Addis Ababa University

MSc Program in Water Resource Engineering and Management (WREM)

August 2024

I. Background

Almost all major development problems in Ethiopia and other Eastern and Southern African (ESA) Countries are water-related: food insecurity, low economic development, recurrent droughts, poor health conditions, urban development, agro-industrial growth, and low energy production. Governments are devoting a very high share of their budget and attracting investments towards poverty alleviation “pro-poor” programs. Large scale donor support provided a vital contribution in the near-term to finance the levels of spending needed to meet these challenges. Over the past two decades, there has been significant progress in key human development indicators. For example, primary school enrollments have increased, child mortality has been reduced, and the number of people with access to improved water supply sources has been increased. Notwithstanding the progress in critical aspects of human development, ESA Countries still need considerable investment and improved efforts to achieve some of the SDG targets. Sub-Saharan Africa as a whole still lags behind most regions in the world when it comes to water access, management, and supply. Worldwide, water has also become an increasingly scarce resource, and in Sub- Saharan Africa, a potential threat to regional security. Due to natural contamination, anthropogenic pollution as well as, unreliable water supply and sanitation infrastructure, only a small percentage of the available water resource can be used for human consumption. Therefore, a multi- disciplinary master’s program in hydrology, water resource engineering and management plays an important role in addressing some of the challenges associated with poor quality life in Ethiopia and the region.

II. Rationale

Our lives and livelihoods are dependent on the natural and engineered water cycles. Accordingly, research and skills development in water treatment and management has never been more vital. Water resources are generated by the natural system, which include atmospheric, surface and sub-surface processes. The natural system is impacted on by the social system, which is mainly characterized by human intervention on the environment. The interaction between these two systems determines the quantity and quality of water resources both spatially and temporally. Water sustains all life forms thereby making it a basic requirement for livelihood needs. In the event of diversifying water use to include domestic, agriculture, industrial, energy, transport and recreation among others, the natural system has been overstretched to the extent that it can no longer sustain the water resources potential required to meet the increasing demand without managing it effectively. The effective management of water resources requires understanding of the environmental processes so that their impacts can be mitigated for sustainable use of the resource. This can be made possible through use of modern technologies which have the capability of analyzing these environmental processes in conjunction with the social system. The scope of the program is outlined in the objectives, which focus the course towards achieving sustainable water resources management.

Water resources potential is on a downward trend especially in Tropical regions where the per capita fresh water availability is less than the global benchmark of 1000 m^3 per year. In view of this fact the water sector in Ethiopia and other ESA Countries has been undergoing reforms in order to adopt cross- sectoral approach. Therefore skills that are compatible with this new paradigm shift in water management need to be disseminated to water resources managers. Such skills require understanding of environmental processes which directly affect water resources potential.

Addressing water challenges requires that water engineers, scientists and managers apply an integrated and interdisciplinary approach, involving hydrological, biophysical, chemical, engineering, economic, institutional, legal, policymaking and planning aspects. The program in Hydrology and water resource engineering and management provides such an approach.

III. Mission

The mission of the program is to enhance the quality of life by ensuring water security for all by providing necessary teaching, research and development inputs, with particular emphasis on water resource engineering and management

IV. Objectives

(a) strengthen AAU's teaching and research capacity to train critical mass of human capacity required to address national and regional development needs,
(b) enhance the capacity of faculty and students to conduct state-of-the-art research and scholarly activities in order to help solve regional problems in water management and climate change issues as well as provide trained research scientists and engineers to support national and regional development goals, and
(c) Provide training and support for the development and adoption of best-practices in teaching, research, academic administration, and management through regional and international partnerships, coupled with mobilization of African Diaspora scientists.

V. Graduate Profile (Competencies)

Graduates will be equipped with the competencies to:

Knowledge and theory

- Have in-depth understanding of the current theories and concepts in both surface and subsurface hydrology, the relevant physical, chemical and biological process interactions between the hydrosphere, the lithosphere, the biosphere and the atmosphere, and have a thorough awareness of the natural and human-induced variability in space and time of hydrological systems; moreover they will be equipped with Integrated Water Resources Management, water resources projects formulation, planning and design.
- For Irrigation engineering have in-depth understanding of hydraulic design, and carryout the design of various hydraulic structures, potential assessment for irrigation development, design and analysis of various dams and appurtenant structures, planning and design of irrigation systems, planning and implementation of irrigation system management and improvement options
- Apply and integrate the relevant physical, chemical, applied mathematical, computational and earth-scientific principles and concepts, and to use information and communication technology within a hydrological context;

Methods, techniques and tools

- Those graduates who will specialize in Hydrology and water resource management will master the major hydrological methodologies and applications with regard to both water quantity and water quality, including techniques for data collection, processing and analysis, and the application of catchment hydrological modeling and aquifer modeling techniques and GIS.
- Those graduates who will specialize in Irrigation engineering and management will master the Irrigation engineering and management methodologies and applications with irrigation design, water management, soil water management and Irrigation scheduling as well the hydrological methodologies common with the water management tack.

Analysis, synthesis and integration

- Analyze the complex inter linkages between water resources, water resources planning, development and management
- Use models in river basin water resources evaluation, water resources allocation, water resources management approaches,
- Critically evaluate the pros and cons of different water resources management strategies including the IWRM, Adaptive water resources management, the ecosystem approach etc
- Have an overall understanding of the economic, legal and institutional aspects of water resources development and management
- Evaluate and analyze hydrological systems and processes at a wide range of scales in both space and time for the purpose of water resources assessment, natural hazards assessment and mitigation, and environmental planning and management
- Use models and software, programming codes to design and manage the irrigation system as well as the structures (For irrigation engineering and management track)

Research

- Have a good knowledge of the relevant literature and the contemporary research questions in the field of hydrology;
- Design and conduct hydrological research and experiments for both application and scientific purposes, either independently or within a team-based framework;
- Critically judge and evaluate their own work and results, as well as prior research or investigations carried out by others;
- Have a research capacity focuses on optimizing irrigation practices, improving water productivity, and developing innovative technologies and management strategies. (irrigation engineering and management track)

General academic skills

- Adequately communicate methodologies, results, evaluations, conclusions and
- Recommendations in oral, written and graphical form to a wide variety of audience;
- Be aware of the importance of hydrology to society, the relationship of hydrology with related disciplines such as ecology, meteorology and climatology, and be able to co-operate within a multidisciplinary and interdisciplinary framework with due consideration of ethical and social aspects related to the application of their knowledge and skills; and Have adopted the academic attitude and learning skills to enhance and broaden the acquired knowledge and application skills in a largely independent manner.

VI. Admission requirement

In addition to the general requirements for Addis Ababa University, admission to **Water Resource Engineering and Management** master's program requires satisfactory completion of a baccalaureate degree at a college or university of recognized standing. Before a candidate will be considered for admission, an application package for admission must be completed and received by the program office. In addition to the application form a number of supplementary documents must be submitted.

Applicants must submit a Statement of Purpose essay of approximately 300-500 words stating clearly and succinctly the reason for seeking graduate study in Water Management at Addis Ababa University, the applicant's career goals, and research interests. The applicant may include information about any unique circumstances, special abilities, awards, achievements, scholarly publications, or professional history that are relevant to the admission decision.
Letters of recommendation from three people who are knowledgeable about the applicant's academic, professional and scholarly ability and potential must be submitted. Applicants should not request letters from individuals who would have an objective conflict of interest (e.g. friends and family). Additional recommendations may be requested.

Official original transcripts from each college or university at which the applicant has completed course work must be on file before an application can be processed.

The applicant must have a BSc Degree in Water Resources Engineering, Hydraulic Engineering, Civil Engineering, Irrigation Engineering, Water Supply and Sanitary Engineering, hydrogeology, geology, geography, environmental engineering or its equivalence and meet any other admission requirements for MSc programmers as per the AAU Senate legislation. regarding applicants from other related disciplines, bridging courses will be recommended to narrow the anticipated deficiencies.

Moreover, all prospective MSc students of the program must sit for and pass the Graduate admission test (GAT) administered by Addis Ababa University before getting admission to the grogram.

He/she must also pass entrance examination administered by the relevant institute.

VII. Duration of the study: 2 years

VIII. Graduation Requirement

A candidate is required to take all the prescribed courses in the curriculum and attain a CGPA of "3.00" and well defended master's thesis research with a minimum result of "satisfactory". Candidate should not score more than one "C" grade. All masters students are required to publish or prepare one publishable manuscript relevant to their thesis work.

IX.Degree Nomenclature:

The Degree of Master of Science in Water Resource Engineering and Management (Hydrology and Water Resources Management)

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The Degree of Master of Science in Water Resources Engineering and Management (Irrigation Engineering and Management)

የሳይንስ ማስተር ዲግሪ በውሃ ሀብት ምህንድስና እና ማኔጅመንት (በመስኖ ምህንድስና እና ማኔጅመንት)

X. Teaching and Learning Methodology

- The full-time program is delivered in modular form, with lectures, seminars, field visits, and a week-long field trip. Instruction includes video conferencing and technology-enhanced learning.
- Practical skills are developed through lectures, fieldwork, group activities, and laboratory sessions. Workshops focused on numerical and computational modelling will be used.
- Structured problem-solving is taught through guided questions, with support from professors and PhD students. This prepares graduates to address complex water-related issues in Eastern and Southern Africa.
- Strong links with water sector organizations provide insights into real-world challenges. Practical components, internships, guest lectures, and collaborative research help students apply their knowledge to transboundary water management in regions like the Great African Rift Valley and the Nile Basin.

XI.Assessment Policies and Techniques

Each module will have formal written examination at the end of each semester and in-class tests. The assessments also involve the preparation of technical reports, field and lab reports, research style articles and oral and poster presentations. Practical skills are assessed through coursework assessments in the form of laboratory and field exercises, technical report writing, oral and poster presentations, field-based reports and research articles. The research project allows the student to demonstrate practical skills to the highest standard. Standard university rules apply.

XII. Grading

Examinations are graded on the following letter grading system, with corresponding points.

Raw Mark	Raw Mark	Raw Mark
[95, 100)	A+	4.00
[85, 95)	A	4.00
[80, 85)	A-	3.75
[75, 80)	B+	3.50

[70, 75)	B	3.00
[65, 70)	B-	2.75
[60, 65)	C+	2.50
[50, 60)	C	2.00
[40, 50)	D	1.00
< 40	F	0.00

Thesis or Dissertation evaluation shall be graded on the following ranking system, with corresponding grading scales and letter grades.

Rank	Grading scale in percent	Letter Grade
Excellent	≥ 85	A
Very Good	$75 \leq X < 85$	B+
Good	$60 \leq X < 75$	B
Satisfactory	$50 \leq X < 60$	C+
Fail	< 50	F

Scoring a grade less than ‘B’ in individual subjects and/or courses by a graduate student may be tolerated. However, to complete the program, and be eligible for graduation, a graduate student shall have to obtain a minimum CGPA of 3:00 (‘B’). Further, such student may not graduate if he scores two or more “C” grades even if he meets the required minimum CGPA of 3:00.

XIII. Resources required and available

13.1 Human Resource (Teaching Staff)

No.	Faculty	Status	Area of expertise	Role
1	Prof Tenalem Ayenew	Existing (AAU)	Hydrogeology, Hydrochemistry, Numerical models for hydrologic and hydrogeological systems	Teaching/Research
2	Prof. Gizaw Mengistu	Existing (AAU)	Climate modeling, remote sensing	Teaching/Research
3	Dr. Beniam Tesfaw	Existing (AAU)	GIS and Water Resources	Teaching/Research
4	Dr. Dessie Nedaw	Existing (AAU)	Hydrogeology	Teaching/Research
5	Dr. Tena Alamirew	Existing (AAU)	Irrigation Engineering	Teaching/Research
6	Dr. Haileyesus Belay	Existing (AAU)	Hydraulic Engineering/Hydrology	Teaching/Research
7	Dr. Sirak Tekleab	Existing (AAU)	Water Resource engineering/Hydrology	Teaching/Research
8	Dr. Zeleke Agide	Existing (AAU)	Water Resource engineering	Teaching/Research
9	Dr. Yonas Girma	Existing (AAU)	Water Resource engineering	Teaching/Research
10	Dr. Nigussie Tekle	Existing (AAU)	Hydraulic Engineering	Teaching/Research
11	Dr. Tekaligne Ayele	Existing (AAU)	Water Resource engineering/Hydrology	Teaching/Research

12	Dr. Tilahun Derib	Existing (AAU)	Water Resource engineering	Teaching/Research
13	Dr. Taye Alemayehu	Existing (AAU)	Groundwater engineering	Teaching/Research
14	Dr. Solomon Gebrehiwot	Existing (AAU)	Water Resources Management, Water shade Management	Teaching/Research
15	Dr. Adey Nigatu	Existing (AAU)	Water Management	Teaching/Research
16	Dr. Gebremedhin Tesfaye	Existing (AAU)	Soil and Water Conservation	Teaching/Research
17	Mamo Kasegne	Existing (AAU)	Hydrometeorology	Teaching/Research
18	Dr. Bayu Chane	Existing (AAU)	Hadraulic Engineering	Teaching/Research

13.2. Material & Infrastructure Resources (Teaching Facilities)

Resource	Available	Required
ICT Resources	High-speed internet, multimedia projectors, computers with up-to-date software	Advanced simulation software for hydrology and water resources modeling
Smart Class rooms	3 Smart class-rooms equipped with state of the art LCD screens and projectors etc, and	Additional Class room
Computing Facilities	2 computer room equipped with 50 high computing capacity.	Additional computing facility equipped with various types of application software
Video conference room	Zoom integrated Video conference room	
Alternative energy source	Solar powered alternative energy sources serving all facilities	Upgrading capacity and scheduled preventive maintenance
Offices	9 offices for admin staff and Faculty and one PhD students work station	Additional offices for Faculties
Knowledge management Platform	Knowledge management platform capable of enabling access to water management information/data	Piloting and testing and enriching with relevant water related information
Library resources	State of the art library service officed by AAU with journal subscription access.	Journal subscription
Websites	University website, host institution pages, online academic journals	Enhanced access to international databases and research networks
Local Resources and Sites and Partnership	Access to local water bodies for field studies, and partnerships with local water management agencies	Additional experimental sites for diverse hydrological and water science studies
Laboratories	ACEWM Water Laboratory (2 functional and one under renovation), Environmental science lab, chemical engineering lab	Specialized labs for remote sensing, isotope hydrology, and advanced water treatment technologies

Software	Standard water management and statistical analysis software	Advanced hydrologic modeling and GIS software

XIV. Quality Assurance

Quality assurance is considered as the most important component of the teaching-learning process. The HOST INSTITUTION uses the following systems of evaluation and monitoring:

- Strictly implementing the admission requirements,
- Preparation of standard module outlines as per the module description,
- Revision of the modules every two years,
- Continuous assessment of educational processes which support training to ensure the learning process' efficiency,
- Assignment of world-class instructors to teach modules, instruct laboratory works, and supervise student projects,
- Identification of standard textbooks for each module,
- Avail teaching materials on HOST INSTITUTION dedicated website,
- Maintain appropriate student/teacher ratio,
- Provide research and teaching skills improvement program for teaching/research staff,
- Provide proper advice to students,
- Evaluation of student performance through, reports, tests, mid semester examinations, seminars and comprehensive final examination,
- Preparation of relevant teaching materials and laboratory manuals,
- Monitoring of instructors performance through student evaluation,
- Monitoring of instructors performance through colleague and Center Leader evaluation,
- Standardization of exams by Centre Academic Committee (CAC),
- internal quality audits to ensure that requirements are fulfilled (proof of the declared achievements), thus supporting the assessment of human performance,
- Implement quality management system based on ISO,
- Communication of the evaluations to instructors,
- Stakeholders feedback on the relevance of the training program and qualities of graduate

Policy and procedures for quality assurance

HOST INSTITUTION will develop a policy and associated procedures for the assurance of the quality and standards of programs and awards. They should also commit themselves explicitly to the development of a culture which recognizes the importance of quality, and quality assurance, in its work. To achieve this, HOST INSTITUTION develop and implement a strategy for the continuous enhancement of quality

Leadership

HOST INSTITUTION is capable of addressing current organizational needs and possesses the agility and strategic management to prepare successfully for its future organizational and market environment. In this context, the concept of innovation includes both technological and organizational innovation to succeed in the future as a region center of excellence for water management

Education

HOST INSTITUTION will directly measure the satisfaction of its learners and other stakeholders, for example with regard to the overall image of the center the level of academic qualifications and attainments, the matching of qualification profiles to the requirements of regional educational and socioeconomic environment

Involvement and participation of international, regional and national academic partners, students and other stakeholders in the learning processes, working and decision-making of the HOST INSTITUTION will strongly contribute towards improving quality and standards

Quality Enhancement Process

The host will further strengthen its:

- Formal admission requirements
- Audition procedures
- Information About and the host and its program
- The host will post the description of the program/course (brochure/flyer/webpage etc.)
- The host will provide all relevant information for potential learners

Documentation

The host will maintain its program/course description both in printed and digital form

Diversity: gender and minorities

The host strives for a balanced percentage of men and women among staff and students, which is in accordance with the principles of gender equality. HOST INSTITUTION will provide special arrangement for minorities and disadvantaged groups without compromising the quality the program

Strategic management

- The HOST INSTITUTION will establish an e-learning strategy that is widely understood and integrated into the overall strategies for institutional development and quality improvement. E-learning policies shall conform to legal and ethical frameworks.

