Engineering Tripos Part IIB, 4D15: Water management under climate change, 2024-25

Leader

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Lecturer

Dr E Borgomeo

Timing and Structure

Lent term. 16 lectures (Eight 2 hour sessions) + coursework. Assessment: 100% coursework.

Aims

The aims of the course are to:

- Recognise the unsustainable feature of current water engineering practice
- An understanding of water management under climate change, and the role that sustainability professionals can play in helping societies adapt to climate change
- The ability to evaluate recent practices and developments in managing all aspects of the water cycle in both developed and developing countries

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the limitations of conventional /traditional water supply and wastewater engineering systems in a sustainability context.
- Appreciate the key features of managing the water cycle in a sustainable manner and the need to meet a variety of resilience criteria.
- Recognise and critically assess the problems and solutions associated with managing water engineering projects.
- Be familiar with key aspects of water management in an international development context
- Recognise global issues in relation to the equitable management, distribution and disposal of water under growing environmental, social and political constraints.

Content

Leonardo Da Vinci remarked that ‘Water … is the cause of life or death, of increase or privation, nourishes at times and at others does the contrary …’. Today, water is at the centre of the sustainable development and climate action agendas. The most serious and high-profile impacts of climate change are being felt through water: floods, droughts, melting of ice and reduced snow cover, amongst others. Water is also a major sustainable development challenge: worldwide, 844 million people lack access to drinking water, and 2.3 billion do not have access to latrines or other basic sanitation facilities, mostly in low- and middle-income countries. High-income countries are also faced with water-related policy and engineering dilemmas. In the UK, the water sector is facing a major governance and investment crisis, and in the US, millions of people are drinking potentially unsafe tap water.

The module explores established and emerging practices for managing water under climate change. The module introduces key water issues around the world, including access to water supply and sanitation, flood and drought risk management, irrigation water service provision, and freshwater ecosystem degradation. Established and emerging engineering and policy practices for addressing these issues under climate change will be reviewed, including risk-based water resources planning, water allocation reform, and nature-based solutions. The interdependencies between water and other critical resources and sectors will be explored, with respect to greenhouse gas emissions, energy use, food security, and recovery of nutrients. The module features discussions of present-day applications, with a focus on case studies from Africa, Asia, and Latin America.

Why Plan and Manage Water?

Climate change expresses itself through water. Nine out of ten ‘natural’ disasters are water-related. Water-related climate risks cascade through food, energy, urban and environmental systems. If we are to achieve climate and development goals, water must be at the core of adaptation strategies and development policy. This lecture describes some of the challenges and opportunities related to water, with examples from around the world. Problems of water management include too much, too little, too polluted, or too expensive water. The lecture also provides an overview of global progress towards Sustainable Development Goals 6 on ensuring availability and sustainable management of water and sanitation for all.

Approaches for Water Resources Planning and Management

Water resources planning and management activities are usually motivated by the realization that there are problems to solve and/or opportunities to obtain increased benefits by changing the management and use of water and related resources. This lecture presents water planning and management approaches, focusing on their technical, financial and economic, institutional and governance aspects. The different paradigms of water resources planning and management are discussed, including top-down planning, bottom-up planning, and Integrated Water Resources Management. The lecture evaluates the engineering paradigms and tools typically used to support planning and management and identifies the potential to update them in light of sustainable development and climate goals. The approaches and framework discussed in this lecture will serve the basis for the sub-sector deep-dives in the following lectures.

Are we going to run out of water?

Households, farms, factories, and ecosystems around the world are being forced to live with less water. Water crises are now amongst the top global risks, and many cities are already facing water shortages. This lecture unpacks the concept of water scarcity to explore its multiple dimensions and map its consequences at global and local levels. What are the main sources of water? And how do societies use it – and value it? Will we run out of water? Taking the world’s most water scarce region (Middle East and North Africa) as a case study, the lecture responds to these questions and evaluates alternative responses to water scarcity, with a focus on engineering options that manufacture new water through wastewater reuse and desalination.

Can clean energy help ease the water crisis?

How does the energy sector use water? What are the potential impacts of energy system transformation on water supplies? And how much energy does the water sector utilize? This lecture explores the ‘nexus’ between energy and water, examining both water for energy and energy for water, and presenting options for integrated energy and water systems planning. Taking the case study of a water utility in Brazil, the lecture discusses pathways to reduce energy consumption in the water sector.

Can we grow more food with less water?

Sustainable food production will not happen if water is not managed properly. Agriculture accounts for 70 percent of global freshwater withdrawals, and remains a major source of water pollution. Against this backdrop, engineers and policy-makers around the world often promote investments to grow more ‘crop per drop’, that is, more food with less water. This lecture explores the opportunities of growing more food with less water, and reveals some of the linkages between food and water policy that engineers need to be aware of when seeking to maximize efficiency in the water sector. Taking the case study of solar-power irrigation systems in India, the lecture discusses the complexities of integrated water-food-energy policy.

Working with nature: can ecosystems-based approaches help achieve water security?

Engineers around the world increasingly work with natural processes to reduce the impacts of floods and droughts, or to improve water quality. This lecture describes multiple types of nature-based solutions, and their benefits in terms of water-related outcomes and broader environmental outcomes. Taking the case study of natural flood management in the UK, the lecture discusses the approaches for working with nature to improve water security.

Sharing water, sharing problems?

As water scarcity increases around the world, the spectre of ‘water wars’ is often evoked by the media and by politicians. While water is indeed a source of tension between and within countries, it is very rarely a direct cause of war or conflict. This lecture reviews the complexities of managing water across boundaries and explores the evidence that helps dispel the myths of water wars. Two case studies from river basins in Africa showcase the potential for water engineering to contribute to cooperative transboundary water management.

Putting it all together: project planning for climate adaptation in the water sector

The course introduced some of the water-related challenges and opportunities encountered around the world, and the tools that are being used to address them. The final lecture combines messages from the previous lectures to draw some general lessons on good practices for climate adaptation in the water sector. The concepts of robustness and adaptive planning are introduced, and a framework for analysis and implementation of projects is evaluated with examples from projects from different parts of the world.

Coursework

Coursework	Format	Due date & marks
Coursework 1: Individual Research Report on a key water related topic An open ended investigation in further detail of one aspect of water engineering practice <u>Learning objective:</u>	Individual Report anonymously marked	day during te Thu week 4 [30/60]

Coursework	Format	Due date & marks
• To develop the ability to seek new information and achieve a balanced critique of the existing literature through individual research of relevant details/topics NOT covered in the lecture programme		
Coursework 2: Resilience assessment of one aspect of water engineering practice A critique of one aspect of current water engineering practice (e.g supply, wastewater dispsoal, drainage, development) against resilience criteria and propose key areas for change Learning objective: • To apply a resilience and sustainable mindset to the delivery of water services	Individual Report anonymously marked	Wed week 9 [30/60]

Booklists

Loucks, D. P., & Van Beek, E. (2017). Water resource systems planning and management: An introduction to methods, models, and applications. Springer

World Bank. (2017). Beyond Scarcity: Water Security in the Middle East and North Africa. The World Bank.

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [3] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

S1

The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

S3

Understanding of the requirement for engineering activities to promote sustainable development.

S4

Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

P6

Understanding of appropriate codes of practice and industry standards.

P7

Awareness of quality issues.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

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