GENERIC MODELING FRAMEWORK FOR INTEGRATED WATER RESOURCES MANAGEMENT

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i. Theoretical and Practical Requirements
ii. Architecture of Modeling Framework
iii. First and Second Level of Integration
iv. Conclusion and Future Work
1 | Global Change

Challenges of humanity: Water | Food | Energy

Integrated Water Resources Management | Global Water Partnership

“Process that promotes the coordinated development and management of water, land and its related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem.”
2 | Complexity of IWRM and Guiding Principles

IWRM GUIDING PRINCIPLES | Simonovic, 2009

- Systems view
- Integration
- Partnership
- Participation
- Uncertainty
- Adaptation
- Science
3 | Methodology Requirements

Objectives of Generic Modeling Framework:

Objective 1 | Address the guiding principles
Objective 2 | Address the complexity of system structure and relations between components
Objective 3 | Address the system behavior in space and time

Specific IWRM Goals of Modeling Framework:

Water allocation | Water Quality Management | Ecosystem protection | etc.
4 | Generic System Architecture

Operational and Institutional (ORR)

Physical system (PS)

Socio-Economic System (SES)

Available Resources

Goals and Objectives

ORR  Actions  Effects  PS  SES

End-User

Problem Identification

Component 1: PHYSICAL SYSTEM
Modeling methodology: Hydrologic Model - \( Q = f(t) \)
Water Quality Model - DO, BOD, \( C^o \)
Hydrodynamic Model - \( H = H(t) \)
Reservoir Operation Model

Component 2: OPERATIONAL RULES AND REGULATIONS
Modeling methodology: Agent-based Simulation
Coalitions forming
Allocating scarce resources
Negotiations
Argumentation

Component 3: SOCIO-ECONOMIC ENVIRONMENT
Modeling methodology: System Dynamics Simulation
(Economic, Energy, and Population sectors)

Simulation Results

System Optimization

IWRM Action Plan
5 | Case Study: The Upper Thames River Basin

Important River Basin Properties

- Average precipitation: 1000 mm/year
- Average annual discharge: 39.5 m³/s
- Land use:
  - 78% Agriculture
  - 9% Urban
  - 12% Forest
- Population: 485,000

Data Source | Upper Thames River Conservation Authority
First Level of Integration

System Structure
7| Physical System: Hydrologic Model

Modules of Hydrologic Model

Computed and Observed Hydrographs at Byron GS

Schematic of Upper Thames Basin Hydrologic Model
8 | Operational and Institutional: Agent-based Model

28 Sub-basins = Actors
Population on the Watershed Level | Stock and Flow Diagram
Level 1: The Integrated Model
11 | Generic System Architecture

Operational and Institutional (ORR)

Physical system (PS)

Socio-Economic System (SES)

Available Resources

Goals and Objectives

ORR Actions ORR

Effects

PS SES

End-User

Problem Identification

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Modeling methodology:
- Hydrologic Model - \( Q = f(t) \)
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- Agent-based Simulation
  - Coalitions forming
  - Allocating scarce resources
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Component 3: SOCIO-ECONOMIC ENVIRONMENT

Modeling methodology:
- System Dynamics Simulation
  - (Economic, Energy and Population sectors)

Simulation Results

System Optimization

IWRM Action Plan
Level 2: WATER QUALITY MANAGEMENT MODEL
Systems analysis techniques

Simulation
- Empirical
  - Deterministic or Stochastic
    - Polynomial
    - Times series
    - Power series
- Physical
  - Deterministic or Stochastic
    - Mass balance
    - Finite difference
    - Finite elements
    - Finite volumes

Optimization
- Linear
- Non-linear
- Dynamic
Upper Thames River Water Quality Model

Concentration

River Kilometer, Reaches 1 – 15

- HAMILTON ROAD
- Pottersburg
- South Thames
- Vauxall
- Thames River

Delaware

(Concentration)

Other Element
Point Source
Withdrawal
Dam

River Kilometer, Reaches 1 – 15

- South Thames
- Thames River

Temperature
BOD

River Kilometer, Reaches 6 – 10

- WWTP Vauxall
- WWPT Greenway
- WWPT Adelaide

Temperature
BOD
**Conclusions and Future Work**

i. Systems View as a guiding principle in IWRM

ii. Modeling framework to describe system behavior in space and time

iii. Interaction between system elements and actors

iv. Dynamic data exchange between system components and detailed representation of all system actors |water sources, users, polluters, etc.|
Thank you for your attention...