Water resources and human behaviour: an integrated landscape management perspective

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ABSTRACT: A two sides balance can be drawn from the last 20 years of active intents to change local, regional and global policies concerning water and global environment issues. On one hand, as a consequence of the "sustainable development" model, there is an increasing awareness of the issues in stake, and environment became a core part of any public policy. International conferences and the investment in scientific research in these areas are an expression of this. Yet, concerns are growing in face of the increasing stress imposed on freshwater resources, climate change and the difficulties to achieve international consensus on specific strategies. This was the focus of discussion in the international conference on climate change organised in Nagoya in December 2010, by ICSS, ICSU and ICPHS. A revision of the conceptual approach to sustainable development, moving beyond a strictly socio-economic understanding of human behaviour and incorporating, as basic strategies, the dimensions of culture, didactics of dilemma and governance, is currently being applied in some scenarios, hopefully with a better result. The paper discusses water resources in the context of climate change from this integrated perspective.

KEY-WORDS: *Integrated landscape management; development; sustainability; water management.*

Conceptual issues

Two decades after the Rio 92 Earth summit, twenty five years after the Brundtland report (COMISSÃO, 1991), it is amidst growing concerns that a new summit is being prepared, in any case with very low expectations. The conference on eco-hydrology was organised in Tomar with these concerns at the backstage: water management is crucial for any human strategy, but water management policies alone face increasing challenges and tribulations. In this paper we intend to briefly discuss this wider context for water management, clarifying concepts and methods, leading to a somewhat different operational scope (BATISTA, 2011). We believe that case studies demonstrate how such an approach renders specific policies (namely water or natural hazards management ones) more resilient in times of change, namely through increasing response capacity to natural or human induced hazards.

Public awareness of global environmental changes undoubting growth had an enormous impact in public policies, from environmental protection legislation to the establishment of environmental ministries and agencies. The private sector has to a large extent embraced the topic, and failure to meet the targets set twenty years ago cannot be simply assigned to lack of interest or engagement. Yet, despite all efforts and speeches, the planet is today in a worst condition, should one consider environmental, social or economic issues (OOSTERBEEK, 2010). There is growing stress on freshwater resources, not enough decrease in pollution indicators and certainly no detailed strategic consensus involving all major stakeholders. These difficulties are reinforced by the perspectives of social disruptions (evident across the globe) and a significant reduction of the economic growth rate.

In this context it is useful to look at previous processes involving human groups. Adaptation to climatic changes in the past (MIRANDA *et al.,* 1986) was always a sequence that combined increased mobility (in almost all cases, people having to move in order to look for a better environment) and technical innovation. Only when both of these were present did humans succeed to avoid the trend that in general comes along with such changes: major extinctions. It may also be understood that mobility was primarily triggered by water shortage. In fact, the shortage of other basic resources can be solved through changing the economy or improving logistics, but this is much harder when one considers water. This overdependence became even greater since, some 10.000 years ago, agriculture started to rapidly become the new structural organiser of territories. The spread of farming is, also, a story of technological advances and growing mobility, through which trade became increasingly important (to serve hereinafter settled groups that would face growing difficulties in the procurement of long distance goods). From then on, evolution has been associated to growing economic and social complexity, this engaging growing energy consumption. Without growth there is no sustainability, and without sustainability there will not be evolution, only collapse (OOSTERBEEK, 2006). With no surprise, all past civilisations collapsed from within, even when with the "help" of outsiders, due to the collapse of the communication and transportation networks. Entropy expresses itself in a very clear way in social and economic networks, whenever their universe is no longer expandable (as to a certain extent is the case today).

There are four main mechanisms that have conditioned transition periods, as the current one we're living in: water management (by no accident a crucial component of all early civilisations), mobility of people, artefacts and commodities (this is at the core of the European Union strategy – MICARELLI, 2002), urbanisation (people turning their back on the countryside and moving into villages and towns, today by the millions, but already 2 millions in ancient Rome – with the technology then available!) and technological divides and disruptions. It is easy to realise that there is no current planetary strategy to any of theses mechanisms.

