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Water No Get Enemy. How Could Water Security Shape Sustainable Water Governance?

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Abstract. This paper discusses the architecture of a theoretical framework aiming at consolidating the concept of water security particularly thanks to the contribution of social ecological economics. This paper takes for granted that water security offers an innovative and relevant perspective to address the issue of the sustainability of the society/resources nexus. However its lack of substance and its protean nature are obvious. In order to exploit its full reformative potential, we propose an analysis based on social-ecosystemic interdependencies and, finally, on the co-production of a robust adaptive regime to shape "securing water paths".

1 Introduction

This research postulates the theoretical and the empirical requirement of using the embryonic notion of water security; validating the plea launched by Bogardi *et al.* (2012: 35), *i.e.* "water security in the 21st century will require better linkage of science and policy, as well as innovative and cross-sectoral initiatives, adaptive management and polycentric governance models that involve all stakeholders". These statements of principle are straightforward. Nevertheless in order to overcome its current state of "nirvana concept" (Molle 2008) we should first give substance to the concept of water security and, secondly, we need to grasp its genesis and rise from a critical perspective.

The canonical definition of water security provided by the Global Water Partnership (GWP) in 2000 remains focused on individual water use in an environmental context (anthropocentric approach). This is why, from a more comprehensive perspective, Cook and Bakker (2012) suggest crossing both imperatives of ecosystem health and human health and redefining the arrangements shaping water governance.

This double orientation constitutes the starting point of our research the general objective of which is to strengthen the notion of water security *via* the theoretical *corpus* of social ecological economics (Norgaard 1994; Spash 2011, 2012) to consider the notion as an ecological and societal issue.

Furthermore, it is particularly relevant to question the kind of governance associated with this concept.

Nevertheless, we consider that the emphasis put on water security in recent years reveals a shift of research on the adaptation of social ecosystems, leading to an increasing assertion of the primacy of "command and control" governance regimes. In response to the attempt to "divide" (Hodson & Marvin 1997) the issue of resource securitization, we propose an analysis based on social ecosystems' dependencies and, finally, on the co-production of a robust adaptive regime to shape "securing water paths".

We show that a "securing water path" implies a social ecological coevolutionary process that links the environment, values, organizations, knowledge and technology involving an iterative, participatory and polycentric governance of social-ecological systems (Ostrom & Janssen 2004). In an adaptive regime characterized by a multitude of decentralized learning processes, the appropriation of the political construction of a common future becomes the central issue.

Institutionalist approaches in terms of "reflexive governance" (Brousseau *et al.* 2012) and "adaptive management" (Pahl-Wostl *et al.* 2010) are relevant. Firstly these approaches rely on the self-regulation capacities of systems of agents at the local level (mutual learning from successes and failures). Secondly these approaches help in understanding the whole system's capacity, in terms of institutional monitoring safeguards, to mitigate the vulnerability generated by decentralized solutions. Thus regulatory power plays a new essential role, which departs from the traditional functions assumed in a "command and control" regime: it must ensure the coupling of decentralized organizational learning and institutional dynamics.

At first this paper attempts to analyze the different meanings of water security. We show that its polysemy generates a lack of substance and operability and we propose a typology of acceptations. The next stage is more theoretical and stems from both institutional and ecological economics. Finally the third stage concludes this research by discussing the application of this theoretical framework to urban water systems.

2 Water Security Relevance: from a "Nirvana Concept" to a Potential for Shaping Sustainable Water Governance

The notion of "water security" grasps different meanings that reveal semantic instability. By and large, comprehensive acceptations aim at redefining water governance (debates on decentralization, devolution, participation, *etc.*) more or less explicitly. We present an overview of the main approaches and propose a typology.

2.1 A Notion Sourced from Practitioners

For operators and local communities, the notion of water security was assimilated a long time ago and refers essentially to the objective of securing water supply. It includes both qualitative and quantitative requirements (Barbier 2011).

Qualitative requirements concern both resources and distributed water (meeting emission, immission and process standards). Upstream, it means to protect resources for the production of drinking water, thanks in particular to water catchment protection areas. This issue is not new. In France for example, the mechanism of groundwater protection areas was set up by a decree-law in 1935 and became mandatory through the 1964 Water Act. As such, Miquel (2003) recommends to identify "sanctuary areas of strategic resources" where resources would be protected both in quantitative and qualitative terms. They should represent 1% of the territory of each district. In addition to these preventive solutions, which also include wastewater treatment and changes in agricultural and industrial practices, communities and operators could also adopt two complementary approaches: curative solutions (sophisticated methods of water treatment) and palliative solutions (dilute pollution, abandon catchments, *etc.*). Quantitative requirements are mainly linked to the risk of service intermittence. In addition to classical strategies to increase supply, quantitative security also involves network interconnection, efficient management of recycled wastewater, as well as drought management.

