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A Model for Developing Integrated and Sustainable Energy and Water Resources Strategies

Ezio Todini

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A MODEL FOR DEVELOPING INTEGRATED AND SUSTAINABLE ENERGY AND WATER RESOURCES STRATEGIES

The aim of this paper is to illustrate a model for developing planning strategies towards sustainable energy and water resource development. Water resources management policies around the world have used widely diversified approaches, since the pattern of development varied in different countries, but general trends are discernible. The traditional planning approaches that dominated last century showed a reliance on physical solutions, major new constructions and large scale water transfers from one region to the other. Today, the planning and decision processes begin to explore efficiency improvements, implement options for managing demand, and reallocate water among users to reduce projected gaps and meet future needs. Following the general principles set forth by the World Commission on Environment and Development (1987), the European Water Framework Directive (WFD) has stressed the necessity of an integrated and sustainable water resources management approach, for improving and maintaining environmental quality, using tools such as full recovery of the costs incurred in water supply, including environmental costs.

Introduction

The global water crisis is mainly one of governance. It will therefore continue if the inertia of the governing class persists; water resources will continuously diminish as a result of population growth, pollution and foreseeable climate change. At global scale, the challenge is to awaken the necessary political will to meet commitments concerning water resources and to avoid dealing with the subject with rhetorical declarations and grandiloquent promises. A number of open questions need the appropriate answers:

- How much have we advanced the awareness of humans (including politicians)?
- In what direction should we go to advance the awareness of people further?
- How can we put water into the minds of people?

Although the experience from developed countries indicates the need to establish the right balance between the market mechanisms and government interference as well as among technical/technological aspects, energy management and social aspects, all the water development and allocation plans seem still to follow a top-down approach, where the 'participatory approach' is only meant as the 'blessing' by the public of already taken decisions.

Even with increasing attention to integration of environmental and social objectives into economic decision making and sectoral strategies, better political understanding is needed of the complexity and drivers of sustainable development. In the absence of better political understanding of these, economic growth remains the predominant driver for the policies of most countries and territories. Short-term economic gains, especially in the conditions of low gross domestic product (GDP), seem politically more attractive than the longer-term benefits associated with integration of sustainability requirements into policy making.

Therefore, there is the need for shared objectives and participated 'description' of all the aspects and facets that may result from the planned resources allocation and management

policies, which suffered in the past (and still frequently suffer today) from top-down approaches. In other words, more than the search for optimised policies, there is the need for a comprehensive description of the overall physical-environmental-social-economical system to make politicians, technicians and in particular stakeholders and end-users, not only able to understand the advantages descending from the proposed strategies, but, most of all, to be aware of the short and long term positive and negative consequences that may arise from their implementation. This description includes a fact finding and analysis phase, in which the real needs of the end-users are established with a participatory approach, followed by a synthesis and communication phase, where the effort has to be placed on the definition of clear and understandable indicators. The clearness of indicators and the ways in which they are communicated to the stakeholders is a fundamental step towards participated decisions, as requested by the WFD. It is in this context that alternative indicators to the GDP, such as:

- The Gross National Happiness (GNH) (Brooks, 2008);
- The Genuine Progress Indicator (GPI) (Talberth et al., 2006);
- The Happy Planet Index (HPI) (New Economics Foundation, 2009),

have been proposed in order to provide a more realistic measure of welfare, quality of life and quality of ecosystems and environment. Unfortunately a wide and more or less official consensus on these new indicators has not yet been reached and they are still unsuccessful experiments to overcome the GDP concept.

The Dominant and the Shifting Paradigms

The term 'paradigm' has been recently introduced, beyond its original Ancient Greek definition, to describe a set of assumptions about reality held in common by a group of people. Philosophers have discussed its true meaning for many years. To ensure the understanding of the word 'paradigm,' a terminology definition is presented along with some of a paradigm's characteristics.

A paradigm may be defined as a set of rules and regulations (procedures, standards or routines) that:
1) establishes boundaries, namely gives the edges or the borders, and
2) provides solutions to problem-solving within those boundaries.
A paradigm is formed through a set of procedures. It is a sign of maturity in the development of the solution to any given problem. Before its formation there is a continual competition between various views that represent incommensurable ways of seeing the world. The laws, theories, applications and instrumentations that are used form the paradigm (Kuhn, 1970).