Traditional responses to social stress deriving from these mechanisms are of two types: social fission (lower energy costs, technological simplification) or up-grading complexity (higher energy costs, technological complexity) focused on major hydraulic constructions (camellones, dams, reservoirs). Today, new strategies (from planetarian water management to a new "Bretton Woods" monetary pact) are required for a new scale of phenomena: globalisation and the so-called "big acceleration" (SANTOS, 2007).

But humans only move in response to given stimulus, and the big acceleration, in all its dimensions (and not only the environmental one) is hardly perceived by most people.

In order to understand why this is so, one must understand how human knowledge and awareness is built, building this understanding from a compound of various disciplines (MAX-NEEF, 2005). Each unit of information is processed and framed within a threefold notional structure: space, time and causality. In fact, to provide non magic causal explanations, it is fundamental to establish sequences through time, understanding its irreversibility, a notion that is not evident at all (FIGURE 01). Out of the three notion, only the first, space, is accessible through a sensorial intelligence (we "feel" where we are), but it is only through a more elaborate reasoning (where technology, i.e., the combination of abstract knowledge with practical techniques, plays a major triggering role), that the notion of time can move beyond circularity and magic. It is because "I make something through a sequence of choices and actions" that "I understand physical causality". Needless to say that in contemporary society, namely for the last four decades, technology became less and less mastered by individuals (as Chaplin foresaw brilliantly in "Modern Times"), this entailing a growing alienation. And alienated people cannot understand the processes of change and the adequate mechanisms to face it.

Processes

In order to set people on the move, towards a new direction and mostly towards new operational strategies, water is an excellent structuring axis.

For centuries humans harnessed rivers for their own purposes, built dams for water reservoirs and hydroelectric power production, dredged, widened and straightened to aid navigation, improve land drainage alleviating flooding, and stabilised land to prevent the loss of buildings and bridges or to protect farmland. All these interventions change the original behaviour of a river and may lead to instability problems, only solved by heavy engineering interventions with consequences to the conservation and amenity value of the riverine environment.

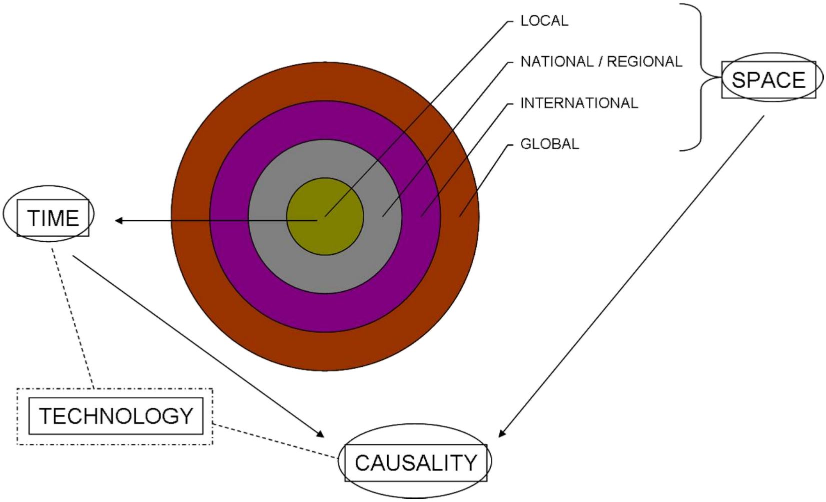

Figure 01

How the notions of space, time and causality relate to scales of mobility and to technology

Integrated landscape management (ILM) is nowadays recognised as fundamental to sustainable management of the world, with particular emphasis on freshwater, as it will be moreover, the main resource for human settlement and survival. The European Union Water Framework Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy *Official Journal L 327, 22/12/2000 P. 0001 - 0073*, implement water resources and ecological assessment as main contributors to the analysis, to provide the basis for management and restoration of hydrological networks. The USA, show a long use of biological surveys to regulate water quality which become a widespread approach, starting from the 1987 amendments to the federal Clean Water Act, where section 101(a) states that its primary objectives are to ‘‘restore and maintain the chemical, physical, and biological integrity of the nation’s waters’’ (MEBANE, 2001). Australia followed the trend, using nationwide water quality analysis through biological indicators since the mid 1990s, to guide water management agencies as well as the National Water Initiative in 2004. In South Africa a national monitoring program has also been developed (ROUX *et al.,* 1999) using ecological assessment, and further developing their knowledge of the biological indicators. Biological measurements provide direct information on the condition of biota resident in the water resource, and therefore on the overall ecosystem condition. The obvious importance to management issues, with direct analytical information, can provide a more sensitive time-integrated assessment of river condition, whereas, physical or chemical variables have in many studies been determined as a insufficient methodological approach in certain environmental conditions (OBERDORFF *et al.,* 2002; NICHOLS *et al.*, 2006; DAVIS *et al.*, 2006).