At the national level Canada could be cited as an example: water security aims at shaping its recent water policy (Norman *et al.* 2010; Zubricki *et al.* 2011). In France, the Council of Strategic Analysis also tackles the issue (CAS 2013). However, water security is dealt with a less comprehensive acceptation than in Canada. France focuses on supply security in a quantitative perspective to face climate hazards.

From the point of view of international organizations, the appropriation of the notion of water security is recent, and the year 2000 marked an important milestone. Firstly, the FAO (2000) issued a document in which water security was seen as a sub-component of food security and equated water scarcity. Note that this thematic continuity is common in pioneering works and both notions have often been confused (Falkenmark & Lundqvist 1998). By mentioning Ohlsson and Turton's "turning of a screw" allegory, this document calls to adopt an approach in terms of adaptation and change "both in society itself and in society's relationship with nature" (FAO 2000: 1-2). Adaptation facing an environmental crisis here refers to the pioneering work of Homer-Dixon for whom social ingenuity, *i.e*. "ideas applied to solve practical social and technical problems" (1995: 590), determines adaptation capacity and is the key factor of institutional change. For him, social ingenuity

takes precedence on technical ingenuity: the latter cannot emerge without the former.

Secondly, the Second World Water Forum organized by the World Water Council (WWC) held in The Hague in 2000, gave birth to a "Ministerial Declaration on Water Security in the 21st Century". Water security comprehends several main challenges: (i) meeting basic needs (access to safe and sufficient drinking water and sanitation); (ii) food security; (iii) protecting ecosystems; (iv) sharing water resources (especially for trans-boundary resources); (v) managing risks; (vi) valuing water and (vii) governing water wisely.

Here, good governance implies "the involvement of the public" and that "the interests of all stakeholders are included in the management of water resources". The implications in terms of governance converge with those of the FAO to increase the degree of consultation and involvement of stakeholders. However, the multidimensional nature of water security appears. Arguably, this feature is largely the result of the involvement of the Global Water Partnership. Its definition is still considered as canonical by many authors: "water security at any level from the household to the global means that every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced" (GWP 2000).

The need to cross both social and environmental issues is confirmed. Nevertheless, van Hofwegen (2009) opposes two limits to this definition: first, it remains focused on individual water use in an environmental context (anthropocentric approach that prioritizes social and environmental imperatives); then, it does not take into account productive uses. This double criticism can also be addressed to the 2006 Human Development Report (UNDP 2006), in which water security aims at "ensuring that every person has reliable access to enough safe water at an affordable price to lead a healthy, dignified and productive life, while maintaining the ecological systems that provide water and also depend on water".

The WWC (2012) adds to health requirements (human security: meeting basic needs) and to environmental requirements (ecological security: ensuring the quantity and quality of water needed for protecting biological diversity and the lives of future generations), a requirement of economic security, *i.e.* "to ensure sufficient water to produce goods and services, means making water available in fair and affordable ways". Here again, the criticism related to the dichotomy environment/society is justified. Despite the attempt to propose a comprehensive acceptation of water security, water only appears as a resource to satisfy uses. This aspect is reflected in the document by a focus on water infrastructures needed to achieve water security.

Though this aspect is central, nevertheless Grey & Sadoff (2007) show that without investment in institutions (rules and organizations in the broadest

sense), infrastructures are insufficient. Here, a problem remains considering the level of analysis: national scale erases local disparities (Vörösmarty *et al.* 2010). For example, Canada appears to be well supplied at the national scale, whereas some regions are water-scarce (Cook & Bakker 2012).

Finally, for UN-Water (2013: 1), "the umbrella of water security" offers "a holistic outlook for addressing water challenges", such as the Sustainable Development Goals that will supersede the Millennium Development Goals after 2015: "water security is defined here as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability". The document concludes with the requirements in terms of "good governance" considering the 10 key points proposed by Burchi (2012), among which: watershed management; polycentric coordination; flexible and decentralized mechanisms related to water rights; IWRM; risk management; protection of freshwater ecosystems, *etc.* Then the necessity to adopt a mode of governance based on consultation and participation is confirmed.

