Complex Water Issues: Transdisciplinary Approaches to Assessing Knowledge and Negotiating Solutions

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Sustainable Water ActioN

Almost 50 years ago, Thomas Kuhn wrote *The Structure of Scientific Revolutions* in which he described accepted scientific methodology as functioning within a set of proven rules and demonstrated conventions that:

govern the definition of terms,

the collection of data,

and the boundaries of a scientific inquiry.

As the scientific investigation progresses, anomalies that cannot be explained will appear within the existing model at which time researchers will begin practicing “revolutionary science”, which means that researchers will:

work outside existing boundaries and

establish new rules and conventions

This approach requires:

discrete scientific issues,

expects change to occur within or as a result of scientific investigation

and generates scientific answers.

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In response to Kuhn's "normal science," Funtowicz and Ravetz, coined the term "post normal" science as the name for a different methodology to address scientific problems that have four distinct characteristics:

(1) uncertain facts;

(2) the potential for conflict among the various stakeholders with respect to the costs, benefits and value commitments involved in the issue;

(3) significant adverse consequences and

(4) need immediate action required to address the problem.

Examples of complex issues involving competing demands for available water with significant consequences

- Coastal wetlands lost in exchange for port expansion and urban and industrial growth. (Pinder and Witherick, 1990)

- Deltaic wetlands preserved at expense of local governments' desire to expand industrial zones (Hesselink,1996).

- Water needed for Spanish national park Coto Don˜ana lost to local str farms. (Ll

- Water needed to mai Aral Sea surrendered for upstream cotton-fields.

Key Components of Developing Methodology

1. **The need to manage uncertainty**. Uncertainty is more than a technical number-range or methodological issue. Ambiguous knowledge assumptions and ignorance give rise to uncertainties as to the underlying facts.

The methodology emphasizes:

quantifying the uncertainty and

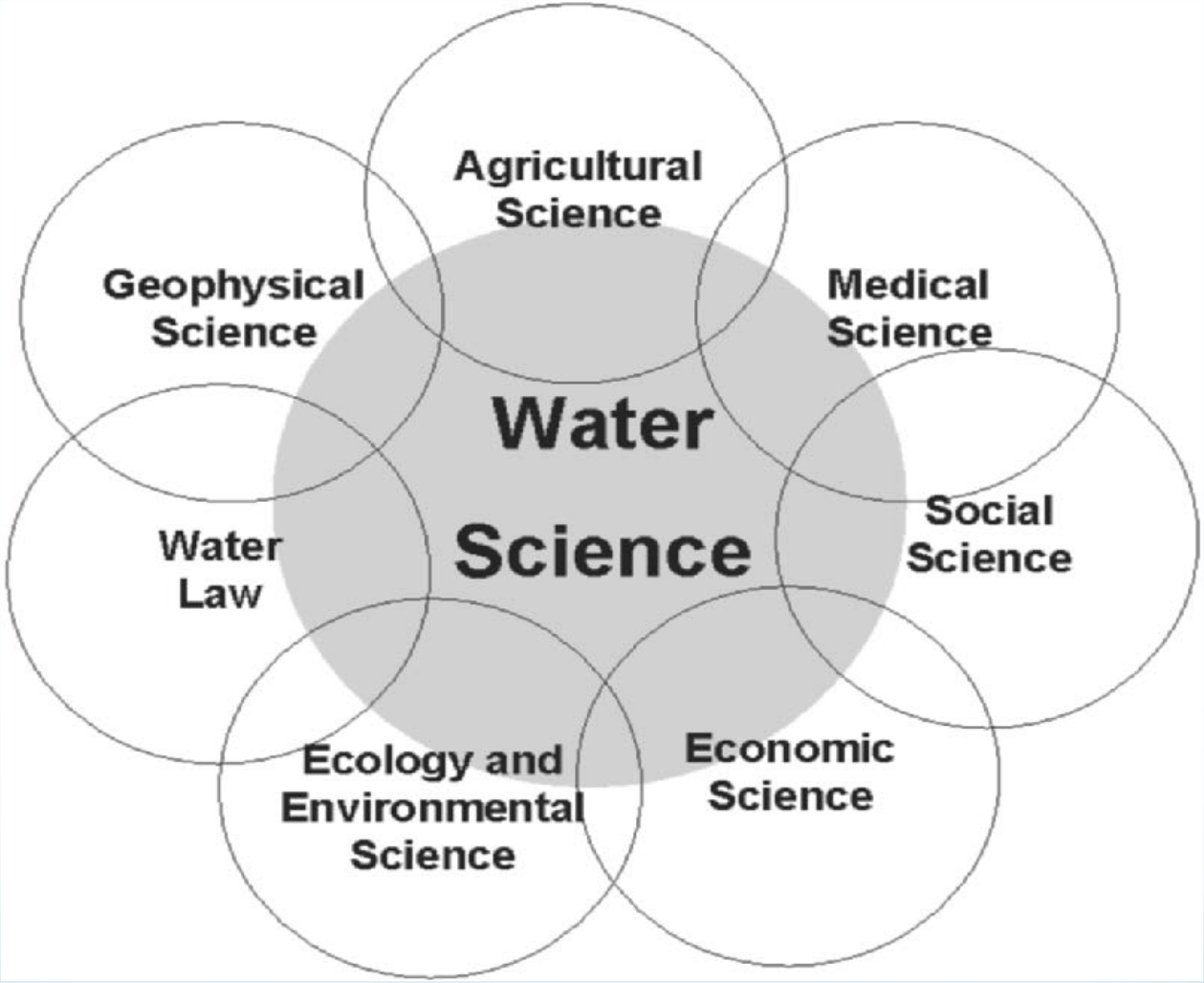
communicating the level of uncertainty.