XV. Modules

15.1 Module and Course Coding

The courses in the master's program for water resource engineering and management are organized in six modules listed in 15.2. The course coding system follows the following approach:

- The course codes for all the courses are preceded by "WREM" which stands for Water Resources Engineering and Management followed by four-digit numbers, explained as follows:
- First digit: Year where the course is given (6 for First year and 7 for second year)

- Second digit: Module (it can be 1,2,3,4,5,6)
- Third digit: Semester where the course is offered (1or 2)
- Fourth digit: Course listing sequence within the semester (1,2,3,…7)
- Thesis has a unique code = WREM7711 and WREM7722

15.2. Module List

1. Module 1: Water Resources Fundamentals
2. Module 2: Water Systems, Management, and Governance
3. Module 3: Hydrologic Modelling and Data Analysis
4. Module 4: Water Quality and Environmental Impact
5. Module 5: Research and Scientific Development
6. Module 6: Irrigation engineering and management

15.3. Modular Structure

Module Number	Module Category	Module Name	Module Competencies	Module Objectives	Integrity Statement	Student with disabilities
1	Core	Water Resources Fundamentals	Graduates of this module will possess a comprehensive understanding of the fundamental principles governing both surface and groundwater hydrology. They will be proficient in assessing, evaluating, and managing water resources, applying advanced hydrological modeling techniques to ensure sustainable water allocation. Additionally, they will have the capability to analyze watershed dynamics and implement soil and water conservation strategies to maintain and improve water quality and land productivity. Through this module, students will be equipped to address complex water resource challenges in various environmental and socio-economic contexts.	The objective of this module is to equip students with a foundational understanding of the key concepts and methodologies in water resources management. Students will learn to analyze and model surface and groundwater systems, assess water availability and quality, and apply practical approaches to the sustainable allocation of water resources. Additionally, this module aims to develop students' abilities to evaluate watershed processes and implement effective soil and water conservation practices, preparing them to address the diverse challenges in water resource engineering and management.	Adherence to academic integrity is mandatory.	Provisions will be made for accessibility.
2	Core	Water Systems, Management, and Governance	Understanding of legal frameworks, economic principles, and governance structures that regulate water resources. Ability to apply these principles to promote equitable and sustainable water management practices.	The objective of this module is to develop a deep understanding of the legal, economic, and governance aspects of water	Adherence to academic integrity is mandatory.	Provisions will be made for accessibility.

			Proficiency in the integrated planning and management of water resource systems. Skills in using tools and models for decision-making to optimize water resource use, considering both technical and socio-economic factors.	management. Students will learn to effectively plan, manage, and govern water resource systems, ensuring sustainable and equitable distribution and use of water in diverse settings. The module aims to prepare students for leadership roles in water management, policy-making, and governance.		
3	Core	Hydrologic Modeling and Data Analysis	Ability to develop, calibrate, and apply hydrologic models to simulate water flow, precipitation-runoff processes, and other hydrological phenomena. Proficiency in using modeling software and interpreting model outputs for practical water resource management. Expertise in analyzing hydrological data, including time series analysis, statistical methods, and data visualization. Skills in handling large datasets, using modern data analysis tools, and applying techniques to extract meaningful insights for water resource planning and decision-making.	The objective of this module is to provide students with the technical expertise to model hydrological processes and analyze hydrological data effectively. Students will gain proficiency in developing and applying hydrologic models, utilizing statistical and computational tools for data analysis, and interpreting results to inform water resource management decisions. This module aims to prepare students to address complex water-related challenges by equipping them with the skills needed to perform accurate modeling and insightful data analysis in	Adherence to academic integrity is mandatory.	Provisions will be made for accessibility.

				various hydrological contexts.		
4	Core	Water Quality and Environmental Impact	Ability to assess, monitor, and manage water quality in different environments. Proficiency in applying chemical, biological, and physical methods to evaluate water pollution, understand its sources, and implement strategies for water quality improvement and protection. Expertise in evaluating the environmental impacts of water resource projects and activities. Skills in conducting environmental assessments, understanding the interactions between water resources and ecosystems, and developing mitigation strategies to minimize negative impacts.	The objective of this module is to equip students with the knowledge and skills necessary to evaluate and manage water quality while assessing the environmental impacts of water-related activities. Students will learn to apply scientific methods to ensure the sustainability of water resources and minimize the ecological footprint of water use. This module aims to prepare students to contribute to the protection of water resources and the broader environment through informed decision-making and effective management practices.	Adherence to academic integrity is mandatory.	Provisions will be made for accessibility.
5	Core	Research and Scientific Development	Proficiency in designing and conducting scientific research, including the formulation of research questions, hypothesis development, and the selection of appropriate methodologies. Ability to critically analyze and synthesize scientific literature and apply rigorous research methods to solve complex problems. Expertise in collecting, managing, and analyzing research data using advanced statistical and	he objective of this module is to develop students' abilities to conduct independent, high-quality scientific research. Students will learn to design robust research projects, utilize appropriate data collection and analysis techniques, and effectively communicate	Adherence to academic integrity is mandatory.	Provisions will be made for accessibility.

			computational tools. Skills in interpreting data, drawing valid conclusions, and effectively communicating research findings. Ability to write scientific reports, papers, and proposals, and to present research findings to both academic and non-academic audiences. Understanding of the peer-review process and the ethical considerations in scientific research.	their findings. The module aims to prepare students for careers in academia, industry, or government, where they can contribute to scientific knowledge and innovation through rigorous research and development practices.		
6	Core	Irrigation engineering and management	Capacity in strong foundation in hydrological processes, proficiency in designing and managing various irrigation systems, water and soil management techniques, the ability to develop effective irrigation schedules based on crop requirements and environmental factors, and an understanding of the legal and ethical considerations governing water resources. Graduates should be able to apply their knowledge to construct and maintain efficient irrigation systems, utilize relevant software and technologies.	The objective of the Irrigation Engineering and Management module is to equip students with the essential knowledge and skills necessary to design, implement, and manage effective irrigation systems. This includes understanding hydrological processes, developing efficient water and soil management techniques, creating irrigation schedules based on crop needs and environmental conditions, and applying water resource management.	Adherence to academic integrity is mandatory.	Provisions will be made for accessibility.

S.N	Module	Courses Code	title	ECTS	Mode of Delivery	**Lecture (hrs)**	**Exercise/Group Work (hrs)**	**Fieldwork (hrs)**	**Lab Work (hrs)**	**Self-study (hrs)**	**Notional Learning time (hrs)**
1	Water Resources Fundamentals		Surface Water Hydrology	5	Sequential	42	15	8	15	55	135
			Groundwater Hydrology	5	Sequential	42	15	8	15	59	135
			Water Resources Assessment, Evaluation, and Allocation	5	Parallel	42	15	15	15	48	135
			Watershed Hydrology, Soil and Water Conservation (Elective)	5	Parallel	42	15	15	15	48	135
2	Water Systems, Management, and Governance		Water Law, Economics, and Governance	5	Sequential	42	15	15	0	48	135
			Water Resources System: Planning and Management	5	Sequential	48	24	15	0	48	135
			Irrigation Water Management (Elective)	5	Parallel	48	15	15	5	48	135
			Groundwater Exploration & Management (Elective)	5	Parallel	32	20	26	9	48	135
3	Hydrologic Modeling and Data Analysis		Hydrologic Modeling and Remote Sensing Hydrology	5	Parallel	48	34	5	0	48	135

			Computational Methods and Programming for Water Resources	5	Parallel	48	34	5	0	48	135
			Remote Sensing and GIS	5	Parallel	48	34	5	0	48	135
			Hydro Informatics (Elective)	5	Parallel	48	34	5	0	48	135
4	Water Quality and Environmental Impact		Aquatic Chemistry and Water Pollution	5	Parallel	48	14	10	15	48	135
			Hydrologic Hazards and River Basin Processes	5	Parallel	48	24	15	0	48	135
			Ecohydrology (Elective)	5	Parallel	48	15	15	5	48	135
5	Research and Scientific Development		Research Methods and Scientific Writing		48	34	5	0	48	135	48
			Thesis		-	-	-	-	-	-	-
6	Irrigation Engineering and Management		Dam Engineering and Appurtenant Structures	5	Parallel	48	24	0	0	63	135
			Gravity Irrigation Systems and Flow control	5	Parallel	48	24	15	0	48	135
			Irrigation Systems Design and Modelling	5	Parallel	48	24	15	0	48	135
			Land drainage and Management of Soil Salinity	5	Parallel	48	24	0	0	63	135
			Soil-Water-Plant Relationships	5	Parallel	48	24	0	0	63	135

I. Semester Course Breakdown

Year 1, Semester I

No.	Code	Module	ECTS
1	WREM 6211	Water Law, Economics and Governance	5
2	WREM 6112	Groundwater Hydrology	5
3	WREM 6213	Water Resources System: Planning and Management	5
4	WREM 6114	Surface Water Hydrology	5
5	WREM 6315	Computational Methods and Programming for Water	5
6	WREM 6316	Remote Sensing and GIS	5
		Semester Total	30

Year 1, Semester II (Hydrology and water resource management stream)

No.	Code	Module	ECTS
1	WREM 6121	Water Resources Assessment, Evaluation and A llocation	5
2	WREM 6422	Aquatic Chemistry and Water Pollution	5
3	WREM 6423	Hydrologic Hazards and River Basin Processes	5
4	WREM 6324	Hydrologic Modeling and Remote Sensing Hydrology	5
5	WREM 6525	Research Methods and Scientific Writing	5
6		Elective	5
		Semester Total	30

List of Elective courses (Hydrology and water resource management stream)

No.	Code	Module	ECTS
1	WREM 6426	Ecohydrology	5
3	WREM 6227	Irrigation Water Management	5
4	WREM 6328	Hydro Informatics	5
5	WREM 6129	Watershed Hydrology, Soil and water conservation	5
6	WREM 6220	Groundwater Exploration & Management	5

Year 1, Semester II

Year 1, Semester II (Irrigation Engineering and Management)

No.	Code	Module	ECTS
1	WREM 6621	Dam Engineering and Appurtenant Structures	5
2	WREM 6622	Gravity Irrigation Systems and Flow control	5
3	WREM 6623	Irrigation Systems Design and Modelling	5
4	WREM 6624	Land drainage and Management of Soil Salinity	5
5	WREM 6625	Soil-Water-Plant Relationships	5
6	WREM 6626	Research Methods and Scientific Writing	5
		Semester Total	30

Year 2, Semester I

No.	Code	Module	ECTS
1	WREM 7711	Thesis I	30
		Semester Total	30

Year 2, Semester II

No.	Code	Module	ECTS
1	WEMM 7722	Thesis II	30
		Semester Total	30

ANNEX

Addis Ababa University

Course Development Template

College____

Department ______________________________________

Program __**Hydrology, Water resource engineering and Management**

Course Title: _ Hydro informatics

Year ______**One**___ **Semester**_____**Two**_________

Instructor:

- Name: _______________________________
- Contact information ___________________
- Office hours: _________________________

No	Section	Contents
1)	Module to which the course belongs:	
	1.1. Module Title	Hydrologic Modelling and Data Analysis
	1.2. Type of Module	Elective
2)	Competencies	Master the skills to manage, process, and analyze hydrological data using advanced informatics tools. Develop proficiency in building, calibrating, and validating hydrological models using computational techniques. Utilize hydroinformatics tools to create decision support systems for effective water resources management. Apply geospatial technologies to analyze and visualize hydrological data for better decision-making. Gain expertise in simulating and forecasting hydrological processes under varying environmental conditions. Explore the use of big data analytics and machine learning in addressing complex hydrological challenges.
3)	Course Type	face-to-face
4)		
	4.1. Course Code	
5)	4.2. Credit Point in ECTS	5
6)	Prerequisite	none

7)	Course Description	Hydroinformatics is the study, design, development, and deployment of hardware and software systems for hydrologic data collection, distribution, interpretation, and analysis to aid in the understanding and management of water in the natural and built environment. This module introduces students to fundamental and advanced hydroinformatics concepts and procedures including automated data collection networks, relational databases and data management software, metadata and semantics, data storage file formats and standards, data transformations and automation of data manipulation tasks to support modeling and analysis, web based data distribution and access using web services, and integrated networks of hydro-climate data. Projects may include designing appropriate data models and automating data loading, manipulation, and transformations in support of data intensive analyses or modeling. Class time will include lectures focused on learning and developing data management, transformation, and task automation skills, class discussions, code writing exercises to solve data manipulation tasks, demonstration of software and data systems, and student presentations of their project work. The course will better prepare students to work in data-intensive research and project work environments and emphasize development of reproducible processes for managing and transforming data in ways that others can easily and completely reproduce on their own to support analyses and modeling. Additionally, this course will better prepare students to work across multiple software platforms.
8)	Learning Outcomes	Upon successfully completing this course, students will be able to: • describe the data life cycle, • determine the dimensionality of a dataset, including the scale triplet of support, spacing extent for both space and time, • generate metadata and describe datasets to support data sharing, • discover and access data from major data sources, • store, retrieve, and use data from important data models used in Hydrology such as ArcHydro, NetCDF, and the Observations Data Model (ODM), • watershed analysis Filled DEM –Flow direction- Flow accumulation-stream network and stream link, • develop data models to represent, organize, and store data, • design and use relational databases to organize, store, and manipulate data, • query, aggregate, and pivot data using Structured Query Language (SQL), Excel, R, and other software systems, • create reproducible data visualizations, • write and execute computer code to automate difficult and repetitive data related tasks, • manipulate data and transform it across file systems, flat files, databases, programming languages, etc., • retrieve and use data from Web services, • organize data in a variety of platforms and systems common in hydrology and engineering, • prepare data to support hydrologic, water resources, and/or water quality modeling, project work
9)	Course Contents	**Basic principles and application hydroinformatics in water management.** **Water Data Opportunities in the Information Age** **Data Management and the Data Life Cycle** **Input geospatial and statistical data and models in water management** **Metadata** **Data Models**

		Database Implementation **Hydrologic and Water Management Modeling** **Analysis of watershed from geospatial data and hydro- informatics** **Watershed analysis Filled DEM –Flow direction- Flow accumulation-stream network and stream link.** **Surface Analysis- Slope, Aspect and contouring** **Database and Climate Projection Data Analysis**
10)	Teaching and learning techniques	• **Interactive Introductions**: Introduce key concepts with interactive discussions in class or on-site, engaging students in the subject matter. • **Chapter-Based Presentations**: Assign students to present on each chapter, fostering deeper understanding and active participation. • **Recap and Engage**: Begin each class or discussion session with a Q&A recap to reinforce learning and encourage critical thinking. • **Ongoing Student Portfolios**: Maintain a portfolio of student activities, providing continuous feedback to support innovation and improvement. • **Adherence to Schedules**: Emphasize the importance of adhering to schedules and understanding the consequences of non-compliance to foster discipline and responsibility.
11)	Assessments	Attendance at all class, field or laboratory activities Being interactive at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
12)	Course Policy	• Attendance at all class, field or laboratory activities • Being interactive during lectures, in class and field work sessions • Presentations • Field and laboratory reports • tests and examinations
13)	Learning Resources	**Reading materials:** • J. Abrahart · Linda M. See Dimitri P. Solomatine (Eds.), Practical Hydro-informatics: Computational Intelligence and Technological Developments in Water Applications. Robert • Praveen Kumar, Jay Alameda, Peter Bajcsy, Mike Folk, and Momcilo Markus, Hydro-informatics: Data integrative approaches in Computation, analysis, and modeling. • Kumar, P., (2005), Hydroinformatics: Data Integrative Approaches in Computation, Analysis, and Modeling, CRC Press, 552 p. • Grayson, R. and G. Blöschl, ed. (2000), Spatial Patterns in Catchment Hydrology: Observations and Modelling, Cambridge University Press, Cambridge, 432 p, full PDF text available at http://www.catchment.crc.org.au/special_publications1.html (Links to an external site.). • Tomer, S.K. (2012), Python in Hydrology, Grean Tea Press, Indian Institute of Science, 147 p. Full pdf texts available at http://www.greenteapress.com/pythonhydro/pythonhydro.html (Links to an external site.). **Journals:** • Remote Sensing of Environment • Journal of Hydroinformatics

College/ Institute: Ethiopian Institute of Water Resources/ ACEWM

Department: Water Resources Engineering and Management

Program: Graduate

Course Title: Computational Methods and computer Programming

Year: One **Semester:** One

Instructor:

- Name: Mamo Kassegn / Haileyesus Belay
- Contact information: mamo.kassegn@aau.edu.et
- Office hours: 8 hours

No	Section	Contents
1.	Module to which the course belongs:	
	1.1. Module Title	Hydrological Modeling and Data Analysis
	1.2. Type of Module	Core Course
2.	Competencies	Computer programming, computational methods
3	Course Type	The course is basically organized as a face-to-face approach in a class room and in computer laboratories. In addition, the course has an e – learning platform to accomplish practical exercises. Communications & assignment submissions will be conducted through a course telegram groups.
4.	Course Identifiers	
	4.1. Course Code	WREM 6012
	4.2. Credit Point in ECTS	5
5.	Prerequisite	None
6.	Course Description	Designed to equip students with the essential programming skills needed to address various challenges in the field of water resources. Students will learn to navigate Python programming environments, using Jupyter notebooks. The curriculum covers fundamental programming concepts such as data types, variables, expressions, control flow, functions, loops, and file handling. Emphasis is placed on data manipulation using the Pandas library and data visualization with Matplotlib. Python programming language with application of water resources engineering and management where students will learn to develop own simple programs to solve equations governing flow and transport in the water environment. Students will gain understanding of both the numerical techniques needed to predict water flows and the underlying physical processes described by the mathematical equations. (Matrix, Time series data, graphs, plots and handling).

