Standards Applied to Water Use: An Attempt to Build up Dynamic Indicators

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Abstract
Climate change, demographic concentration, new needs, sustainable development etc. are many examples of uncontrolled mutations in space and time, which impact on the degree of satisfaction of water needs in the world, and which call for a new analysis of the water issue. This new perspective, in this context of increased uncertainties, means that this has to be put into question. It involves, first, to have understood and assimilated the crucial role played by water in its natural, social, economic, cultural and political environment, by having identified the links which define Men-Water relations. Second, analysing the current water standards implies that we adopt the representation of reality they provide as a reading grid. Furthermore, it is also a way to wonder whether this grid corresponds to the future reality of human societies. Considering so would mean repeating the present development schemes. Not considering so would bring about a new approach, looking for new dynamic decision-making tools adapted to the realities of each field, in order to take into account present needs, as well as future ones. This process is in keeping with the premises of development strategies in a perspective of sustainable development.

Key words: Water; standards; indicators; sustainable development; water scarcity.
JEL Classification: C43; Q25; Q56.

1. Introduction

Nowadays, the multiple constraints with which water resources are confronted are reinforcing and intensifying (*i.e.* economic development and its corollaries, demographical dynamics, climate changes etc.). Thus, trying to tackle those questions requires a new analysis of the water issue in order to understand and assimilate the crucial role played by water in its social, economic, cultural, political and natural environment. This renewal implies a furthering in the knowledge of these questions in this context of increased uncertainties.

Since the notion of Sustainable Development (WCED, 1987) was defined, many environmental indicators have been developed, particularly since the Rio Conference in 1992. This trend was reinforced in the United Nations' Millennium Declaration in 2000 and the adoption of the Eight Millennium Development Goals. More specifically, the debate concerning water scarcity indicators appeared at the end of the 1980s with Falkenmark's "water stress" index. The question of water scarcity being both essential and topical, the debate has grown ever since, via the numerous contributions which have established water as a crucial element of development. Nevertheless, some points need to be clarified in order to build a decision support tool able to drive practices toward sustainable water use.

This paper proposes reflections in terms of water use standards, starting with the hypothesis that the latter constitute a reading grid of the relations which link Men and societies to water. A water use standard will be understood as the combination of three sub-standards for each type of use, *i.e.* a standard related to water quantity, another one expressing water quality, and finally, a process standard, linked with the notion of "best available technology". This basic typology, which is based on the one exposed by Barraqué (2005), could be developed later on, specifically as far as drinking water quality and environmental standards are concerned. Then, a development scenario for a given situation could be designed, comprising as many water use standards as required. When pooled together, these standards will figure a sequence for water use, combining in a meta-water use standard. Indeed, economic development objectives imply choices and decisions in allocating and using water. Standards simultaneously embody sectorial needs and the conclusion of tradeoffs resulting from power struggles and competing usage between these different sectors. Standards are intrinsically linked to social practices and specific social organizations. The generation of standards, as dominating and collectively acknowledged social practices, is brought about by complex processes of interaction. It results from a slow evolution of the man-water relations, and from the sometimes sharp changes that have characterized them. Understanding the water standardization process is essential in defining a new water management method.

However, we can wonder whether standards just constitute the ultimate outcome of a historical evolution and characterize a stage in the economic development process, or whether they can equally found it and help in building a new economic development process by defining appropriate water use.

Our findings suggest that there is no exclusivity. Indeed, standards mark out both the end result of a society's history and the starting point for its future. They are not only considered here as a prism through which a society's development path can be identified. They are also tools to determine a new type of water use by participating in devising scenarios for a water prospective aiming at reaching sustainable water use. First, standards allow regarding scarcity as a social fact and, thus, to manage it and not only to suffer from it. Second, they highlight the inherent complexity of the questions related to water, by integrating the socio-system and the hydro-system in an endless dynamic perspective which combines past and future, the former explaining the latter.

The structure of this paper enables to present what exists, to discuss it and finally to introduce research objectives for creating a new kind of indicators. Thus, the first part exposes the evolution of the debate related to water scarcity by studying the main existing indicators. Theoretical perspectives are coupled with this methodological overview. In a second part, we show that water scarcity is a social fact, precisely set in time and space, which calls for an integrated and dynamic approach. Taking water standards into account helps us characterize useful points for our future indicator. To conclude, the third part introduces the notion of complexity, inherent to the question of water. By proposing a new methodology to link water resources and water requirements and by highlighting the centrality of standards, this paper tries to open perspectives in favour of needs-based water management.

