Preface

Changes in water technologies proceed through a complex interplay of abrupt changes and slow processes of adjustment and hybridization. While the study of technological change has traditionally focused the attention on technical features, more recently an analysis of the relationship between technical changes and deep modifications of the underlying culture and knowledge started, together with the analysis of the social and institutional practices related to them. This comes from a refined understanding of technologies as socio-technical systems whose changes is deeply related to the generative interplay between people and technologies (Bijker, 1997; Trist, Murray, 1993).
The transformation pattern of water technologies is particularly complex in developing or emerging countries, as in these countries indigenous and western cultures met throughout history and produced complex dynamics of socio-technical change and multifaceted processes of domination and resistance. While the interplay of indigenous and Western culture often led to the collapse of traditional systems, some times indigenous technologies resisted to the external domination and evolved through interesting innovation and hybridization patterns. When this happened, key research questions centre around the modalities through which hybrids of knowledge and technologies have been co-constructed from indigenous and external inputs, the modalities through which old concepts and routines mixed with new ones (Lanzara, 1993) and activated generative enactment process leading to change (Weick, 1995), the analysis of key features of traditions and their generative and innovative force (Barbanente *et al.*, 2010; Brunsson, Olsen, 1998; Weick, 1995).

Technological memory

Starting from evidences presented by some case studies on water technology in contexts where tradition and memory still resist to innovation and standardization, we have evoked a concept of 'technological memory' (Borri *et al.*, 2010). The case of the technology of the *jagüeyes* in Mexico – small artificial basins used by villagers in the pre-Hispanic Mexico to satisfy their basic water needs – which today persist where the *Conquistadores* did not arrive or are neglected where the arrival of these implied relevant water technological changes, is meaningful.

Since ancient ages, in arid climate countries, water technology presents extraordinary examples of specific organizations devoted to designing, constructing, and managing complex and ambitious works. The frequent big dimensions of these works and the evidence we have about the impressive collective organization of the human work needed for them should not obscure individual brilliances and contributions. The gradual minor adjustments that have been brought to the original forms of these works through the infinite repetitions of them in different places and times suggest that social forms of cognitions and actions interacted with individual contributions, granting a blend of mutual learning and transfer of memory and creativity.

With the gradual disappearance for many reasons of the productive and market organizations on which certain techniques are based technological memories referring to these suffer transformations and become unusable.

An interesting example of disappearance of a given technological memory due to the destruction of the socio- political organization on which that technique with its materials, markets, and professional abilities was based is presented by the construction of large roofings. Covering large spaces without intermediate supports (see the solution used in Rome during the Empire age for the Pantheon's dome, a semisphere of more than 40 metres of diameter, built in a very sophisticated way with extremely light prefabricated clay pieces settled in concentric circles and linked by light and tenacious mortar) will be impossible for 1.500 years, until the invention of a different building solution (by the way strongly less sophisticated: heavy masonry, made of bricks reinforced by big ribs) for the Gothic dome designed by Filippo Brunelleschi for the cathedral of Saint Mary in Florence (Petrignani, 1978). In this case, the disappearance of the Roman political and productive organization operationally annihilated a technological memory: building history and techniques in exceptionally wide perspective were presumably perfectly known

to Filippo Brunelleschi in Florence or to Andrea Palladio in Venice, the two giants of architecture presumably shared the sectoral technological memory which was needed for emulating the Roman technique of covering large spaces but they did not have anymore the ability of making it operational.
Based on the Newell's and Simon's memory model (human abilities as gradually formed by series of condition-action rules) or to the Anderson's one (abilities based on integration of factual memory and procedural memory), we have assumed a technological memory indexed and stored by three essential attributes: facts, procedures, and judgments about these. In this way, parts of a technological memory, learnt through direct (tradition) or indirect (description) experience, can be gradually disused and in the end deleted or more probably freezed by the attachment to them of attributes of obsolescence and impracticability.
Technological memories are constituted in the agents through direct or indirect – the latter as they can spread outside from local origins – experience and can (i) be limited to simple passive cognition of facts and procedures ("I know that a certain technique exists" or "I saw that technical device while functioning", or "Somebody described me that technical device but I never had a chance to use it ") or (ii) become part of an active inclination of the agent as a direction given by him/her to other agents (political agents can impose to other agents – should these already know it or not know it so that they have to learn it immediately – to adopt that technique), or, further, (iii) become part of a life that uses that technique ("I am a user of that technical devices, should they have functionality problems maybe I would be able to repair them" or "I saw that technical device while functioning, while giving me water availability for long time", or, in the end, (iv) become active ability ("I know very well that technical device as I had the chance of realizing it" or "I was present when this technical device was realized and started its functioning", or "I know how to create this type of technical device here", or "I am a user of this technical device", or "I am not a user of this technical device but I could be a user of it in the future").