Environmental conditions are a decisive variable in terms of Ecological status determination, in many highly variable seasonal water distribution rivers, where reference sites observe deterioration of their ecological bio-assessment status during summer lower flow levels, however chemical analysis of water determines outstanding quality. These facts may seem peripheral to European scientific geographic stronghold, however of major importance to the application of the WFD. These peripheral climatic variations have to be addressed thoroughly, being one of the main objectives of future research the streams where assessment conditions have a seasonal variation, the assessment of regions with wide span of climatic characteristics in the geographical coverage, which are complicated by a variable gradient of altitude and other environmental conditions. As one of many published researches states "The probable impediment to widespread adoption of predictive modelling for bioassessment is the need to produce models tailored to specific geographic regions and specific climatic conditions. This may incur significant costs in countries, such as Australia, which span a wide range of climatic zones." (DAVIS *et al.,* 2006). This requires an in depth knowledge of a wider set of variables and probably a new approach to recommended WFD in order to improve its implementation success. The solution may reside in the integrated landscape management where all variables may be considered as equal both in the ecological, historical and geographical scopes, based on a shared social awareness filtered through the various cultural understandings.

During the last decades natural integrity of river basins and low levels of anthropogenic impact within protected areas rose in society awareness to the social-economical value of freshwater resources (CONSTANZA *et al.,* 1997; NICHOLS *et al.,* 2006). Nevertheless activities, such as irrigation for agriculture and catchments for energy production pose various threats to water quality, flow reduction and ecosystem integrity (WARD and STANFORD, 1995; POFF *et al.,* 1997; RICHTER *et al.,* 2003; CHESTER *et al.,* 2006). Many natural aspects of rivers ecosystem are threatened, for example floods trigger fish to spawn, help insects to begin a new phase of their life cycle, reintroduce sediments and organic matter in streambeds, while very low flows may be critical to riparian vegetation, cause eutrophication and consequently death of aquatic vertebrates.

Most European rivers, as Japan, United States, and others in industrial regions, are now controlled more by humans than by nature. Rather than following the rhythms of the hydrologic cycle, they are turned on and off like pipe works. Societies gathered substantial economic rewards from these modifications to rivers. However, inadequate attention has been paid to the ecological side effects of this development, dismissing entirely the ecosystem functions and impacts on societies. In their natural state, healthy rivers perform numerous ecosystem services, such as water purification, floods and droughts control, and maintaining habitat for fish, birds, and other wildlife. They offer connection between continental interiors and coasts, bringing sediment to deltas and coastal shore, delivering nutrients to fish habitats and estuaries, and maintaining salinity balances. From source to sea in all four dimensions, river ecosystems gather, store, and move snowmelt and rainwater flowing their characteristic natural cycles (ODUM, 1971). Thus diversity and abundance of life in freshwater ecosystems reflect millions of years of evolution and adaptation to these natural rhythms, human activities took little over a century to alter most of these natural characteristics. All these are considerations that most students learn throughout the education process, thus being aware of the systemic nature of the life of rivers. Indeed, hydrology education is a powerful means to promote the understanding of what it means to be an integrated system.

Biodiversity loss, such as Egypt, where before the 1960s dams' diversity of fish accounted for 47 species of fish, whereas today only 17 species are known. The World Conservation Union estimates that 20 percent of the world's 10,000 freshwater fish species are at risk of extinction or are already extinct. According to the US EPA, 37 percent of freshwater fish species in the United States are to some degree at risk of extinction, as are 69 percent of freshwater mussel species (POSTEL, S. and RICHTER, B.). These are just some of the problems involving freshwater ecosystems, the study and understanding of each individual area is part of the larger ecosystem approach.