2. Method: Conceptual and Theoretical Analysis

2.1. Overview of Water Scarcity Indicators

Setting as a starting point the review of the evolution of the international debate on water scarcity for more than thirty years established by Treyer (2007) and the overviews of the history of water scarcity indicators and their criticism elaborated by Feitelson & Chenoweth (2002), Molle & Mollinga (2003) and Rijsberman (2006), we can identify four types of indicators in relation to their degree of integration and their relative complexity: from physical and basic indicators to integrated and qualitative ones.

– Falkenmark's Water Stress Indicator (WSI)

The WSI, created by the Swedish hydrologist Malin Falkenmark in 1989, links water availability and human population at a national scale. It is the most widely used indicator, especially within international institutions. It establishes three thresholds (three standards, expressed as water available per capita per year) related to the needs of the domestic, agricultural and industrial sectors to describe situations of water stress and two levels of water scarcity. This step constitutes an extremely valuable contribution to the debate by suggesting the existence of a "water barrier" and considering water scarcity as a limitation to the developing countries' economic growth potential (Turton & Ohlsson, 1999). Her contribution is said to be the "founding warning signal" (Treyer, 2006).

Estimating the needs of the three main sectors and adopting food self-sufficiency as a goal, she proposes 1,700 $m^3 p^{-1} y^{-1}$ (per capita per year) of renewable water resources as the water stress threshold. Below 1,000 $m^3 p^{-1} yr^{-1}$, the country faces water scarcity and below 500 $m^3 p^{-1} yr^{-1}$, it faces absolute or chronicle scarcity (Falkenmark, 1989).

Indeed, this indicator presents some advantages, essentially linked with its simplicity: data are readily available; it allows setting up a typology and comparing countries in relation with their per capita water availability; its meaning is intuitive and it is user-friendly. Nevertheless, its results hide debatable estimates of the populations' water needs by levelling them and defining universal standards (Büchs, 2007). Furthermore, annual and national averages hide very important disparities at smaller scales and temporalities. The WSI does not include the accessibility of infrastructures whereas it modifies water availability to users; and it does not reflect important variations in demand among countries linked with, for instance, lifestyles, climate etc. (Rijsberman, 2006). Moreover, for Appelgren & Klohn (1999), the standard indices do not incorporate the social, institutional and economic capacity of countries to cope with scarcity. That is why Ohlsson, (2000) balanced the WSI with the UNDP's Human Development Index to build his Social Water Stress Index in order to account for societies' "adaptive capacity".

To summarize, if the amount of water required to satisfy a person's need is identified, the water availability per capita could be a measure of scarcity. Nevertheless, "*how much water we will need per person in the coming decades to satisfy our daily needs is not fixed, as the Falkenmark indicator suggests, but depends on a myriad of policy and personal choices. This is in fact the heart of the matter for the future water scarcity projections*" (Rijsberman, 2006, p. 11).

– Water Scarcity as an Amount of Water Withdrawn

This step consists in a technical analysis based on the understanding of the physical water system's complexity and its future vulnerability. Shiklomanov's supply-demand analysis and his databank make up the background for this type of indicators. However, the authors replace water demand with water withdrawals, considered as a more objective assessment of use.

For instance, Raskin *et al*. (1997) criticize the WSI, as it does not reflect the distinctions between countries over water use, and they present scarcity as an amount of total withdrawals, expressed as a percentage of available water resources. They define a Water Resources Vulnerability Index and suggest that a country is water scarce if its annual withdrawals exceed 20% of annual available water, and severely water scarce beyond 40%. Furthermore, they suggest to stress dependency over transboundary water and to increase their indicator by the amount of shared water (Feitelson & Chenoweth, 2002). This standard is labelled as the "criticality ratio" by Alcamo *et al*. (2000) using their Water Gap global model.

Other authors have developed this kind of indicators, such as Smakthin *et al*. (2004) who describe the WSI as the relationship between total water use (expressed as the sum of water withdrawals for all sectors), water availability ("mean annual runoff") and "environmental water requirements". We should also examine Merrett (1997) and his accounting system pertaining to the "hydrosocial cycle".

Such indicators can be seen as an attempt to take into account ecological use and to pay attention to the future generations' needs. However, Rijsberman (2006) points out three main criticisms: firstly, the data on water resources do not reveal the amount of water which can be made available for human use; secondly, the data do not reveal how much of the water withdrawn is actually consumed (or evapotranspired) and the amount of return flows; thirdly, such an indicator does not reflect societies' adaptive capacity. Molle & Mollinga (2003) add two more criticisms: large differences between countries' water use for irrigation make comparisons dubious, as is reasoning at a nation's scale in this case.

