated objectives and a particular situation.
- To know and learn the most common software and their application to real life problems.
- To become proficient with standard hydrologic modeling software tools.

Course Outline:

- Introduction.
- Modeling concepts and objectives.
- Model Classification: Choice of model complexity.
- Descriptive watershed modeling: Sensitivity analysis, Parameter identification, Parameter estimation, Model evaluation
- Mathematical model verification, Operational model verification.
- Model Overviews: overviewed and used extensively AnnAGNPS, SWAT 2000, WMS, Model Application and Selection
- User Interfaces, GIS, and Decision Support Systems.
- Model Calibration and Testing, Course project.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	N/A
Course Computer Hours:	18
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	18
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	10%
Class Participation:	10%
Mid-term:	10%
Final Exam:	40%
Course Project:	30%

References:

- **Vijay P. Singh 1989,** Hydrologic Systems: Watershed Modeling - Prentice Hall College Div,
- **James Westervelt, 2001** Simulation Modeling for Watershed Management, - Springer publication,
- **User Manuals and Technical Reference Guides for HEC-HMS,** HEC-RAS and HEC-GeoHMS and GeoRAS (Public Domain, available online)

Course Code: NBI-IWRM 156

Course Title: Gender mainstreaming in IWRM

Credit Hours: 2

Prerequisites: General socio-economic knowledge and water resources projects

Summary and General Objective:

Gender awareness exercises and concepts of IWRM development and management of water and its advantages over the currently practiced sector approach. Need for Gender Mainstreaming, in IWRM for Sustainable Development. Approaches to adult education and learning, how to use icebreakers and energizers effectively gender-sensitive approach to training. Strategically integrate of mainstream gender in the project cycle. Identify and collect and/or generate sex, age, socio-economic and cultural disaggregated data. Develop gender-sensitive indicators for IWRM projects. Create a common understanding on the use and application of gender mainstreaming tools. Identify tools and methodologies for policy and organizational analysis and assessment.

Specific Objectives:.

- An understanding of participatory development theory in the context of gender mainstreaming and using poverty-sensitive approaches.
- Appreciate the need for using participatory non-directive approaches when dealing with culturally sensitive issues such as gender and poverty.
- Understand the linkage between use of participatory tools and gender mainstreaming within the project cycle.
- Be able to identify and adapt tools for their specific needs and use.
- Analyze policies/processes in order to facilitate the formulation and implementation of gender mainstreaming strategies at different levels of an organization.
- Understand how to use different tools for gender mainstreaming in policy processes.

Course Outline:

- Gender and Integrated Water Resources Management,
- Gender-Sensitive Training Skills
- Mainstreaming Gender in the Project Cycle
- Gender Mainstreaming Tools
- Gender Mainstreaming in Organizations and Policy Process: From Theory to Practice

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	30
Course Computer/lab Hours:	12
Total Course Hours:	36
Required Self Reading Hours:	5
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/multimedia/case studies role-play.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **GWP, 1998** Integrated Water Resources Management. TEC Background Paper 4.
- **SIDA, 1997,** A Gender Perspective in the Water Resources Management Sector, Handbook for Mainstreaming. Department for Natural Resources and the Environment, Stockholm.
- **UNDP, 1995 Gender Briefing Kit.**
- **UNDP, 2005** Gender Mainstreaming: What it is, how to do it, a resource kit..

- **Caroline O. N. London: Routledge, 1993** Gender Planning and Development: Theory, Practice, and Training. Moser.

Additional Information:

- WHY GENDER MATTERS Gender Mainstreaming in Integrated Water Resources Management A tutorial for water managers by CapNet, IHE-Delft, March 2006
- Policy Development Manual for Gender and Water Alliance Members and Partners January 2003, This publication was produced by the Gender and Water Alliance (GWA), Norwegian Ministry of Foreign Affairs.
- For her IT'S THE BIG ISSUE - Putting women at the centre of water supply, sanitation and hygiene, This publication was produced by the Water Supply and Sanitation Collaborative Council (WSSCC) in collaboration with the Water, Engineering and Development Centre(WEDC), with the support of the Gender and Water Alliance (GWA), Norwegian Ministry of Foreign Affairs, and UNICEF. March 2006.

Course Code: NBI-IWRM 157

Course Title: Mediation, Negotiation Skills and Conflict Management of water recourses issues

Credit Hours: 2

Prerequisites:. Conflict Management/Resolution and Negotiation Skill

Summary and General Objective:

Gain greater confidence to negotiate at all levels Obtain knowledge of strategic negotiation Introduce key concepts in water conflict and alternative dispute resolution methods. To provide the participants an understanding of the nature of conflicts at various levels. It draws participants' attention to differences between conflict resolution and conflict management. examine the various methods that are available for conflict resolution. A few prerequisites for successful conflict resolution will also be discussed. Negotiation skills will also be treated covering most widely used techniques.

Specific Objectives:

- To deepen the understanding of conflict transformation and impart advanced mediation skills
- To strengthen regional water diplomacy.
- Power-based mediation versus confidence building
- Enhanced self-understanding with respect to conflict
- Process facilitation skills
- Mediated negotiations in practice
- Explain the importance information gathering and personal threat assessments
- Interpret the bodies responses to stress/conflict
- Demonstrate strategies and solutions to deal with a variety of conflict situations

Course Outline:

- Mediation; Introduction, Power-based mediation vs confidence building
- Conflict and communication; Personal responses to conflict, Communication, Facilitating good process.

- Mediation Methods; Steps in Mediation; Advanced mediation concepts; The mediation process, Advanced mediation concepts and techniques)
- Case-study
- Evaluation
- Conflict Management /Resolution.
- Methods of Conflict Resolution (Litigation, Alternative Dispute Resolution: Negotiation, Facilitation, Mediation, Arbitration, Other Tools).
- Consensus Building /Stakeholder Approach
- Negotiated Rule Making/ Rational Communication
- Requirements for Successful Conflict Resolution (Willingness to Participate, Opportunity for Mutual Gain, Opportunity for Participation, Identification of Interests, Developing Options, Carrying out an Agreement)
- Negotiation (Principled Negotiation, Stapes of Negotiation)
- Approach & Methods of Negotiation
- Attracting players in Negotiation, The subjects addressed include: (Theory and practice of conflict prevention, Conflict management tools, Skills training in communication, mediation and negotiation, Shared vision development, International water law, Water allocation issues in the context of integrated water resources management, Water diplomacy)

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	24
Course Computer/lab Hours:	18
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/Computer/Lab/exercise.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Harvard Business School Press 2000**, Negotiation and Conflict Resolution ISBN: 1578512360
- **Steven Cohen, 2002,** Negotiating Skills for Managers, McGraw Hill. [ISBN 007138757-9]
- **Ralph A. Johnson, 1992,** Negotiation Basics: Concepts, Skills and Exercises (Unknown Binding by SAGE Publications [ISBN: 0803940521]
- **Allan H. GoodmanSolomon, 2004,** Basic Skills for the New Mediator, Second Edition (Paperback) by Publications [ISBN: 0967097339]

Course Code: NBI-IWRM 158

Course Title: Soil and Water Conservation

Credit Hours: 2

Prerequisites: Agricultural and rural development personals

Summary and General Objective:

The course introduces the problem of soil erosion and land degradation and the climatic effect of the problem. How to model soil erosion, and classification of land and soil. Also it Introduce the concept of water harvesting.

Specific Objectives:

- Describe the main kinds of soil erosion and land degradation.
- Demonstrate an understanding of the climatic and edaphic factors contributing to land degradation
- Use simple methods to model soil erosion
- Assess land degradation using simple classification methods
- Use a simple land classification system
- Describe a range of appropriate agronomic and physical measures to ameliorate land degradation in a drought prone area.
- Design a simple water harvesting scheme
- Discuss the main social, political and economic contributor factors influencing land degradation
- Lay out contours and small gradients using simple surveying implements
- Demonstrate an understanding of the operation of advanced surveying tools

Course Outline:

- Introduction; soil erosion and land degradation
- climatic and edaphic factors contributing to land degradation
- methods to model soil erosion
- Land degradation using simple classification methods

- Land classification system
- Agronomic and physical measures to ameliorate land degradation in a drought prone area
- Introduction to Water harvesting technieque
- the main social, political and economic contributor factors influencing land degradation.
- Soil topography, Layout contours and small gradients using simple surveying implements
- Advanced surveying tools

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	12
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	34
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Paul W., 2006.** Soil and Water Conservation Handbook: Policies, Practices, Conditions and Terms (Sustainable Food, Fiber and Forestry Systems, Food Products Press, 248p
- **Fangmeier, D D, Elliot, W J, Workman, S R and Huffman, R L, 2005.** Soil and Water Conservation Engineering, 1st Edition, Thomson Delmar Learning, 552p
- **Napier, T L, Napier, S M and Tvrdon, J, 1999.** Soil and Water Conservation Policies and Programs: Successes and Failures, CRC, 656p
- **A Manual of Soil and Water Conservation and Soil Improvement on Sloping Lands 2002** The Conservation and Improvement of Sloping Land Volume 1: Practical Understanding, , P.J ISBN 978-1-57808-201-8. Storey

Course Code: NBI-IWRM 159

Course Title: Water rights and governance

Credit Hours: 2

Prerequisites: Political, social, economic and administrative background

Summary and General Objective:

The course focus on water right and the role of water governance
Which Water rights and Governance aspects are water challenges.

Specific Objectives:

- Water Rights and Water Resources
- the formulation and adoption of sustainable legislation, policies and institutions
- the way legislation, institutions and policies are being established, enforced and implemented
- clarification of the roles and responsibilities of all involved stakeholders - local and national government, private sector, civil society - regarding ownership, administration and management of water resources

Course Outline:

- An Overview 0n Water Resources and Water Rights:(Water Resources and Its Utilizations: Definition of water resource, Utilization of Water Resources), (Evolution of Water Rights:(Water rights, Pre-administration system period, Administration system period, the Property Right on Water Resources, the Human Right to Water State practice, the environmental Right to Water)
- The Influence of International Law:(The Human Right to Water: The legal status of the human right to water , The legal content of the human right to water , The obligations of the States, Implementation at national level),(The Environmental Right to Water : The legal status of the environmental right to water, The legal content of the environmental right to water , The obligations of the States, Implementation at national level).
- Comments and Observations on Water Rights Systems:(

- Principles and Structure for an Ideal Water Rights System: (Principles, Structure), Definition of Water Resource, Property Right on Water Resources: (Ownership on water resources, Other types of property right on water resources Advantage of applying the design in China)
- The Human Right to Water: (The human right to water shall be clearly declared in water law, The human right to water shall be given the first priority, The legal content of the human right to water shall be defined), The Environmental Right to Water: (The environmental right to water shall be clearly acknowledged in water law, The environmental right to water shall be given a proper priority , The general legal content of the environmental right to water shall be defined, Concrete provisions shall be provided , Obtaining of ownership on water resources , Obtaining usufruct on water resources, Transfer of the right to draw water under a license, The human right to water, The environmental right to water, Minimum proper water for the important parts of the environment), Water resources governance: (Improving Public Participation and Governance in Water Resources Management, Conventional Approaches, Public Participation and Water Resources Management: A Case study, Public Participation in the Development of a Management Plan for an International River Basin: Case study, Transboundary Environmental Impact Assessment as a Tool for Promoting Public, Participation in International Watercourse Management , Information Technology Approaches, The Internet and the E-inclusion: Promoting Online Public Participation, Promoting Public Participation in Transboundary Waters Management: An Agenda for Peer-to-Peer Learning, Development of an Information System for Collecting Field Information for Environmental Assessment, New Directions in Development of Decision Support Systems for Water Resources Management, Efforts by International Organizations (UNESCO, UNDP,…), Improving Public Involvement and Governance for Transboundary Water Systems: Process Tools Used, Public Participation and Governance: A Nile River Basin's Perspective)

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Computer/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Libor Jansky and Juha I. Uitto,Enhancing 2006** Participation and Governance in Water Resources Management: Conventional Approaches and Information Technology, Edited by United Nation Press,
- **Water Rights:** An International and Comparative Study

Course Code: NBI-IWRM 160

Course Title: Management of Hydrologic. Extremes

Credit Hours: 2

Prerequisites: Basic knowledge of mathematics, statistics, and familiarity with different water resources variables and the need for forecasting

Summary and General Objective:

To provide the participants with an overview of the state-of-the-art methods used in hydrological forecasting, with a major focus on stochastic methods.

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Specific Objectives:

- To get familiarity with the principles and methods of stochastic hydrological modeling.
- To get familiarity with environmental variables that are amenable to prediction and its relation to flood forecasting.
- To get familiarity with the management forecasting framework, methods for long and mid term forecasting, and the specific case of flood and drought forecasting.
- To learn about real time, operational hydrological forecasting approaches, flood warning systems, and concepts of flood risk assessment.

Course Outline:

- Introduction to stochastic hydrologic models and advanced stochastic models.
- Analysis and modeling of droughts.
- Hydrological forecasting concepts and methods.
- Operational flood forecasting.
- Methods for real-time runoff predictions.
- Flood warning systems and flood protection measures.
- Methods for flood risk mitigation.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	21
Course Laboratory Hours:	6
Course Computer Hours:	10
Course Field Hours:	6
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Collier, M and Webb, R H, 2002.** Floods, Droughts, and Climate Change, University of Arizona Press, 160p
- **Boken, V K, Cracknell, A P and Heathcote, R L, 2005.** Monitoring and Predicting Agricultural Drought: A Global Study, Oxford University Press, USA, 496p
- **S. Masky, Taylor & Francis 2004** Modeling Uncertainty in Flood Forecasting Systems, Publishers,

Course Code: NBI-IWRM 1601

Course Title: Water Harvesting

Credit Hours: 2

Prerequisites: Basic knowledge of watershed and Groundwater hydraulics

Summary and General Objective:

The course covers aspects related to rainwater and flood water harvesting including techniques such as planning, management and socio-economic.

Specific Objectives:

- To raise awareness of participants in a widely unknown technology as an alternative to irrigation. Erosion control and recharge of ground water are additional advantages of water harvesting techniques.
- To train staff of national water resources, irrigation and agricultural services in the planning, design and implementation of water harvesting structures for improved rain fed production, supplementary irrigation and livestock watering.
- To make participants familiar with the associated socio-economic problems which go along with the implementation of Water Harvesting.

Course Outline:

- Introduction: Definition, Scope (for what purposes can WH be used for?), (Limitations Historical and recent developments)
- Overview of the Main Groups of WH: Micro-catchments, Macro-catchments (External Catchment Systems), Floodwater Harvesting
- Soil Requirements for WH: Texture & structure, Depth & fertility, Salinity/sodicity, Infiltration rate, Soil water storage capacity, Soil mechanical characteristics
- Agronomic Aspects of WH: Assessment of available water resources to cover the water requirements of different crops, The farming system concept, Choice of species and crop husbandry, Annual crops, Tree crops
- Water Harvesting Techniques,(Microcatchments, Overviews, Advantages and disadvantages, Techniques (Negarim, contour ridges, zay-system etc.), Macrocatchments (External Catchment Systems) Overview, Advantages and disadvantages, Techniques (Hillside conduit systems, stone dams, liman

terraces, cultivated reservoirs, farm ponds shallow wells), Floodwater Harvesting (Large External Catchments) Overview, Floodwater harvesting within the stream bed, Floodwater diversion, Storage)

- Socio-Economic: Factors People's demand & priorities, People's experience with WH techniques, People's participation & gender issues Land tenure and water law issues, Adaptation and adoption, Land suitability & area differences
- Planning of WH Schemes: The most important parameters, Identification of suitable areas

Maximum Number of Participants:	20
Course Duration	1 semester
Course Lecture Hours:	16
Course Computer/lab Hours:	40
Total Course Hours:	36
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Computer/Lab/ Field trips.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Waterfall P. 1998.** Harvesting rainwater for landscape use. Tucson (AZ): The University of Arizona College of Agriculture and Life Sciences.
- **Prinz, D. and Singh, A.K. 2000** "Water Resources in Arid Regions and Their Sustainable Management" Annals of Arid Lands, Special Issue on Research.
- International Rainwater Catchment Systems Association, www.ircsa.org
- **Gould J, Nissen-Petersen E. 1999**.Rainwater catchment systems for domestic rain: design construction and implementation. London: Intermediate Technology Publications. 335 p.
- **Nasser, M. 1999** "Assessing desertification and water harvesting in the Middle East and North Africa: Policy implications", Center for Development Research, (ZEF), (10), 59.

Course Code: NBI-IWRM 1602

Course Title: Environmental Components and Interaction

Credit Hours: 2

Prerequisites: Basic knowledge of sciences and engineering fields

Summary and General Objective:

Provide the Knowledge and skills of the relation between different environmental components and how they interact on each others.

Specific Objectives:

- An understanding of the Main environmental components and their interactions
- An understanding the Processes that define the functioning of ecosystem
- An understanding the Causes and effects of environmental pollution

Course Outline:

- The environment, components of the environment.
- Physical components, Earth surface; the crust, soil and the hydrosphere (water bodies).
- Biological Components; microorganisms, plants and animals.
- Atmosphere; structure and composition of the atmosphere, weather and climate. Human Impact and Ecosystems;
- Historical basis of pollution,
- Renewable and Non-renewable resources,
- Costs associated with resource exploitation.

Maximum Number of Participants: 20
Course Duration: 1 Semester
Course Lecture Hours: 20
Course Laboratory Hours: N/A
Course Computer Hours: 12
Course Field Hours: 12

Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method:	Multimedia – computer applications laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Jackson, A. R. W. and Jackson, J. M., 2000,** Environmental Science: The natural Environment and Human Impact, Second Edition, Pearson Education Limited, London.
- **Peirce, J. J., Weiner, R. F. and Vesilind P.A., 1990,** Environmental Pollution and Control, Fourth Edition, Butterworth-Heinemann, Boston.
- **Enger, E.G. and Smith B. F., 2000,** Environmental Science: A study of Interrelationship, Seventh Edition, McGraw-Hill Companies, Boston.

Course Code: NBI-IWRM 1603

Course Title: Environmental Management System

Credit Hours: 2

Prerequisites: Basic knowledge of sciences and engineering fields

Summary and General Objective:

Introduction of environmental management at different levels in framework of Environmental International declarations.

Specific Objectives:

- Explain the fundamental principles of environmental management systems.
- Be well versed with the available tools for environmental management
- Undertake environmental auditing and monitoring

Course Outline:

- Environmental Management. Introduction to environmental management: macro and micro levels.
- Legal framework and mechanisms:
- The Rio Declaration on Environment and Development; Agenda 21, the global action plan;
- Environmental standards; national environmental policy;
- National environmental action plan, ‘soft’ and ‘hard’ legislation, restrictions and limits.
- The National Environmental Law;
- Environmental Management Systems (EMS). EMS audit and review.
- Environmental report.
- Macro level: National accounting systems.
- Environmental Information Systems.
- Environmental monitoring. Baseline monitoring.
- Monitoring techniques: Monitoring water, air and soil quality.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	20
Course Laboratory Hours:	N/A
Course Computer Hours:	24
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	18
Required Assignment Hours:	12

Teaching Method:	Multimedia – computer applications laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Erickson, S. L. and King, B. J, 1999,** Fundamentals of Environmental Management. John Wiley and Sons.
- **Atchia, M. and Trapp, S., 1995,** Environmental Management: Issues and Solutions. John Wiley and Sons.
- **Dupont, R.R., Baxter, T.E. and L. Theodore (eds.), 1998,** Environmental Management: Problems and Solutions. Lewis Publishers, London.
- **National Environmental management Act, 2004.**
- **Horen, D. J. M. van, Lemmens, A. M. C. and Katima, J. H. Y. 1998,** Environmental Management. Faculty of Engineering, University of Dar es Salaam.

Course Code: NBI-IWRM 1604

Course Title: Wetlands Hydrology

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide an understanding of the control of water and the water table for semi-natural habitats in riparian lands

Specific Objectives:

Participants should be able to;

- Understand the link between wet land water status and plant community structure.
- Understand the links between boundary watercourse systems, soil properties, climate and the position of the water table
- Predict the position of shallow water tables in natural landscapes within and without drained agricultural lands, and understand how soil water regime controls the composition of semi-natural vegetation
- Undertake the design of systems for water table control in both drainage and sub-irrigation situations.
- Select appropriate materials for water table control systems
- Understand the appropriate methods and machines for water table control in wetland areas

Course Outline:

- Introduction: Distinction between wetland and wet land
- Types of water table control problem
- Water budgets in shallow water table situations
- Plant responses to water table control
- Plant community mosaics in shallow water table situations
- Drainage theories
- Steady state and non-steady state solutions for water table control
- Uses and limitations of equations in design

- The link between steady state and non-steady state theories
- Design criteria
- Field and laboratory methods of determining hydraulic conductivity and drainable porosity
- Field variation of soil properties
- Calculation of sum exceedence values
- Pipes and pipe surround
- Water flow to and into pipes
- Entry resistance problems
- Pipe sizes and water table control layouts, practical water table control design
- Water table control structures
- Types of machinery, machine performance and machinery selection for wet land water table control

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Richardson, James, 2000,** Wetlands soil: genesis, hydrology, landscapers and Classification, Lavoisier, France
- **Gilman, Kevin, 1994,** Hydrology and Wetlands Conservation. John Wiley & Sons

Code: NBI-IWRM 109

Course Title: Numerical Methods and Computer Applications in WR

Credit Hours: 2

Prerequisites: Basic knowledge of mathematics and calculus.

Summary and General Objective:

To provide students with the necessary numerical methods and computer programs for dealing with water resources

Specific Objectives:

- To get familiarity with problem formulation and the choice of the method of solution
- To get knowledge with partial differential equations: order, degree, linearity, homogeneity, and solutions
- To get familiarity with the numerical methods: finite element method; finite difference method; and boundary element method

Course Outline:

- An introduction about the need for numerical methods, describe features of numerical methods, problem formulation and the choice of a method
- Difference equation: origin and its use, order, linearity, homogeneity and their solutions, linear constant coefficient difference equations of order greater than one; particular and general solutions of non homogeneous equations.
- Systems of simultaneous linear equations: existence, uniqueness and sensitivity of solutions, condition number of matrices, direct methods of solution, product splitting and Gaussian elimination.
- Special iterative methods: Gauss Jacobi, Gauss Siedel and sufficient conditions of their convergence.
- Partial differential equations: order, degree, linearity, homogeneity and Solutions, characteristic equations, classification of PDE's.
- Finite difference schemes for solving partial differential equations
- Finite element method to solve the equations in domain
- Boundary element method and its uses.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	26
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Richard W. Hamming, R. W. Hamming, 1986,** Numerical Methods for Scientists and Engineers Dover Publications, Incorporated
- **Steven Chapra, 2001,** Numerical Methods for Engineers: With Software and Programming Applications McGraw-Hill Education - Europe

A.2.6 Cluster Area 6

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Ecology Management

NBI-IWRM 161	-	Wetlands Ecology
NBI-IWRM 162	-	Limnology
NBI-IWRM 163	-	Ecological Eng. and Industrial Ecology
NBI-IWRM 164	-	Issues of Tropical Biology
NBI-IWRM 165	-	Wildlife Ecology
NBI-IWRM 166	-	Political Ecology
NBI-IWRM 167	-	Ecology of Lakes – Function conservation & management
NBI-IWRM 168	-	Wetland & River Floodplain Ecology

Master Title: Master Degree in Ecology Management for IWRM

Summary and General Objective:

By successful completion of the master degree, the participant should be able to;

- Understanding the importance of wetlands in integrated water resources management
- The integration between chemistry, physics, hydrology to create a holistic perspective on lakes and other freshwater ecosystems. Human impacts and interactions with aquatic systems and the synthesis of ideas.
- Understanding of ecological processes and natural environments in the tropics and become familiar with principles of environmental management and conservation. The learning goals are critical thinking related to understanding ecological principles, processes and functions, as well as ability to use ecological knowledge for ecosystem management and decision-making.
- Highlight the inter-linkages between questions of peace, conflict resolution, and the process of transformation in water related issues.
- Providing knowledge on wildlife management, with case study on the Nile Basin and how to preserve the wildlife in integrated manner.
- Deeper insights into the functioning of Lake Ecosystems and assessing its ecological integrity
- Promoting functional aspects and management of wetlands and riverine floodplain ecosystems

Specific Objective:

The Students are knowledgeable on:

- Familiarity with the importance of wetlands in integrated water resources management
- Familiarity with the laws and conventions governing the management and conservation of wetland resources in Sub-Saharan Africa
- Raise awareness for the need to manage wetlands and wetland resources on a sustainable basis.