In water resources management, the word 'paradigm' describes a school of thought on prioritizing policy options for the management of water resources. The formulation of a paradigm is a difficult and complicated procedure as it reflects the conflicts between the established scientific and technological approach and the political and social opinions and demands. In order to define the range of, and collect, concepts that describe structural (dams, pipes) and human (administration, financial management) parameters of a water system, one must understand the technical, social, financial, cultural and environmental issues of the paradigm.

The understanding of the existing policy options and actions that have been followed in order to manage water resources and their theoretical background, leads to identification of some basic and distinguished paradigms of water resources management for each region.

Therefore, a dominant paradigm for each region is the existing, traditional way of 'how things have always been done.'

Each paradigm refers to the:
- geographical entities and their grouping regarding physical and human criteria,
- driving forces like population or economic activity trends,
- physical parameters of the available water resources (state, uses, effects),
- planning and measures regarding the available resources.

The first point offers the case studies for the paradigm, the second and third points introduce the analytical methodology and the qualitative and quantitative elements, whereas the fourth point provides the axiological, theoretical and practical socio-economical and political background.

The twentieth century water development paradigm was based mainly on finding new sources of supply to meet new demand. The construction of massive engineering projects for flood control, water supply, hydropower and irrigation, besides having undeniable benefits, also has costs that are not purely economic, such as ecosystem degradation and water resources contamination. As these impacts become more obvious, the approach of water resources development starts to change. A shifting water paradigm is now advocated, which puts the emphasis on incorporating ecological values into water policy. The shifting paradigm is an alternative prioritizing of policy options, and respective actions, aiming at achieving integrated water resources management, particularly in water deficient regions, in a sustainable way.

This shift towards a new paradigm is what is currently being achieved in Europe through the WFD (European Parliament, 2000). The WFD has introduced a new model of water management and planning, which has been prepared in order to accomplish a more effective governance of water in the environment. The directive enforces new structures and behaviours that aim to accomplish integrated water resources management and maintain or improve the environmental integrity of aquatic systems. The current, dominant paradigms will therefore need to shift, as the passage of enforcement deadlines continues, in order to accommodate the legislative aspects of the WFD.

In order to describe both the dominant and the shifting paradigms, one can utilize the indicators already determined in the DPSIR (Drivers-Pressures-State-Impacts-Responses) approach (Smeets et al., 1999), which describes the processes taking place under different sets of conditions. The responses to the state of the water resources, the pressures applied to them and the impacts those pressures have can be used to define the current paradigm in managing the water resources.

Table 1, taken from Grigg (1996), presents elements regarding practices that were used as the dominant paradigm and those that can be used as the shifting paradigm.

The DPSIR Indicators Approach

The DPSIR concept (Smeets et al., 1999) can be used as a basis for a framework to identify and develop indicators for integrated water resources management on a regional scale. The DPSIR framework identifies cause-effect relationships, allows for the separation of categories of issues and provides flexibility for usage and analysis. In this section the main elements of the DPSIR approach are defined, while in the next sections an effort is made to identify the main elements of the DPSIR framework for the regions analyzed.

Practice	Paradigm	Dominant	Shifting
Governance	Authority	Command and control little regulation or participation	Distributed authority, coordinated approach, more regulation, more stakeholder involvement
	Regulatory structure	Weak regulations	Stronger regulations
	Centralization	Centralized	Decentralized
	Process	Simpler, more authoritarian decision-making	Searching for new processes for coordination and conflict resolution
	Ownership	Mostly public ownership	More flexible approach, more privatization
Coordination	Geographic	Little basin or area-wide coordination	Watershed and area-wide approaches
	Competing uses	Priority uses such as irrigation dominated	More complete consideration of competing uses, including environmental
	Purposes	Fewer purposes	More purposes
	Values	Focus on economic goals	Balances values with appropriate consideration of social and environmental values to go along with economic and political
	Stakeholders	Less involvement of units of government and stakeholders	Consideration of views of wide range of stakeholders
	Disciplines	Engineering dominance	Multi-disciplinary
Technical	Hydrologic	Focus on yield of hydraulic structures and systems	Focus on natural systems and sustainability
	Administrative	Simpler command-and-control administrative systems with less regulation and participation	Dynamic process adapting to changing conditions
	Legal	Water law focused on allocation with less emphasis on environmental issues	Extensive bodies of statutory, administrative, and case law
	Engineering	Focus on structural solutions	Consideration of wider ranges of options to include non-structural and management strategies as well as structures
	Planning and assessment	Focus on economic issues	Extensive use of sophisticated planning tools to identify and assess alternatives throughout the planning and decision cycles
	Economic	Traditional benefit-cost analysis	Identifies full range of economic water needs and economic tools for use as incentives
	Ecological	Not very evident in water management	Identifies and considers full range of ecological water needs
Information Technology		Centralized control of limited information	Distributed control of much information on real-time basis
Financial	Fairness and equity	Not very sensitive to social issues	Considers social aspects of financial resources to provide appropriate solutions
	Feasibility	Less stress on ability-to-pay	Advances affordable options
	Subsidies	More subsidies	More market-based
	Continued improvement	Not evident in old paradigms	Enhances water quality and quantity
Education and Ethics	Stewardship	Weakly valued	Added emphasis on stewardship of water resources
	Sustainability	Not in old paradigms directly	Managed on sustainable use basis
	Contributions to society	Less emphasis on contributions to society	Fosters public health, safety, and community good will
	Capacity building	Little attention to capacity-building	More attention to capacity-building