– Economic and Social Scarcity Indicators

Seckler *et al*. (1998) point out those limitations and the fact that the relation between the water withdrawn and the water effectively used is not a clear-cut one. They tend to distinguish between countries which are "physically water scarce" and countries which are "economically water scarce". The second kind of scarcity is based on the assessment of the potential development of infrastructures and an increase in water use efficiency through improved water management policies. Feitelson & Chenoweth (2002, p. 268) insist on water provision for domestic use and environmental uses and define water poverty as: "*a situation where a nation or region cannot afford the cost of sustainable clean water to all people at all times*". This definition is composed of two major elements: the "cost" of developing adequate water supply and sanitation compared to the GNP to estimate its "affordability" (Molle & Mollinga, 2003).

For Rijsberman (2006), the disadvantages of the former indicator are essentially linked with its complex assessment and its strong links to expert judgements because data are not available to assess all the indicator's components. Furthermore, Brown & Holcombe (2004) think that this indicator is open to criticism because it only considers economic investments, while historical lessons teach us that money alone is not sufficient to improve sustainable access to clean water and sanitation.

A useful contribution made by Ohlsson and Turton attempts to understand the social dynamics to cope with water scarcity recognizing it as a social fact. Their work tries to explain how to attain "natural resource reconstruction" — *i.e.* a level of resource withdrawal which is below the natural resource sustainability level — (Allan & Karshenas, 1996), by applying specific water demand management, as a function of a social entity's "adaptive capacity". The model runs in three stages or three turnings of the "water screw" (Ohlsson & Turton, 1999; Turton & Ohlsson, 1999):

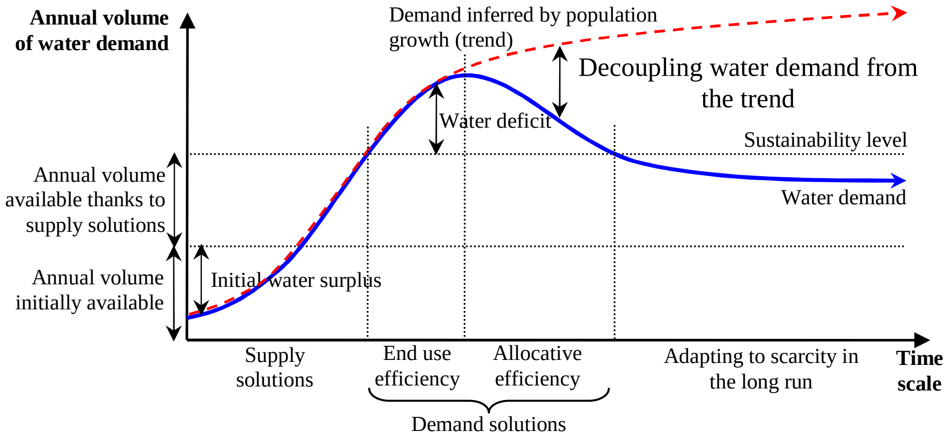
– a supply phase ("getting more"): the government performs a series of "hydraulic miracles" ("heroic engineering") following the recommendations of the hydraulic engineers to implement their strategies based on water supply and large infrastructures — their "*normes de corps*" (Büchs, 2007), or "sanctioned discourse";

– a demand phase ("end-use efficiency measures"): when large-scale engineering solutions are no longer sufficient to increase the available amount of water, a phase of institutional change is needed to save water by doing more per drop. This means changing rules and regulations, administrative bodies and economic incentives (encouraging less water-intensive modes of production, recirculation of wastewater etc.). This acknowledges the birth of some form of heightened social conscience and is an empirically testable manifestation of a given society's adaptive capacity to cope with water scarcity;

– an adaptive phase ("allocative efficiency" or "more value per drop"): to deal with water scarcity in the long run, adaptation has to be based on a better allocation of water, which means both an inter and an intra-sectorial re-allocation of water based on efficiency, or, in other words, to maximize the economic return on every drop of water mobilized (Ohlsson, 2000), by shifting to higher water productivity use (Rijsberman, 2006) or to draw the "soft path for water" (Gleick, 2002).

They consider that: "*the story of changing social uses of water rather forms a spiral movement, oscillating between a perceived scarcity of the natural resource water* [first-order scarcity], *and a perceived scarcity of the social means required to overcome the original scarcity* [second-order scarcity]*; all the while progressing towards ever increased amounts of social resources* [adaptive capacities] *applied to overcome the natural resource scarcity*" (Ohlsson & Turton, 1999, p.2).

Natural Resource Reconstruction:
Decoupling Water Demand from the Demand Inferred by Population Growth



Source: adapted from Turton & Ohlsson (1999), p. 14; Treyer (2007), p. 31.