2.2 Academic Appropriation: a Typology

Over the 1990-2010 period, 418 publications in English refer to water security in the academic literature (including policy reports) and more than 50% of them were published in the last five years (Cook & Bakker 2012; Bakker 2012). However, the appropriation of the term by the scientific community was not accompanied by a clarification.

The first reason that explains the range of meanings and of methodologies used to analyze water security is disciplinary-linked. This conceptual diversity is enhanced by the variety of scales taken into account: from international and national scales (Starr 1991; Turton & Henwood 2002; Pachova *et al.* 2008) to local ones (the city for Lundqvist *et al.* 2003; the watershed for Norman *et al.* 2010). For Cook & Bakker (2012: 6): "the fact that disciplinary toolkits and frameworks imply that water security analyses use different scales complicates and, we would suggest, confounds a meta-analysis of water security across the disciplines". They propose to distinguish between approaches according to their target in four thematic clusters: (i) quantity and water availability; (ii) water related hazards and vulnerability; (iii) human needs; (iv) sustainability. However, they do not shape a typology; thus fourth-type approaches often cross the three other clusters.

Finally, this diversity is expressed by the degree of integration taken into account. According to the categories considered, water security is understood, on the one hand, as a uni-dimensional notion (often confused with water

scarcity); on the other hand, as a multidimensional notion that necessarily involves many uses and/or physical and social dimensions.

One of the most comprehensive definitions is proposed by Grey & Sadoff (2007: 545). Water security is: "the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies". In this perspective, the work initiated by Karen Bakker (that aims at guiding forthcoming Canadian water policies), offers an acceptation that crosses ecosystem health and human health requirements and that questions water governance arrangements. According to these authors, water security encompasses five dimensions: (i) water resources; (ii) ecosystem health; (iii) human health; (iv) infrastructure; (v) governance.

Most research, particularly in social sciences, considers the link between water security and governance as crucial, and lead to recommendations for a renewal of governance: "no freshwater security without major shift in thinking" (Falkenmark 2000). However, they do not really develop these recommendations and, most importantly, they do not base them on a strong theoretical foundation. Thus, our paper is an extension of these perspectives: their conclusions coincide with our starting point.

We propose a typology of acceptations of water security that corresponds to our paper's goal, namely discussing the link between water security and the mode of governance (Fig. 1). Thus, we focus on acceptations that consider this link, without neglecting those that do not (*e.g*. hydrology for the resource dimension). This typology is shaped using two orthogonal axes. The horizontal axis is relative to the object's contour and partitions acceptations of water security according to their degree of integration. The degree of integration intends to reflect the diversity of uses (consumptive, productive, environmental) and interactions considered. In other words, it informs the uni- or multidimensional character of water security. Implicitly, this axis also reflects the interdisciplinary degree of approaches: highly integrated and comprehensive acceptations will necessarily involve more numerous and varied disciplinary *corpora* than poorly integrated ones. The vertical axis reflects the form of governance advocated — explicitly or implicitly — thanks to the degree of stakeholder's involvement that characterizes it. The stakeholder's involvement refers to consultation and participation. It has two components: first, the range of stakeholders involved in the governance process; secondly, the ability of these stakeholders to continuously redefine the goals of governance. This axis classifies the various forms of governance along a *continuum* with two extremes: "command & control" (low degree of stakeholder's involvement) and reflective and adaptive governance (high degree of stakeholder's involvement). This axis also indicates whether the mode of governance advocated is dynamic or static, and therefore the degree of rigidity that characterizes it.

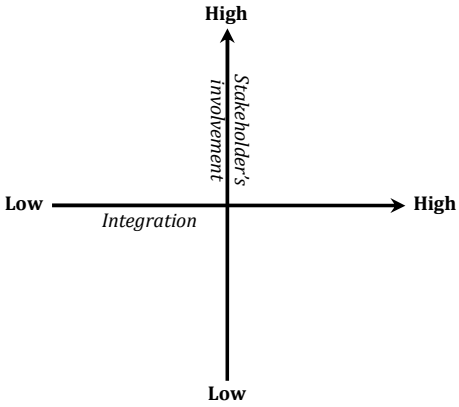

Fig. 1: A typology of water security acceptations: toward a "securing water path".