- Make a wetland inventory and thereafter monitor wetland changes and predict future trends.
- Familiarize the student with the basic concepts of limnology.
- Understanding of the following concepts:
  - Freshwater biota and habitats;
  - The ecology of freshwater;
  - Energetics in freshwater ecosystems
- To get familiarity with ecological processes that assimilate pollutants in the environment
- Familiarity with the application of such system in the treatment of waste produced from anthropogenic activities
- Familiarity with the concept of industrial ecology as applied to industrial pollution prevention
- Familiarity with the application of concepts such as life assessment, cleaner production to minimize waste generation at source.
- Promoting the understanding of special characteristics of tropical river & lake ecosystems. Its interactions with activities/processes in the watershed and relevant ecosystem services.
- To become familiar with biodiversity of the tropics and ecological processes as they apply to tropical ecosystems
- To gain an appreciate for the field of conservation biology
- To appreciate the complexity of the balance between human activity and habitat conservation
- To appreciate the values and traditions of another culture
- Conflicts over Natural Resources; Security, Vulnerability and Violence; Human Rights and Cultural Survival in a Changing Pluralistic World;
- The Role of Science and Technology in Peace and Transformation;
- The Role of the State in Peace and Global Transformation; and Global Economic Crisis. A project also included a special project on Peace and Nile basin regional Security.
- Understand the history and economics of wildlife management in Nile Basin

including important wildlife policy issues

- Become familiar with the natural history of wildlife species with historical, economic, regional or other significance and develop a basic understanding of wildlife ecology. Examine the relationship between wildlife and other natural resources
- Getting an overview about the structure & functioning of lake ecosystems with emphasis on the interaction of physico-chemical & biological processes. Participants are trained how to apply physico-chemical methods and to identify/ quantify major biological components in lake ecosystems and their interlinkages within the food-web. Participants are acquiring the basic knowledge to evaluate the status quo of lake ecosystems for environmental protection & conservation issues (biodiversity, etc.) and for assessing potential environmental impacts (caused by pollution, structural deficits, introduced alien species, bio-manipulation attempts, etc.). Assessment of the effect of environmental impacts on lake ecosystems are enabling participants to integrate basic limnological knowledge in the context of the development of lake management strategies (eutrophication, & pollution, fisheries management, biodiversity/conservation issues, drinking water supply & sanitation).
- Introducing the structure and functioning of wetland & riverine floodplain ecosystems. Participants are trained in various methods for studying physico-chemical processes and biological components/processes and getting insights into the values of wetlands & riverine floodplain systems, both on the ecosystem level and for the utilisation by human beings. Strategies for the conservation & restoration of natural wetland & riverine floodplain ecosystems are promoted and case examples of rehabilitation projects are visited. Participants are enabled to understand the basic principles underlying the use of constructed wetlands for waste-water treatment.

Course Code: NBI-IWRM 161

Course Title: Wetlands Ecology

Credit Hours: 2

Prerequisites: Basic knowledge of integrated water resources management and principles of hydrology

Summary and General Objective:

To provide students with importance of wetlands in integrated water resources management

Specific Objectives:

- To get familiarity with the importance of wetlands in integrated water resources management
- To get familiarity with the laws and conventions governing the management and conservation of wetland resources in Sub-Saharan Africa
- To raise awareness for the need to manage wetlands and wetland resources on a sustainable basis.
- To make a wetland inventory and thereafter monitor wetland changes and predict future trends.

Course Outline:

- An overview of wetlands
- Wetland ecology
- Wetland values
- Wetland management and conservation: issues and challenges
- Threats to wetlands
- Wetland biodiversity issues
- Wetland assessment and monitoring
- Economic valuation of wetland resources
- The use of wetlands in wastewater treatment
- Public awareness and enlightenment and wetland conventions and laws
- Wetland management plan development
- Field work

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	22
Course Laboratory Hours:	NA
Course Computer Hours:	8
Course Field Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Charles D. Stutzenbaker 1999,** Aquatic and Wetland Plants, Texas Parks and Wildlife Press

Course Code: NBI-IWRM 162

Course Title: Limnology

Credit Hours: 2

Prerequisite: Knowledge of biological, chemical and physical

Summary and General Objective:

Limnology is the study of inland waters. This course integrates aspects of chemistry, physics, hydrology, and ecology to create a holistic perspective on lakes and other freshwater ecosystems. Emphasis will be on human impacts and interactions with aquatic systems and the synthesis of ideas.

Specific Objectives:

- To familiarize the student with the basic concepts of limnology.
- After taking this course the student should have an understanding of the following concepts:

  - Freshwater biota and habitats;
  - The ecology of freshwater;
  - Energetic in freshwater ecosystems

Course Outline:

- Introduction to the basic scientific background of environmental issues: hydrology, ecology, biogeochemical cycles, environmental chemistry.
- Limnology: Past, Present, and Future
- Relation between humans and freshwater ecosystem issues:
- Introduction on natural wetlands and constructed wetlands for wastewater treatment, integrated production systems.
- Introduction to running water ecology, biota in streams & rivers.
- Introduction to the Chemistry of Natural Waters
- Pollution microbiology and water quality monitoring
- The Structure of Aquatic Ecosystems

  - Water Chemistry
  - Water and Light

- Water Movement

- Physical limnology, physicochemical parameters, microbial ecology, phytoplankton and primary production, and palaeolimnology.
- Zooplankton & secondary production, fish ecology & fisheries, characterizing food webs, and environmental impact assessment & lake management strategies.
- Ecology of fishponds, fishpond management, fish breeding/rearing farms and fish stocking, fish diseases & parasites and environmental impacts upon fish health status.
- Sources and effects of water pollution, physicochemical and microbiological methods, water quality monitoring approaches and laboratory safety and laboratory quality assurance.
- Field trip

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	22
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications – field work

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Cole, Gerald A. 1994,** Textbook of Limnology, 4th edition. Waveland Press. Prospect Heights, Illinois. ISBN 0-88133-800-1
- **Robert G. Wetzel, 1983,** Limnology, Publisher: Harcourt Brace & Co ISBN: 0030330165
- **Robert G. Wetzel, 2001,** Limnology, Lake and River Ecosystems Publisher: Academic Pr Inc, ISBN: 0127447601

Course Code: NBI-IWRM 163

Course Title: Ecological Engineering and Industrial Ecology

Credit Hours: 2

Prerequisites: Basic knowledge of integrated water resources management and principles of hydrology

Summary and General Objective:

To provide students with ecological processes that assimilate pollutants in the environment, and industrial ecology as applied to industrial pollution prevention

Specific Objectives:

- To get familiarity with ecological processes that assimilate pollutants in the environment
- To get familiarity with the application of such system in the treatment of waste produced from anthropogenic activities
- To get familiarity with the concept of industrial ecology as applied to industrial pollution prevention
- To get familiarity with the application of concepts such as life assessment, cleaner production to minimize waste generation at source.

Course Outline:

- Theoretical ecology. Disturbed balance; human source, industrial source. Disturbed biochemical cycle.
- Control of eutrophyles. Ecological principles and concepts. Ecosystem characteristics. Ecological modeling. Ecotoxicology.
- Defining industrial ecology, industrial ecology as a field of ecology;
- Goals of industrial ecology: sustainable use of resources, industrial ecology and human health, environmental equity; key concepts of industrial ecology: systems analysis, material, energy flows, transformations, multidisciplinary approach, analogies to natural systems, open- vs. closed-loop systems
- Strategies for environmental impact reduction; industrial ecology as a potential umbrella for sustainable development strategies

- System tools to support industrial ecology: life cycle assessment, components, methodology, applications, difficulties, life cycle design & design for environment, needs analysis, design requirements, design strategies, design evaluation;
- Cleaner production: introduction, benefits of a pollution prevention, improved company image, public health and environmental benefits, the environmental management hierarchy, what is pollution prevention, what is not pollution prevention, waste minimization, source reduction, recycling, steps for waste minimization, future needs

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	22
Course Laboratory Hours:	NA
Course Computer Hours:	12
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Mitsch, W.J. Jorgensen, S.E., 1989,** Ecological Engineering John Willey and Sons
- **Ayres, Robert U. and Ayres, Leslie, 1986,** Industrial Ecology: Towards Closing the Materials Cycle. Edward Elgar Publishers, London.
- **T.E. Graedel and B.R. Allenby, 1995,** Industrial Ecology, Prentice Hall
- **Ayres, R.U. and Ayres, L.W., 1996,** Industrial Ecology: Towards Closing the Materials Cycle, Edward Elgar Publishing, Cheltenham, U.K.
- **Socolow, R., Andrews, C., Berkhout, F., and Thomas V. (Eds)**, Industrial Ecology and Global Change, Cambridge University Press, New York

Course Code: NBI-IWRM 164

Course Title: Issues of Tropical Biology

Credit Hours: 2

Prerequisites: Knowledge of biological, chemical and physical

Summary and General Objective:

The students will gain a better understanding of ecological processes and natural environments in the tropics and become familiar with principles of environmental management and conservation. The learning goals are critical thinking related to understanding ecological principles, processes and functions, as well as ability to use ecological knowledge for ecosystem management and decision-making. Promoting the understanding of special characteristics of tropical river & lake ecosystems, its interactions with activities/processes in the watershed and relevant ecosystem services.

Specific Objectives:

- To become familiar with ecological processes as they apply to tropical ecosystems
- To become familiar with biodiversity of the tropics
- To experience the biodiversity of the tropics
- To gain an appreciate for the field of conservation biology
- To appreciate the complexity of the balance between human activity and habitat conservation
- To appreciate the values and traditions of another culture

Course Outline:

- Introduction to tropical ecosystems and their major biomes
- Overview of geology and tropical soils.
- Tropical rainforest structure and function
- Introduction to the diverse roots of Nile basin history Insight Guide
- Life on the edge - introduction to mangroves and coral reefs
- What is a sustainable agriculture in the Tropics?

- Role of disturbance in tropical diversity
- Coevolution and mutualism in the Tropics
- Marshes, Savannas and dry forests of the Tropics. Mar. Places we didn't visit
- Restoring tropical land
- characteristics of tropical river & lake ecosystems, its interactions with activities/ processes in the watershed and relevant ecosystem services
- Geomorphology, land-use & ecohydrology

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	28
Course Laboratory Hours:	NA
Course Computer Hours:	NA
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	16
Required Assignment Hours:	12

Teaching Method: Multimedia – computer applications

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **John Kricher, 1997,** A neotropical companion. Princeton University Press. 2nd Edition ISBN 0-691-04433-3
- **Forsyth, Adrian & Miyata, Ken, 1987,** Tropical Nature. MacMillian, Toronto. ISBN: 0684187108.

Course Code: NBI-IWRM 165

Course Title: Wildlife Ecology

Credit Hours: 2

Prerequisites: Knowledge of biological, chemical and physical

Summary and General Objective:

- Understand the history and economics of wildlife management in Nile Basin including important wildlife policy issues
- Become familiar with the natural history of wildlife species with historical, economic, regional or other significance
- Develop a basic understanding of wildlife ecology
- Examine the use of wildlife as a consumptive resource
- Examine the relationship between wildlife and other natural resources

Course Outline:

- Introduction to Wildlife Management;
  - Wildlife Issues and Stakeholders
  - Wildlife Values and Human Culture
  - Wildlife Ethics
  - Species Recovery vs. Reintroductions
  - Wildlife Issue
- Neglect and Exploitation of Wildlife Resources
- Past Successes in Wildlife Management
- Important Wildlife Species
- Ecosystems and Natural Communities
- Carrying Capacity and Population Ecology
- Biomes
- Animal Behavior and Wildlife Management
  - Animals as individuals
  - Population growth
  - Dispersal, dispersion, and distribution
  - Food and feeding
  - The ecology of behavior
  - Population regulation, fluctuation and competition within species

  - Competition and facilitation between species
  - Predation
  - Consumer-resource dynamics
  - Parasites and pathogens
  - Communities and ecosystems
  - Counting animals
  - Experimental management
  - Model evaluation and adaptive management
  - Conservation in theory
  - Conservation in practice
  - Wildlife harvesting
- Food and Cover for Wildlife
- Disease and Wildlife
- Predators and Predation
- Hunting and Trapping (Consumptive uses of Wildlife)
- Urban Wildlife
- Wildlife control

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	28
Course Laboratory Hours:	NA
Course Computer Hours:	NA
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	12
Required Assignment Hours:	10

Teaching Method:	Multimedia – computer applications – field work

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Sincliair, T., Fryxell J., & Caughley, G., 2005,** Wildlife Ecology, Conservation and Management, BlackWell Pub. ISBN: 9781405107372
- **Eric G. Bolen and William L. Robinson, 1995,** WILDLIFE ECOLOGY AND MANAGEMENT, 3rd Ed., Macmillan Publishing Company / Prentice Hall
- **E. G. Bolen and W. L. Robinson** Wildlife Ecology and Management, 5th Ed.,. A Sand County Almanac, Aldo Leopold.

Course Code:	NBI-IWRM 166
Course Title:	Political Ecology
Credit Hours:	2
Prerequisites:	Knowledge of biological, chemical and physical

Summary and General Objective:.

The student shall be aware of interlinkages between questions of peace, conflict resolution, and the process of transformation.

Topics to be covered: Conflicts over Natural Resources; Security, Vulnerability and Violence; Human Rights and Cultural Survival in a Changing Pluralistic World; The Role of Science and Technology in Peace and Transformation; The Role of the State in Peace and Global Transformation; and Global Economic Crisis. A project also included a special project on Peace and Nile basin regional Security.

Course Outline:

- ecology movements and conflicts over natural resources
- towards sustainability with justic
- Water Conflicts and forest Conflicts
- Conflicts over river water
- Large dams and conflicts in river basins
- Water scarcity and people's alternatives
- Fisheries and conflicts at lakes and seas
- Mining and water conflicts

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	27
Course Laboratory Hours:	NA
Course Computer Hours:	10
Course Field Hours:	NA
Total Course Hours:	32
Required Self Reading Hours:	16
Required Assignment Hours:	12
Teaching Method:	Presentation/case history/group work.

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Shiva, Vandana, 1991,** Ecology and the politics of survival Sage Publications Ltd 6 Bonhill Street London EC2A 4PU and United Nations University Press The United Nations University 53-70 Jingumae 5-chome, Shibuya-ku Tokyo 150, Japan

Course Code: NBI-IWRM167

Course Title: Ecology of Lakes – Function conservation & management

Credit Hours: 2

Prerequisites: Basic knowledge of water resources and environmental system components

Summary and General Objective:

Providing students deeper insights into the functioning of Lake Ecosystems and assessing its ecological integrity

Specific Objectives:

- To Participants are getting an overview about the structure & functioning of lake ecosystems with emphasis on the interaction of physico-chemical & biological processes. Participants are trained how to apply physico-chemical methods and to identify/quantify major biological components in lake ecosystems and their interlinkages within the food-web. Participants are acquiring the basic knowledge to evaluate the status quo of lake ecosystems for environmental protection & conservation issues (biodiversity, etc.) and for assessing potential environmental impacts (caused by pollution, structural deficits, introduced alien species, bio-manipulation attempts, etc.). Assessment of the effect of environmental impacts on lake ecosystems are enabling participants to integrate basic limnological knowledge in the context of the development of lake management strategies (eutrophication, & pollution, fisheries management, biodiversity/conservation issues, drinking water supply & sanitation).

Course Outline:

- Introduction to structure and functioning of lake ecosystems and interaction of physico-chemical & biological processes with emphasis on the pelagic food-web.Hydraulics and physical limnology: lake morphometry, wind effects (waves, current), optical properties (radiation, light), fate of heat (stratification, mixing types and stability, heat storage). Effect of processes within the lake catchment area and calculating nutrient balances.

- Physico-chemical parameters: Oxygen, pH, chloride, iron, silicate, orthophosphate, sulphate, nitrite, nitrate, total phosphorus, total nitrogen, ammonia, ionic balance, conductivity, Redox, alkalinity.
- Microbial community: importance of viruses, bacteria and protozoa in lake ecosystems; microbial interactions in food webs; quantitative and qualitative methods in microbial ecology; methods for assessing abundance, biovolume, biomass and production of microbes; comparing different techniques (epifluorescence microscopy, staining techniques, culturing methods, colony forming units, CASY); grazing experiments.
- Phytoplankton & primary production: ecology, structure and composition, systematics and taxonomy, algal abundance, biomass estimation, measurements of photosynthetic and respiration rates, surrogate parameters (chlorophyll a, pigment analysis), toxin producing cyanobacteria.
- Palaeolimnology: diatoms & chrysophytes as bioindicators for eutrophication, acidification, climate change, and salinity.
- Zooplankton & secondary production (rotifers, copepods, cladocera): ecology and taxonomy, qualitative and quantitative techniques, structure and composition, taxonomy (preparation techniques, identification), methods for estimating abundance & biomass estimates, secondary production, fresh weight and dry weight measurements.
- Fish ecology & fisheries: ecological niches, qualitative and quantitative sampling methods in different habitats, reproduction biology, habitat selection, ontogenetic niche shifts, feeding ecology, ageing techniques, estimation of fish growth, food selection and food consumption, bioenergetics of fish-growth, methods of fish-stock assessment (hydroacoustics, beach-seine, gill-net, push-net, combination of sampling techniques, mark recapture, etc.), aquaculture (net-cages)
- Integrating physico-chemical and biological data for characterising the pelagic food-web of Lake Mondsee (trophic interactions, bottom-up versus top-down effects). Case examples of environmental impacts on lake ecosystems & lake management strategies.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	10
Course Computer Hours:	6
Course Field Hours:	N/A
Total Course Hours:	36
Required Self Reading Hours:	12
Required Assignment Hours:	10

Teaching Method:	Multimedia – case studies – seminar and group discussion

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Simon Jennings, 2001**, Marine Fisheries Ecology, Blackwell Science, UK
- **S. Rivas-Martinez, A. Penas, M.A. Luengo & S.Rivas-Saenz; H. Lieth (Ed.), 2003,**. Worldwide Bioclimatic Classification System. CD-Series: Climate and Biosphere II. CD-ROM.
- **Streams and Ground Waters** (Aquatic Ecology) Array Academic Press
- **R. S. Barnes, K. H. Mann, 2001,** Fundamentals of Aquatic Ecology Blackwell Publishing Limited

Course Code: NBI-IWRM168

Course Title: Wetland & River Floodplain Ecology

Credit Hours: 2

Prerequisites: Basic knowledge of water resources and environmental system components

Summary and General Objective:

Promoting functional aspects and management of wetlands and riverine floodplain ecosystems

Specific Objectives:

- Introducing participants to the structure and functioning of wetland & riverine floodplain ecosystems. Participants are trained in various methods for studying physico-chemical processes and biological components/processes and getting insights into the values of wetlands & riverine floodplain systems, both on the ecosystem level and for the utilisation by human beings. Strategies for the conservation & restoration of natural wetland & riverine floodplain ecosystems are promoted and case examples of rehabilitation projects are visited. Participants are enabled to understand the basic principles underlying the use of constructed wetlands for waste-water treatment.

Course Outline:

- Ecology of wetlands: ecology of water plants, role of macrophytes with respect to physico-chemical features in shallow waters; wetland surveying and methods of impact assessment; production ecology of wetland vegetation; decomposition of organic matter in wetlands; nutrients & water plants.
- Sustainable use of wetlands: wetland dynamics, functions and values of wetlands, production ecology of wetland plants; biodiversity, conservation & management strategies; restoration, policies and strategies for restoration of wetland ecosystems.
- Constructed wetlands: wetland soil processes, nutrient cycling in wetlands, type of constructed wetlands for wastewater treatment.
- Structure, function and value of river floodplain ecosystems: functioning of river floodplain systems - concepts (river continuum, flood-pulse, connectivity, disturbance and stability) and energy & matter flux; global status quo of floodplain

ecosystems; heavily impacted river systems - ecological deficits, constraints of human needs and public interests to establish semi-natural conditions; conservation and restoration strategies.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	10
Course Computer Hours:	6
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	12
Required Assignment Hours:	10
Teaching Method:	Multimedia – case studies – seminar and group discussion

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Simon Jennings, 2001,** Marine Fisheries Ecology, Blackwell Science, UK
- **S. Rivas-Martinez, A. Penas, M.A. Luengo & S.Rivas-Saenz; H. Lieth (Ed.), 2003,.** Worldwide Bioclimatic Classification System. CD-Series: Climate and Biosphere II. CD-ROM.
- **Streams and Ground Waters** (Aquatic Ecology) Array Academic Press
- **R. S. Barnes, K. H. Mann, 2001**, Fundamentals of Aquatic Ecology Blackwell Publishing Limited

A.2.7 Cluster Area 7

A.2.7 Cluster Area 7
Climate and Water

NBI-IWRM 171	-	Introduction to Meteorology and Climate
NBI-IWRM 172	-	Impact of Climate Change on Water Resources
NBI-IWRM 173	-	Introduction to Hydroclimatology
NBI-IWRM 174	-	Climate Variability and Change
NBI-IWRM 175	-	Hydrological Risks and Climate Change
NBI-IWRM 176	-	Climate Vulnerability and Adaptation
NBI-IWRM 177	-	Introduction to Agricultural meteorology
NBI-IWRM 178	-	Climate Analysis and Modelling
NBI-IWRM 179	-	Dynamical Climatology
NBI-IWRM 180	-	Applied Hydroclimatology
NBI-IWRM 189	-	Risk Assessment and Management
NBI-IWRM 186	-	Applications of GIS & RS in WRM
NBI-IWRM 109	-	Numerical Methods for Water Resources

Master of Science Specialized in Water, Environment and Climate

This M.Sc programme will provide the students with the knowledge and skills to the study of **Water, Environment and Climate**. All Graduate students must have 36 credit points, 18 credit points by having successfully completed the core programme (compulsory course of IWRM), 6 credit points for M.Sc thesis.

For graduates who wish to be specialized in **Water, Environment and Climate** he must have 6 credit points by successfully completing 3 specialized compulsory courses of Elements of **Climate, Impact of Climate Change on Water Resources** and **Environmental Impact Assessment and auditing.**

Furthermore, he must have 6 credit points by choosing at least 3 courses from the specialized elective courses which are : **Climate Variability and Change, Climate and Water Resources Dynamics, Vulnerability and Adaptation, Environmental Components and Interaction, Environmental Management System, Risk Assessment and Management.**

Graduate students, who successfully complete the master degree programme, are awarded the title **Master of Science in Civil Engineering.**

The graduate students who wish to have certificate of master degree programme specialized in **Water, Environment** and Climate must have complete the following **compulsory** courses

- The course in **Elements of Climate** comprises introduction on the atmosphere, elements of weather & climate, how they are measured and recorded, analysed, represented and interpreted., Circulation of the oceans, Classification of climates and climatic types, Climate change(causes and implications).
- The course in **Impact of Climate Change on Water Resources** which is directed towards understanding the Effects of Climate Change on the Hydrological Cycle (Precipitation, Evaporation, Soil Moisture, River Flows,…), the Effects Climate Change on Water Withdrawals (World Water Use, Sensitivity of Demand to Climate Change and Impacts of Climate Change on Water Resources and Hazards.
- The course in **Environmental Impact Assessment and auditing** which covers the following topics: The legal context of environmental impact assessment, The process of EIA in practice, in the context of the many different stakeholders, Different methods for the assessment of multi-disciplinary environmental impacts, Preparation of the Environmental Statement, Conducting a live EIA project with choice of application to different sectors, Strategic Environmental

Assessment and other applications of EIA techniques and development of skills in independent research, team work, and project management.

