CE 0337 WATER RESOURCES MANAGEMENT

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CE 0337 WATER RESOURCES MANAGEMENT

- **Introduction**
- **Data analysis ……..Curve fitting, UH**
- **Linear Programming**
- **Integer Programming**
- **Applications in**
  - **Network models....**
  - **Water Models....Reservoirs, Groundwater, Pipe Systems**
  - **CPM & PERT**
  - **Material Models**
  - **etc**

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Reference Books :

Civil and Environmental Systems Engineering by Charles S. Revelle, E.Earl Whitlatch & Jeff R. Wright, Prentice Hall, New Jersey, 2003

İnşaat ve Çevre Sistemleri Mühendisliği (Çeviri **Civil and Environmental Systems Engineering** by Charles S. Revelle, E.Earl Whitlatch & Jeff R. Wright), Çeviren Erdoğan Basmacı, OYTEV Orhan Yavuz Teknik Eğitim Vakfı yayını, İstanbul, 2010

References :

Ossenbruggen, Paul J. *Systems Analysis for Civil Engineers, Wiley, New York, 1984.*

Ulucan, Aydın *Yöneylem Araştırması, Siyasal Kitabevi, Ankara, 2004.*

Can, K. Emre *Lecture Notes.*

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WATER RESOURCES MANAGEMENT

Midterm Exam(s)	35 %
Homeworks & Attendance	15 %
Final Exam	50 %

Midterm Exam I 13 March 2018
Midterm Exam II 17 April 2018

INTRODUCTION TO SYSTEMS ANALYSIS

The Operations Research (OR) Society of America's definition of OR is :

***Operations Research* is concerned with scientifically deciding how to best design and operate man-machine systems usually under conditions requiring the allocation of scarce resources**

- ***Systems Analysis* consists of the systematic development, analysis & comparison of alternative designs, management schemes and policy projects.**
- ***Its aim is to contribute to decisions that insure the most effective design, management scheme or policy.***

In order to define the problem in a mathematical model the following typical questions are asked

- How does the system work?
- What portion of it is controllable?
- Who or what can or does exercise such control and to what purposes or goals?
- What set of alternative systems might better implement those goals?
- How should systems' controls be set to pursue various purposes or goals in the best possible manner?

Interdisciplinary teams

- In many complex and non-traditional problems it is not clear from the start what disciplinary view points will turn out to be most appropriate.
- It is essential that the participants of such work become familiar with the techniques and goals of other disciplines.

- **Modeling** includes a systematic definition of the existing system and formulation of suitable alternatives. Models are essential to study of complex systems.
- Physical Models
- Analogue Models (flow of compressible fluids through glass tubing to represent traffic on congested streets, ground water flows by electrical curcuits)
- **Mathematical Models**

Use of mathematical models.

- The systems approach may be described as an iterative progression through four types of activities :
  - Modeling,
  - Optimization,
  - Evaluation
  - Selection.

Principles of Mathematical Modeling

- **DO NOT** build a complicated model when a simple one suffice
  - **KISS**
  - (Keep it Simple Stupid)
    Bigger and more complicated =/= better
- **Beware of molding the problem to fit the technique**

Principles of Mathematical Modeling

- **The deduction phase** must be conducted rigorously. Models should be validated prior to implementation. Model results should be consistent with reality.
- **A model should not be taken too literally.** Beware of overselling the model. Remember the original assumptions, never say : "Model is correct because of its complexity."

Principles of Mathematical Modeling

- **Ultimate user** should be involved throughout the model construction and validation period. Some of the primary benefits of modeling are associated with the process of developing the model.
- ***GIGO.***

  A model can NOT be better than information that goes into it. It can NOT recognize and correct deficiencies in input. It can NOT generate information. It can only condense and convert.

Principles of Mathematical Modeling

Models can NOT replace **Decision Makers (DMs).** Operations research models can aid DMs and therby permit better decisions. Role of experience, intuiton and judgement can not be overruled.

- The **decision variables** represent some aspect of the system that is controllable by DMs.
- **State Variables** represent some aspect of the system that is affected by a decision and hence are functions of the decision variables

- The models contain pyhsical, financial, economical, political and other restrictions that must be met in the system.

- They also contain statements that define the goals, desires or values of the decision variables with respect to the system.

- This combination of constraints and objectives which are defined in terms of decision and state variables within a mathematical model provides a powerful tool for DMs as they analyze complex systems.