2. **Interdisciplinary and participatory cooperation.** Complex problem solving requires:

scientific teamwork within an interdisciplinary group and

joining effort by specialists from the scientific community and from business, politics, and society.

3. **The management of quality**. An extended peer community includes representatives from social, political, and economic domains who openly discuss various dimensions of uncertainties, strengths, weaknesses, and ambiguities in the available body of scientific evidence and its implications for all stakeholders with respect to the issue at hand.



Malin Falkenmark. *Towards integrated catchment management: opening the paradigm locks between hydrology, ecology and policy-making*. (2004) International Journal of Water Resources Development, 20:3, 275-281.

People and Entities Necessary to Achieve Solutions

Complex water issues involve:

1) the natural world and physical structure made to manage the natural world;

2) the institutional structures designed to manage society;

3) industries, farms, businesses and citizens who live in and benefit from the natural world and society

Each water issue to be addressed requires that the correct group of people and entities be assembled. The typical list of the categories of participants includes:

- Policy Makers whose primary roles concern control, facilitation and prioritization
- Experts who focus on the linkages between the physical and social sciences
- Business, industry, consumers and environmentalists who advance specific needs

Additional considerations to be taken into account in determining the group of necessary people and entities:

Broader participation will assist with adequate social acceptance and active compliance with formal rules and administrative regulation.

Regular interaction between groups in the process could result in improved relations which had been characterized by mistrust.

Industrial and domestic water users will increase their demand for water in coming decades leading to potentially greater conflict with existing users