Integrated landscape management can be the path for new strategies to tackle the problem: we may not control the ways of the planet but we surely can learn from the past.

Methodology

An adequate method needs to build from these considerations offering a "back to basics" approach. Humans survival requires the establishment of networks of relations and activities within the environment (including other human groups) in order to meet needs (KANT, 1802). Economics is this network of relations and activities, and in this sense all humans do "the same" within a similar context and with a similar technology. Yet, humans do it through performances and representations, i.e., they do it in specific, unique, cultural ways, and these also determine the content of their strategies. Economy and culture are one same thing, looked upon from different perspectives. Therefore, there are cultural understandings of economics and environment and this must be the starting point for a methodological design.

Human adaptations to contextual changes are processes where each human group faces the relation involving environment, society and economics through its own cultural approach. This is a compound of acquired knowledge (socially transmitted and generated) and logistics (practical strategies to meet humans needs, based on knowledge and experimentation). The focal target for setting a human group into a dynamics of territorial integrated management must be the perceptions the group has of such territory, what we can call its "perceived landscapes" (SARAIVA, 1999). To design an ILM process one must, then, promote basic territorial units that may bring together into common grounds different and conflictive perspectives and interests, understanding that despite appearances, human behavioural diversity is very limited (FIGURE 02).

Besides structural tools (what we define as "territorial matrix"), technological tools are also very important, namely GIS, since these systems build from spatial coordinates into a time perspective, thus generating causal reasoning. Moreover, because they allow to manipulate variables, indeed they are useful to design culturally perceived landscapes.

Indeed, the integrated management of the territory has to support different types of instruments and systems strategy formulation, planning and management, properly articulated and representative of the agents involved in the service of sustainable development policies (SCHEUNEMANN, 2009).

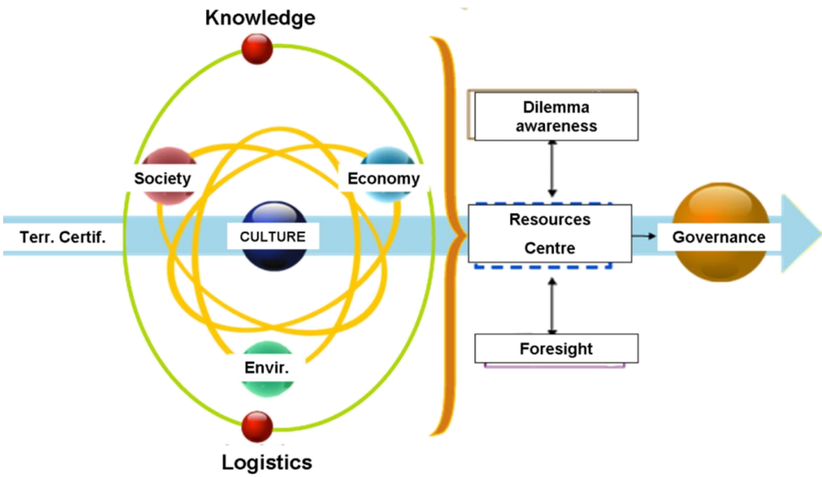

Figure 02
The flow of ILM

This allows for considerable different views of social dynamics in the territory, in its social, environmental and economic integration, made possible by the actions of intervention in the territory, creating structures and mechanisms for participatory governance (ANDRADE and ROSSETTI, 2009), and designing future scenarios.

As an example, part of the study and knowledge on water availability to potential uses of water has focused on its availability and quality, as it is the basis for the definition of policies for water resources management. This information can be done by using

Geographic Information Systems (GIS) mapping technology as a tool, not only for cartographic register but also as simulation models integrated with other spatial and temporal variables, which allow to understand the reality of integrated planning and support effective non-casuistic interventions.

The GIS are tools that enable the integration, manipulation, analysis and visualization of geographic information and their attributes, from a technological component (hardware and software). This manipulation of information is done according to certain methods of analysis and always within a particular organization and scientific field.