7.	Learning Outcomes	After the module is completed, the participants would be able to: • Explain and apply fundamental computational methods for solving mathematical problems, including numerical analysis techniques such as interpolation, integration, differentiation, and root-finding. • Demonstrate proficiency in python programming language by writing, debugging, and optimizing code to implement computational methods. • Design and analyze algorithms for various computational problems, understanding their time and space complexity. • Implement numerical methods for solving ordinary and partial differential equations, including finite difference and finite element methods. • Analyze data sets using computational tools and effectively visualize results using appropriate graphical representations. • Gain experience in using relevant libraries and frameworks (e.g., NumPy, SciPy, Matplotlib in Python) to facilitate computational tasks and enhance productivity.
8.	Course Contents	1. UNIT 1: Introduction to Computational Methods and programming (20%) 1.1. Overview of Computational Methods importance in water resources engineering 1.2. Introduction to algorithms and complexity 1.3. Anaconda interface 1.4. Python data types 1.5. Python loops and data structures 2. UNIT 2: Numerical Methods (30%) 2.1. Root Finding and Numerical Integration 2.2. Linear Algebra (Matrices operations) 2.3. Using NumPy for matrix Operation 2.4. Solving Linear Systems 2.5. matplotlib for water resources engineering 3. UNIT 3: Data Analysis and Visualization (30%) 3.1. Data Handling with Pandas 3.2. Reading/writing data files (CSV, Excel) 3.3. Data manipulation techniques 3.4. Visualization with Matplotlib and Seaborn 4. UNIT 4: Numerical Differentiation¶ (20%) 4.1. Numerical Differentiation Problem Statement 4.2. Finite Difference Approximating Derivatives 4.3. Approximating of Higher Order Derivatives 4.4. Numerical Differentiation with Noise 4.5. Summary and Problems
9.	Teaching and learning techniques	Teaching computational methods and computer programming effectively requires a blend of pedagogical strategies, practical exercises, and supportive resources. • Interactive Lectures • Hands-on Coding Exercises • Problem-Based Learning • Group Projects • Pair Programming • Online Discussion Forums • Cloud Computing and Big Data • e – learning
10.	Assessments	Assignments, programming (Lab), report and project
11.	Course Policy	Students will be oriented at the beginning of the module regarding attendance, classroom code of conducts, due dates of submission of assignments, cellphone use, and unacceptable behavior of plagiarism
12.	Learning Resources	**Core References:**

		Lin, J. (2022). An Introduction to Python Programming for Scientists and Engineers. Shen, C., Phanikumar, M. S., & Fang, Z. (2022). Modelling Hydrology, Hydraulics and Contaminant Transport Systems in Python. Kong, Q., Siauw, T., & Bayen, A. (2020). *Python Programming and Numerical Methods*. Academic Press. Chapra, S. C., & Clough, D. E. (2021). *Applied Numerical Methods with Python for Engineers and Scientists*. McGrawhill Education. Michael G., David E., Risto M., Dirk R., & Tamar S. (2023) *Texts in Computational Science and Engineering*. *Springer Nature Switzerland AG. Part of Springer Nature*. **Online Resources** https://www.w3schools.com/python/pandas https://www.digitalearthafrica.org/ https://pandas.pydata.org/pandas-docs/stable/
13.	Assessment rubrics (optional)[1]	Student learning will be assessed in a variety of ways including continuous assessment in the form of tests, assignments, presentations, etc. To determine the final grade earned results of the continuous assessment and one final exam/summative assessment with a weight of not greater than 50% will be used. Instructors shall monitor the student's academic performance by keeping track of records. Examinations may be oral, written or practical, depending on the nature of the module/course. However, in those cases where examinations are conducted orally, a written record of the student's performance and the basis for the determination of grades shall be kept by the instructor. Furthermore, assessment requirements will be clearly stated with due date. Assignments and projects will be announced on first class with guides and rubrics.

Addis Ababa University

Course Development Template

College____

Department ______________________________________

Program __**Hydrology, Water resource engineering and Management**

Course Title: _ Hydrologic Modeling and Remote Sensing Hydrology

Year ____**One**_______ **Semester** ____**two**_____

Instructor:

- Name: ________________________________
- Contact information ____________________
- Office hours: __________________________

No	Section	Contents
1.	Module to which the course belongs:	
	1.1. Module Title	Hydrologic Modelling and Data Analysis
	1.2. Type of Module	Core
2.	Competencies	Proficiency in developing, calibrating, and applying various hydrologic models to simulate water flow, precipitation, evaporation, and other key hydrological processes in different environments. Ability to acquire, process, and manage hydrological data from various sources, including remote sensing, in-situ measurements, and databases, ensuring data quality and reliability. Expertise in employing advanced statistical, machine learning, and computational techniques for analyzing hydrological data and improving model accuracy. Competence in validating hydrologic models, performing sensitivity analyses, and interpreting results to improve model performance and reliability under varying conditions. Understanding and applying techniques to assess and manage uncertainty in hydrologic modeling, ensuring robust decision-making in water resources planning and management. Ability to integrate different modeling approaches, such as coupling hydrological models with climate, land use, and socio-

		economic models, to assess the broader impacts on water resources. Skill in visualizing and effectively communicating hydrological model results and data analysis outcomes to both technical and non-technical audiences, supporting informed decision-making. Capacity to apply hydrologic models and data analysis to solve real-world water resource challenges, including flood forecasting, drought management, and water quality assessment.
3.	Course Type	face-to-face
4.		
	4.1. Course Code	
	4.2. Credit Point in ECTS	5
5.	Prerequisite	
6.	Course Description	The module will cover a wide range of areas of applications of remote sensing in understanding the hydrology and water fluxes at different scales. It is designed to expose students to the application of remotes sensing data acquisitions, processing, correction, calibration, classification, interpretation and model input parameterization for hydrology. Various air and space-borne sensors, their characteristics and application in the water resources studies will be covered. The processing and model parameter generation of data acquired from active and passive sensors of different radiometric, spectral and spatial resolutions for understanding the major components of the hydrologic cycle will be presented using lectures, exercises, home works and project. The use of remotely-sensed data of various sensors in different electromagnetic spectra for directly or indirectly quantification of evapotranspiration, precipitation, runoff, soil moisture, water quality, water productivity and mapping and delineation of wetlands, floodplains, drainage areas and land

		cover will be presented. Hydrological modeling tools that rely on satellite remote sensing shall be presented including PRMS, SWAT, HEC RAS.
7.	Learning Outcomes	**Learning outcomes:** Upon successful completion of this module, students will be able to: • understand the basic principles and application on remote sensing in hydrological modeling, land-use and catchment characteristics, remote sensing of surface and ground water, remote sensing for water quality • understand the basics of remote sensing, data acquisition and processing • perform various corrections to images, classify and interpret • generate various input parameters for hydrological modeling • integrate remote sensing and GIS to hydrological modeling • validate remotely sensed precipitation with measured values
8.	Course Contents	**Review of Remote sensing concepts and principles:** energy source, electromagnetic radiation, radiation and atmospheric interaction, radiometry, resolutions **Remote sensing principles as applied to water resources management** **Image classification and accuracy assessment: classification algorithms : minimum distance classifier, maximum likelihood classifier** **Remote Sensing in Hydrological Modeling** **Terrain mapping:** DEM, NASA Shuttle Radar Topography Mission (SRTM) and Hydro SHEDS, Global 30-m DEM **Remote Sensing of Surface Water and groundwater:** Groundwater/surface water level, Altimeter, Groundwater-GRACE (Theory, Data and Applications) **Soil Moisture:** AMSR-E, TMI, Radar SAT, Microwave (Principle, products, application and limitation) **Evapotranspiration:** Landsat, MODIS, ASTER sensors, surface energy balance, application and limitation Water quality mapping and modeling using remote sensing

9.	Teaching and learning techniques	The main approach and methods used for teaching are lecture, lab demonstration, hands on tutorial and field excursion.
10.	Assessments	Attendance at all class, field or laboratory activities Interactive at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
11.	Course Policy	Attend lectures attentively and ask questions Submit/present assignments on time Participate actively in group discussions Engage in practical sessions Participate in field studies and report
12.	Learning Resources	**Reading materials:** • Hobbs, R.J., and H.A. Mooney. 1989. Remote Sensing of Biosphere Functioning. Springer-Verlag, New York • Remote Sensing in Hydrology and Water Management Gert A. Schultz· Edwin T. Engman (Eds.) • Remote Sensing and Image Interpretation by Lillisand, T.M. and Kiefer T.W., Jhon Wiley. 1999. **Major Remote Sensing Journals** • Remote Sensing of Environment • IEEE Transactions on Geoscience and Remote Sensing • Journal of Geophysical Research • Geoscience and Remote Sensing Transactions • Sensors • Canadian Journal of Remote Sensing • International Journal of Remote Sensing • Photogrammetric Engineering and Remote Sensing • Cartographica • Cartography and Geographic Information Systems • Geographic Information Sciences • International Journal of Geographical Information Systems

Addis Ababa University

Course Development Template

College/ Institute: Ethiopian Institute of Water Resources/ ACEWM

Department: Water Resources Engineering and Management

Program: Graduate

Course Title: Remote Sensing and GIS

Year: One **Semester:** One

Instructor:

- Name: Taye Alemayehu/ Mamo Kassegn
- Contact information: ***taye_77@yahoo.com***/ mamo.kassegn@aau.edu.et
- Office hours: 8 hours

No	Section	Contents
1.	Module to which the course belongs:	
	1.1. Module Title	Hydrological Modeling and Data Analysis
	1.2. Type of Module	Core Course
2.	Competencies	Software (ArcGIS, QGIS, ENVI, ERDAS Imagine), Python programming language
3.	Course Type	The course is basically organized as a face-to-face approach in a class room and in computer laboratories. In addition, the course has an e – learning platform to accomplish practical exercises. Communications & assignment submissions will be conducted through a course telegram group.
4.	Course Identifiers	
	4.1. Course Code	WREM 6021
	4.2. Credit Point in ECTS	5
5.	Prerequisite	None
6.	Course Description	The course will acquaint students with the application of remote sensing principles and geospatial analysis to water resources. Under the remote sensing part, the course covers concepts and principles of remote sensing and techniques, electromagnetic spectrums sensors and platforms, sensors and atmospheric interactions, Image preprocessing, image interpretation and analysis, and accuracy assessment as applied to water resources management

		and natural resources mapping and analysis. The second part of the course discusses Geographical Information Systems (GIS), a powerful tool required to model the behavior of certain aspects of the earth's surface. This part includes an overview and general principles of GIS, data types, data handling and projections. Basic spatial data analysis will be covered. In the third part, students will learn about the practical component that involves the use of desktop software for image processing and analysis using ERDAS Imagine and QGIS for GIS. The theoretical and practical components to be covered include basic principles and applications of remote sensing and geographical information systems, as well as an overview of the satellite image data and their acquisition and processing for a certain application. Students will be encouraged to do exercises using real cases focusing on their area of interest.
7.	Learning Outcomes	Upon successful completion of this module, students will be able to: • good understanding of remote sensing concepts and principles, including electromagnetic radiation, sensor types, and data acquisition methods and their application for water resource management and related tasks, • understand the fundamental concepts of GIS, including coordinate systems, spatial data models and data integration and management. • apply basic image processing and GIS techniques to solve problems related to water development and management, including planning, mapping, and monitoring, • able to make use of online remotely sensed global datasets and acquire and process remote sensing data from various platforms. • able to utilize remote sensing and GIS software (Imagine, QGIS) for image processing, data retrieval, integration and analysis, and managing spatial data.
8.	Course Contents	Part I: Remote Sensing Basics and Applications for WRM (40%) 1. UNIT 1: Remote Sensing Basics and Applications for WRM 4.6. Definition of Remote Sensing 4.7. Applications of RS 4.8.Electromagnetic Spectrum 4.9. Satellites and Sensors 4.10. Medium Properties- interactions with the Atmosphere Target Interactions 4.11. Visible and Near Infrared

		4.12. Passive and Active Sensing 4.13. Image pre-processing 4.14. Image classification Part II Geographic Information System (30%) 5. UNIT 2: Principles of GIS 5.1.Raster and Vector GIS 5.2. Coordinate Systems 5.3. Geospatial data handling and processing Part III: *Integration of Remote Sensing and GIS for WRM (30%)* 6. UNIT 3: Image processing and data extraction 6.1.Data integration and analysis 6.2.Map layout and visualization
9.	Teaching and learning techniques	The methodological approaches to be followed in this module pay particular attention to learner engagement. The approach generally models the type of teaching methods that the module promotes and there will be no negotiation on that. Under this general direction, here are a few suggestions: **A combination of theoretical instruction, practical application, and interactive learning experiences** • **Classroom lecture:** Instructors are obliged to deliver the course in the classroom. In the process of teaching-learning, students are encouraged to ask questions and interact on the topics. • **Hands-on-training:** provide structured tutorials on remote sensing tools (e.g., ERDAS Imagine, and GIS software (e.g., QGIS). Organize an outdoor/field exercise on data collection where students can collect ground truth data, enhancing their understanding of data validation • **Individual assignments**: to enhance and deepen the student’s knowledge and skill, assignments will be given to the students. Students present their assignments in the classroom to help them learn from each other and develop their presentation skills and confidence. • **Networking and communication:** using the available networking and communication options, students will establish a network within themselves and with their instructor to establish a smooth data-sharing and communication platform.

10.	Assessments	<table><tr><th>Learning tool</th><th>Category</th><th>Total</th></tr><tr><td>1. Assignments and presentations</td><td>two</td><td></td></tr><tr><td>2. Practical assignments</td><td>three</td><td></td></tr><tr><td>3. Exam</td><td>One</td><td></td></tr><tr><td>Total</td><td></td><td></td></tr></table>
11.	Course Policy	Students will be oriented at the beginning of the module regarding attendance, classroom code of conducts, due dates of submission of assignments, cellphone use, and unacceptable behavior of plagiarism.
12.	Learning Resources	**References** **(A) General references** • Remote Sensing and Image Interpretation- Lillesand T., Kiefer R. • DIGITAL IMAGE PROCESSING- John R. Jensen, 2015. Pearson Education • Ni-Bin Chang (2012) - Multiscale hydrologic remote sensing - perspectives and applications-Taylor & Francis • Canada Center for Remote Sensing, Fundamentals of Remote Sensing, Tutorials (https://www.nrcan.gc.ca/maps-tools-and-publications/satellite-imagery-and-airphotos/tutorial-fundamentals-remote sensing/9309) • Paul J. Curran, (1985), Principles of Remote Sensing, Longman Scientific & Technical, England. • Hydrologic Remote Sensing. Yang Hong et al (2017) • Sabins Floyd F. (1994), Remote Sensing: Principles and Interpretation, Jhon Wiley and Sons. • C.P. Lo and Albert K. Yeung (2006), Concepts and Techniques of GIS by, Pearson College Div; 2nd edition • Bernhardsen, T. (1999), Geographic Information System, an introduction, Wiley, 0471321923, 9780471321927 • Stan Arnoff, (1993), Geographic Information Systems: A management perspective. **(b) Journals:** • Remote Sensing of Environment • IEEE Transactions on Geoscience and Remote Sensing • Geoscience and Remote Sensing Transactions • Sensors • Canadian Journal of Remote Sensing • International Journal of Remote Sensing • Photogrammetric Engineering and Remote Sensing

		• Cartographica • Cartography and Geographic Information Systems • Geographic Information Sciences **NOTE:** The respective subject area instructors shall add subject area references and Websites, for they differ from field to field.
13.	Assessment rubrics (optional)[2]	Both continuous and summative assessments will be employed using various forms of instruments that help assess the expected learning outcomes. Thus, final examination, projects and presentations, group works, debates and case studies, research reports, designing courses, lesson planning, and other individual tasks will be applied as appropriate to the experiences of students and departments. Furthermore, assessment requirements will be clearly stated with due date. Assignments and projects will be announced on first class with guides and rubrics.

Addis Ababa University

Course Development Template

College____

Department _______________________________________

Program __**Hydrology, Water resource engineering and Management**

Course Title: _ Ecohydrology

Year _____**One**______ **Semester** ____**Two**________

Instructor:

- Name: ________________________________
- Contact information ____________________
- Office hours: __________________________

No	Section	Contents
1.	Module to which the course belongs:	
	1.1. Module Title	Water Quality and Environmental Impact
	1.2. Type of Module	Elective
2.	Competencies	Develop the ability to analyze and manage the interactions between hydrological processes and ecosystems. Gain proficiency in using models to simulate the dynamic interactions between ecological processes and the hydrological cycle. Apply ecohydrological principles to promote sustainable management and restoration of water resources and ecosystems Optimize ecosystem services through the application of ecohydrological concepts and tools.
3.	Course Type	face-to-face
4.		
	4.1. Course Code	
	4.2. Credit Point in ECTS	5
5.	Prerequisite	none
6.	Course Description	This module builds on perspectives from ecology, hydrology, and ecosystem management to focus on the emerging, interdisciplinary area of ecohydrology. The module introduces the principles and concepts in ecohydrology, ecohydrological approaches, application of ecohydrology in water resource and ecosystem management. This module specifically examines the control of climate, vegetation change, biogeochemical processes and nutrient cycling in aquatic ecosystems.