The unique feature of our research is linked to the purpose of water security. Indeed, with the aim to suggest a common and clear definition, Lautze & Manthrithilake (2012) urge "to move beyond qualitative definitions". As Cook & Bakker (2012: 98), they consider that research would benefit from focusing on the goal, not on the means to achieve water security. Contrarily we adopt a dynamic view of water security: it is not an end, a goal, but a process that is accompanied by a particular mode of governance to continuously enable the dynamic adaptation strategies of users (in the broad sense) in an evolving "hydro-social cycle" (Swyngedouw 2009).

Thus, we adopt the term "securing water path". It targets a sustainable mode of water use (normative notion) and involves: (i) an integrated acceptation, which includes social and ecological requirements, to reflect the relationships between various uses; (ii) an adaptive governance to increase the water path's securing potential. It means to move "beyond infrastructure" (Palmer 2010) to include governance and social learning as key strategies for more effective water governance and management. Theoretically, these conditions involves the need for an interdisciplinary approach to: (i) cross both society and the environment (which is not a scenery for social life); (ii) to account for adaptive dynamics considering ecological constraints and for the production of the environment. That is why we do not offer a conclusive definition of water security but seek to establish a theoretical foundation to approaches that converge to the upper right-hand quadrant of our typology.

3 Water Security Coherence: toward "Securing Water Paths"

The combination of a large number of dimensions related to water security and the unique character of water (which is non-substitutable and vital) imply

that water governance requires "a multi-sectoral, multi-interest and multi-objective analysis in a broad societal context, involving social, economic, environmental and ethic considerations" (Savenije 2002: 741). Thus, our theoretical framework has to comprise all those aspects.

3.1 Comprehensive Acceptation: A Coevolutionary Approach

The ecological economics approach appeared in the late 1980s and brought together, under one banner, works that criticize traditional environmental economics approaches (Costanza & Daly 1987; Spash 1999). This interdisciplinary paradigm presents multiple theoretical and ideological sources of inspiration (Söderbaum 2007).

Here, we focus on the developments that consider the institutional dynamics of the society-environment relationship: how to characterize this relationship and how to understand its evolution to offer alternatives toward a sustainable future? These developments are part of an emerging "social ecological economics" (Spash 2011) or "sustainability economics" (Söderbaum 2007). In a broad sense, institutions as "social decision systems": "provide decision rules both for the use of resources and for the distribution of the income stream derived from such use". Rules adjust and accommodate, over time, conflicting demands from different interest groups in a society. Thus, the distribution of the income steam is one of the key forces of institutional change (Ciriacy-Wantrup 1969: 1319-1320). Institutions embody the formal and informal connections that 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: 207). They epitomize the rules of the game, the balance of power, "entitlements" and all the mechanisms that directly or indirectly frame and influence the management of natural resources (Söderbaum 1992). The institutional arrangement is the outcome of a history specific to a social entity and it governs its future adaptive capacities. It is "path-dependent" (Appelgren & Klohn 1999).

The coevolutionary approach (Norgaard 1984) from an institutionalist perspective offers a sophisticated conceptual framework for understanding the many facets of water security. Based on biology, this concept grasped first an evolving process considering the mutual interaction between two species. It was then extended to interactions between the socio-economic system and the ecological system (Froger 1997: 153). In this approach, the economic system is described as open, interconnected with the natural system with which it interacts. Swaney (1987) devised the principle of "coevolutionary sustainability" endorsing an institutionalist approach defined as holistic, evolutionary and organic. Coevolutionary sustainability explicitly recognizes that environmental systems evolve interdependently along development paths

that may or may not be sustainable and assume that development paths or applications of knowledge "that pose serious threats to continued compatibility of sociosystem and ecosystem evolution should be avoided" (Swaney 1987: 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 provide 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.

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 coexist without harming each other.

In these approaches, nothing is predetermined or ineluctable and the interactions between people and their environment are socially constructed, in terms of physical actions (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 (see below) processes for environmental management in general and for water in particular. 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. 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 (2004: 34), "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".

Kallis & Norgaard (2010: 692) defined five types of coevolution: biological coevolution; social coevolution; gene-culture coevolution; bio-social coevolution and socio-ecological coevolution. The latest corresponds: "to

cases where evolution in the social system affects the bio-physical environment, which in turn affects evolution in the social system. For example evolution of water technologies and consumptive practices spurred the transformation of rivers into dammed reservoirs; in turn the availability of abundant water supplies from dams selected for new water supply technologies and more consumptive water behaviours and practices".