In a process of technical imitation, consisting in introducing an exogenous technique into a place, the whole set of cognitions and resources on which the technique at hand founds is present, so that what results is a – no matter how much relevant – technical change, an ecological variant of the technique at hand, whose inspiring principle (the ontology) remains substantially fixed, obviously in the terms in which the imitator conceptualized that technique or that technique was represented to the imitator (the latter through a technique description to this by a protagonist – primary – or informed – secondary – agent). Therefore in technological transfer and use of a technological memory it is important to distinguish general principles from local applications (Borri *et al.*, 2010).

Influential theories of architecture of cognition see memory as organization of sets of atomic condition-action rules (Newell, Simon, 1972) or, alternatively, frames (Schank, Colby, 1973), while more recently the two alternative forms of memory organization have been seen as complementary (Johnson-Laird, 1988): in a contingent action model, for instance, the use of a causal frame – immediate, non sequential representation of the reality – would be selected first instead of a sequence of atomic rules.

We assume that a technological memory cannot be effectively constituted when the principle of functioning and applicability of its components is not clear in detail: in this case, a technique is not memorized or is destined only to passive cognition: commonsense warns us against both its possible superficiality and its merely normative orientation ("Use that technique, it has a lot of positive credentials!") as sources of potential disasters.

We assume, also, that an operational technological memory – leading to actions – is constituted by facts and explanations about these, and it is not a mere if-then shaped recording of events and phenomena where causal relations are relaxed: anyway, our conceptualization includes the case of a technological memory which functions without incorporating explanation, in form of a black box: we can see a machinery while functioning without understanding why and how this happens. The last assertion, anyway, drives to wonder whether a difference exists between technological memories oriented to implementation but not

necessarily located at the top of the hierarchy of the agent's intelligence in his/her relation with the world and other memories that can relate to and deal with events and natural phenomena the reason of which we do not understand. An interesting hypothesis we are cultivating is that a difference exists, coming from the intuitive perception that in front of unclear natural phenomena all human agents share the same knowledge condition while in front of unclear human phenomena (see the use of an unfamiliar technique) there can be asymmetries among human agents, depending on their familiarity or not with that technique. From here the nonsense for us – a part from possible intentional learning, aimed at entering a circle of technical scholars – of cultivating technological memories that are impracticable for us for some reason: in fact, we face impracticable techniques avoiding their use or delegating this to specialists (see the Nozick's hypothesis about the emergence of a technical rationality more and more inaccessible for non-specialists) (Nozick, 1993).
Coming from the above, the selective constitution of a technological memory, with large or narrow stitches respectively when human agents intuitively perceive that they need a large filter to increase their survival abilities in future solitary confrontations with a technique or that they can delegate a technical problem solving to others (Borri *et al.*, 2010).
In this reasoning the following question is nested: in a water technology like the one of the *jagüeyes,* which presents a problem of technological memory drama in a village community under the push of exogenous innovations, is the *jagüeyes* technological memory diffuse throughout the whole village community or owned only by experts? Our case studies report a technological memory diffuse throughout the whole set of community agents, because of its simplicity that makes that it can be easily memorized and reproduced by all, preserving it from becoming exclusive patrimony of experts. The whole society of the individuals of the village has had to contribute to maintain the *jagüeyes*, so that they became active protagonists of that technique and agents of the related technological memory.
In the end, our water technology case studies allow us to argue in favour of the existence of a technological memory featured by

selective nature, richness of causal relations, variable distribution within the whole set of agents who practise a given technique related to that technological memory, changes deriving from ecology-based utility functions, strong linkages to resource and organizational systems and weak linkages to individuals (this because techniques – differently from what happens for if-then rules for manipulating or recognizing biotic or a-biotic entities – are part of complex social chains and can hardly be implemented in isolation).

Therefore technological memories have high social connotation, are not basic (as they do not pertain to fundamental facts and processes), and like in other social domains accept division of work ("You have that memory which differs from mine …").

In practice, just because of this sociality, technological memories essentially function in interactive ways and cannot be understood, constituted, and experienced in isolation: because of their lack of basic contents, they can be cleaned or at least confined into sleeping memories to be retrieved and activated only in particular conditions of intentionality or need.

We have also found that communities affected by organizational breakings in water technologies suffer from a destruction of their technological memories: they are forced to start from scratch through the adoption of new techniques, often exogenous and worse than the traditional ones.

Dilemmas on water technology

These issues – technological change, in general, and technological memory, in particular – were central in the research developed within the EU-FP6 funded project ANTINOMOS "A knowledge network for solving real life water problems in developing countries: bridging contrasts". The project started from the conviction that a deep investigation of real performance and acceptance of traditional and modern technologies in developing or emerging countries is needed in order to pursue a more holistic understanding of water issues and to increase the link of knowledge to action in real life contexts. In particular, the project tried to overcome the persistent conflict between modern approaches and indigenous solutions to water problems by trying to unveil the knowledge embedded in them as well as their transformation patterns. The conflict between them is, in fact, part of the larger opposition between the knowledge systems in which those technologies are embedded.