		The concepts and principles discussed in the class will have broad applications ranging from site-specific land management to global change responses.
7.	Learning Outcomes	After successful completion of this module, students will be able to: • clearly describe the interaction and feedbacks between ecological, hydrological, and aquatic ecosystems, • evaluate issues in terrestrial water flux, environmental flow, and ecosystem sustainability under increasing variability of climatic conditions, • be familiar with experimental approaches in ecohydrological research, • understanding the ecohydrological changes in contemporary Africa and its development desires that alter ecosystems, • understand the impacts of humans and climate on ecohydrology of an ecosystem, • be familiar with basic modeling approach and remote sensing approach in ecohydrology, • Improve skills in working on research and synthesis in a team context
8.	Course Contents	**Introduction to Ecohydrology:** ecohydrology in watersheds and water systems, key ecohydrologic processes **Ecohydrologic Connectivity:** within terrestrial systems, between terrestrial and aquatic systems **Water Balance Dynamics:** water balance approach, temporal and spatial formulations, ecohydrological modeling principles and probabilistic/stochastic concepts **Vegetation, Water Stress And Transpiration:** soil water deficit, transpiration and its role on the water balance **Temporal Patterns of Variability In Water and Vegetation:** dynamic (time-dependent) formulations for balance of water, nutrients, biomass, species, coexistence and competition models, coupled dynamics of photosynthesis, transpiration and soil moisture: hourly, daily and seasonal dynamics **Spatial Patterns of Variability of Water and Vegetation**: spatially explicit formulations of water balance, nutrients, biomass; cell based modeling approaches, spatially---explicit modeling **Ecohydrology and Nutrient Cycling:** carbon cycling in watersheds and water systems, nitrogen cycling in watersheds and water systems **Applications and Assessment:** global change and water cycle – global perspective, climate change impact on water cycle in the in the African context**,**

		invasive and encroaching species and ecohydrology, vegetation control on groundwater recharge, climate mitigation - carbon sequestration and water trade-off, ecohydrological impact of riparian vegetation, upland, riparian and aquatic linkage – environmental flow **Research Frontiers on Ecohydrology:** application of remote sensing, hydrologic controls on nutrient cycling by vegetation, hydrologic variability, biodiversity and ecosystem structure; (independent work)
9.	Teaching and learning techniques	• Introductory points with interactive discussed in class or settings on site of subject matter • Assignment for presentations at each chapter of the subject • Class or discussions always begin with recapitulation questions and answers • Keeping portfolio of student activities all the way and giving feedback on all student activities to allow innovative improvements • leaning by respecting schedules and consequences of non-compliance
10.	Assessments	Attendance at all class, field or laboratory activities Interactive at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
11.	Course Policy	• Attendance at all class, field or laboratory activities • Interactiveness at lectures, in class and field work sessions • Presentations • Field and laboratory reports • tests and examinations
12.	Learning Resources	**Reading Materials** • Ecohydrology of Water-Controlled Ecosystems: Soil Moisture and Plant Dynamics, by Ignacio Rodríguez-Iturbe (Author), Amilcare Porporato (Author), ISBN-10: 0521036747, ISBN-13: 978- 0521036740, Cambridge University Press, February 26, 2007. • Aquatic Habitats in Sustainable Urban Water Management: Urban Water Series - UNESCO-IHP, by Iwona Wagner (Editor), Jiri Marsalek (Editor), Pascal Breil (Editor), ISBN-10: 0415453518, ISBN-13: 978-0415453516, Taylor & Francis, November 10, 2007

Addis Ababa University

Course Development Template

College____

Department ____

Program ____<u>Hydrology, water resource engineering and Management</u>__

Course Title: <u>_Groundwater Hydrology</u>

Year ___<u>one</u>___ Semester <u>__One</u>

Instructor:

- Name: __________________________________
- Contact information _____________________
- Office hours: ___________________________

No	Section	Contents
1)	Module to which the course belongs:	
	1.1. Module Title	Water Resources Fundamentals
	1.2. Type of Module	Core
2)	Competencies	Explain the types and properties of aquifers, including confined, unconfined, and fractured aquifers, with a focus on hydraulic conductivity, storage, and transmissivity. Analyze groundwater flow dynamics and groundwater flow to wells using principles like Darcy's Law and concepts of hydraulic head and gradients in various hydrogeological contexts. Evaluate the processes influencing the movement and fate of contaminants in groundwater, including advection, dispersion, and chemical reactions. Conduct comprehensive groundwater quality assessments, interpreting hydrochemical data to identify pollution sources and assess the risk to public health and ecosystems. Develop and validate numerical models using software tools (e.g., MODFLOW) to simulate groundwater flow and transport processes under different scenarios. Critically assess existing groundwater management policies, legal frameworks, and

		international guidelines, proposing improvements for sustainable groundwater governance. Evaluate the potential impacts of climate change on groundwater systems, including changes in recharge rates, groundwater levels, and water quality Demonstrate proficiency in conducting field investigations, including drilling supervision, well logging, and water sampling
3)	Course Type	face-to-face
4)		
	4.1. Course Code	
	4.2. Credit Point in ECTS	5
5	Prerequisite	
6	Course Description	The main purpose of the course is to equip students of water resource engineering and management with the knowledge of groundwater occurrence, storage, movement and quality of groundwater. The main topics that will addressed includes aquifer classification, hydraulic properties of rocks, groundwater flow equations, groundwater modeling, groundwater recharge and management, Impact of climate change on groundwater and field techniques in groundwater investigations. The main approach and methods used for teaching are lecture, lab demonstration, hands on tutorial and field excursion.
7	Learning Outcomes	Understand groundwater in the hydrologic cycle, Quantify groundwater flows in natural formations and approaching wells, Understand governing equation of groundwater flow, water balance, contaminant transport and then apply these relationships for practical problems. Understand well hydraulics and pump testing, Locate, design, construct and test water wells for groundwater development.
8	Course Contents	**Introduction:** zone of aeration, zone of saturation, storage coefficients, groundwater table, fluctuation of groundwater table, recharge and discharge areas, definition of aquifer, aquifuge, aquitard and aquiclude, confined and unconfined aquifers

		Aquifer Properties: aquifer parameters – s10pecific yield, specific retention, porosity, stor11age coefficient, Hydrau12lic conductivity, coefficient of permeability and intrinsic permeability, transmissivity, isotropic, anisotropic layered soils, **Groundwater Flow** Darcy's law, steady one dimensional flow, use of tracer techniques in groundwater hydrology, groundwater flow in different types of aquifers. Regional flow and geologic controls on flow, transient flow, aquifer storage and compressibility, unconfined flow, groundwater interaction with streams and lakes, numerical methods, flow in fractured rock **Well Hydraulics:** steady radial flow in confined and unconfined aquifers. introduction, general equation, Theis method, Cooper and Jacob method, Chow's method, solution of unsteady flow equations (derivation not required), analytical groundwater optimization models **Ground Water Exploration:** geologic and hydrologic methods, seismic method, electrical resistivity method, bore hole geo-physical techniques; electrical logging, radioactive logging, induction logging, sonic logging and fluid logging. Magnetic & gravity methods in groundwater targeting. **Ground Water Recharge, Discharge and Balance**: parameters of groundwater balance, estimation of recharge components, groundwater assessment & Balancing, artificial recharge, methods of artificial groundwater recharge, spreading methods, induced recharge, sub surface dams, case histories, groundwater management by conjunctive use
9	Teaching and learning techniques	The main approach and methods used for teaching are lecture, lab demonstration, hands on tutorial and field excursion.
10	Assessments	Attendance at all class, field or laboratory activities Being interactive at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
11	Course Policy	Attend lectures attentively and ask questions Submit/present assignments on time Participate actively in group discussions Engage in practical sessions

		Participate in field studies and report
12	Learning Resources	Willis, R. and W. W-G. Yeh. *Groundwater Systems Planning and Management*, Prentice, Hall, Inc., Englewood Cliffs, New Jersey, 1987. Bear, Jacob. *Dynamics of Fluids in Porous Media.* New York, NY: Dover Publications, 1988. ISBN: 0486656756. Bear, J. *Hydraulics of Groundwater*, Dover Publications, 2007 Todd, D.K. *Groundwater Hydrology*, John Wiley and Sons, New York, 1980. Ahlfeld, D. P. and A. E. Mulligan. *Optimal Management of Flow in Groundwater Systems,*Academic Press, New York, 2000. Istok, J. *Groundwater Modeling by the Finite Element Method,* Water Resources Monograph 13, American Geophysical Union, Washington, D.C., 1989. Davis, S. and R.J.M. DeWiest. *Hydrogeology*, John Wiley & Sons, New York, 1967. Remson, I., Hornberger, G.M., and F.J. Molz. *Numerical Methods in Subsurface Hydrology*, Wiley- Interscience, New York, 1971 Pinder, G.F. and W.G. Gray. *Finite Element Simulation in Surface and Subsurface Hydrology*, Academic Press, New York, 1977. Freeze, R.A. and J.A. Cherry. *Groundwater*, Prentice-Hall, Englewood Cliffs, New Jersey,1977. McWhorter, D. B. and D. K. Sunada. *Groundwater Hydrology and Hydraulics*, Water Resources Publications, Fort Collins, Colorado, 1977. Batu, V. *Aquifer Hydraulics—A Comprehensive Guide to Hydrogeologic Data Analysis*, John Wiley & Sons, New York, 1998 Domenico, Patrick A., and Franklin W. Schwartz. *Physical and Chemical Hydrogeology*. New York, NY: John Wiley & Sons Inc., 1998. ISBN: 0471597627. Freeze, Alan R., and John A. Cherry. *Groundwater*. Englewood Cliffs, NJ: Prentice Hall, 1979. ISBN: 0133653129. *Hydraulics of Groundwater*. New York, NY: McGraw-Hill College, 1980. ISBN: 0070041709. Todd, David Keith. *Groundwater Hydrology*. New York, NY: John Wiley & Sons Inc., 1980. ISBN: 047187616X. **Journals:**

		Journal of Hydrogeology & Hydrologic Engineering Journal of Groundwater Hydrology Contaminant Hydrology Hydrology: Current Research Nature Climate Change

Addis Ababa University

Course Development Template

College____

Department ____

Program **<u>Water Resources Engineering and Management</u>**

Course Title: **<u>Surface Water Hydrology</u>**

Year: **<u>One</u>** **Semester:** **<u>One</u>**

Instructor:

- Name: __________________________________
- Contact information ____________________
- Office hours: ___________________________

No	Section	Contents
1		Hydrology
		Water Resource Fundamentals
2		• Demonstrate proficiency in analyzing and modeling the movement, distribution, and behavior of water across landscapes. • Acquire skills in quantifying surface runoff, understanding streamflow processes, estimating precipitation patterns, and assessing the impact of land use changes on water availability. • Develop expertise in designing and interpreting hydrographs, applying statistical methods to hydrological data, and collaborating with stakeholders to address water-related challenges. • Demonstrate the skill and knowledge in applying determistic models to solve water challenges at Local, National, Regional, and Global scales.

3		-Face-to-face lecture -Seminar/peer learning -Assignment (group and individual based) -Review articles relevant to the course -Field work
4		
		WREM-XXXX
5		5
6	Prerequisite	None
7	Course Description	The main objective of this course is to teach students about fundamentals of both surface and sub-surface hydrology. The course is designed to ensure that students have a thorough understanding about hydrological cycle, unit hydrograph theory, hydrograph analysis, evaporation mechanisms, and estimation methods, including prediction of extreme hydrological events, flood survey, flood routing and rainfall-runoff relations. To understand rainfall-runoff relationship, students will acquaint with the different modelling techniques used in hydrology. Model classification, the principle underlaying the different model types are discussed. Model protocols; forcing data, sensitivity analysis, model parameterization, calibration, validation, and scenario analysis are discussed and demonstrated in real field application.
8	Learning Outcomes	• Apply theoretical concepts to real-world scenarios and emphasizing practical problem-solving skills by integrating theory and practice. • Explore case studies and examples relevant to surface water hydrology. • Identify and make analysis of the natural and human-driven fluctuations in hydrological systems. • Familiarity with hydrological literature and current research inquiries. • Apply and integrate relevant physical, chemical, applied mathematical, and computational scientific principles and concepts in hydrology. • Identify hydrological processes, quantify and interpret their implication on water availability and water use.

		• Obtain skills to use data, information and communication technology within a hydrological context. • Master the major hydrological methodologies and applications with regard to water quantity and quality, including techniques for data collection, processing and analysis, and the application of catchment hydrological modelling. • Evaluate and analyses hydrological systems and processes at a wide range of scales in both space and time for the purpose of water resources assessment, natural hazard assessment and mitigation, and environmental planning and management. • Design and conduct hydrological research and experiments for applied or scientific purposes, independently or within a team. • Recognize hydrology's societal significance and its connections to sister disciplines; ecology, meteorology, and climatology. • Be able to co-operate within a multidisciplinary and interdisciplinary framework with due consideration of ethical and social aspects related to the application of their knowledge and skills.
9	Course Contents	**Unit1. Introduction (5%)** 1.1 The development of hydrology, the hydrological cycle, 1.2 Water balance, human interference on hydrologic cycle, 1.3 Importance of hydrological data. **Unit 2 Precipitation (20%)** 2.1 The atmosphere, precipitation formation, 2.2 Rainfall measurement, intensity, duration and rainfall depth, 2.3 Areal rainfall estimation methods, rainfall 2.4 Data Analysis; data screening, 2.5 Frequency analysis for single parameter estimation, mixed distribution, probable maximum precipitation and analysis of dry spells. **Unit 3. Evaporation (15%)** 3.1 Land surface-atmosphere exchange processes, types of evaporation, factors affecting evaporation, 3.2 Energy balance, Penman open water evaporation,

		3.3 Methods of estimation of potential evapotranspiration, evaporation measurements. **Unit 4. Surface Water Resources (30%)** 4.1 Discharge measurement, rating curves, flood surveys, 4.2 Linear hydrologic system, rainfall runoff transformation, the unit hydrograph, hydrograph analysis, factor affecting hydrograph shape, flow duration curves, 4.3 Flood routing, hydraulic and hydrologic routing, Saint vacant equation. 4.4 Reservoir planning **Unit 5. Rainfall-runoff relationships (30%)** 5.1 Short duration peak runoff, long duration catchment yield, 5.2 Introduction to urban hydrology. 5.3 Types of deterministic hydrological Models 5.3.1 Model conceptualization 5.3.2 Model parametrization 5.3.3 Model calibration and validation 5.3.4 Uncertainties in hydrological models Time allotment: • Lecture hrs 3*16=48hrs • Lab---Not applicable • Fieldwork 0.94hrs*16= 15.04hrs • Self-study 4.5*16=72hrs
10	Teaching and learning techniques	The methodological approaches to be followed in this module pay particular attention to learner engagements. The approach generally models the type of teaching methods that the module promotes and there will be no negotiation on that. Under this general direction, here are a few suggestions: • **Face to face lecture:** Instructor are obliged to deliver the course in class room. In the process of teaching-learning, students are encouraged to ask question and interact on the topics. • **Student centered learning**: Some of the theoretical concept in the course given to the students to learn as a peer learning methodology.

		Instructor will follow-up their understanding through oral presentation in the class room. • **Seminar:** For selected units, semester-based seminar is prepared by the instructor to be presented by the students. The seminar work can be done individual or in a form of group work. • **Individual and group assignments**: to enhance and deepen the student knowledge and skill, for each unit assignments are given to the students. Some of the assignments are organized to be presented in class room. This is anticipated to strengthen their communication skill and sharing knowledge to their colleague. • **Communication and networking:** Communication and networking is an essential component of the teaching and learning processes. In this course students and instructor are communicated via digital communication to share lecture notes, lecture materials, assignments and any relevant data e.g. telegram. Students are encouraging to exchange ideas and make debate on the subject matter through virtual media.
11	Assessments	Six types of assessments along with the percentage of mark distribution are set for this course. • Article review on different topics related to the course (oral presentation) (10%). **(Due date end of second weeks, since class begin).** • Group-Assignment on potential evapotranspiration in different Ethiopian river basin (10%). **(Due date end of fifth weeks, since class begin).** • Individual assignment on data analysis, linear statistical trend analysis (10%). **(Due date end of eight weeks, since class begin).** • Field practice on hydrometry (field report and presentation) (10%) **(Due date end of tenth weeks, since class begin).** • Group-Assignment on demonstration of hydrological model application in Ethiopian river basins (20%). **(Due date end of sixteen weeks, since class begin).** • Final examination (40%) **(Due date based on the academic calendar set by the AAU).**
12	Course Policy	Students will be oriented at the beginning of the module regarding attendance, classroom code of conducts, due dates of submission of assignments, cellphone use, and unacceptable behavior of plagiarism.
13	Learning Resources	**References** 1. Beven, K., 2012. Rainfall-Runoff Modelling The Primer Second edition. 2. Brutsaert, W., 2005. Hydrology: an introduction. Cambridge. 3. McCuen, R.H., 1998. Hydrologic analysis and design. Prentice Hall, 814p.

		4. Shaw, E.M., 1994. Hydrology in practice. Van NostrandReinhold, 569 p. 5. Shaw, E.M., 1989. Engineering hydrology techniques in practice. Ellis Horwood, 350 p. 6. Ward, R.C. and M. Robinson, 1990. Principles of Hydrology, McGraw-Hill, 365 p. 7. Wilson, E.M., 1990. Engineering Hydrology. Mc Millan, 309 p. 8. Web-based sources International reputable Journals: 1. Journal of Hydrology and Earth System Science (HESS) 2. Journal of Hydrology Regional studies 3. Journal of Hydrological Science

Addis Ababa University

Course Development Template

College____

Department _______________________________________

Program ___Hydrology, Water resource Engineering and Management

Course Title: _ Water Resources Assessment, Evaluation and Allocation

Year ____one Semester ___two

Instructor:

- Name: ________________________________
- Contact information ____________________
- Office hours: __________________________

No	Section	Contents
1	Module to which the course belongs:	
	1.1. Module Title	Water resources fundamentals
	1.2. Type of Module	Core
2	Competencies	• Ability to analyze and model the water cycle at various scales, understanding the interactions between different components.