Thus, a securing water path is a socio-ecological coevolutionary process that links the environment, values, organizations, knowledge and technologies. Environmental constraints (quality and quantity of resources, aquatic biodiversity, *etc*.) are neither absolute nor constant: "their effect is seen as conditioning, rather than limiting, social change" (Kallis 2010: 800). By specifying the quantities, qualities and processes estimated as appropriate, institutions frame human action. Thanks to institutions, the goal is to shape governance arrangements that continuously draw "ecological utilization spaces" or "environmental utilization spaces" (Opschoor & van der Straaten 1993). However, these paths cannot be completely fixed *ex-ante*.

Indeed, there is no "cupboard reserved for possibles": "it is the real which makes itself possible, and not the possible which becomes real" (Bergson 1998 [1930]: 185). This is especially true because the ecological constraints that condition institutional change are evolving. However, the definition of prescriptive norms for a desired society can reject certain options such as business as usual. Indeed, the performance of the economic and institutional processes must be assessed based on values that transcend individuals (Froger 1997). Among these values, "environmental compatibility" and the principle of "coevolutionary sustainability" are predominant (Swaney 1987). Thus, although decentralized learning processes are necessary (see below), they cannot totally replace national or international regulatory power to determine prescriptive norms. Sustainable governance will result from the combination of flexibility (consultation and participation) and rigidity (prescriptive norms defining "environmental utilization spaces" and modes of consultation such as democracy).

In a coevolutionary perspective, the objective of sustainable 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). 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 social representations and organisations, as well as water management practices, all of them having emerged through history. Thus, reconsidering governance to cope with water security is key. It has to be adaptable, integrated and dynamic and to respect possible scenarios toward securing water paths.

3.2 Dynamic Acceptation: Adaptive Management to Shape Sustainable Options

This exploratory research aims at answering the call formulated by Spash (2012: 44-45), *e.g.* describing a new "tentative vision for ecological economics". We refer to Ferguson *et al.* (2013) who compare the main "transformative change" approaches of co-evolutionary systems. By identifying a theoretical *continuum* we build the theoretical framework of a "securing water path". Three segments shape this *continuum*: a "taxonomical system", a "theoretical system" and an "operational scheme". Each of them has its proper theoretical and conceptual components (Table 1).

Table 1: Attributes of selected analytic frameworks (adapted from Ferguson *et al.* 2013: 268).

Attribute	SES Sustainability Framework	Panarchy Framework	Management and Transitions Framework
Key references	Cox (2011); Ostrom (2007, 2009); Ostrom & Cox (2010)	Berkes *et al.* (2003); Folke (2006); Gunderson & Holling (2002)	Pahl-Wostl (2009); Pahl-Wostl *et al.* (2010)
Theoretical roots	Resilience; socio-ecological systems; institutional analysis and development	Resilience; ecology; social-ecological systems; complexity	Transitions; social-ecological systems; social learning; institutional analysis and development
Key concepts	Nested tier of variables; networked action situations	Adaptive cycle; panarchy; rigidity trap; poverty trap	Action situation; policy cycle; social learning
Level of theory	Taxonomical system to organize data	Theoretical system to explain conceptual relationship	Operational scheme to test theoretical systems with empirical data
Purpose	Organize variables typologically to aid meta-analysis of case studies	Analyse disturbances and adaptive capacity in dynamic systems	Guide management of water systems by comparative analysis of case studies
Example empirical applications	Intentional communities in Indiana; Voluntary action in tourism for common-pool resource management	Boreal forests in Sweden; Management of the Galapagos Islands	Flood protection in the Tisza basin; Groundwater in the Upper Guadiana Basin

Firstly, as a taxonomical system, the "socio-ecological sustainability framework" (SES) helps in identifying key variables and their interactions (Ostrom 2007, 2009; Cox 2011). It gives a static view of the system and it is coherent with the previously adopted acceptation of securing water path (integrated *via* a coevolutionary approach) (Kallis & Norgaard 2010). The whole system typifies the articulation of two coevolutive sub-systems: (i) the "economic component" related to the reciprocal adjustment of supply and uses (it refers to resource and technology characteristics); (ii) the "institutional component" related to rules which frame the rights to own, appropriate and use water, and to other main elements of coordination (political, organizational and legal)[1].