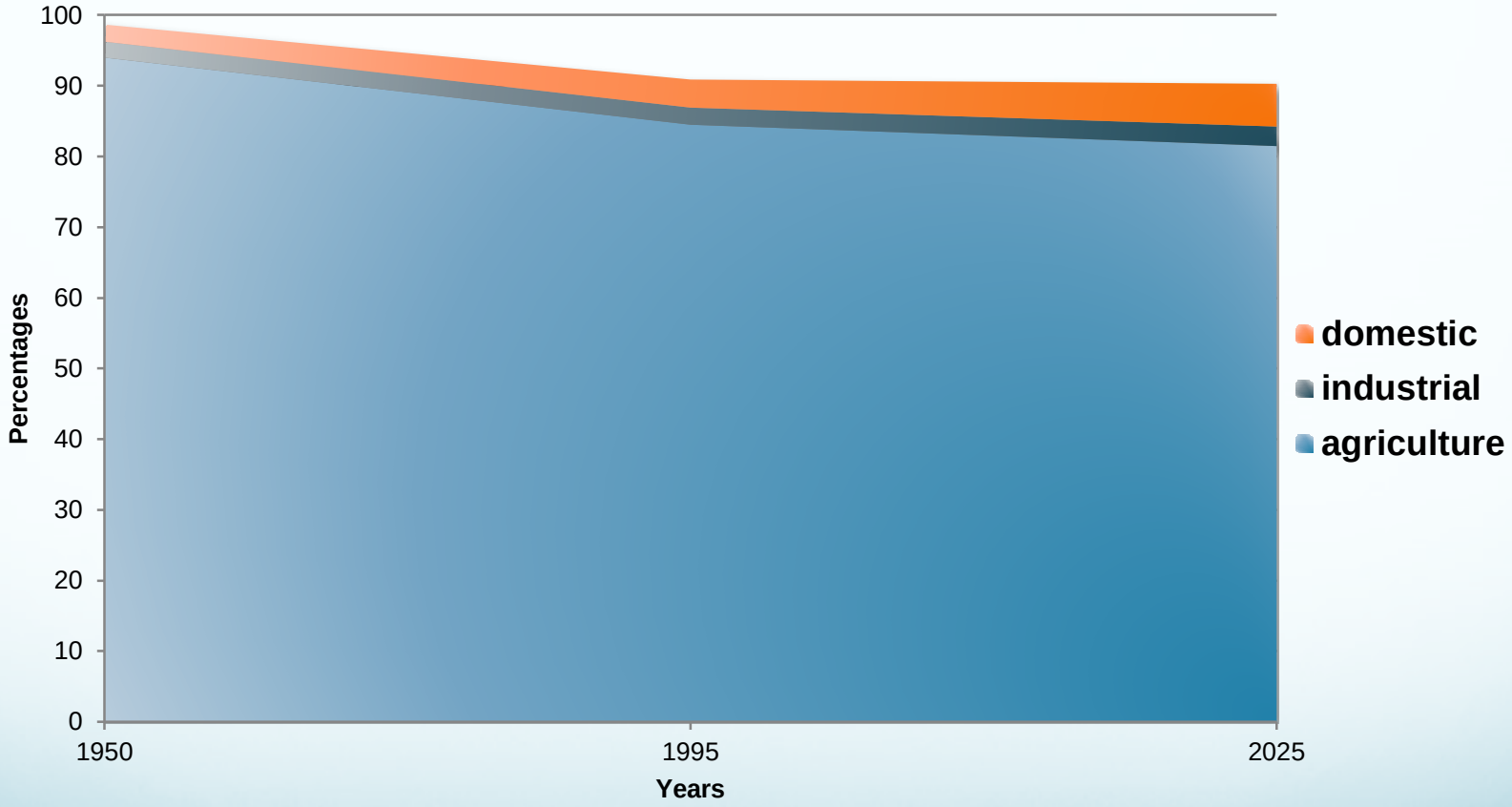
Table 5 Ratio of water withdrawal and consumption to total water withdrawal and consumption by sectors o economic activity (%) by continents (adapted from Shiklomanov & Rodda, 2003).

Continent	1950			1995			2025		
	Agr	Ind	Dom	Agr	Ind	Dom	Agr	Ind	Do
Water withdrawal									
Africa	90.5	7.0	2.6	63.0	8.1	4.4	53.1	18.0	6.
Asia	93.4	2.4	4.2	80.0	6.9	9.9	72.0	9.5	15.
Australia & Oceania	50.0	7.2	39.4	51.0	10.9	23.5	46.8	11.3	26.
Europe	32.2	25.4	41.2	37.4	14.7	44.8	37.2	14.0	45.
North America	53.5	7.9	36.0	43.5	10.7	41.5	41.4	12.3	41.
South America	82.4	9.5	7.9	58.6	17.2	15.4	44.2	22.7	23.
World	78.1	6.3	14.8	66.1	9.1	19.9	60.9	11.6	22.
Water consumption									
Africa	97.9	1.6	0.5	63.8	1.5	0.8	60.5	3.4	1.
Asia	98.0	0.7	1.1	91.0	1.5	2.3	88.4	1.8	4.
Australia & Oceania	81.3	2.0	9.9	69.1	2.2	3.1	64.1	2.1	6.
Europe	67.7	12.6	15.6	71.4	5.6	15.3	66.8	4.3	22.
North America	83.5	4.7	3.6	75.1	5.0	7.2	72.4	6.0	7.
South America	95.0	2.5	1.9	76.4	4.0	3.2	67.4	4.7	8.
World	94.0	2.2	2.5	84.5	2.4	4.0	81.5	2.7	6.