- Minimize $f(x) = x^2 - 3x + 4$
- Minimize $f(X) = 3X_1 + 4X_2$
- Minimize $f(x) = \sin (X)$
- Minimize $f(x,y) = xy - 3x^2 + 4y^2$

- Subject to $g(X) = X_1 + 3X_2 = 5$
- Subject to $g(X) = X_1 + 3X_2 < 5$
- Subject to $g(X) = X_1 + 3X_2 > 5$

- Non negativity restrictions
- $X_1 > 0$, $X_2 > 0$

OPTIMIZATION PROBLEMS

- **Unconstrained or Equality Constrained Problems**
  - Solutions requring derivatives
  - Trial & Error solutions
- **Constrained problems**
  - Nonlinear Constraints
  - Linear Constraints
    - Linear Programs, Linear Integer Programs (74%)
    - Goal Programs
    - Linear Fractional Programs,
    - Quadratic Programs

During World War II, the military management in England employed a team scientists to study the strategic and tactical problems associated with air and land defense of England.

Operations ===========➔ Military Operations

- CPM & PERT
- Optimization problems

WATER

- Too much ====➔ Floods
- Too little ====➔ Droughts
- Not clean ====➔ Sickness
- Not on time
- Not where it is needed

The development of water resources,
for a sufficient quantity and quality of water,
properly distributed in time and space,
requires conception, planning, design,
construction and operation of facilities
to control and utilize water.

Dams, diversions, tunnels, levees,
pipelines, pumping plants,
water treatment plants, aqueducts,
valves, drops, energy dissipators, etc....

The incentive to plan
for increased control of any water resource
often follows a major disaster
such as a flood, a drought, etc.

PROBLEMS

Multiple Goals & Objectives

Irreversibility
Uncertainty
(precipitation, evaporation, sedimentation)

Knowing the principles but taking the risks

Complexity in ground water interactions

Non-Economic effects (Loss of Life)

Worlds major natural disasters :

(Sabah 30 December 2004)

1931 Yangtze river flood
3.7 Million died.

Major project planned many dams were built.

However,
1975 flood resulted 63 dambreak cases
and over 200,000 died.

Worlds major natural disasters

1970 Bangladesh tide ➔ 200,000+ died

North Vietnam Red River flooding ➔ 100,000+ died

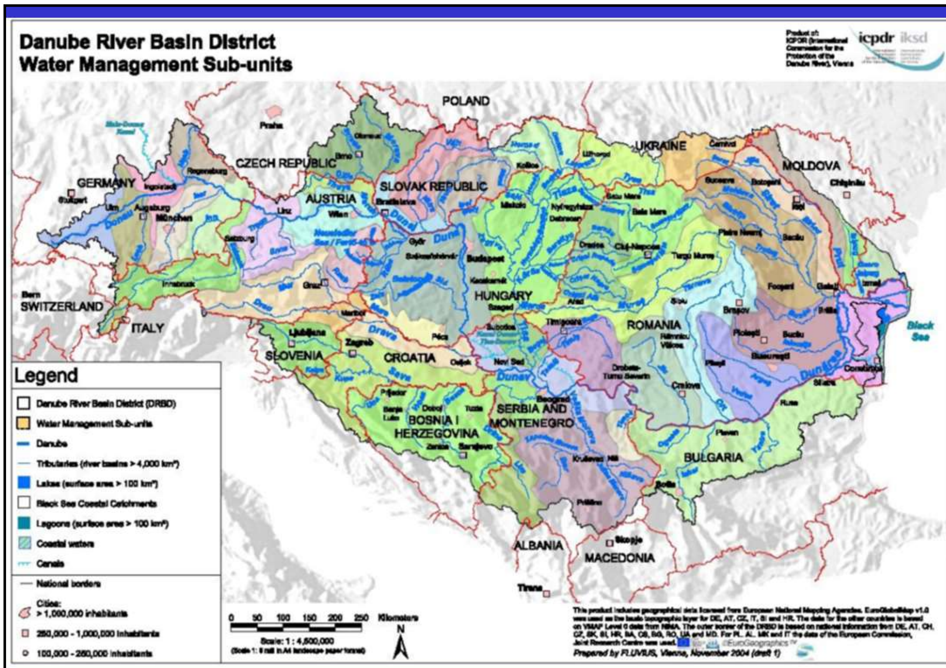
December 2004 Asian tsunami
after a major earthquake ==➔ 22,500 died

Myanmar Storm ➔ 100,000+ died

PROBLEMS

Multiple Goals & Objectives

(due to differences in assesment of the cost & benefits)



Water Framework Directive WFD (2000/60/EC)

Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation at the latest by 2006;
- The overview of the significant water management issues in the river basin at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

Water Framework Directive (WFD) (2000/60/EC) Advisory:

the whole trans-boundary river basins:

the Member State or Member States concerned shall endeavor to establish

appropriate coordination with the relevant non-Member States,

with the aim of achieving the objectives of WFD throughout the river basin district.