Secondly, our theoretical system is based on the conceptual relationships explaining change in socio-ecological systems proposed by the "panarchy framework" (Gunderson & Holling 2002; Ostrom & Jansenn 2004; Folke 2006). In the wider concept of panarchy, the "adaptive cycle" is a heuristic scheme aiming to understand SES dynamics, set off by stakeholders' interaction and by a creative destruction process (Carpenter & Gunderson 2001). It is a four-stage sequence, both varying in time and in intensity (Fig. 2):

- (i) strong growth (r) initiates the cycle;
- (ii) a long accumulative and resource control process during which resilience slows down (K);
- (iii) often triggered by a fast depression, a stage of discharge starts (Ω);
- (iv) the system recurs or reorganizes itself (α).

Evoking Schumpeterian dynamics, the system evolves in two main phases: the first one comprises stages (r) and (K); the second one, stages (Ω) and (α).

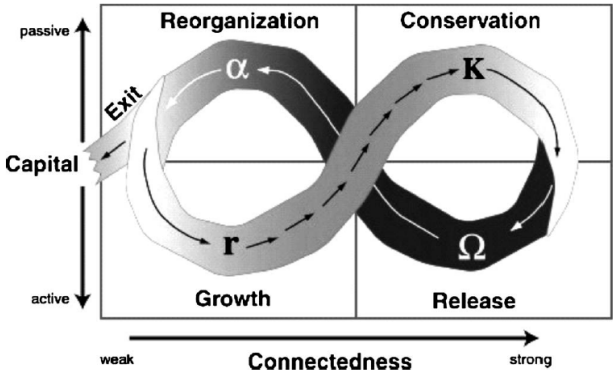

Fig. 2: Adaptive cycle (Blackmore& Plant 2008: 229).

[1] For more details, see also the "water use mode" (Buchs 2012) and the "urban water system" (Bolognesi 2012).

The first phase is relative to the management of the system's production. The objective is to maximise income (Ostrom & Jansenn 2004). Due to a strong control, the system evolves slowly and, contrary to its resilience, the system's connectivity increases. It results in a growing vulnerability to perturbations. Consequently, the risk to experience an undesired steady state emerges. The second phase is an innovative process aiming at increasing the system's flexibility for re-launching positive dynamics. The whole system changes suddenly and needs to be spurred by influential ideas. Stakeholders look for new combinations of inputs to improve the system's properties (Kuhnert 2001). These changes imply strong institutional innovation. Those semi-autonomous and hierarchized sub-systems, linked by triggers, shape the dynamics of the global cycle and, thus, of the whole system. The adaptive cycle reveals that trade-offs and synergies exist between production and resilience. As Falkenmark (2003: 2043) points it: "because driving forces are acting on the social system, ecosystem management is a question of living with change while securing long-term ecosystem productivity". Nevertheless, enhancing resilience is not neutral: it generates costs and gains, justifying the need for consultation and participation.[2]

Two alternative strategies can emerge from the panarchy framework. The first one consists in maximizing gains from phase 1 to finance phase 2 readjustment costs. Three main problems appear:

- strong magnitude of potential shock;
- major risks linked to thresholds and irreversibility;
- significant distance between different steady states (resulting in increasing difficulties to adapt).

The second strategy tries to hold back the destabilizing potential charge during phase 1 and to maximise the capacity to implement innovative switches during phase 2. Four comments about this strategy:

- phase 1 does not follow an objective of maximization any longer;
- the creation of development options becomes a major objective;
- shock magnitude is quite low comparing to the first strategy;
- compared to the first strategy, the proximity between steady states increases and as does shifting frequency.

The implementation of securing water paths requires adopting the second strategy. In the short term, costs increase because the goal to create options partially replaces the maximization of gains. Nevertheless, this strategy is

[2] From the perspective of the coevolutionary approach, gains and costs are non exclusively monetary. Ecosystem services, among others, have to be integrated. By evaluating the interdependencies between economic activity and the environment, Houdet *et al.* (2012) give an illustration of an accounting of the ecosystem services' value in assets and liabilities. On the valuation of ecosystem services, see also the controversial but major paper by Costanza *et al.* (1997).

more sustainable due to a more uniform repartition of costs in time — that enhance intergenerational equity— and to a minimization of the risks linked to development's irreversible consequences. Moreover, the multiplication of potential development alternatives could improve intragenerational equity if the distribution of gains and losses in the population emerges from a collective choice among numerous realistic options.[3]