Using this sequence as a background, this research focuses on explaining the dynamics to cope with water scarcity in the long run. Following the parallel which can be drawn between water and energy, we have to identify the dynamics at work to introduce a double "decoupling" for water consumption: from population growth on the one hand and, on the other hand, from economic development ("less water-intensive economies").
Nevertheless, some questions remain: firstly, how do we evaluate water efficiency? Only as an economic commodity or should we incorporate all the social costs linked to water use (*i.e.* all the environmental and the social externalities)? Secondly, if this sequence shows when we have to start to tackle the problem, we still do not know how to manage it. Thirdly, the linearity of the two thresholds is debatable. On the one hand, hydrological evolutions, particularly linked to climate change, imply that natural water availability may not be steady in the future. For instance, by 2050, Mediterranean countries will face a decrease in their total runoff by 10 to 30% (IPCC, 2007). On the other hand, limitations linked to water supply solutions (dams' sedimentation, lack of new sites to build new dams etc.) imply a decrease in the total amount made available by those solutions (without desalinating seawater). Fourthly, we have to question the hypothesis that, during the initial phase, water needs are satisfied. This may be true only if water is relatively "abundant". The concept of "structural scarcity", which seems to be more adapted for many arid and semi-arid countries, needs to be put forward.

– The Water Poverty Index (WPI)

The former indicators do not take into account water quality, nor the variability and the non-linearity of water supply. Moreover, they are often based on a national scale, which is not really informative in terms of water really available per person. To overcome these shortcomings and to create a decision support tool, Sullivan (2002) and Lawrence *et al.* (2002) presented the results of their research project aimed at establishing an international WPI. We have to note that the term "water poverty" had been introduced two years before by

Salameh (2000) who tried to improve the narrow vision of scarcity by defining a WPI which includes climatic diversity, rainfed agriculture, as well as wastewater treatment and water reuse potentials (Salameh, 2000).

The WPI is described as a holistic policy tool (Sullivan, 2002) and is built on five major components (composed of 17 sub-indicators): firstly, "resources", which represents the total amount of water physical availability as well as its variability and quality; secondly, "access", which stands for access to water for human use in terms of distance, time needed for collection, as well as access for productive uses; thirdly, "capacity", which measures people's ability to manage water and arises from Sen's theory of capabilities; fourthly, "use", as the amount of water used per capita for domestic, agricultural and industrial purposes, in order to express water use efficiency; fifthly, "environment", to reflect both environmental water management and the degree to which water and the environment are taken into account. The result is an index ranging from 0 to 100. Nevertheless, the authors note that "*the information is in the components rather than the final single number*" since it helps in ascertaining the weakest fields and those requiring priority attention (Lawrence *et al*., 2002, p. 10). The Asian Development Bank (2007) has used the same methodology to develop its Index of Drinking Water Adequacy.

This indicator combines physical, social, economic and environmental information and it can be used at the community or sub-basin scales, but is often criticized because of its complexity. We consider that this way to cope with water scarcity has to be explored. Nevertheless, we can add two main criticisms, with the aim of creating an efficient decision support tool: time has to be reckoned with, and water use has to be decomposed in several sectorial uses.

Starting with this kind of integrated approach, this research attempts to build a dynamic and adaptable indicator, using standards to create scenarios for future water uses. As Savenije (2000), we believe that a water scarcity indicator has to comprise the different colours of water (green water, recyclable grey water, virtual water etc.) to highlight water's natural temporal variability, to be adaptable and to identify climatic conditions, to pay attention to shared water and finally, to be based on a comprehensive and situational understanding of water needs. This research should also take in the new international debate on water exchanges via virtual water trading.

Integration between ecosystems and socio-systems is required to capture all the facets of water scarcity. That is why we will try to explore a path toward an approach which merges institutionalism and ecological economics.

2.2. Coping with Water Complexity: Toward an Integrated Theoretical Framework for Sustainability

The combination of a large number of characteristics related to water and its unique character imply that water management requires "*a multi-sectoral, multi-interest and multi-objective analysis in a broad societal context, involving social, economic, environmental and ethic considerations*" (Savenije, 2002, p. 741). Thus, our theoretical framework has to comprise all those aspects. The ethical dimension is mainly linked here to the non-substitutability of this vital resource, for people as well as for their environment. After having acknowledged the complexity of the water system and considering that the concept of water use can only be relevant in a perspective of sustainability, we should adopt a theoretical framework able to include both the economic and the natural systems (the "hydro-system" and more generally the ecosystem) and their interrelations.