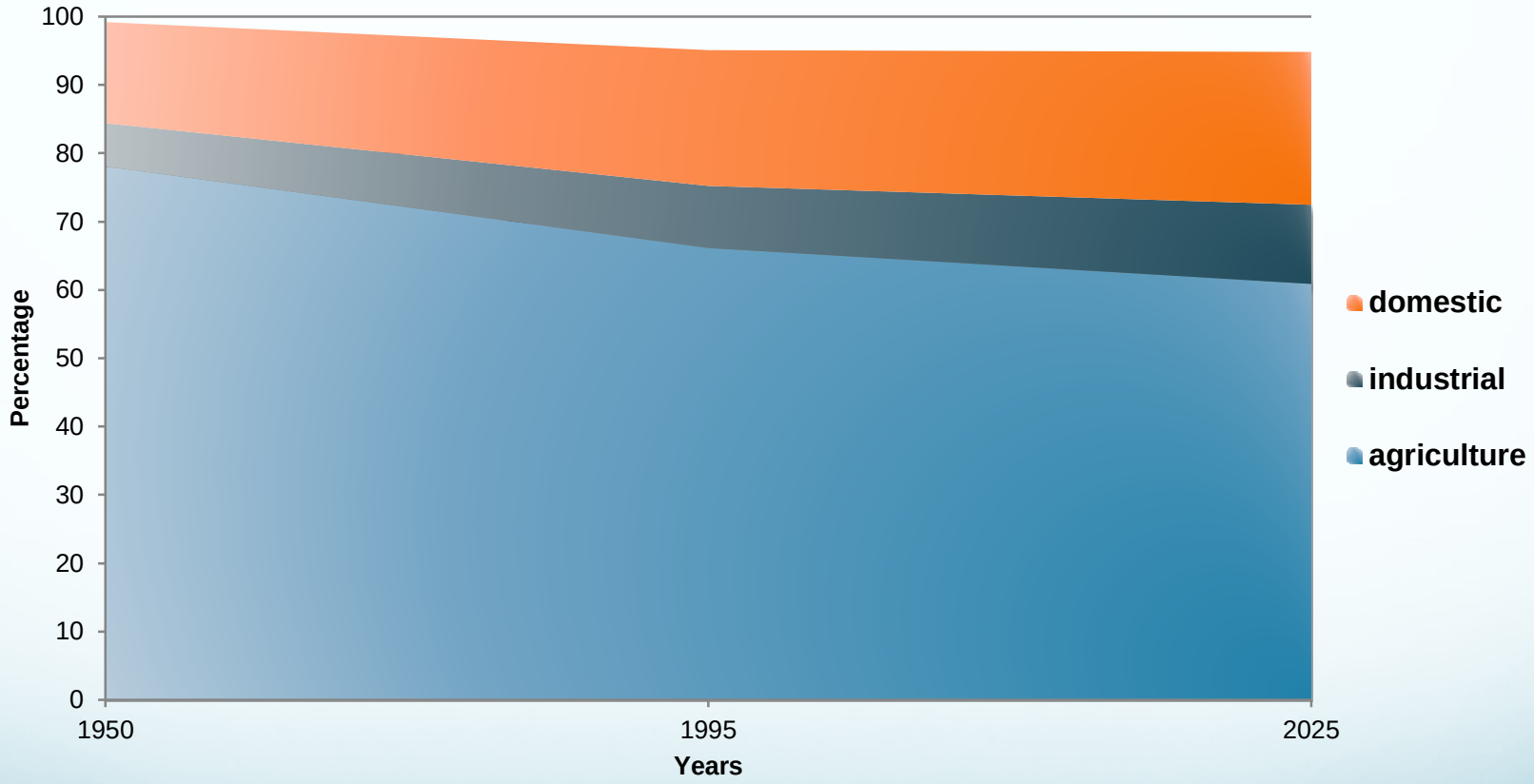
Agr: Agricultural; Ind: Industrial; Dom: Domestic.

Sivakumar, B. (2011) Water crisis: From conflict to cooperation—an overview. *Hydrol. Sci. J.* **56**(4), 531–552.

Changing Worldwide Water Consumption by Use



Changing Worldwide Water Withdrawal by Use



Communication

A key factor in resolving water issues within the designated group and then gaining the attention of society to implement the proposed solutions is proper and effective communication with the people and entities whose cooperation is necessary.