		• Proficiency in collecting, processing, and analyzing hydrological data using tools such as Geographic Information Systems (GIS), remote sensing, and hydrological models. • Competence in applying hydrological models to simulate and predict water availability and flow in various environments. • Skills to quantify water resources, including determining sustainable yields of aquifers and evaluating surface water availability. • Ability to assess the environmental impact of water resources projects, considering ecological, social, and economic factors. • Competence in evaluating water demand across different sectors (e.g., agriculture, industry, domestic use) and understanding the principles of water use efficiency. • Knowledge of water rights, allocation mechanisms, and legal frameworks 3governing water distribution. • Skills in addressing and resolving conflicts over water allocation, considering equity, efficiency, and sustainability. • Ability to work collaboratively in multidisciplinary teams to address water resource challenges.
4	Course Type	face-to-face
	4.1. Course Code	
	4.2. Credit Point in ECTS	5
5	Prerequisite	
6	Course Description	This module will describe how river basin water resources can be managed by calculating the demands and using a systems approach to water resources planning and management. This module describes introduction to water resources planning, identification and evaluation of water management plans: water resources planning objectives, cost-benefit objectives, multi-objectives, plan formation, planning models and solution procedures, objective functions and constraint equation, optimizations methods, water resources planning under uncertainty: probability concepts and their use in water resources planning, application of systems analysis to water resources: deterministic river basin modeling: stream flow estimation, estimation of reservoir storage requirement for water supply, flood

		control aspects, HP production, withdrawals and diversions; synthetic stream flow generation: statistical stream flow generation models, ARMA models and their application in water resources management. Introduction to River basin modeling and management: river basins models, decision support system (DSS), and concepts of sustainability, environmental impacts and their assessment. Water Resources allocation modeling [hydrological models, WEAP]
7	Learning Outcomes	Upon successful completion of this module, students will be able to: • construct and operate of river basin models e.g. WEAP , • quantify water demands for urban, agriculture and industry, • understand fundamentals of water quality models, • understand selected techniques of optimization, • identify available water resources and how these vary in time, • build simple optimization models using Linear Programming, • simulate changes in water quality and relate these to regulations, • evaluate risk in planning for floods and droughts, • plan future demand scenarios based on climate change, • evaluate system management options to optimize water availability, • use simulation software such as WEAP for river basin modeling, • exercise report writing, group work, independent judgment and time management
8	Course Contents	**Identification and evaluation of water management plans:** water resources planning objectives, cost-benefit objectives, multi-objectives, plan formation, planning models and solution procedures, objective functions and constraint equation, optimizations methods. **Water resources planning under uncertainty:** Probability concepts and their use in water resources planning. **Application of systems analysis to water resources:** deterministic river basin modeling: stream flow estimation, estimation reservoir storage requirement for water supply, flood control aspects, HP production, withdrawals and diversions;

		Synthetic Stream flow Generation: statistical stream flow generation models, ARMA models and their application in water resources management. **Introduction to River basin modeling and management:** river basins models, decision support system (DSS), and concepts of sustainability, environmental Climate change and impacts on water resources, use of WEAP software Demand estimation Estimating agricultural demands from irrigation systems **Water Availability versus Quality:** water availability and water quality modeling, statistics, probability and stochastic modeling, water quality modeling **Optimization and performance monitoring:** Optimization of water allocation, Performance monitoring and asset management
9	Teaching and learning techniques	The main approach and methods used for teaching are lecture, lab demonstration, hands on tutorial and field excursion.
10	Assessments	Attendance at all class, field or laboratory activities Interactiveness at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
11	Course Policy	Attend lectures attentively and ask questions Submit/present assignments on time Participate actively in group discussions Engage in practical sessions Participate in field studies and report
12	Learning Resources	• Loucks D.P. and Beek E.V. (2005) Water Resources Systems Planning and Management. UNESCO • Karmouz M., Szidarovszky F., and Zahraie B. (2003) "Water Resources System Analysis", CRC Press • Vedula S., and Mujumdar P.P. "Water Resources Systems", McGraw Hill • Software requirements ○ WEAP, WEAP, CROPWAT, CROPWAT, MATLAB

Addis Ababa University

Course Development Template

College____

Department ____

Program __Hydrology, Water resource engineering and Management

Course Title: _ Watershed Hydrology, Soil and water conservation

Year ____one__ Semester ____Two_____________

Instructor:

- Name: _________________________________
- Contact information ____________________
- Office hours: ___________________________

No	Section	Contents
1)	Module to which the course belongs:	
	1.1. Module Title	Water Resources Fundamental
	1.2. Type of Module	Elective

3	Competencies	Develop the ability to analyze and model hydrological processes within a watershed, considering both surface and subsurface water flow. Understand and evaluate the interactions between soil properties and hydrological processes that influence water retention and movement. Design and implement strategies for soil erosion control to maintain watershed health and water quality. Apply soil and water conservation techniques to sustainably manage water resources in a watershed. Develop integrated approaches to manage watershed resources, balancing ecological, hydrological, and human needs. Assess the impact of land use and climate change on watershed hydrology and develop mitigation strategies.
3	Course Type	face-to-face
4		
	4.1. Course Code	
	4.2. Credit Point in ECTS	5
5	Prerequisite	none
6	Course Description	This module aims to provide students with (1) the knowledge of the hydrological process involved at watershed scale and human impact on water resource management, and (2) the skill to designing watershed specific management strategy. The following major topics will be covered: hydrological process in watershed-focusing on the rainfall-runoff generation process, runoff and flood routing, hydrological analysis; soil erosion process and impact- process and mechanics of soil erosion, erosion hazard assessment and measurement, modeling soil erosion; soil and water conservation-physical soil and water conservation measures, flood control and land drainage, water harvesting; integrated watershed management principles and practices; the sustainable land management movement in Ethiopia – intents and achievements.
7	Learning Outcomes	**Learning outcomes:** Upon successful completion of this module, students will be able to: • explain the physical process involved how runoff is generated in watershed and the contribution of watershed intervention for enhanced water resource management, • identify soil erosion hotspots affecting hydrologic systems in a watershed, and design conservation measures,

		- design watershed development strategies and plans for enhanced water resource development and management, - appraise national/regional sustainable land management effort and its contribution to the water resource development and management
8	Course Contents	**Hydrologic systems in a watershed: the hydrologic cycle** **Hydrologic process in a watershed: rainfall runoff generation process, runoff gauging and flood routing; frequency and time series analysis** **Soils:** **Characterization, genesis and classification of soils. Study of soils in the laboratory.** **Soil erosion: modeling soil erosion process and mechanics of soil erosion; erosion hazard assessment; estimation of soil erosion; and soil loss and sediment yield models** **Soil and water conservation methods and practices: physical and biological measures, water harvesting, earth embankments and farm ponds, management of bad lands.** **Watershed management: rationale for watershed approach, identifying watershed threats and impairments, approaches to integrated watershed management.** **Lessons from sustainable land management practices in Ethiopia**
9	Teaching and learning techniques	**Interactive Introductions**: Introduce key concepts with interactive discussions in class or on-site, engaging students in the subject matter. **Chapter-Based Presentations**: Assign students to present on each chapter, fostering deeper understanding and active participation. **Recap and Engage**: Begin each class or discussion session with a Q&A recap to reinforce learning and encourage critical thinking. **Ongoing Student Portfolios**: Maintain a portfolio of student activities, providing continuous feedback to support innovation and improvement. **Adherence to Schedules**: Emphasize the importance of adhering to schedules and understanding the consequences of non-compliance to foster discipline and responsibility.
10	Assessments	Attendance at all class, field or laboratory activities Being interactive at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
11	Course Policy	- Attendance at all class, field or laboratory activities - Interactiveness at lectures, in class and field work

		sessions • Presentations • Field and laboratory reports • tests and examinations
12	Learning Resources	**Reading materials** • S. L. Dingman, 2002.Physical Hydrology, 2nd edt. • V. T. Chow, D. R. Maidment, L. W. Mays. 2006. Applied Hydrology. • K. J. Beven, 2006. Rainfall-runoff modelling • R. P. C. Morgan 2005. Soil Erosion and Conservation **Journals:** • Water Resources Research • Journal of Hydrology • Advances in Water Resources • Agricultural Water Management Regulated Rivers – Research & Management • Ground Water • Hydrological Processes

Addis Ababa University

Course Development Template

College____

Department ____

Program __Hydrology, Water resource engineering and Management

Course Title: _ Groundwater Exploration & Management

Year ______one_____ Semester ______two_____________

Instructor:

- Name: ___________________________________
- Contact information _____________________
- Office hours: ____________________________

No	Section	Contents
1	Module to which the course belongs:	

	1.1. Module Title	Water Systems, Management, and Governance
	1.2. Type of Module	Elective
2	Competencies	Develop skills in utilizing geophysical and geological methods for the exploration and identification of groundwater resources. Gain proficiency in characterizing aquifers, including determining their properties, boundaries, and potential yield. Apply principles of sustainable management to balance groundwater extraction with recharge and conservation efforts. Build and use groundwater flow models to simulate and predict aquifer behavior under various stress conditions. Implement groundwater quality monitoring techniques to assess and manage contamination risks. Integrate groundwater management into broader water resource management frameworks to ensure holistic and sustainable use.
3	Course Type	face-to-face
4		
	4.1. Course Code	
	4.2. Credit Point in ECTS	5
5	Prerequisite	none
6	Course Description	This course is designed to provide the basic techniques and approaches of groundwater exploration and monitoring. 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, Remote Sensing and GIS application in Hydrogeology, Conventional and nonconventional methods in exploring groundwater, Surface geophysical methods; Principles of geo-electrical surveying, Variable electrode distance techniques, Horizontal profiling, Hydrogeological interpretations. Concepts of basin management: quantity and quality aspects; Alternative basin yield; Evaluation of perennial yield; Modeling tools and techniques for management; Integrated use of surface water and groundwater; Artificial recharge and artificial retention, institutional policy and legal issues in groundwater management, stages of groundwater management, climate change impact on groundwater resources availability and management practice, coping with climate change,

		working with incomplete knowledge, groundwater technology, the basin concepts, the wet buffer concepts, sustainable yield concepts, adaptive management, tools in management, water quality management, water resources administration, international and national policies and regulations on groundwater, groundwater administration, integrated water resources management concepts.
6	Learning Outcomes	Upon successful completion of this module, students will be able to: • understand the fundamental principles of groundwater hydrology and use them to solve problems related to groundwater flow, • describe and explain the most important aspects of how the hydrological process in subsurface environment functions, • explain some of the principal characteristics of hydrological processes, • Develop hydrogeological map
7	Course Contents	**Groundwater exploration:** Groundwater monitoring; geophysical methods; Remote Sensing methods; fracture trace analysis; Pumping test; water point inventory; space geophysics; **Groundwater Management:** Concepts of basin management: quantity and quality aspects; Alternative basin yield; Evaluation of perennial yield; Modeling tools and techniques for management; Integrated use of surface water and groundwater; Artificial recharge and artificial retention, institutional policy and legal issues in groundwater management, stages of groundwater management, climate change impact on groundwater resources availability and management practice, coping with climate change, working with incomplete knowledge, groundwater technology, the basin concepts, the wet buffer concepts, sustainable yield concepts, adaptive management, tools in management, water quality management, water resources administration, international and national policies and regulations on groundwater, groundwater administration, integrated water resources management concepts
8	Teaching and learning techniques	• **Interactive Introductions**: Introduce key concepts with interactive discussions in class or on-site, engaging students in the subject matter. • **Chapter-Based Presentations**: Assign students to present on each chapter, fostering deeper understanding and active participation. • **Recap and Engage**: Begin each class or discussion session with a Q&A recap to reinforce learning and encourage critical thinking.

		• **Ongoing Student Portfolios**: Maintain a portfolio of student activities, providing continuous feedback to support innovation and improvement. • **Adherence to Schedules**: Emphasize the importance of adhering to schedules and understanding the consequences of non-compliance to foster discipline and responsibility.
9	Assessments	Attendance at all class, field or laboratory activities Being interactive at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
10	Course Policy	• Attendance at all class, field or laboratory activities • Interactiveness at lectures, in class and field work sessions • Presentations • Field and laboratory reports • tests and examinations
11	Learning Resources	Willis, R. and W. W-G. Yeh. *Groundwater Systems Planning and Management*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1987. Bear, Jacob. *Dynamics of Fluids in Porous Media.* New York, NY: Dover Publications, 1988. ISBN: 0486656756. Bear, J. *Hydraulics of Groundwater*, Dover Publications, 2007 Todd, D.K. *Groundwater Hydrology*, John Wiley and Sons, New York, 1980. Ahlfeld, D. P. and A. E. Mulligan. *Optimal Management of Flow in Groundwater Systems*,Academic Press, New York, 2000. Istok, J. *Groundwater Modeling by the Finite Element Method*, Water Resources Monograph 13, American Geophysical Union, Washington, D.C., 1989. Davis, S. and R.J.M. DeWiest. *Hydrogeology*, John Wiley & Sons, New York, 1967. Remson, I., Hornberger, G.M., and F.J. Molz. *Numerical Methods in Subsurface Hydrology*, Wiley- Interscience, New York, 1971. Pinder, G.F. and W.G. Gray. *Finite Element Simulation in Surface and Subsurface Hydrology*, Academic Press, New York, 1977. Freeze, R.A. and J.A. Cherry. *Groundwater*, Prentice-Hall, Englewood Cliffs, New Jersey,1977. McWhorter, D. B. and D. K. Sunada. *Groundwater Hydrology and Hydraulics*, Water Resources Publications, Fort Collins, Colorado, 1977.

		Batu, V. *Aquifer Hydraulics—A Comprehensive Guide to Hydrogeologic Data Analysis*, John Wiley & Sons, New York, 1998. Domenico, Patrick A., and Franklin W. Schwartz. *Physical and Chemical Hydrogeology*. New York, NY: John Wiley & Sons Inc., 1998. ISBN: 0471597627. Freeze, Alan R., and John A. Cherry. *Groundwater*. Englewood Cliffs, NJ: Prentice Hall, 1979. ISBN: 0133653129. *Hydraulics of Groundwater*. New York, NY: McGraw-Hill College, 1980. ISBN: 0070041709. Todd, David Keith. *Groundwater Hydrology*. New York, NY: John Wiley & Sons Inc., 1980. ISBN: 047187616X. **Journals:** Journal of Hydrogeology & Hydrologic Engineering Journal of Groundwater Hydrology Contaminant Hydrology Hydrology: Current Research Nature Climate Change

Addis Ababa University

Course Development Template

College____

Department ______________________________________

Program __Hydrology, Water resource engineering and Management

Course Title: _ Irrigation Water Management

Year _____One________Semester two______________

Instructor:

- Name: ________________________________
- Contact information ____________________
- Office hours: __________________________

No	Section	Contents
1	Module to which the course belongs:	
	1.1. Module Title	Irrigation Water Management
	1.2. Type of Module	Elective
2	Competencies	Optimize water use efficiency in irrigation systems through advanced techniques and technologies. Design and evaluate irrigation systems that maximize crop yield while minimizing water loss and energy use. Manage and allocate water resources effectively to balance agricultural needs with environmental sustainability. Develop and implement irrigation schedules based on crop water requirements and soil moisture dynamics. Promote sustainable irrigation practices that reduce environmental impacts and enhance water conservation. Adapt irrigation strategies to cope with the effects of climate variability and change on water availability.
3	Course Type	face-to-face
4		
	4.1. Course Code	
	4.2. Credit Point in ECTS	5
5	Prerequisite	none
6	Course Description	This module prepares the student to apply basic soil, plant, water, and atmospheric principles for the purpose of determining the crop water need (use), both in time and amounts, to sustain agricultural production while protecting the environment. The module covers a range of methods to determine crop water use or evapotranspiration (water requirements), irrigation scheduling, and effective water use. Topics covered include basic soil physical properties, soil-water-plant relationships, irrigation water requirements, irrigation efficiencies and different methods of irrigation, planning, design and management of an irrigation system, impact of irrigation on soil and water quality.
7	Learning Outcomes	Upon successful completion of this module, students will be able to: • build on fundamental soil, plant, water, and atmospheric principles, • determine the required data, apply adequate methods and find efficient

		solutions in regards to soil water and land surface energy balances, crop water needs, and irrigation systems evaluation, • select particular methods and instrumentation to properly design an irrigation scheduling mechanism based on specific field conditions, • Use spreadsheets (EXCEL™) to process instrumentation field data, perform calculations, and produce graphs
8	Course Contents	**Introduction**: African water resources scenario and water management issues related to irrigated agriculture, Irrigation relevance for agricultural production **Irrigation management concepts and system elements**: Relevance of Water Productivity on a general and global scale. Introduction to the problem of water availability and agronomic use; to water footprints; to the concept of 'more crop per drop' **Irrigation in arid and semi- arid tropical climate** **Water for Irrigation:** irrigation hydrologic balance, small scale irrigation, large scale irrigation, irrigation with ground water, irrigation with surface water **Soil Physical Properties:** Definitions and units, Basic soil water physics, Soil bulk density, soil porosity, soil particle density, Soil texture and structure, Soil types, Ethiopian Soils **Soil Water Content:** Measuring soil water content, Measurement methods, e.g., gravimetric, volumetric (capacitance probes, time domain, reflectometry and other techniques), Field application of soil water content, Field capacity, wilting point and available water concepts, Water infiltration in soils **Soil Plant Water Relationship:** Principles of crop water use Evaporation and Evapotranspiration, Potential and crop evapotranspiration, Measurement of evaporation and calculation of evapotranspiration, Crop water requirements, Crop coefficients, Crop growth stages and crop coefficients, crop rooting system, Potential and actual evapotranspiration **Irrigation and Water Management:** Irrigation Methods, Performance assessment of Irrigation Systems, Internal and external performance indicators; Irrigation efficiency, Uniformity of application, Application efficiency, Irrigation adequacy, Conveyance efficiency; **Surface Irrigation Systems:**