In addition to the above courses, it also required from the graduate students specialized in **Water, Environment and Climate** to choose at least 3 courses from the following electives available courses:

- The course in **Climate Variability and Change** which covers the following topics: Understanding Climate Variability Patterns and predictability of the African/ NB monsoon, knowledge of Current and Emerging Forecasting Capabilities Research on climate indicators, Applying Climate Information for Decision Making Interpretation methodologies, and Institutionalizing Climate Information Application Systems National experiences, constraints and opportunities for building climate information and user networks, and emerging issues on the sustainability of the institutionalization process.
- The course in **Vulnerability and Adaptation** covers the following topics: Climatic Change and Risks for Human Development, Human-Environment Systems (Development, Equity, and Sustainability), Society Response, How are Impacts, Adaptation, and Vulnerability Assessed, How do Complexities of Analysis Affect the Assessment, How can this Assessment be used to Address Policy-Relevant Questions? , Adaptation Options and Management Implications, Integration(Water and Other Sectors), Science and Information Needs.
- The course in **Environmental Components and Interaction** involves components of the environment, Physical components, Atmosphere, Human Impact and Ecosystems, Historical basis of pollution, Renewable and Non-renewable resources and Costs associated with resource exploitation.
- The course in **Environmental Management System** covers the following: Introduction to environmental management, Legal framework and mechanisms, Environmental standards, National environmental action plan, The National Environmental Law, Environmental Management Systems, Environmental Information Systems, Environmental monitoring and Limitations.
- The course in **Risk Assessment and Management** covers the following: An introduction to the importance of risk management in water resources management, Principles and methods of evaluating the toxicity of chemicals, Studies of environmental epidemiology and epidemiological control, Evaluation of physical accidents, and evaluation of health risks to progeny associated with exposure to chemicals, Aquatic (marine and freshwater) biotoxins, genetic effects

in human populations, and tests for carcinogenic and mutagenic chemicals, Promotion and enforcement of environmental health quality standards **and** Collaborative effects to study the effects of environmental hazarads.

Summary and General Objective:

This course will enable the students to develop an understanding of the assessment process, its legal context, and specific methodologies that address different types of environmental impacts. Also he will be able to measure vulnerability to climate change, adaptation and mitigation methods, defining and calculating vulnerability to climate change. Knowledge and skills of the relation between different environmental components and how they interact on each others. To be familiar with Hydrological impacts of increased climate variability on river basins, Integrated anticipatory and reactive adaptation strategies, including concepts, principles, assessment frameworks and structural and non-structural measures. Be able to calculate water requirements and water use for planning and scheduling of irrigation. Also he will be able to use general climatic and numerical models used to characterize the large-scale weather processes and tropical meteorological influence on NB weather patterns.

Specific Objectives:

Upon completion of this program, students will be able to have:

- Understanding of Basic concepts and principles of weather and climate, measurement, analysis, representation and interpretation of climatic data and Management of small weather stations.
- Understanding of climate variability and change and its impacts on society and environment, get familiar with climate prediction and assessment capabilities, decision-making processes, and the potential for applying climate information, To build a network of professionals in climate research, climate and weather forecasting, intermediary institutions, communications and end users and To test a pilot curriculum that can be adapted to the national level, as well as to other regions.
- Understanding of the basic concepts of climate changing, How do we measure it, What impact will climate change have on water resources, life on earth, Is human activity the cause of climate change, What are the required mitigation measures, Is it possible to adapt to climate change.

- Understanding of the problem of Climatic Change and its Risks for Human Development, Society Responded, Impacts, Adaptation, and Vulnerability Assessed, Analysis , Assessment, Address Policy-Relevant Questions by using the Assessment.
- Understanding of the problem of Rising global temperatures and expected effect to raise sea level, and change precipitation and other local climate conditions, be aware to Changing regional climate that affect human health, animals, and many types of ecosystems, to be familiar with anthropogenic and natural driving forces and its impacts of increasing climate variability and various concepts of adaptation strategies.
- Understanding of the problem of the Main environmental components and their interactions, Processes that define the functioning of ecosystem and Causes and effects of environmental pollution.
- Understanding of the fundamental principles of environmental management systems, Be well versed with the available tools for environmental management and Undertake environmental auditing and monitoring
- Practice the integration of environmental concerns into the development process, Contribute to and assess the quality of environmental impact assessments and Apply the tools of EIA to facilitate wise IWRM.
- To be familiar with the principles and methods of evaluating the toxicity of chemicals, Environmental epidemiology and epidemiological control, promotion and enforcement of environmental health quality standards, To evaluate the physical accidents and the health risks to progeny associated with exposure to chemicals and To study the aquatic (marine and freshwater) biotoxins, genetic effects in human populations, and tests for carcinogenic and mutagenic chemicals.

Course Code: NBI-IWRM 171

Course Title: Introduction to Meteorology and Climate

Credit Hours: 2

Prerequisites: Basic knowledge of IWRM

Summary and General Objective:

To understand basic knowledge of typical circulation and weather systems over Nile basin and to be familiar with general climatic and numerical models used to characterize the large-scale weather processes and tropical meteorological influence on NB weather patterns.

Specific Objectives:

- Basic concepts and principles of weather and climate.
- Measurement, analysis, representation & interpretation of climatic data.
- Management of small weather stations.

Course Outline:

- The natural composition and structure of the atmosphere.
- The elements of weather & climate - how they are measured and recorded, analyzed, represented and interpreted.
- Radiation, heat balance and surface temperatures.
- Pressure and winds and the circulation of the atmosphere - global & African patterns.
- Circulation of the oceans.
- Atmospheric moisture and precipitation.
- Classification of climates and climatic types.
- Climate change - causes and implications.

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	20
Course Laboratory Hours:	8
Course Computer Hours:	8
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	20
Required Assignment Hours:	16 (in class)
Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Lutgens, F K, Tarbuck, E J and Tasa, D, 2000.** The Atmosphere: An Introduction to Meteorology, 8th Edition, Prentice Hall, 512p
- **Oliver, J E and Hidore, J J, 2001.** Climatology: An Atmospheric Science, 2nd Edition, Prentice Hall, 410p
- **Perry A, 2005.** Applied Climatology: Principles and Practice, 2nd Edition, Routledge, 384p
- **Barry, R G, 2001.** Synoptic and Dynamic Climatology, 1st Edition, Routledge, 608p
- **Von Storch, H and Navarra, A, 1999.** Analysis of Climate Variability: Application of Statistical Techniques, 2nd Edition, Springer, 352
- **Climate Research Communication, 1996.** Natural Climate Variability on Decadal-To-Century Time Scales, National Academy Press, 644p

- **Anderson, D L T and Willebrand, J, 2006.** Decadal Climate Variability: Dynamics and Predictability (NATO ASI Series / Global Environmental Change), 1st Edition, Springer, 493p
- **Doering III, O C, Randolph, J C, Southworth, J and Pfeifer, R A (Eds), 2002**. Effects of Climate Change and Variability on Agricultural Production Systems, 1st Edition, Springer, 296p
- **Van Dam, J C, 2003**. Impacts of Climate Change and Climate Variability on Hydrological Regimes (International Hydrology Series), New Edition, Cambridge University Press, 156p
- **Ribot, J C, Magalhães, A R and Panagides, S, 2005**. Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics, Cambridge University Press; New Ed edition, 189p
- **Salinger, J, Sivakumar, MVK and Motha, R P, 2005.** Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry, 1st Edition, Springer, 362p
- **Kane, S M and Yohe, G W, 2000.** Societal Adaptation to Climate Variability and Change, 1st Edition, Springer, 278p

Additional Information:

- **Climate Change 2001:** Working Group II: Impacts, Adaptation and Vulnerability Ch. 4. Hydrology and Water Resources. Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001**: Mitigation, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001:** The Scientific Basis, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001**: Synthesis Report, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)

Course Code: NBI-IWRM 172

Course Title: Impact of Climate Change on Water Resources

Credit Hours: 2

Prerequisites: Basic knowledge of elements of climate, climate variability and climate models

Summary and General Objective:

To provide the knowledge of mathematical models types used in simulation of climate. Development and structure of selected nembers of the hierarchy of models ranging from energy balance models to general circulation models. Applications to pale climate and future climate scenarios

Specific Objectives:

- Is climate changing? How, Why?
- How do we measure climate change?
- What does it matter? What impact will climate change have on water resources? On life on earth?
- How fast is climate changing?
- Is human activity the cause of climate change?
- What are the required mitigation measures? Can we do anything about it?
- Is it possible to adapt to climate change?

Course Outline:

- Effects of Climate Change on the Hydrological Cycle (Precipitation, Evaporation, Soil Moisture, Groundwater Recharge and Resources, River Flows, Trends in Observed Stream flow, Lakes, Flood Frequency, Hydrological Drought Frequency, Water Quality, Ice Caps, River Channel Form and Stability
- Effects of Climate Change on Water Withdrawals
- Impacts of Climate on Water Resources and Hazards (An Overview, A Global Perspective, Catchments and System Case Studies)

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	8
Course Laboratory Hours:	8
Course Computer Hours:	8
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	20
Required Assignment Hours:	16 (in class)
Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Collier, M and Webb, R H, 2002.** Floods, Droughts, and Climate Change, University of Arizona Press
- **Doering III, O C, Randolph, J C, Southworth, J and Pfeifer, R A (Eds), 2002.** Effects of Climate Change and Variability on Agricultural Production Systems, 1st Edition, Springer, 296p
- **Van Dam, J C, 2003.** Impacts of Climate Change and Climate Variability on Hydrological Regimes (International Hydrology Series), New Edition, Cambridge University Press, 156p
- **Ribot, J C, Magalhães, A R and Panagides, S, 2005**. Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics, Cambridge University Press; New Ed edition, 189p
- **Salinger, J, Sivakumar, MVK and Motha, R P, 2005.** Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry, 1st Edition, Springer, 362p

- Kane, S M and Yohe, G W, 2000. Societal Adaptation to Climate Variability and Change, 1st Edition, Springer, 278p

Additional Information:

- **Climate Change 2001:** Working Group II: Impacts, Adaptation and Vulnerability Ch. 4. Hydrology and Water Resources. Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001:** Mitigation, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001:** The Scientific Basis, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001:** Synthesis Report, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)

Course Code: NBI-IWRM 173

Course Title: Introduction to Hydroclimatology

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To describe the meteorological causes of flooding. To describe mechanisms and processes of flood generation in urban and rural catchments. To use case studies of recent floods in the Nile Basin and world-wide to illustrate the variety of mechanisms and impacts

Specific Objectives:

Participants should be able to;

- Understanding of variety of flood generation mechanisms, with role of rainfall, soil moisture and catchment physiography.
- Understanding of the nature and impacts of urban and rural flooding.
- Understanding of variability and change in floods caused by climatic change and variability

Course Outline:

- Extreme rainfall and its causes: meteorology of storms, rainfall mechanisms
- Quantifying extreme rainfall: Concepts and methods, Probable Maximum Precipitation
- Flood generation Principles of runoff generation and groundwater effects
- Snowmelt: principles and role in flooding
- Seasonality: Role of soil moisture and antecedent wetness in flood generation
- Land use Effects of land use and changes in practice on flood generation
- Free Surface Hydraulics I: Flow principles
- Hydraulics II: Free surface flows; hydraulic structures
- Urban drainage and flooding Storm sewers, drainage and overflow
- Coastal flooding Estuarine flooding and joint probability

- Erosion, Sediment Transport and Fluvial Geomorphology:
- Impacts associated with flooding: debris flows and mudslides
- Climate change: principles and observed changes
- Climate change: modelling and predicted changes
- Climate change: future scenarios and uncertainties
- Flood case studies: Nile Basin and world wide.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Faulkner, Duncan; Robson, Alice; Bayliss, Adrian; Houghton-Carr, Helen; Reed, Duncan, 1999,** Flood estimation handbook Wallingford : Institute of Hydrology
- **McCarthy, James J. et al , 2001,** Climate change 2001 : impacts, adaptation, and vulnerability, contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change New York : Cambridge University Press

Course Code: NBI-IWRM 174

Course Title: Climate Variability and Change

Credit Hours: 2

Prerequisites: Basic knowledge of elements of climate, climate variability and climate models, IWRM

Summary and General Objective:

To provide the knowledge of measuring vulnerability to climate change, adaptation and mitigation methods, defining and calculating vulnerability to climate change.

Specific Objectives:

- Does Climatic Change Represent Opportunities and Risks for Human Development?
- How has Society Responded?
- How are Impacts, Adaptation, and Vulnerability Assessed?
- How do Complexities of Analysis Affect the Assessment?
- How can this Assessment be used to Address Policy-Relevant Questions?

Course Outline:

- Climatic Change Represents Opportunities and Risks for Human Development: Allow Ecosystems to Adapt Naturally to Climate Change, Ensure that Food Production is not Threatened, Enable Economic Development to Proceed in a Sustainable Manner
- Human-Environment Systems: Implications for Development, Equity, and Sustainability
- How has Society Responded? (International Responses, National and Local Governmental Responses, Organizational Responses, Adaptive Responses)
- How are Impacts, Adaptation, and Vulnerability Assessed? (Sensitivity, Adaptability, and Vulnerability, Detection and Attribution of Impacts to Climate Change, Key Determinants of Impacts)
- How do Complexities of Analysis Affect the Assessment? (Regional Climate

Uncertainties, Socioeconomic Uncertainties, Risk and Uncertainty, Low-Probability Catastrophic Events, Valuation Methods—Monetary Measures or Multiple Numeraires, Damage Aggregation and Distributional Effects, Discounting, "Safe Emission Levels," Cost-Effectiveness Analysis, and the Timing of emission Abatement, Validation)

- How can this Assessment be used to Address Policy-Relevant Questions? (United Nations Framework Convention on Climate Change, Links to Biodiversity Loss, Desertification, Deforestation and Unsustainable Use of Forests, Stratospheric Ozone Depletion, and Other Global Environmental Issues, Resource Planners, Managers in National and Regional Institutions, and Actors in Specialized International Agencies)
- Adaptation Options and Management Implications: Water Management Options, Implications of Climate Change for Water Management Policy, Factors Affecting Adaptive Capacity, Adaptation to Climate Change in the Water Sector: An Overview
- Integration: Water and Other Sectors: The No climate Context, Water and Other Related Sectors, Ecosystems, Coastal and Marine Zones, Settlements, Financial Services, Health, Water and Conflict.
- Science and Information Needs: Estimating Future Impacts of Climate Change, Adapting to Climate Change.

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	20
Course Laboratory Hours:	8
Course Computer Hours:	8
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	20
Required Assignment Hours:	16 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Von Storch, H and Navarra, A, 1999.** Analysis of Climate Variability: Application of Statistical Techniques, 2nd Edition, Springer, 352
- **Climate Research Communication, 1996.** Natural Climate Variability on Decadal-To-Century Time Scales, National Academy Press, 644p
- **Anderson, D L T and Willebrand, J, 2006.** Decadal Climate Variability: Dynamics and Predictability (NATO ASI Series / Global Environmental Change), 1st Edition, Springer, 493p
- **Van Dam, J C, 2003.** Impacts of Climate Change and Climate Variability on Hydrological Regimes (International Hydrology Series), New Edition, Cambridge University Press, 156p
- **Ribot, J C, Magalhães, A R and Panagides, S, 2005.** Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics, Cambridge University Press; New Ed edition, 189p
- **Salinger, J, Sivakumar, MVK and Motha, R P, 2005.** Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry, 1st Edition, Springer, 362p
- **Kane, S M and Yohe, G W, 2000.** Societal Adaptation to Climate Variability and Change, 1st Edition, Springer, 278p

Course Code: NBI-IWRM 175

Course Title: Hydrological Risks and Climate Change

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To describe current theory and practice of hydrological risk, risk assessment and how risks may change in the future. To review current information and scenarios of possible future climate change, and how they relate to hydrological and water resource operations. To give hands on practice with state-of-the-art software.

Specific Objectives:

Participants should be able to;

- Understanding and practical familiarity with current approaches to estimating and planning for hydrological risk in the fields of floods and droughts.
- Understanding of processes acting on hydrological systems under climate change, and limitations of current scenario methods
- Ability to estimate hydrological extremes using fundamental data sets and modern statistical methods
- Familiarity with industry standard FEH and LowFlows 2000 software
- Practical ability of how to construct and apply scenarios in planning for future operations

Course Outline:

- Risk Theory of risk, its estimation, practice and management.
- Floods and extreme rainfall: meteorology and hydrology of storm events, probabilistic treatment of flood risk, stochastic modelling of extreme events, flood extent and mapping, current practice in flood risk estimation (Flood Estimation Handbook). Case study.
- Drought: definitions and mechanisms of meteorological and hydrological drought, estimation of low flows, probabilistic treatment of drought risk and inclusion of climatic variability and change, mapping of drought risk in Europe and USA, water resources consequences of drought, operational strategies for dealing with drought. Case study:

- Low Flow Estimation Theory and practice of low flow estimation using computer models.
- Climate variability and change: global warming and its impacts; variability and extremes of rainfall; temperature rise and snowmelt; climate modelling and construction of climate change scenarios for hydrological impact modelling

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)
Teaching Method:	Presentation/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Brassington, Rick 1998,** Field hydrogeology (2nd Edition) Chichester : J. Wiley
- **Faulkner, Duncan; Robson, Alice; Bayliss, Adrian; Houghton-Carr, Helen; Reed, Duncan, 1999,** Flood estimation handbook, Wallingford : Institute of Hydrology
- **Houghton, John, 1996,** Climate change 1995 : the science of climate change Theodore et al Cambridge ; New York : Cambridge University Press
- **Hosking, J. R. M, 1997,** Regional frequency analysis : an approach based on L-moments; Wallis, James R. Cambridge ; New York : Cambridge University Press

Course Code: NBI-IWRM 176

Course Title: Climatic Vulnerability and Adaptation

Credit Hours: 2

Prerequisites: Basic knowledge of elements of climate

Summary and General Objective:

To provide the knowledge of climatological influences on management and planning decision-making. Be familiar with the determination of potential, climatological predictions and production risks of crops and animals, have the knowledge of the climatic regions of NB and climatic indices (including ENSO) for management and planning during droughts and rainfall cycles. Be able to calculate water requirements and water use for planning and scheduling of irrigation.

Specific Objectives:

- To familiarize the latest information and insights from ongoing studies of climate variability and change and its impacts on society and environment
- To familiarize the participants with state-of- the-art climate prediction and assessment capabilities, decision-making processes, and the potential for applying climate information.
- To build a network of professionals in climate research, climate and weather forecasting, intermediary institutions, communications and end users.
- To test a pilot curriculum that can be adapted to the national level, as well as to other regions.

Course Outline:

- Understanding Climate Variability Patterns and predictability of the African/ NB monsoon. ENSO phenomenon as one of the drivers of climate variability, including monsoons, tropical cyclones, and other linear systems which impact climate and local weather elements.
- Current and Emerging Forecasting Capabilities Research on climate indicators. Regional downscaling techniques. Translation techniques and methodologies for interpreting regional forecasts into local climate out looks.

- Applying Climate Information for Decision Making Interpretation methodologies and tools to prepare and use local climate information to support decision making. Improving the dialogue between climate forecasters and climate information users in government and business.
- Institutionalizing Climate Information Application Systems National experiences, constraints and opportunities for building climate information and user networks, and emerging issues on the sustainability of the institutionalization process.

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	20
Course Laboratory Hours:	8
Course Computer Hours:	8
Course Field Hours:	8
Total Course Hours:	32
Required Self Reading Hours:	20
Required Assignment Hours:	16 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Von Storch, H and Navarra, A, 1999.** Analysis of Climate Variability: Application of Statistical Techniques, 2nd Edition, Springer, 352
- **Climate Research Communication, 1996.** Natural Climate Variability on Decadal-To-Century Time Scales, National Academy Press, 644p
- **Anderson, D L T and Willebrand, J, 2006.** Decadal Climate Variability: Dynamics and Predictability (NATO ASI Series / Global Environmental Change), 1st Edition, Springer, 493p

- **Doering III, O C, Randolph, J C, Southworth, J and Pfeifer, R A (Eds), 2002.** Effects of Climate Change and Variability on Agricultural Production Systems, 1st Edition, Springer, 296p
- **Van Dam, J C, 2003.** Impacts of Climate Change and Climate Variability on Hydrological Regimes (International Hydrology Series), New Edition, Cambridge University Press, 156p
- **Ribot, J C, Magalhães, A R and Panagides, S, 2005.** Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics, Cambridge University Press; New Ed edition, 189p
- **Salinger, J, Sivakumar, MVK and Motha, R P, 2005.** Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry, 1st Edition, Springer, 362p
- **Kane, S M and Yohe, G W, 2000.** Societal Adaptation to Climate Variability and Change, 1st Edition, Springer, 278p

Additional Information:

- **Climate Change 2001:** Working Group II: Impacts, Adaptation and Vulnerability Ch. 4. Hydrology and Water Resources. Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)

Climate Change 2001: Mitigation, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)

Course Code: NBI-IWRM 177

Course Title: Introduction to Agricultural Climatology/Meteorology

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

Agricultural Meteorology is concerned with interaction between meteorological and hydrological factors. to discover and define such effects, and thus to apply knowledge of the atmosphere to practical agricultural use

Specific Objectives:

Participants should be able to;

- Identifying interaction between meteorological and hydrological factors
- discover and define such effects, and thus to apply knowledge of the atmosphere to practical agricultural us.
- extend and fully utilize our knowledge of atmospheric and related processes to optimizing agricultural production with maximal use of weather resources and with minimal damage to the environment. Improving quantity and quality of crop and animal production are amongst its priorities

Course Outline:

- Meteorological elements and their measurement;
  - climate of Nile Basin (Africa);
  - the moisture balance -evaporation,
  - soil storage, run-off, drainage;
  - the energy balance - radiation,
  - conduction, convection, evaporation.
- Climate and soil management;
  - plant requirements of moisture and heat; drought, irrigation.
- Soil fertility implications,
  - Accretion, leaching, volatilization, run-off; timing soil-related activities.
- Weather and crop production;
  - crop-weather interactions,
  - photosynthesis, respiration, canopy development,

  - growth rates; horticultural and protected crops.
- Wind and shelter.
- Plasticulture.
- Diseases of field and horticultural crops.
- Climate change.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Doering III, O C, Randolph, J C, Southworth, J and Pfeifer, R A (Eds), 2002.** Effects of Climate Change and Variability on Agricultural Production Systems, 1st Edition, Springer, 296p

Course Code: NBI-IWRM 178

Course Title: Climate Analysis and Modelling

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide knowledge of climate system and global energy balance and its modeling.