Table 1: Elements of Water Management Paradigms (Grigg, 1996).

The DPSIR categories are defined as follows:

- Driving force indicators reflect pressures exerted by natural phenomena and anthropogenic activities that, in general, cannot be easily manipulated but provide essential information to understand the regional context.
- Pressure indicators reflect the pressures exerted on water resources and the water use groups of a region, as a result of the driving forces.
- State indicators assess the current status of water resource.
- Impact indicators assess the effect that pressure has on the state of user groups and resources.
- Responses relate to the social response via policies, laws, measures etc.

These indicators are relevant to the formulation of water resources management paradigms, mainly through analysis of the responses selected to adapt to drivers, relieve pressures, face states and mitigate impacts under conditions of water deficiency (see for example in Table 2 the strategies defined for water resources management in the EU funded project WaterStrategyMan, 2004). The differences in responses between regions suggest the presence of different schools of thought with regard to water management. The dominant paradigms of each region are therefore reflected through these responses, as they have evolved over time under the specific conditions of each region and each distinct country.

There are a number of questions to be answered:

1) Does the present dominant paradigm lead to sustainable management strategies in water resources and energy production?
2) What are the shifting paradigms that can be chosen in the country and/or in the region that can produce sustainable management of water and energy?
3) Can consensus be found on indicators representative of the present and future status?
4) What is the improvement produced by the alternative management strategies with respect to 'business as usual'?
5) What is the impact of climate change on water and energy availability and how can alternative management strategies support adaptation measures?
6) What is the impact of uncertainty in the assessment of the future (climate, demand, available technology, etc.) on the obtained results?

Strategic Policy Options	Actions
a. Supply Enhancement	a1. Unconventional/untapped resources a2. Surface waters and precipitation (direct abstraction, dams, reservoirs) a3. Groundwater (bore holes, wells) a4. Desalination a5. Importing a6. Water reuse
b. Demand Management	b1. Pricing b2. Quotas, regulated supply b3. Irrigation method improvements (drip irrigation, enclosures) b4. Conservation measures in the home (water saving plumbing systems) b5. Recycling in industry and domestic use b6. Improved infrastructure to reduce losses (networks, storage facilities) b7. Raw material substitution and process changes in industry
c. Social Development Policies	c1. Change in agricultural practices (low irrigation crops, genetic improvement) c2. Change of regional development policy (tourism/agriculture limitation)
d. Institutional Policies	d1. Institutional capacity building (education and awareness campaigns, use of standards, public participation, stakeholder involvement, conflict resolution, contingency planning) d2. Economic policies (water pricing, cost recovery, incentives) d3. Environmental policies (enforcement of environmental standards and legislation, monitoring, penalties and fines, impact and risk assessment)

Table 2: Possible Strategic Options in Water Resources Management (WaterStrategyMan Project, 2004).