		Basin irrigation, Border irrigation, Furrow irrigation, Advantages and disadvantages **Sprinkler irrigation system:** System component, Advantages / disadvantages, Application efficiency, System uniformity **Drip irrigation system:** System component, Advantages and disadvantages, Application efficiency, System uniformity **Irrigation System Selection and Institution development;** Definition, Methods, Advantages, Water Quality, Salinity Problems, Economic consideration **Irrigation Estimation Models (IWREDSS)**
9	Teaching and learning techniques	• **Interactive Introductions**: Introduce key concepts with interactive discussions in class or on-site, engaging students in the subject matter. • **Chapter-Based Presentations**: Assign students to present on each chapter, fostering deeper understanding and active participation. • **Recap and Engage**: Begin each class or discussion session with a Q&A recap to reinforce learning and encourage critical thinking. • **Ongoing Student Portfolios**: Maintain a portfolio of student activities, providing continuous feedback to support innovation and improvement. • **Adherence to Schedules**: Emphasize the importance of adhering to schedules and understanding the consequences of non-compliance to foster discipline and responsibility.
10	Assessments	Attendance at all class, field or laboratory activities Being interactive at lectures, in class and field work sessions Presentations Field and laboratory reports tests and examinations
11	Course Policy	• Attendance at all class, field or laboratory activities • Interactiveness at lectures, in class and field work sessions • Presentations • Field and laboratory reports • tests and examinations
12	Learning Resources	**Reading materials:** Hoffman, G.J., R.G. Evans, M.E. Jensen, D.L. Martin, and R.L. Elliott. (2007). Design and Operation of Farm Irrigation Systems

		Adrian Laycock (2007). Irrigation Systems Design, Planning and Construction **Journals:** Journal of Irrigation & Drainage Engineering Agricultural Water Management Water Resources Research

Addis Ababa University

Course Development Template

College: TBD

Department: TBD

Program: MSc in Water Resources Engineering and management

Course Title: Water Law, Economics and Governance (MSc WREM)

Year __________First_________ Semester________I____________

Instructor:

- Name: _________________________________

- Contact information ____ ______________
- Office hours: __ _______________________

No	Section	Contents	Remarks
1	Module to which the course belongs:		
	1.1. Module Title	Water Law, Economics and Management	
	1.2. Type of Module	Water Systems, Management, and Governance	
2	Competencies	Demonstrate an in-depth understanding of national and international water laws, policies, and regulations. Apply economic principles and methods to evaluate the allocation, pricing, and sustainability of water resources. Assess the role of governance structures, institutions, and stakeholder participation in water resource management.	
3	Course Type	Face-to-face, synchronous	
4	Course Identifiers		
	4.1. Course Code	WREM 6211	
	4.2. Credit Point in ECTS	5	
5	Prerequisite	None	
6	Course Description	**Water Law**: study how society allocates and protects its most crucial natural resource — water. Complex rules govern the distribution and management of surface water, groundwater and public water supplies. Many aspects of water law have old origins in historic social needs and conditions, yet many aspects of water law have undergone substantial change to adapt to new social conditions and needs. In this module, the emphasis will be on current legal and policy debates, although we will also examine the history of water development and politics. Although the module will focus on Africa, insights from the course are applicable to water regimes throughout the world, law and policy elsewhere in the world will also be included for comparison. The most important issues to be discussed in this module are: the international principles of shared water resources; the protection of threatened groundwater resources; environmental limits on water development; constitutional issues in water governance; water rights; protection of water quality; challenges to substantively reforming existing water law; and national and regional disputes over water resources.	

		Water Economics: The topic will provide students with economics concepts and methods applied to water governance, management and valuation. Firstly, it aims to introduce participants to some of the goals, objectives and principles of water planning and second, to water resource economics and economic concepts pertinent to water management and planning. It explores principles of water planning and current issues. Students are introduced to economic and social impact analyses which are key aspects of water planning and management. Thus participants are encouraged to develop awareness of the need to integrate economic, social, legal and environmental perspectives in planning against a background of uncertainty and change. **Water Governance:** In this part, students are introduced to frameworks, principles and assessment of water governance at the global/international, national, regional/basin, trans-boundary and local levels. They will unpack core concepts of governance in general and water governance in particular in various socio-political and economic contexts of Africa. Participants will familiarize themselves with one of the major components of water governance, i.e. water security, which is the critical foundation for human, economic and environmental securities. Students will develop critical awareness of the cross-cutting nature of water security, as the cornerstone upon which investment for economic development in Africa relies. Some of the vital elements of water governance, e.g. efficient, equitable, and sustainable sharing of the resources, increased levels of regional co-operation and co-ordination will be discussed. Participants will be armed with the skills of prevention, resolution, management and transformation of resource- related conflicts. Current themes influencing water governance and policy including that of sustainable development, collaborative management, water rights and access, and equity for marginal groups will be covered. Water planning as a key governance mechanism at regional and basin levels form one of the components, with comparisons drawn between Africa and other countries.	
7	Learning Outcomes	Upun successful completion of this module, students will be able to:	

		• Demonstrate their understanding of the role of law in water resource management and the provision of water services in different group as well as individual tasks to be assigned; • understand the nature of conflict over water resources, including competing human demands for various types of water uses; • Explain the structures, institutions and essential elements of international and national water law and the regulation of water services to each other and to the whole class during their presentations; • Illustrate the concepts, which underpin water governance initiatives at different scales i.e. global/international, national, regional/catchment, and local levels using various case studies in groups as well as individualactivities; • Show how water planning as a key governance mechanism in developed and developing country contexts work by using different examples • discuss, critique and evaluate trans-boundary governance arrangements, particularly how they implement international norms for sharing water and their methods of resolving conflict • Apply acquired knowledge and competences of the main economic concepts and terms to the water sector in mini-projects, • Demonstrate using tools such as Cost Benefit Analysis, valuation techniques, economic instruments for water policy, and conflict resolution methods and processes for water management in different projects assigned individually as well in groups. • Deliberate on the importance of participatory water management and the role of private-public partnership in class debates and writing assignments; • Play roles of negotiation and mediation so as to prevent potential resource conflicts in groups; Link water law, economics and governance for effective and efficient management of water in African context	
8	Course Contents	**WATER LAW:**	

		International Water Law: The principles and rules of water use under the existing international legal regimes; the legal framework of water management of transboundary water resources, and conflict resolution over water uses. **Comparative National Water Law:** the basics of water law in the context of their historical development, including water rights, regulation of water, water quality regulations in the African context **WATER ECONOMICS:** The nature, concepts, the subject matter and Principles of Microeconomics and Macroeconomics, methods in microeconomics and macroeconomics. Principles of supply and demand, markets and market structure (perfectly competitive, oligopoly and Monopoly), normal and public goods, equilibrium conditions. Development economics. Pareto optimality conditions The first and second theorems of welfare economics. water and development in Africa, water as an economic good, water demand and supply, social attitudes towards water economic criteria for water allocation **Water valuation:** elements of welfare economics, concepts for water economic valuation, case studies in African contexts, intra and inter- allocations of water resources. Cost-Benefit, rate of Return and Present Value Analysis: concepts, procedure and methods, examples and case studies **Externalities:** positive and negative externalities, formalization, internalization of externalities, elements of water policiesPolicies for pollution control and water quality improvement: formalization (Modeling) of a simple economic system with pollution, externality control policy instruments (taxes, subsidies, standards, penalties, etc.), examples **Water pricing and allocation :** water pricing for various water uses, water tariffs, water affordability (supply and Demand) and social aspects of water pricing, case studies (Cash flow analysis of water projects) **WATER GOVERNANCE:** **Water governance and institutions**: principles, policies and rules of water governance, traditional and formal institutions of water, participatory governance **Water governance mechanisms:** mechanisms and processes of water governance , upstream – downstream perspectives of water governance, national and trans-boundary water governance, decentralization, local water governance, up scaling and out scaling of water governance, hydro-political perspective of water governance, geopolitical context of	

		water governance, resource-related conflict prevention, management, resolution and conflict transformation, case studies **Water Service Provisions and Equity:** looking at drinking water and sanitation in both the public and private sector and focusing on good governance. Equity, fairness, efficiency and sustainability of sharing water resources; •	
9	Teaching and learning techniques	The methodological approaches to be followed in this module pay particular attention to learner engagements. The approach generally models the type of teaching methods that the module promotes and there will be no negotiation on that. Under this general direction, here are a few suggestions: • Instructor(s) presentation using interactive methods (brainstorming, question and answer, mind mapping, small group discussion, buzz groups, etc.) • Independent learning methods such as reading assignments, article reviews, group project works, classroom visits in campus and presentation of reports will be submitted. • Any other methods the instructors consider important for learner engagement will be employed.	
10	Assessments	Both Continuous and summative assessments will be employed using various forms of instruments that help assess the expected learning outcomes. Thus, final examination, projects and presentations, group works, debates and case studies, research reports, designing courses, lesson planning, and other individual tasks will be applied as appropriate to the experiences of students and departments. Furthermore, assessment requirements will be clearly stated with due date. Assignments and projects will be announced on first class with guides and rubrics. *If the general pedagogy instructor handles the module, the tasks and values of the tasks will be revised. Assignments, Project, Test, and report and presentation	
11	Course Policy	Students will be oriented at the beginning of the module regarding attendance, classroom code of conducts, due dates of submission of assignments, cellphone use, and unacceptable behavior of plagiarism	

		*At least 80% attendance is mandatory for the face-to-face and virtual lecture classes	
12	Learning Resources	• Dante A. Caponera, *Principles of Water Law and Administration: National and International*, 2nd edition (2007) • Joseph W. Dellapenna and Joyetta Gupta (editors), *The evolution of the law and Politics of Water,* Springer (2008) • Patricia Wouters, International law: Facilitating Transboundary Water Cooperation (Global Water Partnership Technical Committee (The Background Paper No. 17) [2013] • Convention on the Law of the Non-navigational Uses of International Watercourses (1997) • Salmnan M. A. Salman, The Helsinki Rules, the UN Watercourses Convention and the Berlin Rules: Perspectives on International Water Law (2007) • Agreement on the Nile River Basin Cooperative Framework (English & French) (2010) • Water Law in a Nutshell5th Edition, David Getches, Sandi Zellmer, Adell Amos • Water Resource Economics: The Analysis of Scarcity, Policies, and Projects ,Ronald C. Griffin • Managing Water under Uncertainty and Risk, The United Nations World Water Development Report 4 (2012), Volume 1, Chapter 1, pp 22-42. • Water, a Shared Responsibility, the United Nations World Water Development Report 2 (2006), Chapter 2, (The Challenges of Water Governance). Part 2, pp 54 – 60. • Abera Dalelo (2007 EC), YewuhaGuday: YesinaWuhaTibeb ha-huBeEtiopia …np. (Chapters: 15, 16 • Kilot, Nurit, Deborah Shmuel, Uri Shamir (1997) Institutional Framework for the Management of Transboundary Water Resources, Vol. I, Institutional Framework as reflected in Thirteen river Basins, Water Research Institute, npp, • Luzi, Samuel (2007) Double-Edged Hydropolitics on the Nile: Linkages between domestic Water Policy Making and Transboundary Conflict and	

		Cooperation, Swiss Federal Institute of Technology-Zurich • Mason, Simon A (2004) From Conflict to Cooperation in the Nile Basin, Swiss federal Institute of Technology-Zurich • Tvedt, Terje, ed (2010) The river Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries, I.B.Tauris, London • Waterbury, John (2002), The Nile Basin: National Determinants of Collection Action, Yale University Press New Haven • YacobArsano "Institutional Development and Water Management in the Ethiopian Nile Basin" in Tvedt, Terje, ed (2010) The River Nile in the Post-Colonial Age: Conflict and Cooperation among the Nile Basin Countries, I.B.Tauris, London • YacobArsano (2007), Ethiopia and the Nile: Dilemmas of National and Regional Hydro-politics, Swiss Federal Institute of Technology-ETH, Zurich • Additional latest materials are forthcoming.	

Addis Ababa University

Course Development Template

College: TBD

Department: TBD

Program: MSc in Water Resources Engineering and management

Course Title: Water Resources System: Planning and Management (MSc WREM)

Year __________First_________ Semester________I____________

Instructor:

- Name: ___Haileyesus Belay Lakew________________________________

- Contact information ____haileyesusbelay@gmail.com_______________
- Office hours: __Full Day (Tuesday, Thursday, and Friday)

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No	Section	Contents	Remarks
1	Module to which the course belongs:		
	1.1. Module Title	Water Resources System: Planning and Management	
	1.2. Type of Module	Water Systems, Management, and Governance	
2	Competencies	The module helps participants to have proficiency in systems analysis and optimization techniques, understanding of economic and financial evaluation principles, and skills in water management. Students also develop competencies in decision-making under uncertainty, and integrated water resources management.	
3	Course Type	Face-to-face, synchronous	
4	Course Identifiers		
	4.1. Course Code	WREM XXX	
	4.2. Credit Point in ECTS	5	
5	Prerequisite	None	
6	Course Description	In summary, water resources planning, and management integrates engineering, science, economics, policy, and stakeholder engagement to ensure reliable, equitable and sustainable management of this critical resource. Graduate programs typically include coursework in hydrology, water resources systems analysis, water law and management, and project assessment. The course will use a combination of lectures, case studies, and hands-on exercises to reinforce the concepts and their practical applications. Students will work on a term project that applies the techniques learned in class to a real-world water resources problem. By the end of the course, students will have a solid understanding of the systems approach to water resources planning and management and the ability to apply various optimization and evaluation techniques to support sustainable and equitable decision making	
7	Learning Outcomes	After the module is completed, the participants would be able to: • Understand and explain the fundamental concepts of systems and systems analysis. • Apply classical optimization techniques and the Lagrangian approach to solve nonlinear programming problems relevant to water resource management.	

		• Formulate real-world water resource issues as linear programming problems and solve them using the simplex method. • Analyze multi-stage decision processes and apply dynamic programming techniques to optimize solutions for water resource management challenges. Apply varieties of instructional methods of teaching in the courses they offer.	
8	Course Contents	Unit1. Concept of System and Systems Analysis (10%) • Concept of water system analysis Unit 2 Optimization Using Calculus (Nonlinear programming (20%) • Classical optimization • Langrangian approach Unit 3. Linear Programming (30%) • Formulation and application • Simplex method • Duality Unit 4. Dynamic Programming (20%) • Multi-stage decision processes • Computational procedure • Application examples Unit 5. Water resources risks and action strategies (15%) • Water-related extremes and risks as a challenge for water management • Water risks assessment and collaborative risks management • Proactive approaches and partnership execution for water systems risk management	
9	Teaching and learning techniques	The methodological approaches to be followed in this module pay particular attention to learner engagements. The approach generally models the type of teaching methods that the module promotes and there will be no negotiation on that. Under this general direction, here are a few suggestions: • Instructor(s) presentation using interactive methods (brainstorming, question and answer, mind mapping, small group discussion, buzz groups, etc.) • Independent learning methods such as reading assignments, article reviews, group project works, classroom visits in campus and presentation of reports will be submitted. • Any other methods the instructors consider important for learner engagement will be employed.	
10	Assessments	Both Continuous and summative assessments will be employed using various forms of instruments that help assess the expected learning outcomes. Thus, final examination, projects and presentations, group works, debates and case studies, research reports, designing	

		courses, lesson planning, and other individual tasks will be applied as appropriate to the experiences of students and departments. Furthermore, assessment requirements will be clearly stated with due date. Assignments and projects will be announced on first class with guides and rubrics. *If the general pedagogy instructor handles the module, the tasks and values of the tasks will be revised. Assignments, Project, Test, and report and presentation	
11	Course Policy	Students will be oriented at the beginning of the module regarding attendance, classroom code of conducts, due dates of submission of assignments, cellphone use, and unacceptable behavior of plagiarism *At least 80% attendance is mandatory for the face-to-face and virtual lecture classes	
12	Learning Resources	1. S. Vedula and P.P Mujumdar (2005). Water Resources systems analysis. 2. Loucks, D. P., J. R. Stedinger, and D. A. Haith. (1981). Water Resource Systems Planning and Analysis. 3. Mimikou, M., Baltas, E., & Tsihrintzis, V. (2020). Hydrology and Water Resource Systems Analysis. 4. Jain and Singh (2006) Water Resources Planning and Management. 5. Floudas, C., Pardalos, P. (eds) Optimization in Water Resources. 6. Loucks, D.P., Stedinger, J.R., & Haith, D.A. (1982). Water Resources Systems Planning and Analysis. Prentice Hall Inc. 7. Chaturvedi, M. (2016). Water Resources Systems Planning and Management. Lecture Notes, Veer Surendra Sai University of Technology.	
13	Assessment rubrics (optional)[3]	- Both skill based, and standards-based rubrics shall be adopted in assessing students. - Top achievers and bottom achievers will be assessed in each case and others accordingly marked for each assignment	

[3] Including rubrics is highly encouraged, but it might not be mandatory for every single assignment.