Specific Objectives:

Participants should be able to;

- Familiar with climate modeling
- Knowledgeable of climate interaction with the atmosphere

Course Outline:

- Climate system, global energy balance
- MAGICC energy balance model
- Climate modeling: Why do it? Types of models
- Radiative transfer
- Convective adjustment
- Scientific visualization; Radiative-convective models
- Radiative-convective models
- Atmospheric general circulation modeling
- Coupled general circulation modeling, flux correction
- Climate change experiments, greenhouse gases, aerosols
- Analyze AMIP output
- Radiative-convective model greenhouse gas/aerosol runs
- Volcanic eruptions - model calculations
- Analyze latest SKYHI model outputs
- Nuclear winter
- Nuclear winter experiments with radiative-convective model
- Ozone variations and climatic effect
- Chemistry of tropospheric and stratospheric ozone
- Radiative-convective model simulations of ozone changes

- Land surface modeling
- Land surface feedbacks with radiative convective model
- Detection and attribution of anthropogenic forcing
- Analysis of GFDL control and transient runs

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Peixoto, José P., and Abraham H. Oort, 1992:** *Physics of Climate,* (American Institute of Physics, New York), 520 pp

Additional Information

- Hartmann, Dennis L., 1994: Global Physical Climatology, (Academic Press, San Diego), 411 pp.
- Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson (eds.), 2001: Climate Change 2001: The Scientific Basis (Cambridge Univ. Press, Cambridge), 881 pp. [IPCC Working Group I Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg1/
- McCarthy, James J., Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, and Kasey S. White (eds.), 2001: Climate Change 2001: Impacts, Adaptation, and Vulnerability (Cambridge Univ. Press, Cambridge), 1032 pp. [IPCC Working Group II Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg2/
- Metz, Bert, Ogunlade Davidson, Rob Swart, and Jiahua Pan (eds.), 2001: Climate Change 2001: Mitigation (Cambridge Univ. Press, Cambridge), 752 pp. [IPCC Working Group III Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg3/
- Washington, Warren M. and Claire L. Parkinson, 2005: An Introduction to Three-Dimensional Climate Modeling, Second Edition (Univ. Science Books, Mill Valley, CA), 353 pp

Course Code: NBI-IWRM 179

Course Title: Dynamical Climatology

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

This course is an analysis of factors affecting climatic variations, including solar and terrestrial radiation, atmospheric temperature, pressure and wind patterns, the global hydrologic cycle, and atmospheric chemistry

Specific Objectives:

- This course will provide students with a basic understanding of earth's climate system; practice problem-solving skills and application of scientific concepts; discussion of current climate issues (ENSO, drought, etc.)

Course Outline:

- **Definition of climate**
  - Composition and mass of the atmosphere
- Temperature; Shortwave and Longwave radiation
  - Vertical temperature structure of the atmosphere and ocean
  - Principles of radiative transfer: blackbodies, selective absorbers
  - Spatial distribution of shortwave radiation
- **Radiation**
  - The solar unconstant
  - Longwave radiation and Greenhouse effect
- **Global Cycles**
  - Global energy budget
  - Global carbon budget
  - Global water budget
- **Atmospheric Water**
  - Saturation and humidity
  - Evaporation and condensation
  - Adiabatic lapse rates
- **Clouds and Precipitation**
  - Instability

- Lifting mechanisms and cloud types
- Precipitation mechanisms

- **Climate Dynamics**
    - Momentum/Pressure Gradients
    - Coriolis forces; Geostrophic winds & currents
    - Frictional winds; effects of curvature
    - Atmospheric dynamics
- **Tropical/Subtropical Circulation Systems**
    - Return midterm; introduction to circulation systems
    - Zonally averaged circulations
    - Large scale regional circulations
- **Midlatitude Circulation Systems**
    - Jet streams / thermal wind
    - Waves in the westerlies
    - Cyclones and fronts
- **Oceanic Circulation Systems**
    - Structure of ocean current systems
    - Ekman and Sverdrup flow
    - Thermohaline circulation
- **Local Circulation Systems**
    - Thermally direct circulations
    - Surface energy budgets I
    - Surface energy budgets II
- **Climate Models**
    - Energy balance models
    - General circulation models
- **Climate change**
    - Pre-Holocene variability
    - Holocene variability
- **Short-term Climate Change**
    - Seasonal/interannual variability and prediction
    - The ENSO cycle in the tropical Pacific
    - ENSO-related variability outside the tropical Pacific
- Anthropogenic Climate Change
    - Stratospheric ozone deplection
    - Global warming

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	38
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Dennis L. Hartmann**, Global Physical Climatology , Academic Press, pp. 411
- **Climate Change 2001:** The Scientific Basis, Contribution of Working Group I to the Third Assessment of the Intergovernmental Panel on Climate Change, J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson, Cambridge University Press.
- **D. A. Randall (Ed) 2000,** General Circulation Model Development: Past, Present and Future, Academic Press,
- **W. R. Cotton and R. A. Anthes, 1989**, Storm and Storm Dynamics, Academic Press,
- **J. R. Holton, 1992,** An Introduction to Dynamic Meteorology, Third Edition, Academic Press,

Additional Information

- Hartmann, Dennis L., 1994: Global Physical Climatology, (Academic Press, San Diego), 411 pp.
- Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson (eds.), 2001: Climate Change 2001: The Scientific Basis (Cambridge Univ. Press, Cambridge), 881 pp. [IPCC Working Group I Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg1/
- McCarthy, James J., Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, and Kasey S. White (eds.), 2001: Climate Change 2001: Impacts, Adaptation, and Vulnerability (Cambridge Univ. Press, Cambridge), 1032 pp. [IPCC Working Group II Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg2/
- Metz, Bert, Ogunlade Davidson, Rob Swart, and Jiahua Pan (eds.), 2001: Climate Change 2001: Mitigation (Cambridge Univ. Press, Cambridge), 752 pp. [IPCC Working Group III Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg3/
- Washington, Warren M. and Claire L. Parkinson, 2005: An Introduction to Three-Dimensional Climate Modeling, Second Edition (Univ. Science Books, Mill Valley, CA), 353 pp

Course Code: NBI-IWRM 180

Course Title: Applied Hydroclimatology

Credit Hours: 2

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To quantitatively understand the earth's hydrological cycle, climate variability and climate change from a system point of view

Specific Objectives:

Participants should be able to;

- Understanding hydrological cycle
- Identification cause for climate variability and climate change.

Course Outline:

- Atmosphere, Oceans, and Land.
- Basics of weather and climate and their mathematical equations.
- Radiation, Convection, Clouds, Precipitation, and General Circulation.
- Physical processes having an impact on precipitation and evapotranspiration at the earth's surface.
- Key global change issues explored using simple web-based climate models or state-of-the-art climate models

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Lab/Field work.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Dennis L. Hartmann,** Global Physical Climatology , Academic Press, pp. 411
- **Climate Change 2001:** The Scientific Basis, Contribution of Working Group I to the Third Assessment of the Intergovernmental Panel on Climate Change, J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson, Cambridge University Press.
- **D. A. Randall (Ed) 2000,** General Circulation Model Development: Past, Present and Future, Academic Press,
- **W. R. Cotton and R. A. Anthes, 1989,** Storm and Storm Dynamics, Academic Press,
- **J. R. Holton, 1992,** An Introduction to Dynamic Meteorology, Third Edition, Academic Press,

A.2.8 Cluster Area 8

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DSS – Data collection and Hydro-Informatics

NBI-IWRM 181	- GIS and database management
NBI-IWRM 182	- Principles and components of DSS for IWRM
NBI-IWRM 183	- Hydro-Informatics
NBI-IWRM 184	- DSS & Methods of data collection and management
NBI-IWRM 185	- Integrated Water Information System
NBI-IWRM 186	- Applications of GIS & RS in WRM
NBI-IWRM 187	- Managing Strategies
NBI-IWRM 188	- Knowledge Management for Decision makers in WS
NBI-IWRM 189	- Risk Assessment and Management
NBI-IWRM 109	- Numerical Methods for Water Resources

MSC Title: DSS - Data collection and hydro-Informatics

Summary and General Objective:

- The objective of the course is to recognize the constraints and applicability of models in integrated water resources management. Introduces the concept of database structure to GIS projects and provides skill training in the use of relational databases for spatial and multiple table queries. This course aims at giving an introduction to Remote Sensing (RS) in the context of IWRM.
- 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
- To provide a tool by which the system, targets and challenges can be simulated since most of them are non-structures. It can help in Setting Long term Integrated Water Resources plans on National Level; introducing clear picture for the proposed alternatives and projects that are running under different scenarios; and the decision maker can select the best alternative or modify some alternatives until he gets the best results he/she wants.

Specific objects:

- Understand the relationship between GIS analysis and database management, understand how to balance the requirements of database performance and cost, understand how to evaluate needs, develop a GIS database and implement the data collection for a GIS project, understand how to make effective use of tools of database management.
- Giving an introduction to Remote Sensing (RS) in the context of IWRM. In this course students acquire a base of geographic knowledge and data collection methods used in RS and GIS. capture data included in the DSS, updating data records and files, interrelate data from different sources, retrieve data for queries and reports
- Handle personal and unofficial data so that users can experiment with alternatives solutions based on their judgment, perform complex data manipulation tasks based on queries, manage data through data dictionary, provide support to several interdependent or sequential decisions, support all

- To handle the data in the context of IWRM for Flood damage prevention or reduction. Protection of economic development, conservation storage, river regulation, recharging ground water, water supply, development of power, protection of life etc.
- Understand the fundamentals of water-related processes and advances in a wide range of hydroinformatics technologies
- Know how to choose and use advanced models applied to water-related assets in a wide variety of hydraulic engineering, hydrologic and environmental situations, including water resources and flood management and other problems of civil engineering
- Know about software tools available on the market, and their possible advantages and limitations
- Be able to provide advice to users of advanced information and communication technology tools

Course Code: NBI – IWRM 181

Course Title: GIS and database management

Credit Hours: 2

Prerequisites: Basic knowledge of computer and CAD.

Summary and General Objective:

Introduces the concept of database structure to GIS projects and provides skill training in the use of relational databases for spatial and multiple table queries. Structured Query Language (SQL) is used. Students design, develop, maintain, query and modify a variety of GIS databases. Database importing, exporting, and file conversion are also covered.

Specific objects:

- Understand the relationship between GIS analysis and database management.
- Understand how to balance the requirements of database performance and cost
- Understand how to evaluate needs, develop a GIS database and implement the data collection for a GIS project
- Understand how to make effective use of tools of database management.

Course Outline:

- Introduction, database management systems, database models.
- Database operations and relational algebra.
- Database design using entity-relationship methods.
- Database normalization.
- Geo-database design.
- Streams and river networks.
- Census units and boundaries.
- Addresses and locations.
- Parcels and the cadastre.
- Surveying federal lands.
- Using raster data.
- Cartography and the base map.
- Building geo-databases.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	20
Course Laboratory Hours:	-
Course Computer Hours:	30
Course Field Hours:	-
Total Course Hours:	50
Required Self Reading Hours:	24
Required Assignment Hours:	18

Teaching Method:	Multimedia – computer applications - exercise

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Arctur & Zeller, 2004,** Designing Geo-databases: Case Studies in GIS Data Modeling, ESRI,
- **Tim Ormsby, et. al., 2001,** Getting to Know ArcGIS Desktop,ESRI Press
- **Scott Hutchinson and Larry Daniel, 2000.,** Inside ArcView GIS, Third Edition, Albany, NY: OnWord Press
- **Angela Whitener, Paula Loree, and Larry Daniel, 1999,** Inside MapInfo Professional, Second Edition, Santa Fe, NM: OnWord Press.

Course Code: NBI – IWRM 182

Course Title: Principles and components of DSS for IWRM

Credit Hours: 2

Prerequisites:

Summary and General Objective:

The objective of the course is to recognize the constraints and applicability of models in integrated water resources management. The lectures are built around case studies related to flood risk (both coastal and rivers), ecology, and shipping. Each lecture is combined with an assignment, which deals with the same problem for a different case than the one presented during the lecture. The following themes are subject of the lectures:

Course Outline:

- Identifying key processes and variables. System conceptualization. Case study DSS for the Nile River.
- Appropriate spatial resolution of data: case study
- Probabilistic design of flood defence works: the Nile river works
- Scenario uncertainty and uncertainty propagation in models and model chains
- Evaluation techniques and multi-criteria analysis: case study
- The role of norm setting: flood risk norms: economic cost-benefit analysis vs. accident statistics
- Integrated modelling: the Nile river (combining multiple objectives of hydropower, shipping Vegetation ecology, and flood safety)

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	38
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)
Teaching Method:	Presentation/software in modeling – case studies

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **E. Turban and J. Aronson, 1998,** Decision Support Systems and Intelligent Systems (Fifth Edition). Prentice-Hall: Upper Saddle River, NJ
- **R. Sprague, Jr. and H. Watson, 1996**, Decision Support for Management. Prentice-Hall: Upper Saddle River, NJ
- **David Olson and James Courtney, 1992,** Decision Support Models and Expert Systems, Macmillan Publishing Company.
- **A. Sage, 1991,**.Decision Support Systems Engineering, John Wiley and Sons
- A. Golub, 1997, Decision Analysis: An Integrated Approach, John Wiley and Sons, New York, NY.

Additional Information:

Examples of Existing Decision Support Systems (DSS)

- AQUATOOL – Polytechnical University Valencia
- ENSIS – NIVA
- MIKE BASINS - DHI
- RIBASIM – Delft Hydraulics
- SPATIAL DSS – NTUA
- WATERWARE – Eureka 487
- WEAP – Stockholm Institute

Course Code: NBI – IWRM 183

Course Title: Hydro-Informatics

Credit Hours: 2

Prerequisites:

Summary and General Objectives:

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.

Specific Objectives:

- Understand the fundamentals of water-related processes and advances in a wide range of hydroinformatics technologies
- Know how to choose and use advanced models applied to water-related assets in a wide variety of hydraulic engineering, hydrologic and environmental situations, including water resources and flood management and other problems of civil engineering
- Know about software tools available on the market, and their possible advantages and limitations
- Be able to provide advice to users of advanced information and communication technology tools

Course Outline:

- Hydroinformatics and flood management
- Hydroinformatics and Water Scarcity
- Hydroinformatics and Urban Water Management
- Hydroinformatics and Environmental Integrity
- Hydroinformatics and Water Resources
- Hydroinformatics and Coastal Waters Management
- Simulation modeling
    - numerical methods
    - ecohydraulics
- Data mining, knowledge discovery and data-driven modeling
    - neural and fuzzy systems

  - machine learning
  - chaos theory
  - wavelets theory
  - pattern recognition and classification
- Optimization and control
  - global optimization and randomized search
  - automatic models calibration
  - optimal real-time control
- Uncertainty and risk in water resources
- Internet-based computing and collaborative decision making
- Knowledge management

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	22
Course Computer Hours:	22
Total Course Hours:	44
Required Self Reading Hours:	20
Required Assignment Hours:	10 (in class)

Teaching Method: Multimedia – computer applications, exercise .

Course Examination Method (Grading System): NA

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Price, R K, 2005,** Research, education and information systems in the context of a framework for flood management. In Transboundary Floods: Reducing Risks and Enhancing Security through Improved Flood Management Planning , NATO Advanced Study Workshop, Oradea , Romania , May
- **Price, R K, 2005,** Growth and significance of hydroinformatics. Chap 5 in River Basin Modelling for Flood Risk Mitigation, Springer,
- **Price, R K, 2005,** The application of hydroinformatics. Chap 6 in River Basin Modelling for Flood Risk Mitigation, Springer
- **Price, R K, 2005,** Strategy and Role for ICHARM. Report to UNESCO

Course Code: NBI – IWRM 184

Course Title: DSS and Methods of data collection and management

Credit Hours: 2

Prerequisites: Basic knowledge of surface and groundwater hydrology; social and environmental laws.

Summary and General Objectives:

To provide a tool by which the system, targets and challenges can be simulated since most of them are non-structures. It can help in Setting Long term Integrated Water Resources plans on National Level; introducing clear picture for the proposed alternatives and projects that are running under different scenarios; and the decision maker can select the best alternative or modify some alternatives until he gets the best results he/she wants.

Specific Objectives:

- Capture data included in the DSS
- Updating data records and files
- Interrelate data from different sources
- Retrieve data for queries and reports
- Handle personal and unofficial data so that users can experiment with alternatives solutions based on their judgment.
- Perform complex data manipulation tasks based on queries
- Track data use within the DSS
- Manage data through data dictionary
- Support various managerial levels Top to bottom.
- Provide support to several interdependent or sequential decisions.
- Support all phases of the decision making process.

Course Outline:

- Part 1 covers raw data; status access; and decision support systems
- Part 2 covers the Basis of decision making, and general analysis capabilities models

- Part 3 covers Computer-Based Decision Support and solution suggestions
- Part 4 covers Knowledge Management Techniques, and evaluation and control laws (expected, proposed).
- Part 5 covers multi-participant decision support, and future development plans

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	24
Course Laboratory Hours:	24
Course Field Hours:	-
Total Course Hours:	48
Required Self Reading Hours:	10
Required Assignment Hours:	6

Teaching Method:	Multimedia – case studies and Computer applications.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:.

- **Turban E. and J. Aronson, 1998,** Decision Support Systems and Intelligent Systems (Fifth Edition). Prentice-Hall: Upper Saddle River, NJ
- **Sprague R., Jr. and H. Watson, 1996,** Decision Support for Management. Prentice-Hall: Upper Saddle River, NJ.
- **David Olson and James Courtney, 1992,** Decision Support Models and Expert Systems, Macmillan Publishing Company.
- **Sage A., 1991,** Decision Support Systems Engineering, John Wiley and Sons.
- **Golub A., 1997,** Decision Analysis: An Integrated Approach, John Wiley and Sons, New York, NY.

Additional Information:

Examples of Existing Decision Support Systems (DSS)

- AQUATOOL – Polytechnical University Valencia
- ENSIS – NIVA
- MIKE BASINS - DHI
- RIBASIM – Delft Hydraulics
- SPATIAL DSS – NTUA
- WATERWARE – Eureka 487
- WEAP – Stockholm Institute

Course Code: NBI – IWRM 185

Course Title: Integrated Water Information System

Credit Hours: 2

Prerequisites: Basic engineering and other social sciences

Summary and General Objective:

To handle the data in the context of IWRM for Flood damage prevention or reduction. Protection of economic development, conservation storage, river regulation, recharging ground water, water supply, development of power, protection of life etc. To facilitate data entering, retrieving and processing, To prepare proper data for modeling and prediction etc..

Course Outline:

- Main categories of information River Basin Management
- General Information, Hydrological Information, River Structures, Flood Mitigation, Water Supply Management, River Environmental Management, and Watershed Management
- Principle kinds of water resources data required
  - Rainfall: Amount of storm rainfall, intensity, duration, coverage
  - River Stage: Maximum stage, stage hydrograph during floods, propagation of flood wave along the streams and tributaries, flood profiles
  - Discharge: Maximum and minimum discharge, flood frequencies, flood discharge hydrograph
  - Evaporation: Seasonal and annual evaporation rate
  - Sediment: Rate of suspended and bed load transport
  - Rainfall, River Stage, Discharge and Sediment
- Types of works and measures
  - Dams, storage reservoirs, levees, flood walls, channel Improvement, floodways, pumping stations, flood plain zoning, flood forecasting
- Unified data format
- Link with GIS, RS and modeling tools
- Domestic and Industrial Water Supply, Watershed Management, Sediment Control, Salinity Control and Artificial Rain
- LAND DEVELOPMENT, Agricultural Irrigation & Drainage

Maximum Number of Participants: 20

Course Duration: 1 semester

Course Lecture Hours:	26
Course Laboratory Hours:	-
Course Computer Hours:	12
Course Field Hours:	-
Total Course Hours:	38
Required Self Reading Hours:	10
Required Assignment Hours:	6

Teaching Method:	Multimedia – case studies and Computer applications.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- Water Quality And Pollution Control Handbook,

Additional Information:

Detailed water information system includes:

- Acid Rain and Acidic Water Problems,
- Agriculture and Forestry Water Relationships
- Aquatic Organisms and Water Quality Relationships
- Biological Contamination and Water Quality Impacts
- Chemical Contamination and Water Quality Impacts
- Climate and Water Impacts
- Construction/Landscaping and Land Disturbance Impacts
- Desalination/Desalinization
- Fisheries (Aquaculture) Production and Water Quality

- GIS Applications to Water Resources
- Groundwater Information
- Health/Personal Care Products and Water Quality
- Hydrological Modification and Water Problems
- Hydroponics
- Irrigation Information
- Karst Conditions (Sinkholes) and Water Problems
- Kids Stuff on Water
- Land Use/Management Impacts on Water Quality
- Natural Disasters and Water Impacts
- People and Water Quality Relationships
- Ponds and Pond Management
- Radiological Agents and Water Quality
- Recreational Activities and Water Quality
- Sediment Contamination and Water Quality Impacts
- Storm Water Runoff and Management

Course Code: NBI – IWRM 186

Course Title: Applications of GIS and RS in Water Resources Managements

Credit Hours: 2

Prerequisites: Basic knowledge of water resources, computer and CAD.

Summary and General Objective:

This course aims at giving an introduction about application of Remote Sensing (RS) in the context of IWRM. In this course students acquire a base of geographic knowledge and data collection methods used in RS and GIS.

Specific Objectives:

- Acquisition and compilation of data from maps, field surveys, air photographs and satellite images.
- Use of remotely sensed imagery for change detection, calculation, and analysis is explored.
- Image processing and remote sensing capabilities of raster GIS to introduce remote sensing concepts such as image classification.

Course Outline:

- Introduction to remote sensing and digital image processing as a source of input to geographic information systems.
- Electromagnetic energy and remote sensing, Electromagnetic energy, Waves and photons, Electromagnetic spectrum, Active and passive remote sensing; Energy interaction in the atmosphere, Absorption and transmission, Atmospheric scattering; Energy interactions with the Earth's surface, Spectral reflectance curves
- Sensors and platforms; Sensors, Passive sensors, Active sensors; Platforms; Image data characteristics; Data selection criteria; Availability of image data; Costs of image data
- Image processing; Perception of colour; Histograms; Linear colour coding; Colour composites; Filter operation, Noise reduction, Edge enhancement, Application of filters; False colour images; Vegetation index
- Digital Image classification; Principle of image classification, Image space,

Feature space, Image classification; Image classification process, Preparation for image classification, Classification algorithms; Validation of the result; Problems in image classification

- Software and hardware requirements for RS.

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	-
Course Computer Hours:	16
Course Field Hours:	-
Total Course Hours:	40
Required Self Reading Hours:	24
Required Assignment Hours:	18 (in class)

Teaching Method: Multimedia - Computer RS Applications.

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Allard M.J. Meijerink, Hans A.M. de Brouwer, Chris M. Mannaerts, Carlos R. Valenzuela 1994**. Introduction of G.I.S. for Practical Hydrology
- **Lucas L.F. Janssen (ed.).Wim H. Bakker, Lucas L.F. Janssen, Michael J. C. Weir, Ben G. H. Gorte, Christine Pohl. 2000**. Principles of remote sensing (ITC Educational textbook Series; 2).

Course Code: NBI-IWRM187

Course Title: Managing Strategies

Credit Hours: 2

Prerequisites: Basic knowledge of water resources and environmental system components

Summary and General Objective:

To provide students with the necessary tools for developing managing strategies for water resources, environmental systems, and also human resources

.

Specific Objectives:

- To get familiarity with the concept of strategy and the strategy formulation process as applied to water resources
- To get familiarity with strategy implementation processes applicable to water resources
- To get familiarity with the water supply and water quality planning tools, legal/institutional aspects of water resources, and integrative land and water management

Course Outline:

- Identifying the scope and target groups of the strategy
- Defining the principles of the strategy
- Framing the concept of the strategy (Strategy Formulation Process)
- Moving from strategy to action (Strategy Implementation Process)
- Strategy development in IWRM framework

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	32
Course Laboratory Hours:	NA
Course Computer Hours:	NA
Course Field Hours:	0
Total Course Hours:	32
Required Self Reading Hours:	12
Required Assignment Hours:	10

Teaching Method:	Multimedia – case studies – seminar and group discussion

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%
Course Project:	NA

References:

- **Berkoff, J. , 1994,** A Strategy for Managing Water in the Middle East and North Africa, Directions in Development, World Bank, Washington, USA. (ISBN 0-8213-2709-7)

Course Code: NBI-IWRM188

Course Title: Knowledge Management for Decision Makers in the Water Sector

Credit Hours: 2

Prerequisites: Basic knowledge of water resources and environmental system components

Summary and General Objective:

Providing students deeper insights into the functioning of Lake Ecosystems and assessing its ecological integrity

Specific Objectives:

- Increasingly make major investment and/or strategy decisions that depend on digital tools and advanced media
- Feel a responsibility for creating an enabling environment, in which the capacity of individuals and groups are utilised optimally
- Direct major initiatives where access to, and exchange of, knowledge is a critical success factor.
- Favor learning through a case-based approach, with hands-on practical training and frequent interaction among peers and experts...