Integrated Planning Approaches

Water and energy can be viewed as part of a unique problem, namely the exploitation of natural resources, which implies noticeable feedback effects on the socio-economic welfare from human beings, on the ecosystems and on the environment. Therefore, following the consideration expressed in the introduction, a sustainable planning approach to water resources and energy exploitation implies the use of integrated planning, where all the components of the problem and their future interaction and trends are analysed. The integrated planning approach, must be based on:

An assessment phase, which includes (1) a fact finding phase and the analysis of the present state (the dominant paradigm); (2) the assembling of all the necessary information into a unique geo-referenced and relational database; (3) the definition and description of the stakeholders and of the inter-relations and the feedbacks among the different sub-systems (economic, social, environmental, etc.); (4) the gathering of proposed development plans and the definition of alternative plans and measures (the shifting paradigm); and (5) the consensus on a number of simple but effective, indicators to be clearly understood by the politicians, the stakeholders and the end-users.

A planning phase, which includes (1) the definition of scenarios relevant to the drivers (such as population growth, land use patterns, climate change, etc.) and the pressures (water and energy demand, water and energy supply sources, wastes generation, etc.); (2) the definition of strategies, namely the combination in time of scenarios and intervention or management options; (3) the simulation of the different alternative strategies over predefined time horizons; and (4) the analysis of results in terms of the defined indicators and the selection of the most appropriate strategies.

Accordingly there is the basic need for integrating all the available data. The integrated planning approach implies the setting up of a geo-referenced database which will allow integration of all the information, ranging from the historical data to the future scenarios, from the dominant paradigm to the shifting paradigm options, from the strategies to the indicators. This allows for the development of appropriate decision supporting tools that will enable (1) capacity building; (2) verification and traceability of the planning strategies adopted; (3) dissemination of results towards the stakeholders and in particular to the public; and (4) updating in time of the planning phases. Also, capacity building is an essential prerequisite to the integrated planning of water and energy resources due to the complexity and the interdisciplinary requirements of sustainable planning towards the definition of a common technical language and understanding, using the same tools to be implemented.

Concluding Remarks and Foreseeable Future

Although national plans may have been prepared for energy production and water resources exploitation, which include plans for drinking water, irrigation, sanitation and flood control, in many countries of the world, the present water resources and energy exploitation is far from being fully satisfactory.

Today, one of the major stakes in energy and water resources exploitation is sustainability, namely the capacity of reconciling high efficiency and effectiveness of interventions with the environmental compatibility and the actual needs and demands of the populations involved, who may be significantly affected by the foreseen climatic changes, as anticipated by the Intergovernmental Panel on Climate Change (IPCC, 2007).

In order to reach sustainability, which implies shared objectives and participated 'description' of all the wide variety of aspects stemming from the water allocation problem, there is the need for a comprehensive description of the overall physical-environmental-social-economical system to make politicians, technicians and in particular stakeholders and end-users, not only able to understand the advantages descending from the proposed strategies, but, most of all, to be aware of the short and long term positive and negative consequences that may arise from their implementation.

The main objectives for a national energy strategy are commonly declared as:

a) to guarantee security of energy supply;
b) to enhance an efficient and economic use of energy, with minimal environmental impacts, in order to support the sustainable development of the whole economic sector.

While the key issues and challenges in water resources exploitation are:

a) to carry out a comprehensive water resources assessment, including inter alia an evaluation of the current institutional set-up, water resources and demand inventory, regional water balances and assessment of water quality issues;
b) to review and update the legal instruments (amendments of Law on Water Resources and Environmental Protection, passing of additional regulations, etc.;
c) to support institutional capacity building for most urgently needed water administration units, in particular for licensing and enforcement, and preparation of river basin hydrological plans;
d) to improve management and enhance protection of groundwater sources;
e) to prioritize investments on dam safety, flood protection, wetlands conservation and restoration and watershed management.

Clearly, in order to meet several of these objectives, and at the same time retain clear and meaningful indicators, it is necessary to operate through appropriate higher level decision support systems, such as the one proposed by Todini (2008), which must allow for the integration of all the above mentioned aspects, the evaluation of the different decision alternatives at stake and the generation of the appropriate indicators. In addition, it implies the need for an essential capacity building programme aimed at creating in each country a local task force of technicians who, in collaboration with international and local experts in the different fields (economy, sociology, ecology, water resources, energy, etc.), will perform a fact finding exercise, assemble all the information in the decision support system, define and describe the inter-relations and the feedback among the different sub-systems (economic, social, environmental, etc.) and translate the results into simple but effective, shared indicators to be clearly understood by the politicians, the stakeholders and the end-users.

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Insights is edited by Michael O'Neill, IAS Director and Professor of English.
Correspondence should be directed to Audrey Bowron (a.e.bowron@durham.ac.uk).