The real power of the GIS is its ability to integrate the analysis of spatial and attribute data. GIS systems improved user interfaces and expert systems to advise the user on how to utilize the existing database and software to obtain the desired resource information. Berry (1987) identified many advantages of the use of cartographic models. These models are capable of dynamic simulations and provide spatial "what if" analysis.

GIS tools are an important part of the ILM methodology as a support that facilitates the management of interactions between the physical and human activities, as well as with the sustainable use of resources. But for this administration to be effective one needs to access geographic information updated , to guide decisions, as well as the whole process of gathering information, allowing according to Reis, (1993) to synthesize thematic information through drawn images, symbols and graphic conventions, formalized by means of cartographic representations.
This information is translated into cartographic representations and interrelated, creating new documents which will support the implementation of specific actions of territorial management. The quality of this type of information should be ensured to obtain reliable results when crossing data and its subsequent analysis.

For instance, in the development of human activity based on climatology, should not be ignored the role of other physical variables in the evolution of climate and its impacts on socio-economic systems and political functioning GIS as tools to integrate and model the territorial realities .

In this context it is essential that public bodies make available information on WEB-GIS platforms, so that it is possible to perform spatial analysis for overlapping information, furthermore this information should be public and widely available.

One example is the National System of Information Water Resources (SNIRH), created by the Institute of Water (INAG) in Portugal, which provides free environmental data, including data on water, as well as a web-GIS platform, providing access to spatial data via "Web Map Service (WMS) " – an open format of "open Geospatial Consortium (OGC)" – with the aim of providing geographic information in a standardized way.

Case studies

This approach is being implemented in different specific contexts.

One example is Mação, a medium size municipality in the Tagus basin, in Portugal, affected by the increase of ageing population and decrease of overall residents, as well as by soil erosion and decay of former major economic activities. After major fires that dramatically affected Portugal in 2003 (a "natural" hazard induced by soil management policies), contributing to destroy almost the entire territory, an ILM strategy has been launched. As operational tools were created a centre of knowledge resources (Instituto Terra e Memória – a partnership involving the municipality, the Polytechnic Institute of Tomar and NGOs) and several so-called "spaces of memory", located in more remote and isolated parts of the municipality. As driving projects, apart from creating a common territorial brand ("Mação") and setting a very detailed GIS system for forest monitoring and management, a Museum specialised in Prehistoric Art (a major heritage of the basin that occurs in the municipality) became the core for several policies (youth, culture, tourism, education, quality production). The museum offers a permanent exhibition on the dawn of agriculture and the logics of human adaptations to environmental changes. Cultural heritage, namely the traditional cultural rural landscapes, became the main integration driver. In this way, the museum embraces education but, also, economics (since rural productions are still the main economic activities) or environment (its main content), and the model became also a media success, which contributed to counter the isolation effects of being an inland poor municipality. ILM became a major set of operational tools to organise an efficient response to the hazards occurred in 2003.

Another extreme example of ILM is the ongoing building of the Açu super-harbour, in Brazil, 300 Km north of the city of Rio de Janeiro (OOSTERBEEK/SCHEUNEMANN *et al.*, 2011). This is the largest private investment of Southern America, involving the establishment of a major logistic hub, associating mineral processing, long distance naval trade, shipyards, energy production and several other components, the whole covering 9.000 ha of constructions and involving a demographic regional growth from current 500.000 to well over one million. The method of ILM development was based in the same assumptions, and a resources centre was established (called "Centro de Conhecimento") alongside a still growing "spaces of memory" network. This dynamic is currently the cradle for integrative projects, from traffic planning to schools enhancement.

A further step in the process will be the establishment of regional observatories on ILM and its effects and an independent certification of the territories managed with this methodology.

In both cases, despite different driving themes was different (heritage in one case, the industry in the other), ILM proceeds by bringing together, in every step, the notion of dilemmas (and not only problems that may be solved), the strategy to improve critical thinking (fighting alienation) and the didactics of the 3+1 axis of ILM for sustainable development (environment, economy, society + cultures). And, in both cases, water management seats at the heart of the debates and strategies to pursue.

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