Thirdly, to be complete, the theoretical governance scheme allowing to shape securing water paths must integrate operational considerations. As an operational scheme, we use the "management and transitions framework" which shapes the notion of "adaptive management" (Pahl-Wostl 2009). Adaptive management involves maintaining the adaptive capacity of a system *via* social learning, participation and the elaboration of a road-map: "adaptive capacity refers to the ability of a resource governance system to first alter processes and if required transform structural elements in order to better cope with experienced or expected changes in the societal or natural environment" (Pahl-Wostl *et al.* 2010: 572). This kind of management conflicts with a regime of governance based on control and prediction, as those located in the lower part of the typology presented above. In this case, managers target desired states whilst preserving and developing mechanisms of the system's reorganisation (Walker *et al.* 2002). Thus: "adaptive management is here defined as a systematic process for improving management policies and practices by systemic learning from the outcomes of implemented management strategies and by taking into account changes in external factors in a pro-active manner" (Pahl-Wostl 2010: 573).

Taking an institutionalist point of view, the learning capacity improves the potential of coordination because institutional change rests upon a trial-error approach (Ostrom 1990). Thus, stakeholders question their habits and mental representation by modifying their behaviours. Hodgson (2007) calls this process "reconstitutive downward causation". This learning capacity endogenizes institutional change but does not downplay the relationship between behaviour and finality. In the dynamics of an adaptive cycle, learning stimulates the emergence of influential ideas needed for the reorganization of the system during the second main phase. As well as learning, participation increases the range of these ideas and enables the making of concerted choices toward securing water paths (upper part of the typology). Moreover, the combination of these two principles of governance develops the reflexive dimension of governance (Brousseau *et al.* 2012). Due to these mechanisms, a securing water path increases the degree of intentionality in governance.

[3] Thus, securing water path and IWRM are distinct considering their status: the first one is a process meanwhile the latter could be seen as a modality of its operationalization (on this discussion, see Cook & Bakker 2012).

Thus, adaptive management accelerates the frequency of the recursive loops that link stakeholders and the social structure. We call recursive loop the sequences of upward causation and reconstitutive downward causation in the interactions between stakeholders and institutions (Hodgson 2007). This frequency highlights the fact that institutions have to be "agent sensitive institutions" to build securing water paths. These institutions are those "in which the reigning equilibria or convention can be significantly altered if the preferences or dispositions of some agents are changed, within a feasible set of personality types" (Hodgson 2006: 16).

To summarize, following a securing water path requires a type of governance that tends to continuously conserve and build options. Instead of trying to forecast, the goal is then to establish favourable conditions for adaptability, *i.e.* the emergence of feasible and varied alternative strategies. Incorporated in a trial-error approach, managers and stakeholders build an evolving process to cope with vulnerability.[4] Consequently, technical and operational choices cannot get round both the complexity of local situations to regulate and the deliberative determination of the rules of collective choices.

4 Water Security Governance: A Discussion Stemming from Urban Water Systems

The theoretical mechanisms presented above need to be confronted with reality. Because this research is exploratory we only consider their potential concrete manifestation. Following Spach (2012), a normative vision is necessary at this point of the analysis. To draw the outline of this vision we refer to Heynen *et al.* (2006: 11-13), whose scope could be synthesized in three key points: the system's history, the democratic process of the stakeholders' involvement and, the consideration of "non human actants".

Firstly, "environments are combined socio-physical constructions that are actively and historically produced, both in terms of social-content and physical-environment qualities" (Heynen *et al.* 2006: 11). This statement reveals a form of path dependency in the co-evolution of the system which is crucial for governance. For example, in 1989, the British water services were privatized and most of the new companies did not invest sufficiently in water infrastructure. Consequently, during the 1995 major drought, the system was unable to satisfy users: "from this perspective, the Yorkshire drought was neither simply a freak of nature, nor an isolated case of spectacular mismanagement of a water supply system, but rather what Neil Smith terms 'produced scarcity in nature' (Smith 1984, 60). The restructuring of YWS

[4] For example, to cope with global warming, Magnan *et al.* (2012) propose a methodological scheme in three steps to shape "vulnerability paths".

[Yorkshire Water System] post privatization entailed changing flows of information and reconfiguring of resource and quality management techniques, altering not only decision-making practices but also the sanctioned actors and information involved in decision making" (Bakker 2000: 22).