Starting with this acknowledgment for the whole environment, Swaney (1987) devised the principle of "coevolutionary sustainability", endorsing an institutionalist approach defined as holistic, evolutionary and organic. In this approach, the economic system is described as an open system, interconnected with the natural system with which it interacts. In his opinion, "*coevolutionary sustainability means simply that development paths or applications of knowledge that pose serious threats to continued compatibility of sociosystem and ecosystem evolution should be avoided. Coevolutionary sustainability explicitly recognizes that environmental systems evolve interdependently along development paths that may or may not be sustainable. Currently, human activity is breaking existing ecological chains and establishing new ones that alter the potential paths for further evolution*" (Swaney, 1987, p. 1750). Dietz & van der Straaten (1992) furthered this approach by accounting for the phenomena of circular interdependencies, cumulative causality and feedback, which inherently occur between both systems. They give three recommendations to set up an improved theoretical framework:

– firstly, the economic process is as an open system, with various impacts on the ecological system and *vice versa*;

– secondly, ethical judgements pertaining to both the quantity and the quality of natural resources we would like to preserve for future generations have to be reckoned with;

– thirdly, the theoretical framework has to be relevant for the analysis of the forces at stake in a given society and the institutional barriers which hinder sustainable development (Dietz & van der Straaten, 1992, p. 44).

This approach is related to the idea of strong sustainability promoted by the supporters of Ecological Economics, who mainly handle two principles: firstly, man-made and natural capitals are complementary and cannot indefinitely be substituted; secondly, the principle of entropy, arising from the second law of thermodynamics, stresses the fact that a system cannot work without producing waste (Daly, 1999). The association between Swaney's Neoinstitutional Environmental Economics and Ecological Economics is synthesised, for example, by Söderbaum (2007) when he mentions "Sustainability Economics".

These logics recognize that human action can affect the environmental systems' evolution and break some causality chains, sometimes irreversibly. Furthermore, environmental externalities are presented as endemic and not as episodic, principally because of the economic principle of "cost shifting" (made easier by temporal and geographical distance). The question is to determine the adequate institutional arrangement to allow people and the environment to subsist without harming each other. In these approaches, nothing is predetermined nor ineluctable and the interactions between people and their environment are socially constructed, in terms of physical actions on the one hand (withdrawals, waste, maintenance etc.), but also in terms of representations, or "images" to adopt Boulding's (1966) phrase. These approaches insist on the importance of culture, social norms, individual and social learning processes for environmental management in general and for water in particular (Pahl-Wostl *et al*., 2008).

They also attempt to comprise and assume the complexity of environmental problems and aim at grasping the scope of the relations connecting the natural and the economic systems. This kind of approach is particularly recommended for the water issue (Petit, 2002). Indeed the non-acknowledgment of this complexity partly explains the failure, from an environmental and human point of view, of many projects aiming at promoting adequate water management (Sullivan, 2002). Those integrated approaches *de facto* reject simplistic solutions. Thus, according to Barraqué, "*management of such a particular common property as water is, does require a complex institutional arrangement. Simple and straightforward solutions designed for the sake of pure economic efficiency, like privatisation of water rights and their transferability, may well end up as unsustainable*" (Barraqué, 2004, p. 34).

Institutions embody the formal and informal connections which shape the relationships between individuals, and between individuals and society in terms of "*customary or instrumental behavioural patterns, political organisations, and economic systems, etc.*" (Opschoor & van der Straaten, 1993, p. 207). They epitomize the rules of the game, the

balance of power, "entitlements" and all the mechanisms which directly or indirectly frame and influence the management of natural resources (Söderbaum, 1992).
The institutional arrangement is in keeping with the concept of "mode of water use" ("*mode d'usage de l'eau*") developed by Arrus (2000) and defined as the unification of, on the one hand, the level of needs' satisfaction (corresponding to the type of mobilization, sectorial repartition and social and environmental practices) and, on the other hand, the management mode (defined through its economic, legal and institutional form). The mode of water use varies depending on the situations and enables the labelling of practices as wasteful or economical, polluting or clean, and so on. This institutional framework, or institutional arrangement, determines a given mode of water use in accordance or not with a development path compatible with sustainable development. Indeed, it is the outcome of a history specific to a social entity and it governs its future adaptive capacities. This is why we believe it is "path-dependent" (Appelgren & Klohn, 1999).
In a perspective of sustainable development, the objective of "coevolutionary development" requires an institutional change, concerning practices (withdrawals, distribution and use) as well as representations, or "thinking habits", to adapt the economic and social system to the natural system (Aguilera-Klink *et al*., 2000).