Course Outline:

- Complexity Management in the 21st Century
- The Knowledge Economy
- Major Challenges for the Water Sector
- The Knowledge Creating Organisation; Private and Public
- Leadership in the Knowledge Organisation
- Intellectual Capital and Processes to organise and disseminate knowledge
- People, Knowledge, and Capacity Building in Water Sector Organisations
- The Role of Indigenous Knowledge
- The Knowledge Cycle and its Management
- Integrating Knowledge and Performance Systems Roles and Responsibilities in the Knowledge Organisation
- Knowledge Assets and Customer Value

- Knowledge Mapping: locating and connecting an organisation's knowledge assets
- Choosing the appropriate ICT tools for organisational knowledge gain
- Organisation Learning: applying knowledge for continuous improvement
- Data, information and knowledge-based systems Process modelling
- Decision Support Systems (DSS) for the Water Sector
- Virtual workspaces and Communities of Practice (CoPs)
- Communication for Senior Leaders: videoconferences, electronic boardrooms.
- Internets, Intranets, E-portals and Knowledge (Partner) Networks Examples of Water Networks
- E-learning and on-the-job training methods

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	24
Course Laboratory Hours:	10
Course Computer Hours:	6
Course Field Hours:	0
Total Course Hours:	32
Required Self Reading Hours:	12
Required Assignment Hours:	10

Teaching Method:	Multimedia – case studies – seminar and group discussion

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	30%
Course Project:	20%

References:

- **UNESCO-IHE,** 2006

Code: NBI-IWRM 189

Course Title: Risk Assessment and Management

Credit Hours: 2

Prerequisites: Basic knowledge of mathematics, sciences and engineering fields

Summary and General Objective:

To provide students with the necessary studies of health risks to progeny associated with exposure to chemicals, heath quality standards, and the effects of environmental hazards.

Specific Objectives:

- To be familiar with the principles and methods of evaluating the toxicity of chemicals.
- To be familiar with environmental epidemiology and epidemiological control
- To evaluate the physical accidents and the health risks to progeny associated with exposure to chemicals
- To be familiar with promotion and enforcement of environmental health quality standards
- To study the aquatic (marine and freshwater) biotoxins, genetic effects in human populations, and tests for carcinogenic and mutagenic chemicals.

Course Outline:

- An introduction to the importance of risk management in water resources management
- Principles and methods of evaluating the toxicity of chemicals
- Studies of environmental epidemiology and epidemiological control
- Evaluation of physical accidents, and evaluation of health risks to progeny associated with exposure to chemicals
- Aquatic (marine and freshwater) biotoxins, genetic effects in human populations, and tests for carcinogenic and mutagenic chemicals.
- Promotion and enforcement of environmental health quality standards
- Collaborative effects to study the effects of environmental hazards

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	29
Course Laboratory Hours:	N/A
Course Computer Hours:	6
Course Field Hours:	N/A
Total Course Hours:	32
Required Self Reading Hours:	12
Required Assignment Hours:	10

Teaching Method:	Multimedia – computer applications laboratory and field instruments

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	50%

References:

- **Yacov Y. Haimes, 2004,** Risk Modeling, Assessment, and Management –Wiley-IEEE Publisher

A.2.9 Cluster Area 9

A.2.9 Cluster Area 9
Hydropower Engineering Development

NBI-IWRM 191	-	River Basin Management
NBI-IWRM 192	-	Open Channel hydraulics
NBI-IWRM 193	-	Hydropower Engineering and Management
NBI-IWRM 194	-	Dam Construction and Rehabilitation
NBI-IWRM 195	-	Reservoir Storage and Hydropower
NBI-IWRM 196	-	Hydropower Electro-mechanical equipments
NBI-IWRM 197	-	Small Hydropower Plants and Alternate Energy
NBI-IWRM 198		Sources
NBI-IWRM 199	-	Design of Components of Hydropower Systems
NBI-IWRM 153	-	Hydraulic Transients in Hydropower Systems
NBI-IWRM 186	-	Participatory Watershed Management
NBI-IWRM 109	-	Application of GIS and RS in WRM
	-	Numerical Methods for Water Resources

M.S.C Title: Hydropower Engineering Development

Summary and General Objective:

This course provides understanding principles of dam design, construction, operation, regulation and rehabilitation. This course enables students to plan, design and analyze various components of hydropower schemes such as types of turbines, their characteristic and performance along with the associated equipments. It covers structural and mechanical components from water intake through water conveyances and powerhouse up to return flow to Original River

Specific Objectives:

- Development of hydrodynamic equations and their applications to the open channel flow. Applications for transient regime in channels: kinematic and diffusive waves Applications for hydraulic design of prismatic channels and stilling basins. Various types of measuring equipments. Flow over broad crested weir, through a contraction, underneath a gate.
- Familiarity with type of dams and their functions, how to select a suitable dam type for give conditions, field investigation for construction (structural and geotechnical), How to propose a dam design based on long-term hydrologic analysis, familiarity with aspects related to dam operation, safety and rehabilitation
- Describing forms of energy focusing on water energy, the status of global energy supply and sources as well as the situation in the Nile basin. Emphases are on hydropower projects and development including feasibility, implementation and maintenance along with economic.
- To get familiar with different types of turbines, features, arrangement and performance, main components, equipments and instrumentation of hydropower plants.
- Advanced understanding and working knowledge on main principles and practices used in the analysis and hydraulic design of dams for storage, regulation and hydropower development. Principles and operation of the sediment in reservoirs and operation rules. Evaluating the impacts of in-stream flow works over the appropriate timescales. Understanding steady and unsteady flow, transient flow and periodic flow (oscillatory), column separation and water hammer

- Advanced knowledge on use of the surface and underground storage for water harvesting. Systems for rain and floodwater harvesting.
- Familiarize participants with recent advances and updated framework of integrated river management, planning, monitoring and surveying (remote sensing) and operation and maintenance of riverine (sub-) systems, including the treatment of hydraulic infrastructure works, watercourses and riparian land areas (floodplains).
- To understand the relationships between natural water resources and socio-economic systems, concepts and measures to improve the performance of water resources systems and principles and advances in planning and implementation of hydraulic engineering and water resources development schemes in river basins.
- Understanding the various aspects in analyzing data and developing strategies, including planning and implementation of hydraulic infrastructure works for different geographical and time scales, for the purpose of establishing river basin development schemes
- This module develops specialist scientific knowledge and understanding of how rivers function at the basin, reach and channel levels and to use this knowledge of the 'natural' process system as a basis for managing rivers and wetlands effectively. The emphasis is on Nile river environments, within a global context. The module identifies the main controls and areas of leverage (human intervention) within fluvial systems at different spatial and temporal scales. It apprises the specialist skills required for efficient investigation of rivers and wetlands from hydrological, geomorphological and ecological perspectives and evaluate critically the inter-relationships between pure and applied fluvial research. The module allows debate about current issues involved in river/ wetland management and conservation within a framework of European and International policy. There is critical evaluation of the role of different specialists within multi- and inter-disciplinary river management teams.

Course Code: NBI – IWRM 191

Course Title: River Basin Management

Credit Hours: 2

Prerequisites: Basic hydraulics and Water Resources

Summary and General Objective:

This course covers the broad spectrum of river management including planning, monitoring, developing strategies and infrastructure works. It provides the students with the state of the art of the related topics.

Specific Objectives:

- Familiarize participants with recent advances and updated framework of integrated river management, planning, monitoring and surveying (remote sensing) and operation and maintenance of riverine (sub-) systems, including the treatment of hydraulic infrastructure works, watercourses and riparian land areas (floodplains).
- Familiarize participants with relationships between natural water resources and socio-economic systems, concepts and measures to improve the performance of water resources systems and principles and advances in planning and implementation of hydraulic engineering and water resources development schemes in river basins.
- Familiarize participants with various aspects in analyzing data and developing strategies, including planning and implementation of hydraulic infrastructure works for different geographical and time scales, for the purpose of establishing river basin development schemes
- This module develops specialist scientific knowledge and understanding of how rivers function at the basin, reach and channel levels and to use this knowledge of the 'natural' process system as a basis for managing rivers and wetlands effectively. The emphasis is on Nile river environments, within a global context. The module identifies the main controls and areas of leverage (human intervention) within fluvial systems at different spatial and temporal scales. It apprises the specialist skills required for efficient investigation of rivers and wetlands from hydrological, geomorphological and ecological perspectives and evaluate critically the inter-relationships between pure and applied fluvial research. The module allows debate about current issues involved in river/

wetland management and conservation within a framework of European and International policy. There is critical evaluation of the role of different specialists within multi- and inter-disciplinary river management teams.

Course Outline:

- River System Management;
- Principles of integrated management of riverine systems, including the role of monitoring and modelling forecasting and the use of decision support systems.
- Water Resources Development; potentials and uses of water resources and factors affecting these, including the scope and role of hydraulic engineering in WRM/WRD projects.
- Workshop on River Basin Development; problem analysis, policy making, planning and engineering aspects; integration of scales in time and space; exercises and computer simulations on water supply and demand and floodplain management.
- Computational Hydraulics; linking physical processes and mathematical descriptions and comparison of traditional methods with modern mathematical modeling techniques; hands on experience with mathematical models; physical Models; physical laws and modeling; reproduction of various hydraulic phenomena like 2D and 3D flows in rivers, over and through the hydraulic structures, sediment transport, morphology, air entrainment and local scour.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Laboratory Hours:	-
Course Computer Hours:	4
Course Field Hours:	10
Total Course Hours:	32
Required Self Reading Hours:	20
Required Assignment Hours:	10 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	20%
Mid-term:	-
Final Exam:	60%
Course Project:	-

References:

- **Beek, E. van & D.P. Loucks, 2005.** Water Resources Systems Planning and Management - an introduction to methods, models and applications. UNESCO. Paris, France.
- **Anderson, M. G., Walling, D. E. and Bates, P. D. (eds)m 1996,** Floodplain Processes (Wiley, Chichester)
- **Best, J. L. and Bristow, C. S, 1993,** Braided Rivers Geological Society Special Publication No. 75
- **Billi, P., R.D. Hey, C.R. Thorne and P. Tacconi, 1992,** Dynamics of Gravel-bed Rivers (Wiley, Chichester)
- **Boon, P. J. and Calow, P., 1992,** River Conservation and Management (Wiley, Chichester)
- **Brookes, A., 1988,** Channelised Rivers: perspectives for environmental management (Wiley, Chichester)
- **Brown, A. and Quine, T., 1999,** Fluvial Processes and Environmental Change (Wiley, Chichester)
- **Carling, P. and Beven, K., 1989,** Floods: hydrological, sedimentological and geomorphological implications (Wiley, Chichester)

Course Code: NBI – IWRM 192

Course Title: Open Channel Hydraulics

Credit Hours: 2

Prerequisites:

Summary and General Objective:

To provide the participants with a basic knowledge of Uniform and non-uniform steady and unsteady flow in rivers and hydraulics of control structures. Emphasis is put onto the hydraulic concepts, Sediment transport in rivers and hydraulic roughness; floodplain roughness, River systems as process-response systems; river morphology, river characteristics and impacts of anthropogenic interventions in river systems, riverine ecosystems in floodplains; water quality and impact of hydraulic structures

Specific Objectives:

- Development of hydrodynamic equations and their applications to uniform and non-uniform flow
- Experimental results as support to the theory such as velocity distribution, characteristics of turbulence and friction coefficients for fixed and mobile channel beds, composite roughness, flow in curves and instabilities at the free water surface
- Gradually and rapidly varied flow, equations of water surface profiles
- Hydrodynamic equations and different methods of solution
- Applications for transient regime in channels: kinematic and diffusive waves Applications for hydraulic design of prismatic channels and stilling basins
- Various types of measuring equipments.
- Flow over a broad crested weir, through a contraction, underneath a gate
- sediment transport phenomena
- Properties of the sediment, Initiation of particle motion,
- Transportation mechanics bed forms, alluvial roughness, Floodplain roughness
- Prediction of sediment transport. Sampling techniques. Elaboration of sediment data.

Course Outline:

- River systems and river hydraulics; types of flow and hydraulics of control structures;
- Transient regime in channels: kinematic and diffusive waves, sudden failure of a dam,
- Hydraulic design of prismatic channels and stilling basins.
- Hydraulic laboratory tests
- Sediment Transport in Rivers and River Dynamics.
- riverine, hydraulic and morphological impacts of anthropogenic interventions.
- Computational methods for river engineering.
- Riverine ecosystems and water quality.
- Relation between riverine ecosystems and environmental factors in floodplains.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	20
Course Laboratory Hours:	10
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	35
Required Self-Reading Hours:	10
Required Assignment Hours:	10 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System): NA

Assignments:	20%
Class Participation:	20%
Mid-term:	20%
Final Exam:	40%
Course Project:	-

References:

- **Chang, H.H., 2001,** Fluvial processes in river engineering, Krieger Pub Co [ISBN: 1575242125]
- **Jansen, P.Ph., L. van Bendegom, J. van den Berg, M. de Vries & A. Zanen,** 1979, Principles of River Engineering; The Non-Tidal Alluvial River. Pitman, London [ISBN 0-273-01139-1]
- **Rijn, L.C. van, 1993,.** Principles of Sediment Transport in Rivers, Estuaries and Coastal Seas. Aqua Publications, Amsterdam [ISBN 90-800356-2-9]
- **Thorne, C.R., Hey, R.D., Newson, M.D. eds., 1997,** Applied Fluvial Geomorphology for River Engineering and Management. John Wiley and Sons, England, 376 pages [ISBN 0-471-96968-0]
- **Chow, V.T. , 1983** Open Channel Hydraulics, McGraw-Hill
- **Petersen, M., 1985,** River Engineering, Prentice Hall [ISBN: 013781352X]

Course Code: NBI – IWRM 193

Course Title: Hydropower Engineering and Management

Credit Hours: 2

Prerequisites:

Summary and General Objective:

The course is mainly aimed at describing forms of energy focusing on water energy, the status of global energy supply and sources as well as the situation in the Nile basin. Emphases are on hydropower projects and development including feasibility, implementation, operation, and maintenance along with economic aspects, planning, design and management.

Specific Objectives:

By the end of the course the student will able to:

- Grasp and understand planning criteria for energy demand coverage,
- Types of hydropower plants and their classification,
- Learn essential components of hydropower schemes and
- Design of diversion structures usable in hydropower schemes.
- To get familiar with implementation, operation and maintenance
- To learn how to prepare tender documents

Course Outline:

- Classification of hydropower plants: low, medium, and high-head plants.
- Planning and design of hydroelectric power installation: hydropower development cycle: pre-construction (planning), implementation (engineering, construction and supply) and operation (management and operation of hydropower installation).
- Fundamental theory of water availability and demand: flow, power and load duration curves.
- Design of hydropower plants: intakes, power canals, forbear, surge in power canals and penstocks, surges tanks, water hammer analysis, tunnels, power houses, draft tube, anchorage and supports. Characteristics and selection of valves, turbines, turbine location and cavitation problem. Biologicals of water power development.
- Dependence of hydropower generation on hydrology. Flow-duration analysis.

Analysis of power and load-duration curves. Regulation of power generation in storage type hydropower plants.

- Application of Environmental consideration to Hydropower Projects:
- Environmental Mitigation, Monitoring & Management plans,
- Valuation and economic aspects of environment in hydropower projects:
- The concept of value and the environment; Economic causes of environmental degradation, valuation techniques,
- Hydropower Project Management. Phases of hydropower development:
- Study phase – reconnaissance, pre-feasibility, and feasibility.
- Economic Design Criteria. Methods of screening of hydropower development alternatives.
- Tenders and contract Administration. Power market studies.
- Issues of Regional Power Trade. Issues of Rural Electrification.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/case studies

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	20%
Mid-term:	20%
Final Exam:	40%
Course Project:	NA

References:

- **Imeche (Institution of Mechanical Engineers) 2005,** Hydropower, New Projects, Rehabilitation, and Power Recovery By:, Publisher: John Wiley & Sons Inc ISBN: 1860584799
- **Mosonyi, E. WaterPower Development, 1987.**Vol. 1 Low-head Power Plants, Akademiai Kiado, Budapest,

Course Code: NBI – IWRM 194

Course Title: Dam construction and Rehabilitation

Credit Hours: 2

Prerequisites: Civil Engineering background

Summary and General Objective:

By the end of the course the student will gain skills in selection, design, construction and rehabilitation of a dam.

Specific Objectives:

- Familiarity with type of dams and their functions
- How to select a suitable dam type for give conditions
- Field investigation for construction (structural and geotechnical)
- How to propose a dam design based on long-term hydrologic analysis
- Familiarity with aspects related to dam safety and rehabilitation

Course Outline:

- Dam Construction Design
- Hydrologic/Hydraulic Engineering and Analyses for dam construction
- Geotechnical Engineering
- geotechnical investigation and field and laboratory investigations
- Earth dams, Rockfill dams, R.C. dams, Gravity dams and their foundation
- slope protection
- Emergency Drawdown and Warning Plan
- erosion protection measures
- Spillway Design Flood and supplement the existing outlet works - dam breach analysis
- masonry gravity structure, spillway and outlet culvert earth embankment
- quality management system to maintain the existing wetland and aquatic habitats
- Hydrologic failure of dams (which flood to be considered in Design – cost versus safety tradeoff)

- Dam Rehabilitation Design
- Construction Inspection
- Dam Inspection
- Remedial Design
- Construction Management/Oversight and inspection
- Diagnostic-Feasibility Study
- dam stabilization, remedial measures developed to improve stability
- safety of the structure
- specifications for rehabilitation
- The remedial work consisted of upstream and downstream stabilizing berms designed to resist erosion during overtopping of the dam, seepage control, and erosion protection of the slopes
- spillway capacity; visual inspections; rehabilitation; decommissioning; instrumentation; and operations, maintenance and emergency action planning

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	20
Course Laboratory Hours:	8
Course Computer Hours:	12
Course Field Hours:	10
Total Course Hours:	35
Required Self Reading Hours:	10
Required Assignment Hours:	10 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	20%
Mid-term:	20%
Final Exam:	40%
Course Project:	-

References:

- **Robert B. Jansen (Editor), 1988**, Advanced Dam Engineering for Design, Construction, and Rehabilitation, Publisher: Van Nostrand Reinhold, [ISBN: 0442243979]
- **Lecture Series, Phoenix, Arizona, June 1994**, Dam Safety Modification and Rehabilitation: 14th Annual USCOLD, United States Committee on Large Dams, United States Publication Date: January 1994[ISBN: 1884575056]
- **Loren R. Anderson (Editor) 1993**, Geotechnical Practice in Dam Rehabilitation: Proceedings of the Specialty Conference, Publisher: Amer Society of Civil Engineers [ISBN: 0872629112]
- **J. A. Llanos, M. Cabrera, J. Yague, F., Saenz De Ormijana (Eds), 2002**, Dam Maintenance and Rehabilitation: Proceedings of the International Congress on Conservation and Rehabilitation of Dams, Madrid, Spain, 11-13 November 2002, November 2002 Publisher: Balkema [ISBN: 9058095347]
- **Ronald C. Hirschfeld, Steve J. Poulos (Eds) 1987**, Embankment Dam Engineering; Casagrande Volume Publication Publisher: Krieger Pub Co [ISBN: 0898749972]
- **Alfred R. Golze, 1977** Handbook of Dam Engineering, Publication Date: January [ISBN: 0442227523]

Course Code: NBI – IWRM 195

Course Title: Reservoir Storage and Hydropower

Credit Hours: 2

Prerequisites: Civil engineering, hydrology

Summary and General Objective:.

Advanced understanding and 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 construction and operation. Principles and operation of the sediment in reservoirs and operation rules. Evaluating the impacts of in-stream flow works over the appropriate timescales. Advanced knowledge on use of the surface and underground storage for water harvesting. Systems for rain and floodwater harvesting.

Specific Objectives:

- To learn river hydrology analysis and reservoir storage for power generation
- To study static and dynamic analysis of dams
- To be familiar with works associated with dam construction, operation and maintenance to secure hydropower generator.

Course Outline:

- Dams; importance; historical development & trends; examples; failures & lessons.
- 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.
- Case studies and exercises on dam analyse and design.
- Reservoir sedimentation; flushing schemes and sedimentation process. Operation rules.
- Typical arrangements & layouts.

- Principles and experiences in analyse and design of headrace works, canals, tunnels, surge tanks, penstocks.
- Small-scale schemes; design and operation principles.

Maximum Number of Participants:	
Course Duration:	14 days
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/software in modeling – case studies

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Moris, G L and Fan, J, 1997.** Reservoir Sedimentation Handbook, 1st Edition, McGraw-Hill Professional, 848p
- **Robert B. Jansen (Editor), 1988**, Advanced Dam Engineering for Design, Construction, and Rehabilitation, , Publisher: Van Nostrand Reinhold, [ISBN: 0442243979]
- **Ronald C. Hirschfeld, Steve J. Poulos (Eds) 1987**, Embankment Dam Engineering; Casagrande Volume, Publisher: Krieger Pub Co [ISBN: 0898749972]
- **Alfred R. Golze, 1977,** Handbook of Dam Engineering, , Publication Date: January [ISBN: 0442227523]

Course Code: NBI – IWRM 196

Course Title: Hydropower Electro-mechanical Equipment

Credit Hours: 2

Prerequisites: Background on fluid mechanics mechanical engineering

Summary and General Objective:

The course gives details of different types of turbines, their characteristic and performance along with the associated equipments.

Specific Objectives:

To get familiar with:

- Different types of turbines, features, arrangement and performance
- Main components, equipments and instrumentation of hydropower plants.

Course Outline:

- Turbines, main data and characteristics.
- Turbine performance tests.
- Pelton turbines, Francis turbines, Kaplan turbines, bulb turbines – General arrangement and typical features, function and design of components, site erection and dismantling, instrumentation, monitoring and condition control.
- Turbine governors – main components, governor performance, governor testing.
- Main turbine valves and their general arrangement.
- Hydropower generators.
- Transformers in hydropower plants.
- Transmission and Distribution.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)
Teaching Method:	Presentation/software in modeling – case studies

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	20%
Mid-term:	20%
Final Exam:	40%
Course Project:	NA

References:

- **Imeche (Institution of Mechanical Engineers), 2005**, Hydropower, New Projects, Rehabilitation, and Power Recovery By: Publisher: John Wiley & Sons Inc ISBN: 1860584799

Course Code: NBI – IWRM 197

Course Title: Small hydropower Plants & Alternate Energy Sources

Credit Hours: 2

Prerequisites: Basic knowledge of sciences and engineering

Summary and General Objective:

The objective of this course is to acquaint students with planning, design and construction of small hydropower schemes, addressing also similarity and differences with large schemes. Furthermore, the course introduces other regenerative energy sources vis-à-vis hydropower.

Specific Objectives:

- To study aspects of small hydropower schemes
- To be familiar with different sources of renewable energy such as: solar, wind, geothermal, biomass and tidal.