Secondly, "socio-ecological 'sustainability' can only be achieved by means of a democratically controlled and organized process of socio-environmental (re)-construction" (Heynen *et al.* 2006: 13). The transformation of water governance in Munich during the 1990's is particularly relevant. All along the 19th century, drinking water was never treated in Munich. The quality of water was protected by an active municipal land-purchasing policy. But, with the development of modern agriculture, water became polluted and this generated a foul taste. Thus, after deliberating, the city council devised financial compensations to encourage farmers to switch to organic farming. These incentives were formalised *via* peculiar contracts: "farmers under contract are thereby bound by two obligations: namely by having contracted with the potable water distributor and by their contractual commitment to the organic farming association" (Krimmer 2010: 706). In the end, for an increase of only 0.7 eurocent per m^3, water is still untreated and meets both sanitary and organoleptic criteria.

Thirdly, "processes of metabolic change are never socially or ecologically neutral" (Heynen *et al.* 2006: 13). The regulatory changes in the British water sector mentioned above illustrate this point, as does the analysis of the water sector in Athens carried out by Kallis (2010). It focuses on the co-evolutionary process of water reforms in the Greek capital city considering two both evolutionary and interconnected sub-systems. On the one hand, the "policy system" grasps alternative policies of water supply; on the other hand, the "household system" tallies with the urban population behaviours and characteristics of uses. He notes that "the household and policy systems are in coevolutionary interaction with a bio-physical environment in and out of the city. They transform this environment and evolutionary adapt to their transformations […]. Biophysical conditions —together with socioeconomic and cultural conditions— constitute part of the selection environment for alternative household practices or policy actions" (Kallis 2010: 800). Thus, the chosen paths contribute to determining possible futures depending on the actors' perception. Using this conceptual framework, the author explains the vicious circle characterising the evolution of water uses in Athens and, finally, he proposes a "soft water path" (Gleick 2002), which consists in deviating governance modalities toward a participative and local management and to put an end to centralised management focused on infrastructural development and on top-down control of users.

Implicitly these three key points show us that: "non human 'actants' play an active role in mobilizing socio-natural circulatory and metabolic

processes" (Heynen *et al*. 2006: 11). They are determinant in the *modus operandi* of stakeholders' involvement and their acceptation of securing water paths. In that way, Flipo (2004) demonstrates the central role of indicators to make complexity "commensurable" for stakeholders. Indicators become an "actant object" because they question the determination of collective action problems (description, perception, objectification, solution scenarios, *etc*.) (Le Bourhis 2001; Latour 2006). Renou (2013) offers a stylized version of such indicators tracing a "sustainability area" for urban water system. This "sustainability area" identifies different alternatives toward securing water paths.

In this paper we did not mention the political dimension of securing water paths. We really think that politics and power determine the output of governance, even more so in the context of integrated and deliberative acceptation as promoted here. The main political challenge is to build a form of democracy that "protects social diversity" and new political rights for the population (right to a healthy environment, right to water, right to vote, *etc.*). However this new form of political citizenship can only operate if it is supported by other (economic, social and cultural) "citizen spaces", providing a way of overcoming the dialectical tension between the stakes of a new political citizenship and the challenges in terms of sociability and solidarity.

Institutional approaches based on polycentric (rather than state-centred) and multi-level governance (from the meta-constitutional to the operational level) provide a way out of fruitless dichotomies (public/private, formal/informal, mercantile/non-mercantile, *etc*.) highlighting new categories able to grasp social, technical and territorial diversity. However, by maintaining the assumption of neutral interaction between (autonomous) actors and (given) rules in the analysis, the author rules out the possibility of seeing polycentric governance as a socio-political process in which a wide diversity of individual strategies are deployed (Saravanan 2008). But, as the latter points out, looking forward to frame sustainable and concerted solutions should be based on a vision that grasp the complexity of "decision-making arenas" or "action arenas" (Ostrom 1990). A new line of research is thus emerging. It aims at focusing on complex natural systems, on the combined contributions of the game paradigm (Ost & Kerchove 2001) and on empowerment (Cleaver 2007). Regulatory power will play an essential role here, *i.e*. "instituting" collective action", which departs from the traditional functions assumed in a "command and control" regime: it must ensure the coupling of decentralized organizational learning and institutional dynamics. These conclusions provide innovative perspectives for our agenda for further research in order to define such action arenas that could help designing securing water paths.

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