Considering that water is at the heart of the triptych which illustrates sustainable development — namely the economy, society and the environment —, any attempt to deal with it entails an approach which comprises these three aspects. Furthermore, inter and intra generational equity has to be taken into account, considering that water needs have to be managed following local specificities, due to the preponderance of the social representations and the social organisation, as well as the water management practices, all of them having emerged through history. Thus, reconsidering the tools to manage water scarcity is key. They have to be adaptable, integrated and dynamic to reflect the complexity of the water issue and to test scenarios as tools for a water prospective. They have to be based on a comprehensive theoretical framework able to highlight the complexity of the interactions at stake and on an operational definition of development understood as sustainable. This definition has to be decomposed in a set of measures defining guidelines for sustainable water use.

3. Results: Scarcity as a Geographically and Temporally Situated Social Fact

Water scarcity is a relative notion which can be defined only in keeping with human activity and the environment's needs. Thus, water use standards, as specifications related to the quantity, quality and process for a given use, are tools to identify situations of scarcity or abundance. Recognizing scarcity as a geographically and temporally situated social fact enables making room for manoeuvre in order to manage it and not only to suffer from it.

3.1. Standards Define the Intensity of Scarcity

The example of salinity standards, which define several water classes depending on the quantity of salt per litre of water (*e.g*. UNESCO-WMO's standards: freshwater <1,000 mg l^{-1}, brackish water <10,000 mg l^{-1}, saltwater >10,000 mg l^{-1}), helps us understand how standards can determine the quantity of water available and, hence, can modify our representation of scarcity. Indeed, estimates stating that the total amount of available water is below 1% of the total volume of water on Earth are partly founded on such criteria.
In fact, standards provide a reading grid to evaluate the hydrological situation, as they allow identifying eventual situations of abundance or scarcity. This is for example the objective of the WSI. Nevertheless, this normative vision determining universal thresholds does not accurately assess reality. For instance, even though the indicators for the three Maghreb

countries are below 1,000 $m^3 p^{-1} yr^{-1}$ (scarcity threshold), does it mean the same regarding renewable water availability per capita per year estimated at 460 m^3, 970 m^3 and 470 m^3 for Algeria, Morocco and Tunisia respectively in 2002 (FAO, 2008)? Is the situation that critical in Algeria and Tunisia, below the chronicle scarcity threshold as is Israel (which has to put up with less than 300 m^3)? Do these countries have the same adaptive capacity to scarcity?
Those universal standards not only hide geographical disparities, but they also tend to erase distinctions between populations, their modes of consumption, their organisations etc. Indeed, water is not only a quantitative question (what is more, not only freshwater has to be taken into account); qualitative considerations, such as social, cultural and political concerns, should also be considered. Water has to be examined interacting with all the links which define a society. Characterizing a country's situation implies emphasizing *ex-ante* the modes of consumption at all levels: first, at the sectorial level, by assessing the relative share of each sector in the total amount of water consumed; then, at the individual level, in order to understand the differences for each society in relation to the progress of their development process, to socio-economic characteristics, to culture, and to the prominence of the environment and climate and their related representations.
The standards defining access to water provide another example of the role played by standards in the conception of indicators. Nowadays, the WHO and the UNICEF consider "reasonable" water access as: "*the availability of at least 20 litres per person per day from a source within one kilometre of the user's dwelling*"; specifying that this definition "*does not imply that the level of service or quality of water is 'adequate' or 'safe'* " (WHO-UNICEF, 2000, pp. 77-78). Access to water and sanitation is actually defined in terms of availability of given water supply technologies and specified as "improved" or "not improved". The evaluation of the improvements in reaching Target 10 of the seventh Goal of the Millennium Development Goals, which consists in "*halv*[ing]*, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation*", is based on these considerations.
Those laudable, but in no way new, objectives to improve access to water and sanitation for "developing" populations, become controversial once we decipher the pertaining discourses. Actually, during the International Drinking Water Supply and Sanitation Decade (1981-1990), the water access standard was defined as access to the network, with 200m as the maximum distance. Isn't this double weakening of this standard, regarding both quality of service and maximum distance, a sign of institutional withdrawal and a consequence of a willingness to overestimate the results of institutional indicators?

Studying the generation of standards enables to understand the present situation of a given population. Yet, their meaning has to be cautiously examined. This is even truer for universal standards, which are disconnected from the local substratum and from populations' needs. Standards have to be used in reference to concrete situations in order to assess not only the present state, but also the prospective improvements for a given population.