Course Outline:

- Energy and the Environment
- Life cycle costing
- Small/mini/micro hydropower plants
  - Hydroelectric power
  - Non-conventional hydropower
  - Storage system
- Solar energy and its application
  - Solar resources
  - Solar thermal system
  - Photovoltaic system
- Wind energy and its application
  - Wind resources
  - Power from wind
  - Wind energy conversion system
  - Large scale applications
- Geothermal energy and its application
- Biomass energy and its application
- Tidal energy.

- Fuel cells
- Hybrid system
- Electric utility integration
- Value assessment
- Economic aspects of small hydropower plants
- Application aspects of small hydropower plants

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	30
Course Computer Hours:	4
Total Course Hours:	34
Required Self Reading Hours:	20
Required Assignment Hours:	10 (in class)

Teaching Method: Multimedia.

Course Examination Method (Grading System):

Assignments:	20%
Class Participation:	10%
Mid-term:	20%
Final Exam:	40%
Course Project:	NA

References:

- **Tong Jiandong Zheng Naibo Wang X. Ding Huishen, 1996,** Mini Hydropower, John Willy & Sons (UNESCO Energy Eng. Series) ISBN 0471962643
- **Micro Hydro Electric Power (1983),** Technical Paper No. 1, MF 22-531, by Ray Holland.
- **Micro hydropower Handbook(1983),** Volume l, MF 22-533, and Volume II, MF 22-534 books, 920 pages, by EG&G Idaho for the U.S. Dept. of Energy,

Course Code: NBI – IWRM 198

Course Title: Design of components of hydropower schemes

Credit Hours: 2

Prerequisites: Fluid mechanics, civil/mechanical engineering

Summary and General Objective:

This course enables students to plan, design and analyze various components of hydropower schemes. It covers structural and mechanical components from water intake through water conveyances and powerhouse up to return flow to original river.

Specific Objectives:

- To study the hydraulic design of water intake, conveyance system
- To learn the function surge tanks and water hammer
- To get familiar with powerhouse design, turbines and generators

Course Outline:

- Water Intake: components, arrangements, construction and design
- Free surface conveyance: hydraulic design, sediment transport wave and oscillations, constructional details and stabilization
- Sedimentation trap: constructional arrangements and design
- Pressurized pipes conveyance (penstocks): types, water hammer analysis and dynamic loads pressure waves, bends, supports and expansion joints, design of anchor blocks
- Pressure tunnels and shafts: constructional details
- Manifolds: types and design
- Surge tanks and surge chambers: arrangements, purposes, types and constructional arrangements, surge analysis, special arrangements
- Gates and valves in conveyance systems: types, hydraulic characteristics, arrangements operation

- Power house: Types and layouts, design
- Hydropower machines (turbines and governors): various turbine types, design basics, turbine components, governors, valves , draft tubes
- Generators and exciters

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	24
Course Computer/lab Hours:	16
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)
Teaching Method:	Presentation/software in modeling – case studies

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Harvey, A, 1993.** Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes
- **Inversin, A R, 1986.** Micro-Hydropower Sourcebook: A Practical Guide to Design and Implementation in Developing Countries
- **Mosonyi, E. , 1987.**WaterPower Development, Vol. 1 Low-head Power Plants, Akademiai Kiado, Budapest

Additional Information:

Hydropower Development covered in a Book Series by The Norwegian University of Science and Technology (NTNU), Division of Hydraulic and Environmental Engineering, has initiated a project with the objective of covering the total sphere of topics of hydropower development in a book series consisting of 17 volumes.

1 Hydropower Development in Norway
2 Coordinating Hydropower and Thermal Power
3 Environmental Effects. Assessment
4 Landscape Design in Hydropower Planning
5 Planning and Implementation of Hydropower Plants
6 Economic and Financial Analysis of Hydropower Projects
7 Hydrology
8 Hydraulic Design
9 Rock Engineering
10 Rockfill Dams
11 Concrete in Hydraulic Structures
12 Mechanical Equipment
13 Electrical Equipment
14 Power House Design
15 Construction Management
16 Transmission and Distribution
17 Maintenance Management of Hydropower Plants

Course Code: NBI – IWRM 199

Course Title: Hydraulic Transients in Hydropower Systems

Credit Hours: 2

Prerequisites: Fluid mechanics, Hydraulic Engineering and computer skills

Summary and General Objective:

Closing a value at the downstream end of a single pipe, produces propagation and reflection of waves. Classification and causes of hydraulic transient are discussed in this course.

Specific Objectives:

- In relation with hydropower, to get familiar with:
- Steady and unsteady flow
- Transient flow and periodic flow (oscillatory)
- Column separation and water hammer

Course Outline:

- Fundamentals of steady flow in closed conduits.
- Causes of hydraulic transients in conduits and in open channels.
- Basic equations of unsteady flow in closed conduits.
- Methods of characteristics for numerical computation of unsteady flow in pipes. Boundary conditions in pipe systems – reservoirs with constant and variable water level, closed and open valves of various types, pipe junctions, pipe network systems, surge tanks, pumps, turbines, etc.
- Hydraulic transients in hydroelectric power plants.
- Transient cavitations and column separation methods for controlling hydraulic transients.

Maximum Number of Participants:	20
Course Duration:	1 semester
Course Lecture Hours:	26
Course Computer/lab Hours:	12
Total Course Hours:	32
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/software in modeling – case studies

Course Examination Method (Grading System):

Assignments:	15%
Class Participation:	15%
Mid-term:	20%
Final Exam:	40%
Course Project:	10%

References:

- **Zipparro, V J and Hans Hasen, H, 1992.** Davis' Handbook of Applied Hydraulics, 4th edition, Mcgraw-Hill (Tx), 1056p
- **Hauser, B, 1995.** Practical Hydraulics Handbook, 2nd edition, CRC, 359p
- **M. Hadif Chaudhry, 1979,** Applied Hydraulic Transients,. VanNostrand Reinhdd Comp. NewYork, London.

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9 Rock Engineering
10 Rockfill Dams
11 Concrete in Hydraulic Structures
12 Mechanical Equipment
13 Electrical Equipment
14 Power House Design
15 Construction Management
16 Transmission and Distribution
17 Maintenance Management of Hydropower Plants

Appendix B

Proposed Short Course Modules

1. Principles of IWRM
2. Applied Hydrogeology
3. Impacts of Climate Change on Integrated Water Resources
4. DSS and Methods of data collection and management of database
5. Environmental Impact Assessment and Auditing
6. GIS and Remote Sensing Applications in Water Resources
7. Groundwater Assessment and Utilization
8. Groundwater Exploration and Monitoring
9. Water resources assessment tools
10. Water Harvesting Techniques in Different Climatic zones
11. Water Quality Modeling
12. Water Quality Assessment
13. Dam construction and Rehabilitation
14. Surface water physical and numerical modeling
15. Gender mainstreaming in IWRM
16. Mediation and Negotiation Skills
17. Water rights and governance
18. Water Ethics, Law of Policy
19. International Environmental Law
20. Hydropower Management
21. Knowledge Management for Decision Makers in the Water Sector
22. Sustainable agriculture and geo-information systems
23. Community water quality monitoring programme
24. Climate analysis and modeling
25. Introduction to meteorology and climatology
26. Environmental flow assessment

Short Course Title: Principles of IWRM

Prerequisites: Professionals working water resources, policy makers, media experts, and related professionals

Summary and General Objective:

Specific Objectives:

- To get familiarity with the definition of IWRM
- To get knowledge of water concepts relevant to and consistent with IWRM
- To get familiarity with water demand per sector
- To get familiarity with systems thinking and problem analysis

Course Outline:

- Introduction to IWRM
- Enabling Environment and Institutions
- Demand Management
- River Basin Planning and Management
- Sanitation and Health
- Financing and Economic dimensions
- Ground water management
- IWRM and Agriculture
- Conflict Resolution
- Sustainability of Ecosystems
- Gender Mainstreaming in IWRM
- Stakeholder Participation/Involvement
- Local Water Management
- Public-Private-Partnerships in Water Management
- Water Policy
- Preparation of national IWRM plans

Maximum Number of Participants:	20
Course Duration:	1 Semester
Course Lecture Hours:	40
Course Laboratory Hours:	5
Course Computer Hours:	10
Course Field Hours:	5
Total Course Hours:	60
Required Self Reading Hours:	20
Required Assignment Hours:	18

Teaching Method:	Multimedia – computer applications – laboratory and field instruments

References:

- Capacity Building for Integrated Water Resources Management CapNet and Global Water Partnership (GWP) toolkits in IWRM. http://www.cap-net.org//
- Successful Project Managements Brown, M. (1992) Hoddle and Strongton, Kent, 111p
- Introduction to Systems Thinking and High Performance Systems Richmond, B. Peterson, S. Charyk, C. (1994) Hannover

Short Course Title: Applied Hydrogeology

Pre-requisite: Basic knowledge of groundwater geology and well hydraulics

Course Textbook: Groundwater and wells – Second Edition, Fletcher G. Driscoll. 1986, Johnson Filtration Systems Inc., St. Paul, Minnesota 55112

Course Objectives: Upon completion of the course, participants will be provided with hands-on experience on hydrologic characteristics of earth materials and geology of groundwater occurrence in addition to estimation of hydraulic properties.

Course Contents:

- Hydrologic cycle,
- Groundwater components,
- runoff and stream flow
- Estimate of recharge into groundwater system
- Hydrologic characteristics of earth materials
- Geology of groundwater occurrence
- Principles of groundwater flow
- Darcy's law
- Types of aquifers
- Transmisivity and Storativity
- Pump tests and estimate of hydraulic parameters of aquifers
- Assignments

Maximum Number of Participants: 15
Course Duration: 6 days
Course Lecture Hours: 24
Course Field Hours: 8
Course Computer Hours: 16
Total Course Hours: 48
Required Self Reading Hours: 10
Required Assignment Hours: 6 (in class)

Teaching Method: field work, computer application

References:

- Applied Hydrogeology – C.W. Fetter – McMillan Publishers, Second Edition, 1988.
- Groundwater, Freeze, R.A. and Cherry, J.A. 1979, Prentice-Hall Inc.

Short Course Title: Impacts of Climate Change on Integrated Water Resources Management

Prerequisites: Basic knowledge of IWRM

Summary and General Objective:

Upon completion of this course participants should be able to understand causes of climate change, climate change models, tracing historical trends starting from the Ice Ages and the last 1000 years. Participants should be able to identify basic methods for determining past climates, to identify causes for climate change and to classify causes based on time-scales, the scientific basis to analyze and critique policy issues related to global warming.

Specific Objectives: Through out and at the end of the course, specific answers to the following questions:

- Is climate changing? How, Why?
- How do we measure climate change?
- What does it matter? What impact will climate change have on water resources? On life on earth?
- How fast is climate changing?
- Is human activity the cause of climate change?
- What are the required mitigation measures? Can we do anything about it?
- Is it possible to adapt to climate change?

Course Outline:

Part1: Covers the following:

- The controlling factors and feedbacks in the climate system
- The forcing factors that cause climate change
- Changes in climate on the geological and historical time scale
- Climate variability and change
- How do we determine climate change
- What is the evidence that the climate changes
- What is the evidence that the climate change is anthropogenic and not natural
- Greenhouse gases, aerosols (Global warming potential, lifetime, sources),Carbon cycle

Part 2: Covers the following”

- Main uncertainties
- Different types of climate scenarios (synthetic, analogue(space/time), GCM)
- Climate scenarios and global change scenarios
  - Basic principles of GCMs
  - Climate sensitivity
  - AGCM’s and AOGCM’s
  - Ability to simulate current climate
  - Ability to simulate forcings like El Nino, Vulcanic eruptions
  - Different experiments, equilibrium experiments and transient experiments
  - Projections of climate
  - Comparison of different models
  - Ensembles

Part 3: Covers the following:

- Measuring sea level rise
- Observed trends in sea level
- Causes of sea level rise
- Thermal expansion of the ocean
- Estimates for sea level rise
- Effects in different countries

Part 4: Covers the following:

- Different types of hydrological models
- Required calibration and validation of hydrological models for this application
- Differences in time and space resolution of the hydrological and climate models

Part 5: Covers the following:

- Changes in the river flows due to changes in rainfall pattern
- Impact of climate changes on the hydrological characteristics of dams
- Alternatives for flood and drought management

Maximum Number of Participants:	20
Course Duration:	6 days
Course Lecture Hours:	18
Course Laboratory Hours:	4
Course Computer Hours:	4
Course Field Hours:	8
Total Course Hours:	34
Required Self Reading Hours:	4
Required Assignment Hours:	2 (in class)
Teaching Method:	Multimedia – field work, computer application, lab work

References:

- IPCC third assessment report Climate Change 2001: Impacts, Adaptation and Vulnerability.

Short Course Title: DSS and Methods of data collection and management of database

Prerequisites: Basic knowledge of surface and groundwater hydrology; social and environmental laws.

Summary and General Objectives:

To provide a tool by which the system, targets and challenges can be simulated since most of them are non-structures. It can help in Setting Long term Integrated Water Resources plans on National Level; introducing clear picture for the proposed alternatives and projects that are running under different scenarios; and the decision maker can select the best alternative or modify some alternatives until he gets the best results he/she wants.

Specific Objectives:

- Capture data included in the DSS
- Updating data records and files
- Interrelates data from different sources
- Retrieve data for queries and reports
- Handles personal and unofficial data so that users can experiment with alternatives solutions based on their judgment.
- Perform complex data manipulation tasks based on queries
- Tracks data use within the DSS
- Manage data through data dictionary
- Supports various managerial levels Top to bottom.
- Provides support to several interdependent or sequential decisions.
- Supports all phases of the decision making process.

Course Outline:

Part 1 covers raw data; status access; and decision support systems

Part 2 covers the Basis of decision making, and general analysis capabilities models

Part 3 covers Computer-Based Decision Support and solution suggestions

Part 4 covers Knowledge Management Techniques, and evaluation and control laws (expected, proposed).

Part 5 covers multi-participant decision support, and future development plans

Maximum Number of Participants: 20
Course Duration: Two weeks
Course Lecture Hours: 36
Course Laboratory Hours: -
Course Computer Hours: 24
Course Field Hours: 8
Total Course Hours: 68
Required Self Reading Hours: 10
Required Assignment Hours: 6

Teaching Method: Multimedia – Field work, and Computer applications.

References:

- E. Turban and J. Aronson, Decision Support Systems and Intelligent Systems (Fifth Edition). Prentice-Hall: Upper Saddle River, NJ (1998)
- R. Sprague, Jr. and H. Watson, Decision Support for Management. Prentice-Hall: Upper Saddle River, NJ (1996).
- David Olson and James Courtney, Decision Support Models and Expert Systems, Macmillan Publishing Company, 1992.
- A. Sage, Decision Support Systems Engineering, John Wiley and Sons, 1991.
- A. Golub, Decision Analysis: An Integrated Approach, John Wiley and Sons, New York, NY, 1997.

Additional Information:

Examples of Existing Decision Support Systems (DSS)

- AQUATOOL – Polytechnical University Valencia
- ENSIS – NIVA
- MIKE BASINS - DHI
- RIBASIM – Delft Hydraulics
- SPATIAL DSS – NTUA
- WATERWARE – Eureka 487
- WEAP – Stockholm Institute

Short Course Title: Environmental Impact Assessment and Auditing

Prerequisites: Basic knowledge of environmental, social, and cultural.

Summary and General Objective:

To provide participants with hands-on experience on how to accommodate water resources development and management within the context of environmental, social and cultural preservation and improvement.

Specific Objectives:

- To get the environmental considerations be integrated into the development process so as to make it sustainable in the long term.
- To evaluate the impacts of the dams that contributed to some environmental problems.

Course Outline:

Principles and procedures

- Introduction and principles
- Origins and development
- Agency and legislative context

Process

- Starting up / early stages
- Impact predication, evaluation and mitigation
- Participation, presentation and review
- Monitoring and auditing: after the decision.

Practice

- Overview of practice to date
- Environmental impacts assessment and new settlements
- Environmental impact assessment of projects not subject to planning control
- Comparative practice

Prospects

- improving the effectiveness of project assessment
- widening the scope: strategic environmental assessment

Environmental legislation and regulation.

Maximum Number of Participants:	15
Course Duration:	8 days
Course Lecture Hours:	24
Course Laboratory Hours:	8
Course Computer Hours:	8
Course Field Hours:	16
Total Course Hours:	56
Required Self Reading Hours:	4
Required Assignment Hours:	2 (in class)

Teaching Method: Multimedia – field work, computer application, lab work

References:

- Introduction to Environmental Impact Assessment – John Glasson, Riki Therivel and Andrew Chadwick – UCL Press, 1994.
- Environmental Impact of Water Resources Projects - M. Abdel Motaleb - Hydraulics Research Institute, Egypt, 2006.
- Environmental Impact Assessment – B. Petry, P. Boeriu and Dr. M. Abdel Motaleb - Hydraulics Research Institute, Egypt, 2005.
- Environmental Impact Assessment, Annex - B. Petry and P. Boeriu - Hydraulics Research Institute, Egypt, 2001.
- Environmental Impact Assessment, Theory and Practice – Peter Wathern – Academic Division of Unwin Hyman Ltd., 1990.
- Standard Handbook of Environmental Engineering – Robert A. Corbitt – McGraw-Hill,Inc, 1989.

Short Course Title: GIS and Remote Sensing Applications in Water Resources Managements

Prerequisites: Basic knowledge of computer and CAD.

Summary and General Objective:

This course aims to give an introduction to Geographic Information Systems (GIS). This course covers the basic concepts of a GIS. Principles of cartography and spatial analysis will also be covered. The intent of this class is to prepare the student for advanced training using specific GIS software packages. Moreover, introduction to Remote Sensing (RS) will be carried out. In this course students acquire a base of geographic knowledge and data collection methods used in subsequent courses in GIS. Introductory raster and vector GIS operations are discussed and reinforced in computer lab work. Subjects include the acquisition and compilation of data from maps, field surveys, air photographs and satellite images. The use of remotely sensed imagery for change detection, calculation, and analysis is explored. Image processing and remote sensing capabilities of raster GIS are used to introduce remote sensing concepts such as image classification.

Salient Features

Generic Concepts covering the complete spectrum of GIS -Overview on Remote Sensing and Digital Image Processing
Hands-on Experience on the state -of-the art software
Lectures on GIS Applications by experts who have handled live projects

Course Outline:

- Fundamentals of GIS-Introduction to basic concepts including definition of GIS,

  History, the principles, techniques, procedures and terminology of geographic information systems, and digital representation and data acquisition.
- Mapping the spherical Earth including, geodesy, grids, datums, and projection systems.
- Geographic data concepts- Geospatial data components, data types/models, database management, RDBMS concepts, database design.
- Raster based GIS. Spatial referencing in raster based GIS: definition and representation of raster data, concepts of raster based GIS data structure, data

capture and basic operations of spatial analysis with raster GIS.

- Vector based GIS: Definition, concepts of vector based GIS, data structures, data capture and operations of spatial analysis with vector GIS.
- Advantages and disadvantages in raster and vector based GIS.
- Elementary spatial analysis and modeling.
- Surfaces and TINs.
- Introduction to remote sensing and digital image processing as a source of input to geographic information systems.
- Overview of GPS and its applications.
- Software and hardware requirements for GIS.
- GIS project planning, management and implementation techniques.
- Hands -on practical exposure using ArcGIS and ERDAS IMAGINE.

Maximum Number of Participants:	20
Course Duration:	18 days
Course Lecture Hours:	40
Course Computer Hours:	60
Total Course Hours:	100
Required Self Reading Hours:	20
Required Assignment Hours:	10 (in class)

Teaching Method: Multimedia - Computer GIS & RS Applications.

References:

- Clarke, K.C. (2003), ***Getting Started with Geographic Information Systems,*** 4th Edition. Upper Saddle River, NJ: Prentice Hall.
- DeMers, M.N. (2000), ***Fundamentals of Geographic Information Systems,*** 2°d Edition. New York: John Willy & Sons Inc.
- Longley, P.A. et al **(2001),Geographic Information Systems and Science.** New York: John Willy & Sons Inc.

Short Course Title: Groundwater Assessment and Utilization

Pre-requisite Course: Basic knowledge of groundwater hydrology and hydraulics

Course Objectives:

- The course explains the principles of groundwater systems analysis and provides a robust, practical introduction to the main analysis techniques used to assess the quality and quantity of ground water resources.
- The course will introduce data management and aquifer analysis software and provide valuable knowledge of the main methods of sampling and measurement of the hydraulic and common chemical properties of aquifers and groundwater systems through lectures, field sessions and hands-on practical issues. Importantly participants will learn about the limitations of the methods available and the practical issues of making measurements in geological media as well as being guided through the approaches available for interpretation.

By the end of the course the participants will:

- gain understanding of recharge and discharge from groundwater systems, and of the response of aquifers to pumping,
- appreciate the factors controlling the efficiency of pumping wells and insights into the key issues in contaminant hydrologeology,
- develop the ability to apply the main test-pumping analysis techniques,
- understand the key analytical approaches for estimating recharge,
- be able to identify groundwater influences on stream flows using graphical analysis methods,
- use main hydrochemical classification and display diagrams, and apply these in the assessment of natural and contaminated ground waters

Course Outline:

- Groundwater systems: hydrostratigraphy and aquifer boundaries,
- Natural inorganic hydrogeochemistry; hydrochemical facies,
- Groundwater-surface water interactions,
- Groundwater recharge assessment,

- Drilling and test-pumping of wells; groundwater sampling & monitoring strategies,
- Determination of aquifer properties by test-pumping,
- Groundwater resource evaluation.

Maximum Number of Participants: 15
Course Duration: 6 days
Course Lecture Hours: 24
Course Field Hours: 6
Total Course Hours: 36
Required Self Reading Hours: 4
Required Assignment Hours: 4 (in class)

Teaching Method: field work, computer application

References:

- Applied Hydrogeology – C.W. Fetter – McMillan Publishers, Second Edition, 1988.

Short Course Title: Groundwater Exploration and Monitoring

Prerequisites: The course is addressed to postgraduates and professionals in hydrogeology and water resources management: civil engineers, environmental engineers, geologists and hydrologists who are engaged in the investigation, management, and protection of groundwater resources

Summary and General Objective:

The course intends to train participants up to the level that data collection and monitoring tasks can be individually performed. The course will teach the participants the principles of groundwater data collection and monitoring and the use of software to process and analyse the information. The experiences of data collection and monitoring will be obtained through a series of lectures, hands-on training in class exercises and computer workshops.

On the conclusion of this course, the participant should:

- Know how to carry out groundwater data collection and analyses procedures relating to hydrogeological mapping and well inventories, surface geophysics, exploration drilling, well design, pumping tests and groundwater monitoring.
- Be familiar with the most popular groundwater codes: GEWIN, AQUIFERTEST, FREQ and NETGRAPH.
- Be able to visualise the application of data collection and monitoring techniques within the wider framework of groundwater studies.

Course Outline:

The following outline provides a summary of the content of the course and includes the main areas of instruction and a list with problems that will be addressed :

- Introduction; Need for data collection and monitoring, Management and planning of surveys and networks
- Available data and basic surveys; How to handle available data?, Hydrogeological interpretation of remote sensing data, Hydrogeological mapping and well inventories
- Surface geophysical methods; Principles of geo-electrical surveying, Variable electrode distance techniques, Horizontal profiling, Hydrogeological interpretations

- Exploration drilling; Selection of well sites, Drilling methods and their applicability, Geological and geophysical well logging; water quality sampling, Well design criteria and design methods, Well development
- Pumping tests; Principles of pumping tests, Field guidelines and data processing, Preliminary interpretation, Analyses of constant yield tests
- Introducing monitoring networks; Introduction, Basic concepts and procedures
- Design of networks; Network density for estimating global mean, Monitoring of diffuse pollution, Monitoring of waste disposal sites, Network density graph, Determination of network density with Kriging, Determination of sampling frequency
- Instructional problems; Preparation of hydrogeological maps and sections, Interpretation of a Schlumberger measurement (GEWIN), Preparation of a well log, Analytical analysis of a step-drawdown test, Analytical interpretation of constant yield tests (AQUITEST), Error analysis using Kriging (GEO-EASE), Designing an adequate network (NETGRAPH), Interpretation of time series and assessing sampling frequency (FREQ)

Maximum Number of Participants:	15
Course Duration:	10 days
Course Lecture Hours:	24
Course computer Hours:	30
Course Field Hours:	6
Total Course Hours:	60
Required Self Reading Hours:	4
Required Assignment Hours:	4 (in class)

Teaching Method: field work, computer application

References:

- Applied Hydrogeology – C.W. Fetter – McMillan Publishers, Second Edition, 1988.