Addis Ababa University

Course Development Template

College: TBD

Department: TBD

Program: MSc in Water Resources Engineering and Management (Irrigation Engineering & Management)

Course Title: Dam Engineering and Appurtenant Structures

Year: Year I Semester: Semester II

Instructor:

- Name:
- Contact information:
- Office hours: ___________________________

No	Section	Contents	Remarks
14)	Module to which the course belongs:		
	1.1. Module Title	Dam Engineering and Appurtenant Structures	
	1.2. Type of Module	Irrigation Engineering and Management	
15)	Competencies	To develop a basic understanding of the engineering behavior of concrete and embankment dams and their appurtenant structures through appreciation of the geotechnical, geological, structural, hydraulic/ hydrological aspects relevant to dam planning, design and construction. The student will understand the design principles of hydraulic structures related to dams and be able to develop competence to provide the dam safety inspections and suggest the remedial measures for assuring the dam safety.	Here, indicate only to which competencies this course contributes. You don't need to write new competencies here; select one or more competencies from the module competencies.
16)	Course Type	The course is given in a face-to-face type of delivery, i.e., lectures. Its assessment comprises of class exercises, assignments/projects and final exam	You may also indicate the principal mode of course delivery: e.g., Lab, e-learning, Seminar, Practicum/ Field Attachment, Senior Essay/Thesis/Dissertation.
17)	Course Identifiers		
	4.1. Course Code	WREM 6621	
18)	4.2. Credit Point in ECTS	5	
19)	Prerequisite		Indicate the prerequisite course/s and skills for each course, practicum, or thesis (if any).
20)	Course Description	Water storage, Dams: purposes, classification and types, criteria for dam site selection: geotechnical and hydrological data for dam site selection and design, reservoir planning, dam capacity and its determination, Concrete dams design and analysis: site suitability, design and analysis of concrete dams: gravity dams, arch dams, buttress dams; Embankment dams: types, site suitability, design and analysis, failure modes, construction aspects of dams; Advanced methods for dam design and analysis. Dam appurtenant structures, spillways: purposes, types, design; dam outlet works: purposes	Overall introduction to the course

		and types, stilling basins: types and design; energy dissipaters; dam outlet works: types, components, bottom outlets, gates and valves; dam instrumentation and surveillance.	
21)	Learning Outcomes	Upon completion of the course students are expected to: ▪ Recognize fundamental information about dam storage and water usage, technical and social aspects of the dams. ▪ Design a dam, its foundation and its appurtenant structures, ▪ Identify the effect of loading conditions on a dam body and its appurtenant structures, ▪ Describe the fundamental issues related to monitoring of a dam after construction, ▪ Discuss the problems encountered on the lifespan of a dam, ▪ Gain knowledge of dam behaviour throughout the life of a dam, namely under construction, impoundment, in operation and in long term behaviour ▪ Be familiar with dam failures and mechanisms of these failures. ▪ Be familiar with inadequate plans/designs/constructions and their consequences. ▪ Be able to explain why an appropriate instrumentation system is needed and what has to be measured to predict the performance of a dam.	What are the main learning outcomes students should demonstrate in terms of knowledge, skills, and values and demonstrate in the form of capability? The learning outcomes should be assessed during and at the end of the course. They should be clear and specific enough to guide the selection of content, learning experiences, or assessment techniques. Use only one verb for each learning outcome and examine whether the course's learning outcomes include higher-level learning outcomes, knowledge, skills, and character development. Ensure that the learning outcomes also include 21st-century skills such as digital literacy, critical thinking, teamwork, problem-solving, learning to learn, etc.
22)	Course Contents	**Chapter I: Dams: Classification and Site Selection (10%)** 1.1. Elements of Dam Engineering 1.2. Classification of Dams 1.3. Data Required for Site Investigation, Selection of Sites and Type of Dam 1.3.1. Topographical Data 1.3.2. Geological and Geotechnical Data 1.3.3. Hydrological (Water Resources) Data 1.4. Investigations – Site and Material **Chapter II: Design & Analysis of Concrete Dams (25%)** 2.1. Concrete Dam Types and Characteristics 2.2. Design and Analysis of Concrete Gravity Dams 2.3. Design and Analysis of Concrete Arch Dams 2.4. Design and Analysis of Concrete Buttress Dams 2.5. Roller Compacted Concrete (RCC) Dams 2.6. Construction Aspects of Concrete Dams 2.7. *Chapter Examples and Exercises* **Chapter III: Design and Analysis of Embankment Dams (20%)** . Types of Embankment Dams . Causes of Failure and Criteria for Safe Design of Embankment Dams	The course content could include major and subsections, as necessary. Integrating field experiences, practical activities, emerging issues, projects, and technology integration is necessary.

		. Seepage Through Embankment Dams . Stability Analysis of Embankment Dams . Construction Aspects of Embankment Dams 5. *Chapter Worked Examples and Exercises* **Chapter IV: Dam Appurtenant Structures (25%)** 4.1. Spillways 4.1.1. Purposes of Spillways 4.1.2. Types of Spillways 4.1.3. Design of Spillways *4.1.4. Worked Examples and Exercises (Spillways)* 4.2. Dam Outlet Works 4.2.1. Purposes of Outlet Works 4.2.2. Types & Components of Outlet Works 4.2.3. Design Considerations for Outlet Works 4.2.4. *Worked Examples and Exercises (Outlet Works)* 4.3. Energy Dissipators 4.3.1. Purposes of Energy Dissipators 4.3.2. Types of Energy Dissipators and Stilling Basins 4.3.3. *Worked Examples and Exercises (Energy Dissipators)* **Chapter V: Gates and Valves (10%)** 5.1. Introduction 5.2. Types of Gates and Their Selection 5.3. Types of Valves and Their Selection 5.4. Hydrodynamic Forces Acting on Gates *5.5. Exercise (Reading assignment)* **Chapter VI: Dam Safety: Instrumentation & Surveillance (10%)** 6.1. Introduction 6.2. Instrumentation 6.2.1. Application and Objectives 6.2.2. Parameters in Monitoring Dam Behaviors 6.2.3. Design Principles 6.2.4. Types and Operating Principles 6.2.5. Instrument Planning 6.3. Surveillance *6.4. Literature Review Type Assignment*	
23)	Teaching and learning techniques	The course is given in a face-to-face type of delivery, i.e., lectures. ▪ After lecture of each chapter is completed, chapter examples are done; ▪ Chapter exercises/assignments are given to students to be submitted on deadlines; ▪ Projects in the form of literature review and design assignments are given to students; ▪ Finally, the course is concluded by final examination and its assessment.	Map the interface between learning outcomes and identified teaching and learning techniques. Examine if the techniques can help students develop the learning outcomes/or competencies of the course.
24)	Assessments	Both Continuous and summative assessments will be employed using various forms of instruments that help assess the expected learning outcomes. Thus, three exercise (design & analysis) based assignment, one literature review assignment, and final examination covering all chapters of the course; comprised of concept, analysis and design questions. The literature review and	Assessment requirements are clearly stated, along with due dates. Assignments and projects are announced in first class, along with guides and rubrics.

		design exercises are done individually. Assignments and projects will be given at the end of each chapter and submission deadlines are announced at the same time.	
25)	Course Policy	Students will be oriented at the beginning of the module regarding attendance, classroom code of conducts, due dates of submission of assignments, cellphone use, unacceptable behaviour of plagiarism, and punctuality	
26)	Learning Resources	**References** **(A) Core readings** 1. Novak, P., Moffat, A.I.B., Nalluri, C. and Narayanan, R. (2007). Hydraulic Structures, 4th ed. Taylor & Francis. 2. USBR (1987). Design of Small Dams, 3rd ed., Water Resources Technical Publication. 3. Fell, R., MacGregor, P., Stepeldon, D., Bell, G. and Foster, M. (2015). Geotechnical Engineering of Dams, 2nd ed, CRC Press. 4. USACE EM1110-2-2200 (1995). Gravity Dam Design, 5. USACE EM1110-2-2300 (2004). General Design Considerations for Earth and Rockfill Dams. **(B) General references** 1. USACE EM1110-2-1911 (1995). Construction Control for Earth and Rockfill Dams. 2. Kutzner, C. (1997). Earth and Rockfill Dams: Principles of Design and Construction, A.A. Balkema. 3. Tanchev, L. (2014). Dams and Appurtenant Hydraulic Structures, 2nd ed., CRC Press.	
27)	Assessment rubrics (optional)[4]	Rubrics for the assessment of assignments	Developing rubrics for assignments/projects is very important because they help to establish clarity and transparency regarding assessment criteria and enhance fairness and quality.

Addis Ababa University

Course Development Template

College: _TBD______

Department: __TBD______

Program: MSc in Water Resources Engineering and Management (Irrigation Engineering & Management)

Course Title: Gravity Irrigation Systems and Flow control

Year: First_______ Semester: _II

Instructor:

- Name:
- Contact information:
- Office hours:

No	Section	Contents	Remarks

1.	Module to which the course belongs:		
	1.1. Module Title	Irrigation Systems Design	
	1.2. Type of Module	Irrigation Engineering and Management	
2.	Competencies	- Students will be able to: - make a layout of gravity irrigation system components - make a hydraulic design of headwork and conveyance systems and structures - able to design and apply flow control systems in gravity irrigation - able to design and install flow measuring structures in irrigation systems	Key competencies as a result of completion of this course
3.	Course Type	- This course is an engineering design course focused on hand on hands-on practices in design of irrigation systems components. The learning methods are mainly synchronous, but also consist of significant asynchronous elements (for self-study, and individual assignments and exercises)	The course delivery methods consist of Lectures, Group exercises, Seminar, and Field practice.
4.	Course Identifiers		
	4.1. Course Code	WREM 6622	
5.	4.2. Credit Point in ECTS	5	
6.	Prerequisite	-	-
7.	Course Description	The overall purpose of this course is to equip students with the knowledge and skills required for design of all elements of gravity irrigation systems from the headwork to water distribution systems. It will address design of headworks, water conveyance systems, distribution systems, design of various canal structures, flow measuring structures, flow control systems and structures. The course focusses on gravity irrigation systems for water abstraction, conveyance and distribution, including flow control structures for water regulation and distribution. The course delivery will principally be based on lectures, group works, and hand on practicals on design of various elements of irrigation systems. In general, synchronous learning methods will be adopted although it also has significant asynchronous elements.	
8.	Learning Outcomes	After completion of this course, students will be able to: - Make a layout of technically sound gravity irrigation systems - Analyze irrigation system layouts for technical and financial appraisal	

		- Design diversion headworks with all its appurtenant structures - Design lined and unlined canals for water conveyance in gravity irrigation systems - Design various canal structure for flow regulation and control - Apply different design aids/software for design of various elements of irrigation systems - Design flow measurement structures in open canals systems. - Solve complex problems related to layout and design of gravity irrigation systems - Develop skills of team work to analyze and address problems in a group.	
9.	Course Contents	**1. Introduction to irrigation systems** - Irrigation and its roles - Key constituents of irrigation systems - Irrigation technologies and systems - Gravity vs non-gravity irrigation - Formal vs informal irrigation - Community managed irrigation systems **2. Diversion headwork** - principles for water diversion - river intakes - components of diversion headwork - Weirs and barrages - Design of components of headwork - Surface flow analysis for diversion headwork - Sub-surface flow analysis for headwork design - Stability of diversion headwork **3. Conveyance and distribution systems in irrigation**	

		- Irrigation canals - Horizontal and vertical layout of canals - Design of lined and unlined canals - Canal scouring and sedimentation - Tractive force approach for design - Aids in design of canals **4. Canal structures** - Purpose of canal structures - Types of canals structures - Regulating structures, cross drainage structures - Design principles for canal structures - Sediment management in irrigation systems **5. Flow control and measurement in gravity irrigation systems** - Mechanisms of flow control - Types of flow control - Suitability of flow control methods - Flow measurement in irrigation systems - Flow measuring principles - Types of flow measuring structures: - Design and installation of flow measuring structures	
10.	Teaching and learning techniques	Generally active/cooperative learning approaches will be adopted. The teaching methods include lectures (virtual or face to face), group works, project works, case studies, field works and visits, individual studies. These diverse approaches will enable students achieve the learning outcomes.	

11.	Assessments	The assessment techniques are: - Group work projects, individual projects, quick tests, field work reports, design appraisal reports, mid-term exam, final exam.	
12.	Course Policy	- Assignments need to be strictly submitted before the due date and time. - Students need to be cautious of the use of AI in individual and group assignments. Contents generated from use of AI will be carefully assessed. - At least 80% attendance is mandatory for the face-to-face and virtual lecture classes - Students should not copy from each other on individual assignments and project works.	
13.	Learning Resources	- Sharma, S. K. (2017). *Irrigation engineering and hydraulic structures*. S. Chand Publishing. - Singh, V. P., & Su, Q. (2022). *Irrigation engineering: Principles, processes, procedures, design, and management*. Cambridge University Press. - Asawa, G. L. (2006). *Irrigation and water resources engineering*. New age international. - Laffan, J. (2015). *Irrigation: Measuring and monitoring* (Vol. 2). NSW Agriculture.	
14.	Assessment rubrics (optional)[5]	- Both skill based and standards-based rubrics shall be adopted in assessing students. - Top achievers and bottom achievers will be assessed in each case and others accordingly marked for each assignment.	

Addis Ababa University

Course Development Template

College: _TBD______

Department: __TBD______

Program: MSc in Water Resources Engineering and Management (Irrigation Engineering & Management)

Course Title: Irrigation Systems Design and Modelling

Year: First Semester: II

Instructor:

- Name:
- Contact information:

- Office hours:

No	Section	Contents	Remarks
1	Module to which the course belongs:		
	4.1. Module Title	Surface Irrigation Systems Design and Modelling	
	4.2. Type of Module	Irrigation Engineering and Management	
2	Core competencies	It is expected that at the conclusion of this course students will have attained the following competencies 1. Identify appropriate irrigation solutions for agricultural applications. 2. Evaluate the meteorological, biological, and economic effects of different irrigation approaches. 3. Design irrigation systems that provide target irrigation levels and crop yields. design optimum layout 4. Appraise the costs and benefits of contrasting irrigation designs 5. Acquaint students for design and evaluation of various surface irrigation methods,	What are the core competencies students should demonstrate at the end of the course?
3	Course Type (Lab, e-learning, Seminar, Practicum/ Field Attachment, Senior Essay/Thesis/Dissertation)	Lecture based	
4	Course Identifiers		
	4.1. Course Code	WREM 6623	
	4.2. Credit Hrs/ECTS/	5ECTS	
5	Semester and Year		
6	Prerequisite	None	
7	Contact	Yonas Girma (PhD) +251911893736 Monday, Friday (09:30am – 2:30pm)	
8	Course Description	This course provides a comprehensive overview of various types of irrigation systems. Systems described in this course include: surface, sprinkler, and Localized types. The surface irrigation method is the application of irrigation water to the soil surface by gravity. With the sprinkle irrigation method, water is applied at the point of use by a system of nozzles (impact	

No	Section	Contents	Remarks
		sprinkler heads, spray nozzles, etc.) with water delivered by surface or buried pipelines. Sprinkler irrigation systems are classed by operation of the laterals. The three main types of sprinkle systems (laterals) are fixed, periodic move, and continuous/self move. Localized irrigation is the broad classification of frequent, low volume, low pressure application of water on or beneath the soil surface by drippers, drip emitters, spaghetti tube, subsurface or surface drip tube, basin bubblers, and spray or mini sprinkler systems. It is also referred to as drip or trickle irrigation.	
9	Integrity Statement	All assignments and projects submitted for fulfillment of course requirements are required to be original and the student's own work, and unethical conduct such as cheating or claiming others' works as one's own will result in failing marks and severe repercussions.	AAU Legislation
10	Students with Disability	Students with disabilities will get all feasible supports from the lecturer and designated university authorities.	
11	Learning Outcomes	It is expected that at the conclusion of this course students will have attained the following outcomes: 1. Acquaint students for design and evaluation of various surface irrigation methods, provide exposure of new cutting-edge technologies to the students in design of drip and sprinkler irrigation systems including selection of pipe and fertigation techniques. 2. Demonstrated understanding of basic engineering principles and methods for selecting, designing, and operating pressurized and surface (free flow) irrigation systems, as well as identifying suitable irrigation solutions for agricultural applications. 3. Ability to design irrigation systems that achieve desired irrigation levels and agricultural yields. 4. Appraise the costs and benefits of contrasting irrigation designs	
12	Course Contents	Unit1. Surface Irrigation 1 Introduction to surface irrigation	

No	Section	Contents	Remarks

		• Components of a surface irrigation system
		• The four phases of surface irrigation
		• Infiltration and contact time
		2. Criteria for the selection of the surface irrigation method
		• Furrow irrigation
		• Border strip irrigation
		• Basin irrigation
		• Criteria for the selection of the surface irrigation method
		3. Design parameters
		• crop and irrigation water requirements
		• net and gross depth of water application
		• irrigation frequency and irrigation cycle
		• system capacity
		4. Operation and maintenance of surface irrigation systems
		Unit 2. Sprinkler Irrigation Design
		2.1 Principles of preliminary design
		• Preliminary sprinkler irrigation design
		• Net depth of water application
		• Irrigation frequency at peak water demand and irrigation cycle
		• Gross depth of water application
		• Preliminary system capacity
		2.2. Principles of design adjustment
		• Final design steps for periodic move systems
		    o Sprinkler selection and spacing
		    o Layout and final design
		• Design of a semi-portable sprinkler irrigation system for individual farms and scheme
		• Design of travelling irrigators
		• Preliminary and final design steps
		2.3 Sprinkler selection
		• Tow-path spacing Travel speed Standing positions, times and hose length	

No	Section	Contents	Remarks
		• Selection of the traveller • Total dynamic head requirements and Head loss in mainline • Power requirements • System operation and Maintenance of traveling irrigators 2.4 Operation and Maintenance of Sprinkler System • Sprinkler Performance Evaluation Unit 3 LOCALIZED IRRIGATION SYSTEM 3.1 Introduction of localized irrigation 3.2 Preliminary design steps • Crop water requirements • Irrigation requirements • Leaching requirements • Irrigation frequency and duration • Emitter selection 3.3 Final design steps for a point- source drip irrigation system • Pipe size Laterals Manifolds Mainline determination • Total head requirement • Power requirement 3.4 Maintenance of Localized-irrigation System Unit 4 Pump Selection • Types of Pumps • Size of pumping unit • Head Discharge Curve • Power Requirement and Pump Selection Unit 5 Multipurpose and Special Applications 5.1 Introduction • Germination • Environmental Control • Fertilizer and Chemical Application 5.2 Fertigation System • Need of fertigation • Advantages and limitations of fertigation	
13	Teaching and learning techniques	Classroom instruction Field Visit	

No	Section	Contents	Remarks
14	Assessments	Students will be evaluated on the basis of examinations project work and Assignments. There will be two mid-term exams and a final exam. The course grade will be determined based upon the following percentages: Assignment/Visit Reports = 30% Project = 30 % Final Exam = 40%	
15	Course Policy	Late assignment submission will not be accepted without prior arrangement with the instructor. When arranged, a penalty of 20% per day late submission will be assessed on these assignments. Make-up exams will be given only for university approved excuses or when you have a note from a medical professional. No cell phones on in the classroom. Please keep your email correspondence written in a professional style. Students are encouraged to discuss and collaborate, however, the final work you submit should be distinctly your own. CSU policies on academic integrity will be rigorously enforced in this course	
16	Learning Resources		
	16.1.Textbooks	Class Handouts and directed readings.	
	16.2. References	Brouwer, C., Prins, K., Kay, M., & Heibloem, M. (1988). Irrigation water management: irrigation methods. Training manual, 9(5), 5-7. Michael, A. M. (2009). Irrigation Theory And Practice-2Nd Edn: Theory and Practice. Vikas publishing house. Walker, W. R., & Skogerboe, G. V. (1987). *Surface irrigation. Theory and practice* (p. 386pp). Laycock, A. (2007). Irrigation systems: design, planning and construction. Cabi. Hoffman, G. J., Evans, R. G., Jensen, M. E., Martin, D. L., & Elliott, R. L. (Eds.). (2007). Design and operation of farm irrigation systems (pp. 863p-863p). St. Joseph, MI: American Society of Agricultural and Biological Engineers. Manual, F. I. (2002). Planning, Development Monitoring and Evaluation of Irrigated Agriculture with Farmer Participation—Volume II Module 7. Harare: The Food and Agriculture Organization of the United Nations.	