Effective communication requires:

1. Respect

2. Language your audience finds understandable and useful.
    - Limit the use of jargon and acronyms
    - Limit the use of abbreviation unless truly warranted and if truly warranted, then define and use consistently with accepted practice in branch of study and within document/presentation
    - Limit the need for your audience to consult a dictionary

3. Presentations and documents that clearly state issues, analysis and conclusions avoid ambiguity and misunderstandings.

Read the excerpt from a homeowner's policy on the next slide. Determine whether the insurance company is obligated to pay for damages caused by dripping honey that occurred after the homeowner exterminated a hive of honeybees that had been living in a hive in the attic of his house.

***Roberts v. State Farm Fire & Cas. Co.*,** 146 Ariz. 284, 705 P.2d 1335 (Az. Sup. Ct. 1985)

We insure for all risks of physical loss to the property described in Coverage A except for loss caused by: ....

6. wear and tear; marring; deterioration; inherent vice; latent defect; mechanical breakdown; rust; mold; wet or dry rot; contamination; smog; smoke from agricultural smudging or industrial operations; settling, cracking, shrinking, bulging, or expansion of pavements, patios, foundations, walls, floors, roofs or ceilings; birds, vermin, rodents, **insects** or domestic animals. If any of these cause water to escape from a plumbing, heating or air conditioning system or household appliance, we cover loss caused by the water. We also cover the cost of tearing out and replacing any part of a building necessary to repair the system or appliance. We do not cover loss to the system or appliance from which this water escaped. **Any ensuing loss from items 1 through 6 not excluded is covered**.

- 4. Communication should be in a form useful to the end user.

- 5. Communication should be frequent and regularly scheduled.

Governance

Decision Making by a Group (Bottom Up)

- One paper describes the successful efforts to manage the Em River Basin which involved many competing interests. In that case the group included: local government agencies, angling associations, local history associations, pulp paper factory, and nature conservation association.
- Decision-making was by consensus. If common agreement on an action could not be reached with a large majority of the stakeholders, then the action was not taken.

Collaborative governance

"Collaborative governance" often entails efforts generated from the bottom up, where government is involved but does not necessarily lead the process.

A key feature of collaborative governance, especially for environmental management, is the creation and action over time of deliberative partnerships that create and implement management plans.

Mandated Participatory Planning

Mandated participatory planning (MPP) has been used by the Water Framework Directive to implement policy. It involves multi-level governance, participatory governance, and nested policy cycles.

Participatory governance is the inclusion of affected stakeholders, especially non-governmental parties, in policy making.

It operates by higher levels of government structuring lower-level participatory planning.

Modelling Can Aid in Decision Making

The creation and refinement of a model furthers communication because it:

- reveals assumptions that may otherwise not be articulated

- requires decisions on concrete, tangible issues

It can generate probable results of a variety of decisions under consideration.

It can provide probable results in a shorter time than the result of a particular decision would materialize if actually implemented.

It can alert the group to potentially adverse responses to a particular decision.

It can provide support for a particular decision or group of decisions

Examples of Models that have been developed to address specific issues

- FARM is a decision support matrix (DSM) designed to allow farmers and land use planners to investigate certain land units and land management practices in terms of runoff and flood generation and highlights measures that can be implemented to mitigate these.
- Desert Research Institute (DRI), in collaboration with SAHRA, developed a model to test the plausibility of developing a water leasing system for the Middle Rio Grande basin

SWAGMAN Farm is being used to help guide whole-farm water balance and net recharge options for environmental management. It can also compute an optimum mix of crops for which the water table rise and soil salinity remain within the allowable constraints for given hydroclimatic conditions while economic returns are maximized.

This model integrates agronomic, climatic, irrigation, hydrogeological and economic aspects of irrigated agriculture under shallow water table conditions at a farm scale.

Conclusions

The evolving methodology of transdisciplinary research applicable to complex problems provides a good framework to address the major water issues facing society.

- The complexity of the issues requires that they be accurately portrayed which means clear statements of assumptions and the uncertainty inherent in the problems and possible solutions.

- Research teams should be transdisciplinary and should include those additional entities and people necessary to find and implement a solution or set of solutions to a well defined problem.

- Appropriate structures should be adopted by the groups to:
  facilitate research and communication,
  provide education regarding the water issues and
  implement solutions