Short Course Title: Water resources assessment tools

Prerequisites: Basic knowledge of climatology, surface hydrology, and hydraulics.

Summary and General Objective:

To provide participants with hands-on experience on using field measurements and models applications to determine the hydraulic properties of the watersheds such as basins' characteristics and unit hydrograph parameters, etc.

Specific Objectives:

- To get familiarity with different approaches that can be used to determine properties of watersheds
- To practice using different programs and software packages to analyze field data and determine watershed characteristics
- To study the hydrology deals with the processes of land-surface and near-surface hydrology relating to soil water movement, stream flow dynamics and their interaction with groundwater.
- To understand data analysis systems deal with the processing of spatial hydrological data and with statistical data analysis, including the use of current data software, and with the ability to judge and evaluate hydrological data processing methods.

Course Outline:

Part 1 covers an introduction about monitoring networks, measuring rainfall depths in gauge stations and measuring flow rates

Part 2 covers an introduction about modeling of stream and dam routing

Part 3 covers a field trip to conduct fieldwork, protection projects components against flash floods and water harvesting component project

Part 4 covers the use of different analysis methods and different software packages to analyze the different basins and determine the properties of the watershed

Part 5 covers the practical application using GIS and remote sensing techniques to determine the hydraulic properties of land use and hydrological analysis

Maximum Number of Participants:	15
Course Duration:	8 days
Course Lecture Hours:	24
Course Laboratory Hours:	8
Course Computer Hours:	8
Course Field Hours:	16
Total Course Hours:	56
Required Self Reading Hours:	4
Required Assignment Hours:	2 (in class)
Teaching Method:	Multimedia – field work, computer application, lab work

References:

- Handbook of Applied Hydrology – VenTe Chow – A compendium of water resources technology, 1964.

Short Course Title: "Water Harvesting Techniques in Different Climatic zones" Water Harvesting (Design of Water Harvesting Structures and Techniques)

Prerequisites: Basic Knowledge of meteorology; surface water hydrology and open channel flow hydraulics.

Summary and General Objectives:

To develop and strengthen the human capacity to manage the water resources by the wide range of methods and techniques of water harvesting which are based on the basic point, namely, source of water available, required storage duration and intended use

Specific Objectives:

- To strengthen the training capabilities of the participants with the different methods of meteorological data analysis
- To practice using different techniques and surface water packages of estimating the runoff hydrograph with respect to changes in time and space
- To improve the capabilities of the participants in selecting the site and design the appropriate water harvesting structures.

Course Outline

Part 1:Covers an introduction about different meteorological and rainfall measurements and methods of rainfall analysis and runoff estimation.

Part 2: Covers an introduction to Water Harvesting Systems, and different methods of analysis and software packages of rainfall-runoff at unguided catchments where there are no available real measurements.

Part 3: Covers an introduction to WH techniques by systems (Micro-catchments, Macro-catchments WH techniques by systems, Introduction to spate Irrigation), and a field trip to set up the field investigations for the site selection of the water harvesting strictures

Part 4: Covers the Socioeconomic consideration in planning and implementation of WH systems, and the hydraulic and structure design of the selected water harvesting structures

Part 5: Covers the operation and maintenance, monitoring and evaluation, and the general procedures of planning the different water harvesting applications such as: agriculture, domestic, etc.

Maximum Number of Participants:	15
Course Duration:	10 days
Course Lecture Hours:	24
Course computer Hours:	30
Course Field Hours:	6
Total Course Hours:	60
Required Self Reading Hours:	4
Required Assignment Hours:	4 (in class)

Teaching Method: Multimedia field work, computer application

References:

- Waterfall P. 1998. Harvesting rainwater for landscape use. Tucson, The University of Arizona College of Agriculture and Life Sciences.
- Moh. 1999-a, "Basic Studies for Flash Floods Protection", Ministry of Housing and New Communities, August 1992.
- Mohamed A. Sonbol , F. Mtalo , and M. Abdel-Motteleb, 2005 “Watershed Modeling of Wade Sudr and Wade Al-Arabain in Sinai Egypt” International Conference of UNESCO, FLANDERS FIT FRIEND/NILE Project, Towards a better Cooperation, 12-15 Nov. 2005, Sharm El-Sheikh, Egypt.
- Nasser, M. 1999 “Assessing desertification and water harvesting in the Middle East and North Africa: Policy implications”, Center for Development Research, (ZEF), (10), 59.
- Prinz,D. and Singh,A.K. 2000 “ Water Resources in Arid Regions and Their Sustainable Management” Annals of Arid Lands, Special Issue on Research.
- UNDP, 2003 “Sustainable Development in Egypt” Final Report. Cairo, Egypt
- WRRI, 2002-a ," Integrated Rural Development Project for North and South Sinai Uplands-Ser 67", Water Resources Research Institute, National Water Research Center, Ministry of Water Resources and Irrigation, Egypt.
- International Rainwater Catchment Systems Association, www.ircsa.org
- Gould J, Nissen-Petersen E. 1999.Rainwater catchment systems for domestic rain: design construction and implementation. London: Intermediate Technology Publications. 335 p.

Short Course Title: Water Quality Modeling

Prerequisites: Basic knowledge of water sciences, computer & field instruments

Summary and General Objective:

The main objective of the course is to make participants literate in the field of water quality modeling and able to understand the fundamentals of water quality modeling. The topics will be covered at an introductory to intermediate level, depending on how one defines such terms

Course Outline:

- Introduction to Water Quality Modeling
- Hydrodynamics and Water Quality
- Dissolved Oxygen
- Nutrients
- Algae
- Solids and Sediment
- Coliforms
- Toxics
- Thermal Effects
- The Impact of Point and Non-Point Sources
- Relationship of Watershed and Water Quality Models
- Modeling of Rivers
    - Overview
    - Existing models
    - Examples
- Modeling of Lakes and Reservoirs
    - Overview
    - Existing models
    - Examples
- Modeling of Estuaries, Harbors, and Bays
    - Overview
    - Existing models
    - Examples
- TMDL Calculations
    - Methodologies
    - Case studies

Maximum Number of Participants:	15
Course Duration:	10 days
Course Lecture Hours:	24
Course computer Hours:	30
Course Field Hours:	6
Total Course Hours:	60
Required Self Reading Hours:	4
Required Assignment Hours:	4 (in class)

Teaching Method:	Multimedia field work, computer application

References:

- *Wu-Seng Lung (2001) Water Quality Modelling for Wasteload Allocations and TMDLs, John Wiley & Sons*
- *Michael L. Deaton, James J. Winebrake(1999) Dynamic Modeling of Environmental Systems (Modeling Dynamic Systems. Springer Verlag*
- *Kolditz. Olaf (2002) Computational Methods in Environmental Fluid Mechanic. Springer-Verlag Berlin and Heidelberg GmbH & Co. KGs*
- *G.P. Karatzas, A.C. Payatakes, V.N. Burganos (1998)Computational Methods in Water Resources: Computational Methods in Contamination and Remediation of Water Resources 12th (Water Studies) WIT Press*
- Geochemistry, Groundwater and Pollution- Appelo, C and Postma, D, AA Balkema, 1996
- Physical and Chemical Hydrogeology - Domenico, PA and Schwartz, FW, Wiley, 2nd ed., 1998

Short Course Title: Water Quality Assessment

Prerequisites: Basic knowledge of computer & field instruments

Summary and General Objective:

The objective of this course is to acquaint participants with the principles, techniques and management issues used in water quality description, monitoring and assessment.

Course Outline:

- Water quality and monitoring: natural water quality and water pollution; designing and optimization of water quality monitoring programmes; physico-chemical and biological water quality assessment; groundwater quality monitoring.
- Data analysis and presentation: descriptive statistics; statistical testing; using significance levels in water quality monitoring; regression analysis; exercises; presentation of data.
- Aquatic ecotoxicology: Environmental characteristics of pollutants; sources, transport and fates; modelling; risk assessment.
- Water quality modelling: definitions and concepts; mathematical backgrounds; modelling BOD/DO in a river system using the SOBEK model; modeling the Danube river water quality; case studies and hands-on computer exercises.
- Fieldwork water quality monitoring: water and sediment sampling; storage and preservation methods; field measurements.
- Excursion in the field of water quality monitoring and/or modelling.

Maximum Number of Participants:	15
Course Duration:	10 days
Course Lecture Hours:	24
Course computer Hours:	30
Course Field Hours:	6
Total Course Hours:	60
Required Self Reading Hours:	4
Required Assignment Hours:	4 (in class)
Teaching Method:	Multimedia field work, computer application

References:

- *Wu-Seng Lung (2001) Water Quality Modelling for Wasteload Allocations and TMDLs, John Wiley & Sons*
- *Michael L. Deaton, James J. Winebrake(1999) Dynamic Modeling of Environmental Systems (Modeling Dynamic Systems. Springer Verlag*
- *Kolditz. Olaf (2002) Computational Methods in Environmental Fluid Mechanic. Springer-Verlag Berlin and Heidelberg GmbH & Co. KGs*
- *G.P. Karatzas, A.C. Payatakes, V.N. Burganos (1998)Computational Methods in Water Resources: Computational Methods in Contamination and Remediation of Water Resources 12th (Water Studies) WIT Press*
- Geochemistry, Groundwater and Pollution- Appelo, C and Postma, D, AA Balkema, 1996
- Physical and Chemical Hydrogeology - Domenico, PA and Schwartz, FW, Wiley, 2nd ed., 1998

Short Course Title: Dam construction and Rehabilitation

Prerequisites: Engineers, geologies and hydro-geologist who are engaged in hydraulic structures and dam engineering works

Summary and General Objective:

By the end of the course the student will gain skills in selection, design, construction and rehabilitation of a dam.

Specific Objectives:

- Familiarity with type of dams and their functions
- How to select a suitable dam type for give conditions
- Field investigation for construction (structural and geotechnical)
- How to propose a dam design based on long-term hydrologic analysis
- Familiarity with aspects related to dam safety and rehabilitation

Course Outline:

- **Dam Construction Design**
- Hydrologic/Hydraulic Engineering and Analyses for dam construction
- Geotechnical Engineering
- geotechnical investigation and field and laboratory investigations
- Earth dams, Rockfill dams, R.C. dams, Gravity dams and their foundation
- slope protection
- Emergency Drawdown and Warning Plan
- erosion protection measures
- Spillway Design Flood and supplement the existing outlet works - dam breach analysis
- masonry gravity structure, spillway and outlet culvert earth embankment
- quality management system to maintain the existing wetland and aquatic habitats
- Hydrologic failure of dams (which flood to be considered in Design – cost versus safety tradeoff)
- **Dam Rehabilitation Design**
- Construction Inspection
  - Dam Inspection
  - Remedial Design
- Construction Management/Oversight and inspection

- Diagnostic-Feasibility Study
- dam stabilization, remedial measures developed to improve stability
- safety of the structure
- specifications for rehabilitation
- The remedial work consisted of upstream and downstream stabilizing berms designed to resist erosion during overtopping of the dam, seepage control, and erosion protection of the slopes
- spillway capacity; visual inspections; rehabilitation; decommissioning; instrumentation; and operations, maintenance and emergency action planning

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	40
Course Laboratory Hours:	10
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	60
Required Self Reading Hours:	10
Required Assignment Hours:	10 (in class)

Teaching Method:	Multimedia – field work, computer application, lab work

References:

- Advanced Dam Engineering for Design, Construction, and Rehabilitation, Robert B. Jansen (Editor), Publication Date: October 1988, Publisher: Van Nostrand Reinhold, [ISBN: 0442243979]
- Dam Safety Modification and Rehabilitation: 14th Annual USCOLD Lecture Series, Phoenix, Arizona, June 1994, United States Committee on Large Dams, United States Publication Date: January 1994[ISBN: 1884575056]
- Geotechnical Practice in Dam Rehabilitation: Proceedings of the Specialty Conference, Loren R. Anderson (Editor) Publication Date: April 1993 Publisher: Amer Society of Civil Engineers [ISBN: 0872629112]
- *Dam Maintenance and Rehabilitation: Proceedings of the International Congress on Conservation and Rehabilitation of Dams, Madrid, Spain, 11-13 November 2002,* Authors: J. A. Llanos, M. Cabrera, J. Yague, F., Saenz De Ormijana (Eds) Publication Date: November 2002 Publisher: Balkema [ISBN: 9058095347]
- Embankment Dam Engineering; Casagrande VolumeRonald C. Hirschfeld, Steve J. Poulos (Eds) Publication Date:June 1987 Publisher: Krieger Pub Co [ISBN: 0898749972]
- Handbook of Dam Engineering, Alfred R. Golze, Publication Date: January 1977[ISBN: 0442227523]

Short Course Title: Surface water physical and numerical modeling

Prerequisites: Professionals with background on Mathematics, Hydraulics, Computational fluid dynamics

Summary and General Objective:

This course aims at providing the participants with the state of the art of surface water modeling. They will be familiarized with structure of equation systems, numerical solution techniques and their representation in modelling systems and practical. They will get practical experience with standard models and develop an understanding of steady flow modeling in rivers.Introduce of the use and design of hydraulic model studies as a tool for improving hydraulic engineering solutions.

On completion of this course the participants are able to

- Programs a computer code for calculating free-surface flow in canals and provide interpretation of a series of test involving various initial and boundary conditions
- Build a river flood model using SOBEK 1D and 2D, including specification of geometry and boundary conditions
- Understand and explain the foundations of mathematical modelling
- Explain how modelling software is developed, how to identify the type of model to use for a given application, how to select the modelling software, what modelling software is available, and how to instantiate and use a model safely in the context of a project
- Describe the application of modelling in different situations involving rivers and coastal waters
- Specify, design and build a simple modelling system

Specific Objectives:

On completion of this module the participants are 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

- Explain how to model the concentration of substances in the flow
- 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 and indicate if the scheme is likely to exhibit numerical diffusion, dispersion and/or instability and Implement different numerical schemes for water related problems
- Know about the main notions and types of information and knowledge systems and implement information systems using database technology using the Borland Delphi application development environment and MS-Access

Course Outline:

- Introduction of primary features, how to set up branch geometry, cross sections, roughness, structures, boundary conditions, running a model.
- Exercise on the various free surface profiles (backwater, drawdown), etc. Use of commercially available packages.
- Exercise on hydraulic jump, mass, momentum and energy balance.
- Exercises on sudden changes in geometry.
- Hands on experience with mathematical models
- Physical laws and modeling. Application area of physical models. Application of dimensional analysis in theory of similarity. Derivation and use of scale laws, and conditions.
- Scale effects, accuracy of measurements and costs as determining factors for scale selection.
- Design, calibration and verification of hydraulic scale models. Reproduction of various hydraulic phenomena like 2D and 3D flows in rivers, over and through the hydraulic structures, sediment transport, morphology, air entrainment and local scour.

- Physics of flood generation; flood wave propagation in natural rivers; introduction to SOBEK 1D or HAC-RAS; exercises on flood waves in regular channels; exercise and workshop on modelling floods in a real 1D system
- Context of modelling; nature of modelling; conceptualisation; physically-based modelling software; modelling in the context of projects; building a model, calibration and verification, confirmation, verifying the structural integrity of the model domain, working with model uncertainty, applying a confirmed model including base line performance; mathematical modelling in practice.
- Developing modelling and graphical components of water-based system using standard numerical and computer graphics toolboxes

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	40
Course Laboratory Hours:	10
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	60
Required Self Reading Hours:	10
	10 (in class)
Teaching Method:	Multimedia – field work, computer application, lab work

References:

- Hornberger, G.M., Raffensperger, J.P., Wiberg, P.L. and Eshleman, K.N. *Elements of physical hydrology.* John Hopkins Univ. Press, 1998.
- Chow, V.T. *Open Channel Hydraulics*, McGraw-Hill, 1983

Short Course Title: Gender mainstreaming in IWRM

Prerequisites: General socio-economic knowledge and water resources projects

Summary and General Objective:

- Gender awareness exercises and concepts of IWRM development and management of water and its advantages over the currently practiced sectoral approach
- Need for Gender Mainstreaming, in IWRM for Sustainable Development.
- Approaches to adult education and learning, how to use icebreakers and energizers effectively gender-sensitive approach to training.
- Strategically integrate of mainstream gender in the project cycle. Identify and collect and/or generate sex, age, socio-economic and cultural disaggregated data. Develop gender-sensitive indicators for IWRM projects. Create a common understanding on the use and application of gender mainstreaming tools.
- Identify tools and methodologies for policy and organizational analysis and assessment.

Specific Objectives:

By successful completion of the course, participants are expected to:

- Have acquired a basic understanding of participatory development theory in the context of gender mainstreaming and using poverty-sensitive approaches.
- Appreciate the need for using participatory non-directive approaches when dealing with culturally sensitive issues such as gender and poverty.
- Understand the linkage between use of participatory tools and gender mainstreaming within the project cycle.
- Be able to identify and adapt tools for their specific needs and use.

- Analyze policies/processes in order to facilitate the formulation and implementation of gender mainstreaming strategies at different levels of an organization.
- Understand how to use different tools for gender mainstreaming in policy processes.

Course Outline:

- *Gender and Integrated Water Resources Management,*

  This section sets the platform for a common understanding of basic concepts that relate to gender, gender mainstreaming and integrated water resources management. It facilitates a better understanding of gender issues within the IWRM framework through a case-study and discusses general strategies for promoting IWRM at different levels – policy, institutional and grassroots.

- *Gender-Sensitive Training Skills*

  The section recognizes that even trainers need skills to manage a gender-sensitive and participatory course. The module aims at taking participants through the training cycle and focuses on some effective strategies for facilitation and workshop management. It also provides the participants an opportunity to share experiences and lessons learned in managing gender and IWRM trainings.

- *Mainstreaming Gender in the Project Cycle*

  Different IWRM projects are being developed to respond to both the practical and strategic needs of women and men. Through a hands-on experiential learning approach, the module provides checklists and suggests strategies to enhance better design, implementation, monitoring and evaluation of projects with a gender perspective. The module further explores collection of sex-disaggregated data and other strategies to generate gender analytical information within the project cycle.

- *Gender Mainstreaming Tools*

  The section aims at assisting those intending to mainstream gender within their projects with practical tools for situational assessment, analysis and planning. It also aims at demonstrating simple, learner-centered, gender- and poverty-sensitive participatory tools that can be used within the policy, program and project levels.

- *Gender Mainstreaming in Organizations and Policy Process: From Theory to Practice*

  An enabling environment is necessary to make gender- and poverty-sensitive perspectives a norm for different types of organizations. This module therefore looks at tools for formulating policies and designing of influencing organizations to be gender-sensitive. It also introduces the new GWA Policy Development Manual, a tool recommended for all its member organizations as a starting point for gender mainstreaming within organizations.

Maximum Number of Participants: 20
Course Duration: 6 days
Course Lecture Hours: 26
Course Computer/lab Hours: 10
Total Course Hours: 36
Required Self Reading Hours: 5
Required Assignment Hours: 10 (in class)

Teaching Method: Presentation/multimedia/case studies role-play.

References:

- Integrated Water Resources Management. TEC Background Paper 4, GWP, 1998.
- A Gender Perspective in the Water Resources Management Sector, Handbook for Mainstreaming. Department for Natural Resources and the Environment, SIDA, Stockholm, 1997.
- Gender Briefing Kit. UNDP, 1995.
- Gender Mainstreaming: What it is, how to do it, a resource kit. UNDP, 2005.
- Gender Planning and Development: Theory, Practice, and Training. Moser, Caroline O. N. London: Routledge, 1993.

Additional Information:

- WHY GENDER MATTERS Gender Mainstreaming in Integrated Water Resources Management A tutorial for water managers by CapNet, IHE-Delft, March 2006
- Policy Development Manual for Gender and Water Alliance Members and Partners January 2003, This publication was produced by the Gender and Water Alliance (GWA), Norwegian Ministry of Foreign Affairs.
- For her IT'S THE BIG ISSUE - Putting women at the centre of water supply, sanitation and hygiene, This publication was produced by the Water Supply and Sanitation Collaborative Council (WSSCC) in collaboration with the Water, Engineering and Development Centre (WEDC), with the support of the Gender and Water Alliance (GWA), Norwegian Ministry of Foreign Affairs, and UNICEF. March 2006.

Course Title: Mediation and Negotiation Skills

Prerequisites: Water professionals with different back ground

Summary and General Objective:

The aim of the course is to contribute to regional water security and peace through strengthening water diplomacy.

- Gain greater confidence to negotiate at all levels
- Obtain knowledge of strategic negotiation
- Achieve a conclusion to both parties
- Return to the workplace with well-practiced negotiating techniques relating to their own individual situations

Specific Objectives:

- The subjects addressed include:
    - To deepen the understanding of conflict transformation and impart advanced mediation skills
    - To strengthen regional water diplomacy.
    - Power-based mediation versus confidence building
    - Enhanced self-understanding with respect to conflict
    - Dynamics of communication
    - Process facilitation skills
    - Facilitating the mediation process
    - Mediated negotiations in practice

Course Outline:

- Mediation; Introduction, Power-based mediation vs confidence building
- Conflict and communication; Personal responses to conflict, Communication, Facilitating good process
- Mediation Methods;
- Steps in Mediation;
- Advanced mediation concepts; The mediation process, Advanced mediation concepts and techniques
- Case-study and Roleplay
- Evaluation

- Attitudes for Mediators; Be objective, Be supportive, No judging, Steer process & Win/win
- Managing Emotions
  - Handling Yourself Don't indulge Don't deny Create richer relationships
  - Handling Others
- Willingness to Resolve; Projection and Shadow, Does the situation inform or inflame?
- Mapping the conflict
- Designing Options; What are the range of options? Use the tools below to generate ideas. Clarifying tools, Generating tools, Selection
- Negotiation skills; Five basic principles
  - Be hard on the problem and soft on the person
  - Focus on needs, not positions
  - Emphasise common ground
  - Be inventive about options
  - Make clear agreements
- Third Party Mediation; Attitudes for Mediators, Be objective, Be supportive, No judging, Steer process, Win/win
- Broadening Perspectives; Respect and value differences

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	20
Course Computer/lab Hours:	40
Total Course Hours:	60
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Computer/Lab/exercise role-play.

References:

- Negotiating Skills for Managers, By Steven Cohen (2002), McGraw Hill. [ISBN 007138757-9]
- Negotiation Basics: Concepts, Skills and Exercises (Unknown Binding), (1992) by Ralph A. Johnson, SAGE Publications [ISBN: 0803940521]
- Basic Skills for the New Mediator, Second Edition (Paperback) (2004) by Allan H. GoodmanSolomon Publications [ISBN: 0967097339]

Additional Information:

- Win Win Approach; *I want to win and I want you to win too.* The Win/Win Approach is about changing the conflict from adversarial attack and defence, to co-operation. It is a powerful shift of attitude that alters the whole course of communication.
- Creative Response; *Problems or Challenges*, The Creative response to conflict is about turning problems into possibilities. It is about consciously choosing to see what can be done, rather than staying with how terrible it all is. It is affirming that you will choose to extract the best form the situation.
- Empathy; *The Tasks of Active Listening, Empathy* is about rapport and openness between people. When it is absent, people are less likely to consider your needs and feelings. The best way to build empathy is to help the other person feel that they are understood. That means being an active listener. There are specific listening activities relevant to different situations - information, affirmation or inflammation.
- Appropriate Assertiveness; *When to use “I” Statements*, The essence of Appropriate Assertiveness is being able to state your case without arousing the defences of the other person. The secret of sucess lies in saying how it is for you rather than what they should or shouldn’t do. “the way I see it...”, attached to your assertive statement, helps. A skilled “I” statement goes even further.
- Co-operative Power; Responding to Resistance from Others, When faced with a statement that has potential to create conflict, ask open questions to reframe resistance. Explore the difficulties and then re-direct discussion to focus on positive possibilities.