3.2. Standards as Links between Natural and Human Worlds

Standards provide a link between the two systems presented previously by modifying the physical economic constraints which affect the environment, as well as the representations of water and the environment.
Standards frame human actions by specifying the quantities, qualities and processes estimated as appropriate. Our partial misunderstanding of the environment and the unpredictability of environmental decisions, mainly due to synergetic effects, thresholds effects and delayed reactions, prevent total market management because of unavoidable, as they are endogenous to the system, market failures. Thus, an "Ecological Utilization Space", or "Environmental Utilization Space" for Opschoor & van der Straaten (1993), has to be determined. Actually:

"*standards being sustainable from an ecological point of view must be imposed on economic activities. These ecological standards are derived from insights into the functioning of the ecocycles, combined with ethical views regarding the quantity and the quality of natural resources we would like to leave behind for future generations*" (Dietz & van der Straaten, 1992, pp. 43-44).

This logic governs the indicators aiming at defining a threshold for withdrawals (*e.g.* the "criticality ratio"). However, even though they are necessary, they are not sufficient and make up only a part of the Ecological Utilization Space, which has to be optimised after having been defined.

Recognizing the prominence of standards means affirming the complementarity between economic tools on the one hand, and command and control tools on the other hand. This synergy is vital for environmental questions and for water in particular, due to its political aspect (water is an absolute need), to the ethical questionings it introduces and, finally, as it is essential to anchor its management in a perspective of sustainability by taking into account future generations. Those constraints shape standards in order to frame practices toward sustainable water use.

Furthermore, applying standards allows modifying the representation and the image of water scarcity, by making it a social rather than a physical phenomenon. Aguilera-Klink *et al*. (2000) show that the vision of an expected society and social order and its relationship with the environment are social processes. Analysing the example of Tenerife, they stress that social processes reinforce the perception of water as a capital asset and a commodity, and not as an "ecosocial asset", which has brought about an overexploitation of resources and a present situation which is critical. Another example, described by Cambon (1996), is the emergence of the water network in the 19th century as the new freshwater supply standard, which led to the disconnection of users from water resources and to the modification of the "social aquosity". Water use is no longer associated with the collective share of a common resource but with the individual ownership of a private commodity.

The representation of water influences practices, which, in turn, modify the perception of the resource. This dynamic and evolutionary process has to be deciphered to analyse the present situation. Thus, understanding and grasping the water issue implies a study of the social process which has shaped the current practices for water extraction, distribution and use in general. Water scarcity is often perceived only as a physical scarcity, linked to a shortage of resources rather than to the implementation of modes of use related to a given rationale (Aguilera-Klink *et al*., 2000). As an illustration, the perceived scarcity in Morocco is not only due to a decrease in rainfalls, but also supposedly to an overconsumption caused by the expansion of tourism (with a standard of 800 litres per night per tourist) and by irrigated agriculture for exports (*e.g.* "Christmas tomatoes"), as for the cases of the Souss Basin (Agadir) and the Haouz Basin (Marrakech).

3.3. Using Standards to Build on Scenarios toward Dynamic Indicators

After having established the framework and characterised the field work, projections have to be carried out in order to examine the possibilities to design a development scenario and to highlight some issues: is the development scenario suitable for sustainable water use? How many types of water (runoff water, groundwater, rainwater, recycled grey water, virtual water etc.), considering both their quantity and quality, will we need? How to do it taking into account the technologies at hand and, mainly, the available financial means?

All these questions need to be tackled in order to put water practices and uses at the heart of a given population's economic and social development. The goal is to build up a decision making tool able to comprise all water types in order to allocate them in accordance with each

use. A prior characterization of the availability of resources and the various types of use on the considered territory appears as a prerequisite.
Added to its practical aspect, this tool involves a reflective dimension, as it enables to question the contents of the development scenario regarding water use. Can we put up with water-intensive uses in a situation of water scarcity? Here we are faced with the same questionings on the evaluation of the efficiency of water allocation as previously presented.
The State's intervention in the economy, via the management of public building construction, territorial planning and investments' programming, puts forward the complementarities of standards and regulation tools, and it corresponds to incentives to adopt certain standards (to mobilize, extract and use water) over others. For the authority, the aim is to settle conflicts over water use, *i.e*. drinking water, agricultural water and industrial water. Thus, it determines water use standards to promote some types of water use (*e.g.* tourism in Morocco) highlighting a specific development path by doing so. However, the various configurations regarding water uses are not final and they depend on political and socio-economic choices. For example, since Algeria became independent forty years ago, it has changed the sectorial sequence to allocate its water resources three times by adopting, first, an *agriculture—industry—population* scheme for ten years, then, for ten years, an *industry—agriculture—population* scheme and, for twenty years, the *population—industry—agriculture* sequence (Arrus, 2000). By and large, the trend has emerged all around the Mediterranean Basin which consists in a shift in water uses in favour of water for domestic purposes at the expense of agricultural use.
Each mode of water use is correlated with a range of associated standards. Thus, standards can become common tools (applied by water users' associations, water agencies, irrigators, consumers etc.) and, hence, represent a democratic counterbalance providing that people are enlightened about their meaning. Actually, economic development planning is related to choices in allocating water in keeping with macro-economic criteria in a context of scarcity heightened by increased competing demands.
Our methodology, which aims at building a holistic and dynamic indicator, allows testing a development path and comparing it to a reference scenario promoting sustainable development. It will be based on an iterative approach modifying water use standards in successive simulations to determine the best options. This flexible indicator will be adaptable to different contexts. In order to do so, a databank, regrouping associated water use standards for a range of uses, is being developed. As far as water quality is concerned, we will determine several water classes, using, for instance, the water quality assessment system ("SEQ-Eau") adopted by France in 1999 which defines five water classes in keeping with multiple parameters.