Principles

- Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such
- It is necessary to develop an integrated Community policy on water to preserve, protect and improve the quality of the environment
- the precautionary principle, preventive action environmental damage should, be rectified at source
- the polluter should pay subsidiarity
- The involvement of all stakeholders (the PUBLIC)

PROBLEMS

Irreversibility

CANADIAN Lake Diefenbaker case :

- ✓1949 lake was planned to provide irrigation for 200K ha.
- ✓1962 estimate more than 100K ha.
- ✓Hydropower production (winter) added.
- ✓Project was completed in 1967.
- ✓Five penstocks were built, 3 turbines installed.
- ✓1973 only 6,500 ha were under irrigation
- ✓Recreational use of the reservoir was planned afterwards
- ✓ Out of 16 provincial parks, the three on Lake Diefenbaker
- ✓ ranked 12,13,14!!!
- ✓Water Supply and Flood Control Objectives
- ✓ were not successful as well!!!

PROBLEMS

Uncertainty
(precipitation, evaporation, sedimentation)

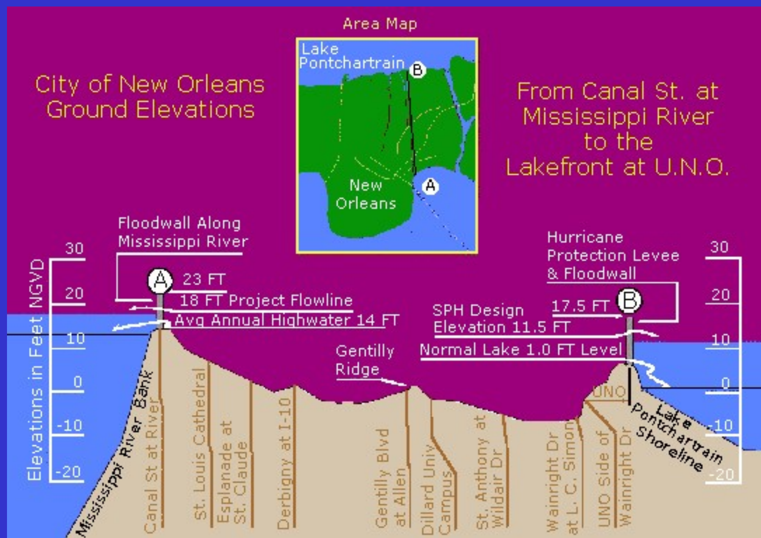
Knowing the principles but taking the risks

Complexity in ground water interactions

Non-Economic effects (Loss of Life)

Floods in Turkey

Year	Number of floods	Number of deaths	Inundation area (ha)
1956	3	90	178 668
1957	29	185	49 336
1962	20	18	94 014
1963	55	34	191 983
1966	26	31	137 971
1968	61	29	170 029
1969	22	7	125 104
1972	23	24	21 076
1973	10	23	44 188
1975	16	44	7 242
1979	5	61	2 950
1980	10	11	48 473
1984	1	-	28 457



http://en.wikipedia.org/wiki/Image:New_Orleans_Levee_System.gif
This image is a work of an U.S. Army Corps of Engineers employee, taken or made during the course of the person's official duties. As a work of the U.S. federal government, the image is in the public domain

Early successful Systems Applications

- Washington DC Metropolitan area
- Great Lakes Power Limited

Washington DC Metropolitan Area (60's)

Several solutions ranged in cost b/w $200M -$1B

- 16 major reservoirs
- Recycling of estuarine water (w/ treatment)
- Drilling new wells

Each had political, social, environmental or economic difficulties.

By 1977, after 25 years of study, the problem was nowhere near solution

Washington DC Metropolitan Area (60's)

- ✓ In contrast the agreements reached in July 1982 are based primarily on almost costless, cooperative, **improved operations of existing facilities**, using state-of-the-art flow and daily demand forecasting techniques.
- ✓ Construction of one small local reservoir (Little Seneca costing $30M), but even that reservoir is important not so much for the quantity of water it stores, **but for the additional operational flexibility** it provides.
- ✓ Overall system yield has been increased by nearly 50%, and individual project yields by as much as 200%.

Great Lakes Power Limited (Canada)

- All of GLP's plants are under remote control. Total generating capacity is 297MW from 12 hydroelectric stations in four river systems.
- A preliminary assessment of the advantages of computer-based decision support system for GLP operations indicated a savings of approximately $1M per year in power purchases from Ontario Hydro.

HISTORY

- US Water Policy Commision (1950)
- Harvard University Water Resources Program (1955)
- Univ. Of California Water Resources Center (1957)
- Universities Council in Hydrology (1963)
- Water Resources Act (Approved by US Congress,1964)

- State Meteorological Org. (Devlet Meteoroloji İşleri, **DMİ**)
- State Hydraulic Works (Devlet Su İşleri, **DSİ**)
- Electrical Power Research Survey & Development Administration (Elektrik İşleri Etüt İdaresi, **EİEİ**)
- General Direc. of Rural Services (Köy Hizmetleri Genel Md, **KHGM**)