Short Course Title: Water rights and governance

Prerequisites: Political, social, economic and administrative background

Summary and General Objective:

The course focus on water right and the role of water governance, in which Water rights and Governance aspects are water challenges. Water governance as defines by UNDP, is the range of political, social, economic and administrative systems that are in place to develop and manage water resources and the delivery of water services, at different levels of society.

Increasing water scarcity, water services shortfalls and escalating pollution are socially and politically induced challenges. The water crisis is increasingly about how we, as individuals, and as parts of a collective society, govern the access to and control over water resources and their benefits. Poor people are disproportionately at disadvantage to have secure access to safe potable water and basic sanitation as well as water for productive uses in agriculture and other economic sectors.

The water governance work of government agencies, civil society organisations and other stakeholders in developing countries. It facilitates South-South collaboration and promotes exchange of experiences and best practices, through for example multi-stakeholder dialogues, and takes an integrated approach to water resources management through improved governance solutions

Water rights and Governance promotes improved water governance reform and implementation. Works with multiple thematic areas that range from integrated water resources management, transboundary water and water supply and sanitation to climate variability, gender and capacity building.

Specific Objectives:

The course addresses:

- Water Rights and Water Resources
- the formulation and adoption of sustainable legislation, policies and institutions
- the way legislation, institutions and policies are being established, enforced and implemented
- clarification of the roles and responsibilities of all involved stakeholders - local and national government, private sector, civil society - regarding ownership, administration and management of water resources

Course Outline:

An Overview 0n Water Resources and Water Rights:

Water Resources and Its Utilisations

Definition of water resource

Utilisation of Water Resources

Evolution of Water Rights

Water rights: a changing concept

Pre-administration system period

Administration system period

Water Rights: the Property Right on Water Resources

Water Rights: the Human Right to Water

State practice

Water Rights: the Environmental Right to Water

The intrinsic value and the right of the environment

The legal status of the environmental right to water

The Influence of International Law

The Human Right to Water

The legal status of the human right to water

The legal content of the human right to water

The obligations of the States

Implementation at national level

The Environmental Right to Water

The legal status of the environmental right to water

The legal content of the environmental right to water

The obligations of the States

Implementation at national level

Comments and Observations on Water Rights Systems

Principles and Structure for an Ideal Water Rights System

Principles

Structure

Definition of Water Resource

Property Right on Water Resources

Ownership on water resources

Other types of property right on water resources

Advantage of applying the design in China

The Human Right to Water

The human right to water shall be clearly declared in water law
The human right to water shall be given the first priority
The legal content of the human right to water shall be defined

The Environmental Right to Water

The environmental right to water shall be clearly acknowledged in water law
The environmental right to water shall be given a proper priority
The general legal content of the environmental right to water shall be defined
Concrete provisions shall be provided
Obtaining of ownership on water resources
Obtaining usufruct on water resources
Transfer of the right to draw water under a license
The human right to water
The environmental right to water
Minimum proper water for the important parts of the environment

Water resources governance

- Improving Public Participation and Governance in Water Resources Management
- Conventional Approaches
- Public Participation and Water Resources Management: A Case study
- Public Participation in the Development of a Management Plan for an International River Basin: Case study
- Transboundary Environmental Impact Assessment as a Tool for Promoting Public
- Participation in International Watercourse Management
- Information Technology Approaches
- The Internet and the E-inclusion: Promoting Online Public Participation
- Promoting Public Participation in Transboundary Waters Management: An Agenda for Peer-to-Peer Learning
- Development of an Information System for Collecting Field Information for Environmental Assessment
- New Directions in Development of Decision Support Systems for Water Resources Management

- Efforts by International Organizations (UNESCO, UNDP,)
- Improving Public Involvement and Governance for Transboundary Water Systems: Process Tools Used
- Public Participation and Governance: A Nile River Basin's Perspective

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	20
Course Computer/lab Hours:	40
Total Course Hours:	60
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method: Presentation/Computer/Lab/Field work.

References:

- Enhancing Participation and Governance in Water Resources Management: Conventional Approaches and Information Technology, Edited by Libor Jansky and Juha I. Uitto, United Nation Press, January 2006
- Water Rights: An International and Comparative Study

Additional Information:

Water Rights in China: Law, Practice and Problems

Water Resources Situation in China

- Water resources and its utilisation
- Main issues in water utilisation

Chinese Legal System: an Overview

- Evolution of Chinese legal system
- Legislative bodies and hierarchy of laws
- Current Chinese legal system
- Water legal norms

Definition of Water Resource

- What is water resource?
- Difference between “water” and “water resource”?

Property Right on Water Resources

Ownership on water resources

Right to draw water and use right on water resources

Problems identified

The Human Right to Water

Legal Provisions

Practice

Problems identified

The Environmental Right to Water

Legal provisions

Practice

Problems identified

Water Rights Systems in South Africa and South Australia

Justification of Selection

Legal Regime in South Africa

Water resource and water use

The human right to water

The environmental right to water

Legal Regime in South Australia

Definition of water resource

Property right on water resources

The environmental right to water

Short Course Title: Water Ethics, Law of Policy

Prerequisites: Professionals who are working in water resources management, and political and legislation skills

Summary and General Objective:.

The course aims at introducing water law and water ethics including the environmental one, in the framework of international initiatives and the effect of these laws and ethics in the IWRM. These frameworks are also necessary to address issues such as the allocation of limited water resources and its relationship to efficiency, productivity, valuation, as well as equity and social justice. This is especially significant for consideration of environmental conservation and sustainability for future generations within integrated water resources management contexts

Specific Objectives:.

- Familiarity with water ethics principals
- Learning policy relationship to regulations and laws
- Familiarity with water laws and international treaties

Course Outline:

- Generic Issues: Theory Building
  - Defining Issues; Water Ethics, Environmental Ethics: Schools of Thought, Ethics, Normative Behavior, Law, and Social Responsibility, Water Ethics: Global Perspectives
  - Methodology: Action Research & Networking
  - The Soft Path Approach in IWRM
- Water Ethics Principles
  - Human Rights and Dignity
  - Equality
  - Solidarity
  - Stewardship
  - Defining Water as a Common Good
  - Ethics in Decision Making and Governance
  - Ethics on the Transboundary Level
  - Water Ethics In Islam

- Actualizing Water Ethics in the Arab Region and The Nile Basin
    - Characteristics and Complexity of Water Crisis; Water Crisis in The Arab Region, Water Crisis in The Nile Basin
    - Key Drivers for Future Action
    - The Need for a Network for Water Ethics
- Initiatives and Institutions for Actualizing Water Ethics
    - UNESCO-COMEST Initiative
    - The Work of RENEW Nodes: Vision, Mission, and Strategies
- Policy and Water Resource Management
    - Concept of policy
    - Policy relationship to regulations and laws
    - Policy formulation
    - Policy and IWRM structures national, regional and international
    - Technological developments in IWRM
- Water law
    - Basic principles of law and relationship to policy and policy objectives: sources of law, international treaties;
    - Divisions of law - civil/criminal, public/private etc; English legal system, courts, common law; Environmental regulatory agencies and public inquiries;
    - political philosophy and public perceptions (needs and demands).
    - Water law: Water resource management – conservation, control, allocation. Water resource protection – quality objectives, pollution control.
    - Water supply and waste water disposal – rights and obligations.
    - Water environment protection – habitats (wetlands), flooding, drainage.
    - Water recreation – bathing, navigation, boating, fishing.

Maximum Number of Participants:	20
Course Duration:	10 days
Course Lecture Hours:	20
Course Computer/lab Hours:	40
Total Course Hours:	60
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)

Teaching Method:	Presentation/Role-play – case studies

References:

- McCaffrey, S.C. (2001). The Law of International Watercourses, Oxford University Press, Oxford.
- 1997: United Nations Convention on the Non-Navigational Uses of International Water Courses,
- Abu Zeid, M. and Hamdy, A. (2004). "Water Crisis and Food Security in the Arab World: Where We Are and Where Do We Go? The Mediterranean Agronomic Institute of Bari, Italy.
- Acreman, M. (2004). Water and Ecology, Series on Water and Ethics, Essay 8, UNESCO, COMEST.36, I.L.M. 700.
- Laki, S.L., Management of Water Resources of the Nile Basin, 6 Int'l J. Sustainable Dev. & World Ecology 288 (1998)
- International Environmental Law, Policy and Ethics, (2000) Alexander Gillespie, Oxford University Press ISBN: 0198298722

Additional Information:

Brennan, A. and Y. Lo (2002). ‘Environmental Ethics’ in *The Stanford Encyclopaedia of Philosophy (Summer 2002 Edition),* E. N. Zalta , ed, Available at: http://plato.stanford.edu/archives/sum2002/entries/ethics-environmental/

Short Course Title: International Environmental Law

Prerequisites: It is recommended, but not required, that students have some knowledge of public international law

Summary and General Objective:

This course provides a general introduction to international environmental law and policy. An examination of the rules of public international law that bear on the rights and duties of states in regard to the world's environment.

The course concentrates on legal and policy responses to global-scale environmental challenges, including deforestation, biodiversity loss, climate change, ozone depletion, hazardous substances, and the loss of living marine resources.

Course Outline:

- After reviewing the rise of the international environment agenda,
- the legal and policy responses to global-scale environmental challenges, including deforestation, biodiversity loss, climate change, ozone depletion, hazardous substances, and the loss of living marine resources.
- The emerging framework of global environmental governance is surveyed and critically evaluated.
- principally on the dynamic of treaties, negotiations, and non-state actors, and much less on domestic legislation
- Many of the following subjects are studied: the structure of international environmental law;
    - the duties of states to prevent environmental harm;
    - the duties of states to cooperate in order to minimize environmental harm;
    - rights and duties arising from sovereignty, common property, and common heritage principles;
    - the roles of international organizations and nongovernmental organizations in protecting the environment;
    - disposal and transportation of hazardous waste;
    - marine and air pollution;
    - deforestation; and nuclear pollution.

Maximum Number of Participants:	20
Course Duration:	8 days
Course Lecture Hours:	40
Course Computer Hours:	10
Total Course Hours:	50
Required Self Reading Hours:	20
Required Assignment Hours:	10 (in class)

Teaching Method: Multimedia.

References:

- Differential Treatment in International Environmental Law (2003), By Philippe Cullet, Published by Ashgate Publishing Ltd ISBN:0754623149
- Principles of International Environmental Law (2003), By Philippe Sands, Published by Cambridge University Press ISBN 0521521068
- International Environmental Law, Policy and Ethics, (2000) Alexander Gillespie, Oxford University Press ISBN: 0198298722

Short Course Title: Hydropower Management

Prerequisites: Professionals on hydrology, civil engineering, basic economic

Summary and General Objective:

The course covers the know-how of hydropower projects and development including feasibility, implementation, operation and maintenance along with economic aspects.

Specific Objectives:

- To learn the development of hydropower projects
- To get familiar with implementation, operation and maintenance
- To learn how to prepare tender documents

Course Outline:

- Hydropower Project Management. Phases of hydropower development:
- Study phase – reconnaissance, pre-feasibility, feasibility.
- Implementation phase. Operation and maintenance phase.
- Economic Design Criteria. Methods of screening of hydropower development alternatives.
- Selection of optimum hydropower plant layout. Socio-economic analysis. Environmental Impact analysis.
- Tenders and contract Administration. Power market studies.
- Issues of Regional Power Trade. Issues of Rural Electrification.
- Dependence of hydropower generation on hydrology. Flow-duration analysis. Analysis of power and load-duration curves. Regulation of power generation in storage type hydropower plants.

Maximum Number of Participants:	20
Course Duration:	one week
Course Lecture Hours:	20
Course Computer/lab Hours:	16
Total Course Hours:	36
Required Self Reading Hours:	15
Required Assignment Hours:	10 (in class)
Teaching Method:	Presentation/software in modeling – case studies

References:

- Mosonyi, E. WaterPower Development, Vol. 1 Low-head Power Plants, Akademiai Kiado, Budapest, 1987.
- Fritz, J.J., Resource Assessment and project feasibility Ch. 11 in Small and Mini Hydropower System, USA, 1984.

Short Course Title: Knowledge Management for Decision Makers in the Water Sector

Prerequisites: Basic knowledge of water resources and environmental system components

Summary and General Objective:

Providing students deeper insights into the functioning of Lake Ecosystems and assessing its ecological integrity

Specific Objectives:

- Increasingly make major investment and/or strategy decisions that depend on digital tools and advanced media
- Feel a responsibility for creating an enabling environment, in which the capacity of individuals and groups are utilised optimally
- Direct major initiatives where access to, and exchange of, knowledge is a critical success factor.
- Favor learning through a case-based approach, with hands-on practical training and frequent interaction among peers and experts.

Course Outline:

- Complexity Management in the 21st Century
- The Knowledge Economy
- Major Challenges for the Water Sector
- The Knowledge Creating Organisation; Private and Public
- Leadership in the Knowledge Organisation
- Intellectual Capital and Processes to organise and disseminate knowledge
- People, Knowledge, and Capacity Building in Water Sector Organisations
- The Role of Indigenous Knowledge
- The Knowledge Cycle and its Management
- Integrating Knowledge and Performance Systems Roles and Responsibilities in the Knowledge Organisation

- Knowledge Assets and Customer Value
- Knowledge Mapping: locating and connecting an organisation's knowledge assets
- Choosing the appropriate ICT tools for organisational knowledge gain
- Organisation Learning: applying knowledge for continuous improvement
- Data, information and knowledge-based systems Process modelling
- Decision Support Systems (DSS) for the Water Sector
- Virtual workspaces and Communities of Practice (CoPs)
- Communication for Senior Leaders: videoconferences, electronic boardrooms.
- Internets, Intranets, E-portals and Knowledge (Partner) Networks Examples of Water Networks
- E-learning and on-the-job training methods

Maximum Number of Participants:	20
Course Duration:	6 days
Course Lecture Hours:	24
Course Laboratory Hours:	0
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	36
Required Self Reading Hours:	12
Required Assignment Hours:	10

Teaching Method:	Multimedia – case studies – seminar and group discussion

Short Course Title: Sustainable agriculture and geo-information systems

Prerequisites: Basic knowledge of water resources and agriculture, computer

Summary and General Objective:

To provide knowledge and skills in designing and executing agricultural (land use) surveys and studies, based on using remotely sensed images and GIS, in order to produce land use maps and assessments concerning the performance of specific agricultural land use systems, i.e.:

Specific Objectives:

- Skills in recording agricultural land use (management) information
- Skills in selecting suitable crops by agro-ecological zone and estimating impact of water availability on productivity.
- Skills in handling, interpreting and classifying site-wise land use data
- Skills in preparing, based on aerospace and ground data, a land use map
- skills in analysing land use data sets using crop growth modelling to assess yield gaps and sustainability issues
- Skills in interpreting land use data both bio-physical as socio-economical in the context of farming systems.

Course Outline:

- Defining practical land use and land use classification concepts
- Agro-ecological zoning, crop selection methods, and water-yield relationships.
- Land cover survey techniques using RS-data and (mobile) GIS-solutions.
- Land use survey techniques, e.g. interview techniques, secondary data collection, sample schemes, etc., using RS-data and (mobile) GIS-solutions..
- Land use data versus farming system data.
- Spatial data infrastructures for land use data sets.
- Quantitative analyses, relating attributes of land use and land resources to productivity and sustainability indicators; use of Land Quality Indicators (LQI's)
- Comparative performance analysis (in agro-ecosystems)

- Spatial crop growth modelling
- Satellite sensors for land use mapping and quantitative production monitoring (introduction).

Maximum Number of Participants:	20
Course Duration:	6 days
Course Lecture Hours:	24
Course Laboratory Hours:	0
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	36
Required Self Reading Hours:	12
Required Assignment Hours:	10

Teaching Method: Multimedia – case studies – seminar and group discussion

Short Course Title: Community Water Quality Monitoring Program

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide capacity for enhancing community understanding of their environment, water quality and the need to monitor water quality for their protection

Specific Objectives:

Participants should be able to;

- Identifying elements of environment
- Understanding Water quality parameters and their implications.
- Understand the monitoring of water quality and their protection
- The rule of community in water quality issues

Course Outline:

- Introduction to environmental and water quality protection
- Water quality aspects (physical, chemical and microbiological)
- Community activities and water quality pollution
- Water quality monitoring: Importance of macro-invertebrates and fish as indicators of water pollution
- Water quality monitoring: Simple methods for water quality testing
- Water quality data analysis, interpretation and reporting
- Designing community water quality monitoring programmes

Maximum Number of Participants: 20
Course Duration: 6 days
Course Lecture Hours: 24
Course Laboratory Hours: 0
Course Computer Hours: 10
Course Field Hours: 10
Total Course Hours: 36
Required Self Reading Hours: 12
Required Assignment Hours: 10

Teaching Method: Multimedia – case studies – seminar and group discussion

References:

- **David A Wardle 2002,** Communities and Ecosystem, Princeton UP
- **Wu-Seng Lung 2001**, Water Quality Modelling for Waste load Allocations and TMDLs, John Wiley & Sons

Short Course Title: Climate Analysis and Modelling

Prerequisites: Basic hydrology, water resources and related issues

Summary and General Objective:

To provide knowledge of climate system and global energy balance and its modeling.

Specific Objectives:

Participants should be able to;

- Familiar with climate modeling
- Knowledgeable of climate interaction with the atmosphere

Course Outline:

- Climate system, global energy balance
- MAGICC energy balance model
- Climate modeling: Why do it? Types of models
- Radiative transfer
- Convective adjustment
- Scientific visualization; Radiative-convective models
- Radiative-convective models
- Atmospheric general circulation modeling
- Coupled general circulation modeling, flux correction
- Climate change experiments, greenhouse gases, aerosols
- Analyze AMIP output
- Radiative-convective model greenhouse gas/aerosol runs
- Volcanic eruptions - model calculations
- Analyze latest SKYHI model outputs
- Nuclear winter
- Nuclear winter experiments with radiative-convective model
- Ozone variations and climatic effect
- Chemistry of tropospheric and stratospheric ozone
- Radiative-convective model simulations of ozone changes
- Land surface modeling
- Land surface feedbacks with radiative convective model
- Detection and attribution of anthropogenic forcing
- Analysis of GFDL control and transient runs

Maximum Number of Participants:	20
Course Duration:	6 days
Course Lecture Hours:	24
Course Laboratory Hours:	0
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	36
Required Self Reading Hours:	12
Required Assignment Hours:	10
Teaching Method:	Multimedia – case studies – seminar and group discussion

References:

- **Peixoto, José P., and Abraham H. Oort, 1992:** *Physics of Climate*, (American Institute of Physics, New York), 520 pp

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- Hartmann, Dennis L., 1994: Global Physical Climatology, (Academic Press, San Diego), 411 pp.
- Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson (eds.), 2001: Climate Change 2001: The Scientific Basis (Cambridge Univ. Press, Cambridge), 881 pp. [IPCC Working Group I Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg1/
- McCarthy, James J., Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, and Kasey S. White (eds.), 2001: Climate Change 2001: Impacts, Adaptation, and Vulnerability (Cambridge Univ. Press, Cambridge), 1032 pp. [IPCC Working Group II Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg2/
- Metz, Bert, Ogunlade Davidson, Rob Swart, and Jiahua Pan (eds.), 2001: Climate Change 2001: Mitigation (Cambridge Univ. Press, Cambridge), 752 pp. [IPCC Working Group III Third Assessment Report] http://www.grida.no/climate/ipcc_tar/wg3/

Washington, Warren M. and Claire L. Parkinson, 2005: An Introduction to Three-Dimensional Climate Modeling, Second Edition (Univ. Science Books, Mill Valley, CA), 353 pp

Short Course Title: Introduction to Meteorology and Climate

Prerequisites: Basic knowledge of IWRM

Summary and General Objective:

To understand basic knowledge of typical circulation and weather systems over Nile basin and to be familiar with general climatic and numerical models used to characterize the large-scale weather processes and tropical meteorological influence on NB weather patterns.

Specific Objectives:

- Basic concepts and principles of weather and climate.
- Measurement, analysis, representation & interpretation of climatic data.
- Management of small weather stations.

Course Outline:

- The natural composition and structure of the atmosphere.
- The elements of weather & climate - how they are measured and recorded, analyzed, represented and interpreted.
- Radiation, heat balance and surface temperatures.
- Pressure and winds and the circulation of the atmosphere - global & African patterns.
- Circulation of the oceans.
- Atmospheric moisture and precipitation.
- Classification of climates and climatic types.
- Climate change - causes and implications.

Maximum Number of Participants:	20
Course Duration:	6 days
Course Lecture Hours:	24
Course Laboratory Hours:	0
Course Computer Hours:	10
Course Field Hours:	10
Total Course Hours:	36
Required Self Reading Hours:	12
Required Assignment Hours:	10
Teaching Method:	Multimedia – case studies – seminar and group discussion

References:

- **Lutgens, F K, Tarbuck, E J and Tasa, D, 2000.** The Atmosphere: An Introduction to Meteorology, 8th Edition, Prentice Hall, 512p
- **Oliver, J E and Hidore, J J, 2001.** Climatology: An Atmospheric Science, 2nd Edition, Prentice Hall, 410p
- **Perry A, 2005.** Applied Climatology: Principles and Practice, 2nd Edition, Routledge, 384p
- **Barry, R G, 2001.** Synoptic and Dynamic Climatology, 1st Edition, Routledge, 608p
- **Von Storch, H and Navarra, A, 1999**. Analysis of Climate Variability: Application of Statistical Techniques, 2nd Edition, Springer, 352
- **Climate Research Communication, 1996.** Natural Climate Variability on Decadal-To-Century Time Scales, National Academy Press, 644p
- **Anderson, D L T and Willebrand, J, 2006.** Decadal Climate Variability: Dynamics and Predictability (NATO ASI Series / Global Environmental Change), 1st Edition, Springer, 493p
- **Doering III, O C, Randolph, J C, Southworth, J and Pfeifer, R A (Eds), 2002.** Effects of Climate Change and Variability on Agricultural Production Systems, 1st Edition, Springer, 296p
- **Van Dam, J C, 2003.** Impacts of Climate Change and Climate Variability on Hydrological Regimes (International Hydrology Series), New Edition, Cambridge University Press, 156p
- **Ribot, J C, Magalhães, A R and Panagides, S, 2005.** Climate Variability, Climate Change and Social Vulnerability in the Semi-Arid Tropics, Cambridge University Press; New Ed edition, 189p
- **Salinger, J, Sivakumar, MVK and Motha, R P, 2005.** Increasing Climate Variability and Change: Reducing the Vulnerability of Agriculture and Forestry, 1st Edition, Springer, 362p
- **Kane, S M and Yohe, G W, 2000.** Societal Adaptation to Climate Variability and Change, 1st Edition, Springer, 278p

Additional Information:

- **Climate Change 2001:** Working Group II: Impacts, Adaptation and Vulnerability Ch. 4. Hydrology and Water Resources. Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001:** Mitigation, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001:** The Scientific Basis, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP)
- **Climate Change 2001:** Synthesis Report, Intergovernmental Panel on Climate Change (IPCC) the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP