Spatial Decision Support Systems for Integrated Water Resources Management

Possible Ways Ahead

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Presentation at a Workshop on
Spatial Analysis for the Sustainable Management of the Indus Basin in Pakistan

May 26, 2003
Outline of Presentation

• Context: Integrated Water Resources Management
• Decision Support Systems (DSS)
  – Knowledge Base
  – Models
• Illustrative DSSs
• Possible Paths Ahead
Why Integrated Water Resources Management?

...this is why we need IWRM in a basin context!!!
Watersheds and Basins

- Micro-Watershed
- Sub-Watershed
- Watershed
- Sub-Basin
- River Basin
Branch Headworks
Branch Distributary Drain
Command Area of Outlet
Sodic Land Patches
Wetlands & Waterlogged Areas
Branch Drainage Basin
Outlets
Minor
Distributary Drainage Basin
Drain
River
Importance of a Spatial Perspective

Integrated Water Resources Mgmt.

- River Basin Planning & Management is inherently Spatial
- Need to examine
  - relationship between administrative and hydrologic boundaries
  - upstream-downstream linkages
  - environmental issues: pollution and natural resources management (water quality, sodicity/salinity, waterlogging, public health)
  - surface and groundwater management
  - multi-sectoral demands
  - spatial distribution of costs and benefits
- Need for spatial characterization of issues, constraints and options
Pakistan Water Sector Strategy

**Insufficient data-base and inadequate information availability**

has been identified as a primary constraint in sustainable WRM and Irrigation management.
## Pakistan Water Resources Strategy

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Fully</th>
<th>Partially</th>
<th>A Little</th>
<th>Not at all</th>
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</thead>
<tbody>
<tr>
<td>The country’s capability and resources in <strong>water-related R&amp;D</strong> meet its information requirements for water resources development and management</td>
<td>✓</td>
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<tr>
<td>The country’s capability and resources in <strong>allied areas of R&amp;D</strong> (social, environmental, etc.) meet its information requirements for water resources development and management</td>
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<td><strong>Hydrological and Climatological databases</strong> meet the country’s requirements for planning and design of water resources developments</td>
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<td><strong>Environmental databases</strong> meet the country’s requirements for planning and design of water resources developments</td>
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<tr>
<td><strong>Socio-economic databases</strong> meet the country’s requirements for planning and design of water resources developments</td>
<td>✓</td>
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<tr>
<td>The country’s capability and resources in <strong>hydrological and climatological services</strong> meets its requirements for operational management of water</td>
<td>✓</td>
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</table>
Water “Sector” Linkages

Agriculture

Urban Water Supply

Transport

National Goals (drinking water, food security)

Risk (floods, droughts)

Environmental (pollution, ecology)

Energy

Social/Public Health
Environmental & Social Indicators in Water Resources Management

Sample Environmental Indicators

- Water Resources (Surface & GW)
- Spatial & Sectoral Competition for water
- Water Quality (Surface & GW)
- Waterlogging/Salinity
- Overextraction/Recharge
- Land Use/Land Cover
- Watershed Degradation/Erosion/Siltation
- Natural Habitats / Wetland Management
- Coastal Zone Management (incl. salinity intrusion)
- Weed/Exotic Species Management
- Fisheries/Livestock Management
- Pesticide & Fertilizer Use
- Climate Change
- Environmental Safeguards
- Capacity

Sample Social Indicators

- Stakeholder Views & Consultation
- Poverty & Livelihoods
- Distribution of Benefits
- Equity
- Gender Issues
- Access to Relevant Information
- Farmer Organization Performance
- Participation in Decision Making
- Empowerment
- Decentralization
- Conflict Resolution
- Cultural Property
- Public Health
- Vulnerable Groups
- Social Safeguards
- Capacity
The Main Problems

• Knowledge Base
  - Comprehensiveness
  - Information Access

• Analytical Capacity
  - Concerted efforts to Analyze Problems in a Holistic Manner
  - Modern Information Management and Analysis

• Institutional
  - “Shared Vision” Planning & Management
  - Access to Relevant Expertise and Lessons
  - “Project” Mode of working
The Primary Opportunities

- Recognition of the Problems
- Past and Ongoing Work on Knowledge Base and Analytical Capacity
- Reform Agenda
- Learning from Worldwide Experiences
- Rapid IT advances
Decision Support Systems

Information System
GIS, Spreadsheets, Databases, Documents, Web, Other Software

Data
Information
Knowledge
Decision-Making

Issues
Hydrologic Cycle, Quality, Allocation, Economic, Social, Institutional, Legal, Environmental, ...

Models
Optimization/Simulation
Planning/Management/Operation
Decision Support Systems

**Information Systems**
- Geographic Information Systems
- Interactive Spreadsheets
- Databases
- Internet
- Other Documents

**Models**
- Optimization/Simulation
- Deterministic/Stochastic
- Operation/Management/Planning

**Disciplines**
- … Public Policy, Hydrology, Engineering, Economics, Environment, Ecology, Law, Politics, ...

**Actors**
- … Government, Academic, NGOs, International Institutions, Research, Consultants, General Public, Other Stakeholders...

Decision Making
Sample Questions/Issues to be Addressed by DSS

- What are the Benefits of Cooperation?
- What are the Costs of Inaction?
- What are the Inter-sectoral and Inter-regional Tradeoffs?
- What are the Major Constraints to Development in each Sector/Region?
- What are the Investment Priorities?
- What are the Environment-Development Linkages?
- What are the Long-term Planning Implications (vs. Planning for the Short-term)?
Information Systems

User Interaction
- Maps
- Classification
- Queries
- Scenarios
- Simple Models
- DSS Interfacing

GIS Databases
- Land Use
- Agriculture
- Urban
- Demographic
- Environment
- Flows
- Groundwater
- Energy
- Transport
- Projects - current/proposed
- Economic

Outputs
- Maps/Overlays
- Tables
- Statistics
- Links
- Spatial Analyses
- Model Outputs

Other Tools
- Internet
- Spreadsheets
- Databases
- Presentations
- Documents
- Programs/Models
Sample Modeling Systems

Land Use
• Urbanization
• Cropping Patterns

Water Supply
• Hydrologic Cycle
• Conjunctive Use

Water Demands
• Irrigation
• Industrial
• Domestic
• Livestock
• Hydropower

Management Options
• Hardware
• Software

Water Allocation
• Inter-Sectoral
• Inter-Regional

Water Supply
• Surface Water
• Groundwater

Production
• Hydropower
• Agricultural Products

Management Designs
• Hardware
• Software

Economic
• Benefit Distribution
• Shadow Prices
Sample Modeling Framework

The Story at a Demand Node

Precipitation

Domestic Industry Livestock

Agriculture Irrigated

Agriculture Barani

Return Flows

Inflow

Losses

Inflow Outflow

In-Stream Uses

Groundwater
Modern Spatial Toolkit

- GIS
- GPS / Modern Survey Tools
- Remote Sensing
- Modern Hardware
- Modern Software
- Modern Platforms (www)
- Modern Applications/DSS
- and most important… Skilled Staff with multi-sectoral perspectives

...along with all the old-fashioned insights, knowledge, expertise
Demonstration of Sample Spatial Information Systems and Interactive Models
The Roadmap...

Problems (identified by workshop participants)

- **Access** (restrictions, lack of sharing tendency and protocols, cost)
- **Adequacy** of data
  - Quality (incl. data standards)
  - Coverage (comprehensiveness, updating, stocktaking of what’s out there)
- Inadequate DSS use and **link to decision-making**
- Low **awareness** on spatial information systems and analysis (knowing what’s out there, who’s who, senior management, adequate training)
- Low **technical and resource capacity** for modern IT penetration (skilled manpower, hardware, software, modern DSS) in many organizations
- Lack of **focal point**; lack of inter-agency coordination and cooperation

Potential Path Ahead

- Inventory and gap analysis
- Public access to relevant information
- Identify key decisions to be made
- Decision Support System development (information systems and modeling)
- Appropriate Institutional Capacity Development (Focal Point, Inter-institutional links, training/awareness)
- Link to decision making
Key Principles

• Make best use of available information – not wait for the “best” data and tools to become available

• Develop a “Shared Vision” for sustainable development, management and operation in the Indus Basin from a multi-sectoral perspective

• Make information available

• Explore modern IT options

• Focus on Training and Awareness

• Require an appropriate level of analysis for decision-making
…finally…

Remember the client!!!