No	Section	Contents	Remarks
	16.3. Lab Materials and Equipment		
	16.4. Website, ICT and Digital Technology		
17	Assessment rubrics	Total =100% Term grades for this course will use the +/- grading system as described in the AAU catalog. The following scale will be used: A+>93; A ≥ 93; A- ≥ 90; B+ ≥ 87; B ≥ 83; B- ≥ 80; C+ ≥ 77; C ≥ 70; D ≥ 60; F < 60.	

Addis Ababa University

Course Development Template

College Ethiopian Institutes of Water Resources

Department Water Resource Engineering and Management

Program MSc in Water Resource Engineering and Management (Irrigation Engineering & Management)

Course Title: Land Drainage and Management of Soil Salinity

Year First Semester II

Instructor:

- Name: ________________________________
- Contact information ____________________
- Office hours: __________________________

No	Section	Contents	Remarks
1.	Module to which the course belongs:		
	1.1. Module Title	Irrigation Management	
	1.2. Type of Module	Land Drainage and Management of Soil Salinity	
2.	Competencies	The module helps participants develop the ability to understand the possible causes, impacts, and mitigation measures of soil salinity in agricultural fields. Understand the mechanisms and techniques of soil samples taken for analysis, work in a laboratory to identify the level of salinity, test the impacts of the remedial measures, and utilize tools to analyze and interpret the results.	
3.	Course Type	It will be delivered either face-to-face, or synchronous, or asynchronous, etc.)	
4.	Course Identifiers		
	4.1. Course Code	WREM 6624	
5.	4.2. Credit Point in ECTS	5	
6.	Prerequisite	None	
7.	Course Description	Soil characterization and drainage characteristics, land drainage problems, and their diagnosis, need for land drainage, land drainage system types: surface drainage, sub-surface drainage, combined drainage systems, drainage criteria, drainage spacing, design of surface drainage systems, design of sub-surface drainage systems; Soil salinity: causes, primary and secondary salinization, soil salinity classes, irrigation water quality, effects of salinity on soil and crops, determining soil salinity; Assessing the suitability of saline water for irrigation, Practices to control Salinity in Irrigated Soils, leaching, the impact of irrigation methods on soil salinity, Strategies for use of Saline Waters for irrigation, Beneficial use of multiple water supplies for irrigation,	
8.	Learning Outcomes	After the module is completed, the participants would be able to: 2. demonstrate a thorough understanding of the nature and process of salinity problems 3. distinguish the level of salinity in testing by taking samples from the field 4. test parameters in the laboratory to identify elements causing soil salinity. 5. design a drainage system in the field and demonstrate different techniques to drain excess water from agricultural field 6. apply and use tools to analyze soil salinity	

		7. understand the construction and management concepts of drainage infrastructure 8. understand the relationship between drainage and soil salinity	
9.	Course Contents	**Unit1. Introduction (15%)** 1.1.General 1.2 Properties of Soil 1.3 Land Drainage (Need, Benefit, Classification, Investigation, …) 1.4 Drainage Investigations 1.5 Tools for Land Drainage & Soil Salinity Assessment **Unit 2 Soil Salinity & Irrigation Water Quality (25%)** 2.1 Primary & Secondary Salinization 2.2. Soil Salinity Classes 2.2 Effects of Soil Salinity on Soil and Crops 2.3 Determining Soil Salinity 2.4 Practices to Control Salinity **Unit 3. Surface Drainage (25%)** 3.1. General 3.2. Components of Surface Drainage System 3.3. Types of Surface Drainage 3.4. Planning and Design Considerations 3.5. General Design Procedures 3.6. Specific Design Procedures 3.6.1. Lined Canals 3.6.2. Unlined Canals 3.7. Management and Operation of Surface Drainage **Unit 4. Subsurface and Special Types of Drainage (25%)** 4.1. General 4.2. Types and Components 4.3. Planning and Design Considerations 4.4. Subsurface Drainage Design 4.4. 1. Pipe Drain 4.4.2. Deep Ditch Drain 4.4.3. Tube-well Drain 4.4.4. Mole Drain 4.5. Interception Drainage 4.6. Bio-drainage **Unit 5. Drainage Structures (10%)** 5.1. Junction Box 5.2. Vent and Relief 5.3. Crossings 5.4. Outlets 5.5. Energy Dissipaters 5.6. Gates	.

<table>
<tr><td>10.</td><td>Teaching and learning techniques</td><td>The approach generally models the type of teaching methods that:
Team teaching approach between general and subject area method instructors
Instructor(s) presentation using interactive methods (brainstorming, question and answer, mind mapping, small group discussion, lab works, etc.)
Independent learning methods such as reading assignments, article reviews, group project works, field data collection, doing lab., write and present reports
Field observation
Working in a laboratory</td><td></td></tr>
<tr><td>11.</td><td>Assessments</td><td>Both Continuous and summative assessments will be employed using various forms of instruments that help assess the expected learning outcomes. Thus, final examination, projects and presentations, group work, lab work, case studies, research reports, designing courses, lesson planning, and other individual tasks will be applied as appropriate to the experiences of students and departments. Furthermore, assessment requirements will be clearly stated with a due date. Assignments and projects will be announced in the first class with guides and rubrics.</td><td></td></tr>
<tr><td>12.</td><td>Course Policy</td><td>Students will be oriented at the beginning of the module regarding attendance, classroom code of conducts, due dates of submission of assignments, cellphone use, and unacceptable behavior of plagiarism</td><td></td></tr>
<tr><td>13.</td><td>Learning Resources</td><td>List textbooks, references, lab materials and equipment, Website, ICT, and Digital Technology essential to complete the course.</td><td></td></tr>
<tr><td>14.</td><td>Assessment rubrics (optional)[6]</td><td><table>
<tr><th>Learning tool</th><th>Category</th><th>Total mark (in %)</th></tr>
<tr><td>4. Reading assignments and presentation</td><td>One</td><td>15</td></tr>
<tr><td>5. Article review</td><td>One</td><td>15</td></tr>
<tr><td>6. Term paper/project/lab work and presentation</td><td>At least two</td><td>30</td></tr>
<tr><td>7. Written test</td><td>One – final exam</td><td>40</td></tr>
<tr><td>Total</td><td></td><td>100</td></tr>
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Addis Ababa University

Course Development Template

College: TBD

Department: TBD

Program: MSc in Water Resources Engineering and Management (Irrigation Engineering & Management)

Course Title: Soil Water Plant Relations

Year I Semester: II

Instructor:

- Name:
- Contact information :

- Office hours:

No	Section	Contents	Remarks
1.	Module to which the course belongs:		
	1.1. Module Title	Soil Water Plant Relations	
	1.2. Type of Module	Irrigation Engineering and Management	
2.	Competencies	• Recognize how the physical, chemical, and biological characteristics of soil affect the movement and retention of water. • Understand the mechanisms of plant water uptake, transpiration, and water stress. • Explain the complex interactions between soil, plants, and water in various ecosystems • Perform soil property analysis in a lab. • Solve problems related to water deficit in irrigated crop production • Design execute field research on soil plant and water relations • Effectively convey ideas both in writing and verbally on soil, plant, and water relations • Recognize the importance of effective management of soil for sustainable agricultural water management and environmental protection	Here, indicate only to which competencies this course contributes. You don't need to write new competencies here; select one or more competencies from the module competencies.
3.	Course Type	Face to face supported with laboratory analysis	
4.	Course Identifiers		
	4.1. Course Code	WREM 6625	
5.	4.2. Credit Point in ECTS	5	
6.	Prerequisite	None	
7.	Course Description	Soil-plant-water relations is intended to explore the mechanisms of in which soil plant and water interact for healthier crop production. It describes the principles of water relations within soils, followed by the uptake of water and its subsequent movement throughout and from the plant body. The major topics covered in the course include (i) soil properties - such as texture, structure, clay content and mineralogy that influence water retention and movement in soil; (ii) soil water - soil water potential, matric potential, osmotic potential, and their effects on plant water uptake; iii. Plant water relations - plant water uptake mechanisms, transpiration, water stress, and drought tolerance; iv. water movement- infiltration, percolation, and capillary rise of water in soil; alternative method of estimating crop water requirement and crop water production function, v. agricultural water management.	

8.	Learning Outcomes	Upon successful completion of the Soil-Plant-Water Relations course, students should be able to: • Understand the fundamental properties and characteristics of soil in relation to water retention and movement. • Describe the mechanisms of water uptake by plants and the factors that influence this process. • Explain the concepts of soil water potential, matric potential, and osmotic potential and their impact on plant water relations. • Analyze the movement of water through soil and the factors affecting infiltration, percolation, and capillary rise. • Evaluate the impact of soil-plant-water interactions on plant growth, development, and productivity. • Conduct experiments and analyze data related to soil properties, plant water status, and water movement in the soil-plant system. • Use computer models and remote sensing to evaluate soil water relation • Communicate effectively on topics related to soil-plant-water relations and their implications for sustainable agriculture and environmental management.	
9.	Course Contents	1. Introduction to the soil plant water relations 2. Soil water relations 2.1. Properties of soil: soil separates, soil texture, soil structure, 2.2. Properties of water 2.3. Role of water in plants 3. Soil and water characteristics 3.1. Physical properties of soil 3.2. Soil texture and structure 3.3. Methods of determining soil texture and structure 3.4. Soil pore formation, characteristics and influence 4. Water Retention in soil 4.1. Properties of water and its relation to soil 4.2. Surface tension, adhesion and other derived properties 4.3. Measurement of soil moisture potential 4.4. Soil water content and energy relations 5. Soil moisture dynamics 5.1. Saturated water flow in soils 5.2. Unsaturated water flow in soil 5.3. Infiltration models and measurement 6. Plant atmosphere relations 6.1. Evapotranspiration and Crop Water Requirement	

		6.2. Water use efficiency and Water production function 6.3. Water- yield relations of major crops 7. Irrigation agronomy of major crops in Ethiopia 7.1. Crops and Their Water Requirements 7.2. Water stress and drought tolerance	
10.	Teaching and learning techniques	• Lectures – face to face and videos, • Laboratory Exercise, • Field demonstration • Computer modelling – Cropwat/Aqua crop/	
11.	Assessments	• Home take assignments, • Laboratory analysis reports • Field work reports, • Final Examination	
12.	Course Policy	75% class attendance, submission of home-take assignments, laboratory reports, and final examination	
13.	Learning Resources	List textbooks, references, lab materials and equipment, Website, ICT, and Digital Technology essential to complete the course.	
14.	Assessment rubrics (optional)[7]	Group assignment (25%) Laboratory report (15%) Field trip report (20%) Final examination (40%)	Developing rubrics for assignments/ projects is very important because they help to establish clarity and transparency regarding assessment criteria and enhance fairness and quality.
15.		Kirkhom M. B. 2023. Principles of Soil and Plant Water Relations. 3rd Edition Elsevier MOA, 208. Guideline on Irrigation Agronomy, Addis Ababa	

Addis Ababa University

Course Development Template

College: TBD

Department: TBD

Program: MSc in Water Resources Engineering and Management (Irrigation Engineering & Management)

Course Title: Research Methods and Scientific Writing

Year I Semester: II

Instructor:

- Name:

- Contact information :
- Office hours:

No	Section	Contents	Remarks
1	Module to which the course belongs		
	4.1. Module Title	Research Methods and Scientific Writing	
	4.2. Type of Module	Research and Scientific Development	
2	Core competencies	• Knowledge on the philosophy of research and scientific method as applied to WREM • Ability to formulate an appropriate both qualitative and quantitative research design in WREM • Ability to conduct a comprehensive systematic literature reviews • Ability to think critically and analyze complex problems. • Ability to formulate research questions and hypotheses. • Skill in selecting appropriate research methodologies and techniques. • Understanding of sampling techniques and statistical analysis. • Knowledge of data collection and analysis methods. • Skill in using statistical software for data analysis • Ability to interpret research findings and draw conclusions. • Ability to conduct comprehensive literature reviews. • Awareness of ethical principles in research • Ability to communicate effectively in both written and oral forms	
3	Course Type (Face to face computer exercise)	• Face to face lecture, • Computer exercise – statistical software and literature search Individual assignments	
4	Course Identifiers		
	4.1. Course Code	WREM 6626	

	4.2. Credit Hrs/ECTS/	5	
5	Semester and Year	Year I Semester II	
6	Prerequisite	No	
7	Instructor - Name - Contact information - Office and Office Hrs	Tena Alamirew (PhD) MWF (8:00 -10:00 am)	
8	Course Description	The course is designed to equip students with the necessary skills and knowledge to conduct rigorous and ethical research in the field of soil and water engineering and management. The course will cover a range of research methodologies, data analysis techniques, and scientific writing skills essential for conducting independent research, and persuasive manner. The course will cover topics such as philosophy of research and the scientific method, research design and analysis, parametric and non-parametric method of data analysis, experimental design and analysis, academic writing, proper structure and organization of scientific papers, effective systematic literature review (PRISMA) and citation practices, appropriate ways of presenting and communicating findings, and revision and editing strategies. Besides, students will also acquire knowledge on how to respond peer review feedbacks.	
9	Integrity Statement	Students are expected to produce their work free of plagiarism or with appropriate acknowledgment of the sources.	AAU Legislation
10	Students with Disability	All possible supports will be provided to students with disability	
11	Learning Outcomes	Upon successful completion of the course, students will be able to: • Understand the principles of philosophy of research and scientific inquiry and apply them to research in soil and water engineering and management; • Conduct comprehensive systematic literature reviews to identify relevant research and evaluate its quality by accessing appropriate scientific global databases. • Critically evaluate research literature and identify strengths, weaknesses, and limitations	

		• Design and implement research projects using appropriate quantitative and qualitative methodologies and techniques. • Collect and analyze data effectively using statistical methods and data analysis software. • Write clear and effective scientific reports that communicate research findings effectively. • Adhere to ethical principles in research and ensure data integrity. • Collaborate effectively with other researchers to conduct interdisciplinary research.	
12	Course Contents	1. **Introduction to Research Methods** 1.1. Definition of research and scientific method 1.2. Research Philosophy – Ontology and epistemology 1.3. Research Typology – the Research Onion 1.4. Research Ethics **2. Research design and analysis** 2.1. Theory of sampling 2.2. Statistical techniques in data analysis – 2.3. Fundamental concepts in test statistic 2.4. Parametric statistic 2.5. Non parametric statistics 2.6. Design and analysis of comparative experiments 2.7. Design and analysis of factorial experiments 2.8. Use of statistical software for data analysis – SPSS and R 2.9. Statistical analysis of time series data 3. **Academic writing** 3.1. Undertaking systematic literature review 3.2. Artificial Intelligence in Academic Writing 3.3. Writing research proposal 3.4. Writing thesis or dissertation 3.5.Preparation of Journal article/manuscript	
13	Teaching and learning techniques	Face to face lectures Computer exercise Individual assignment (proposal development and manuscript review)	
14	Assessments	• Assignment Reports (15) • Systematic Review (10%) • Sample Proposal and Thesis (15%) • Comprehensive Final Exam (60%)	

15	Course Policy	• A student with 25% absenteeism will not have a final assessment and provide • Over 10% of plagiarism will pose a repeat of the assignment • A student who fails to submit an assignment or proposal within a given deadline will cause failure of the course • Punctuality is mandatory, and those who come late to class may not be allowed to enter the classroom	
16	Learning Resources	Books, Lecture Notes, Websites	
	16.1.Textbooks	See under References	
	16.2. References	i. John W. Creswell (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. ii. Helsel , D. R. et al (2020). Statistical Methods in Water Resources, USGS iii. Zar, J. H Biostatistical Analysis. 4^{th} Edi, Prentice Hall iv. Gastel, B. and Day, A. How to write and publish a Scientifc paper (8^{th} edt.) Greenwood.	
	16.3. Lab Materials and Equipment	NA	
	16.4. Website, ICT and Digital Technology	Zotero – for reference manager, Turnitin – as online plagiarism checker.	