Standards are the expression of a rationale which became dominant at a certain time. As Barraqué's (2005) chronology shows, the three main episodes of water management, implemented successively by civil engineers ("*génie civil*"), sanitary engineers ("*génie sanitaire*") and environmental engineers ("*génie environnemental*"), have been translated in the generation of specific standards for each episode considered. However, today's standards are not only the reading grid of past evolutions, they are also essential in their intrinsic future dynamics to build on scenarios and possible worlds, proper to given social entities. They are tools which link water uses and resources to fight against the idea of universal water management solutions. We expect that the confrontation between, on the one hand, water needs and, on the other hand, water uses' standards — as tools which allow organizing and shaping the representations of water itself, and its political, social, economic and technical modalities of appropriation and affectation to competitive or non-competitive uses — will produce a new kind of dynamic indicators.

4. Conclusion: Water Complexity as the Starting Point of a New Perspective on the Water Issue

The key to progress — sustainable water use as a component of sustainable development — lies in the furthering of knowledge, principally concerning the influence of people's actions on their environment. Recognizing and filling in the gaps is required to go beyond obvious solutions, whose present success can be explained mainly because they are easy to implement (*e.g.* trading of property rights). The increasing complexity of the system due to the integration of the various facets of water (vital, unsubstitutable, renewable, unequally distributed in time and space, etc.) calls for a prior reflection on the very nature of water.

Even though water can be regarded as a unique resource due to its cycle and renewability, we have to consider it as polymorph, because of its multiple uses. Water is at the same time an unsubstitutable vital ecosocial asset, an environment and a production input. Thus, the environmental and socio-economic dimensions of water have to be taken into account as indissociable components of the same reality. This dialectic of water is based on its multicriterial aspect which tends to intensify, each new perspective on water bringing new associated criteria. Bearing in mind all these criteria is key to grasp the complexity of the water system and its resultant, which stresses the main goal when discussing an appropriate water policy.

Therefore, the assessment of an adequate allocation of water should involve all these elements and go beyond a simple cost-advantage analysis. Due to the strong externalities specific to water use, social costs have to be taken into account. An allocation of water depending on social opportunity costs estimated on the basis of a multicriterial assessment could possibly be implemented. If water prices were proportional to social opportunity costs, the water satisfying basic needs would be almost free and the water for speculative use, very expensive. This could provide an interesting approach in defining a reference scenario aiming at specifying sustainable water use.

Applying standards means acknowledging, on the one hand, the complexity of the global water system and, on the other hand, the unpredictability of environmental decisions, which call for a new dynamic and iterative approach. Thus, we will adopt Tsoukas & Hatch's definition of complexity (2001) which states that complexity is due to : (a) the non-linearity of causes and effects; (b) the fractal aspect of some phenomena; (c) the existence of recursive symmetries between the various scales considered; (d) the system's sensitivity to sometimes infinitesimal perturbations; (e) the existence of retroactive loops or feedback. Moreover, Dosi & Egidi's (1991) two types of uncertainty (namely, "substantive" uncertainty, due to a lack of information, and "procedural" uncertainty", due to the agents' computational and cognitive limits), which are at stake in environmental questions, should not be dismissed.

All these elements, local specificities and the social organisation related to water provide the basis for this work with the objective of conceiving a decision support tool as a composite indicator in a perspective of sustainable development. This indicator will be supported by a methodology for needs' and water use standards' analysis; thus, it will allow accounting for the durability of water uses for a given development scenario and the exogenous changes impacting on the resource, *e.g.* climate change.

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