While mainstream international interventions are still mainly devoted to transfer modern Western technologies to developing countries, local contexts are mainly seen as limiting factors for an easy transfer of external solution instead than a source of useful knowledge for water problems. In this vein, traditional technologies and practices are still often perceived in the mainstream as based on irrational beliefs and myths, thus being subjective, context-specific, and lacking a sound cause-effect basis (Millar, Curtis, 1999). They are considered to be the product of a non-scientific system of thought, which should be "modernized" through the transfer of other systems of thought (Kloppenburg, 1991). In the attempt to challenge this simplistic view, the ANTINOMOS project developed the analysis of several modern and indigenous technologies in India, Mexico, and South Africa.

The papers collected in this volume are the results of the research directly and indirectly related to the ANTINOMOS project. They were discussed during the last project conference held in Bari on November 2010. Five of the papers contained in the volume were written by project partners (Elisa Roma et al., Maria Luisa Torregrosa et al., Daniel Murillo Licea et al., José Luis Martínez Ruiz et al., Dino Borri et al.) while four papers were written by researchers interested to contribute to the ANTINOMOS debate through the account of their own research experience (Luigi Berardi et al., Amin Nawada et al., Mahmoud Hozayn et al, Raffaele Giordano et al.).

The two papers contained in the first section, "Intersections", aim to explore multi- and trans-disciplinary issues on human settlements, reflective of multiple and hybrid cultures.

The paper by Elisa Roma, Alison Parker, and Paul Jeffrey describes an innovative multidimensional framework (namely RECAP) for the assessment of water and sanitation technology performance in developing countries. The model tries to overcome the limits of pure technological approaches by stressing the importance of the assessment of social aspects and users' perception and by giving voice to recipients and providers of the transferred technologies through participatory post-implementation evaluations.

The paper by Luigi Berardi, Daniele Laucelli, and Orazio Giustolisi describes the architecture of a decision support system (DSS) for the definition of optimal medium-term rehabilitation plans for the management of water distribution networks. The components of this tool, as well as a real life application in the Apulia region, is illustrated.

The section "Practices" aims at including alternative, self-sustaining, innovative, and democratizing practices, aimed at transforming the natural and life spaces of local communities. It is composed of five papers.

The paper by María Luisa Torregrosa, Jordi Vera, Karina Kloster, and Beatriz Torres explores the reproductive forms of technologies by unravelling the social and cultural processes that made possible the technology's appropriation, its social assimilation as well as its use and maintenance. This is done with reference to four case studies about the use of two Mexican water technologies, one rooted in the pre-Hispanic period, namely the Jagüey, and the other imported by the Spaniards after the Arab influence.

The paper by Daniel Murillo Licea, and José Luis Martínez Ruiz describes the main hydraulic technologies of pre-Hispanic origin in Mexico as well as the cultural aspects of their construction and their links to the Mayan cosmology. By so doing, it tries to define the potential for their actual use in Mexico as well as the scope for the use of the so called "appropriate technologies" by indigenous communities in Mexico.

The paper by José Luis Martínez Ruiz, Daniel Murillo Licea, Markus Starkl, Ricardo López, and Nelly Libeyre critically discusses potential and limits of the transfer of technological models based on the analysis of a case study where a traditional technology, namely a roof water harvesting system, has been recently equipped with a modern treatment technology based on UV rays, namely the tUVo system. In particular, it tries to identify key reasons for the lack of social acceptance and the disuse of that

system, which nevertheless proved to be technically and economically viable.
On the basis of a case study in Jericho in the Occupied Palestinian Territories, the paper by Amin Nawahda and Samar Shanti discusses a model for sustainable water resources development, which is based on releasing the stresses on the ground and surface waters and protecting the environment. The integration between water and sanitation systems based on the reservoir control approach is an essential element of the proposed model.
Finally, the paper by Mahmoud Hozayn , Amany Abdel-Monem, and Amira Abdul Qados describes the key impacts of the use of magnetic water for agriculture based on a pilot experiment conducted in the screen green house of Agronomy Department, National Research Centre, Dokki, Giza, Egypt, with the final aim to discuss a tool for improving crop production in Egypt.
The section ”Vision” aims at encouraging discussions about possible futures, virtual worlds, dream pieces, and anticipation of experiments. It is composed of two papers.
The paper written by Raffaele Giordano, Giovanni. Passarella, and Michele Vurro proposes a methodology based on a Fuzzy Cognitive Map (FCM) to support the elicitation and the analysis of stakeholders' perceptions of drought, and the analysis of potential conflicts raised by the implementation of mitigation strategies. An accounts of the application of this method in a drought management process in the Trasimeno Lake area (Umbria Region) is also accounted for.
The paper written by Dino Borri, Domenico Camarda, Laura Grassini, and Mauro Patano deals with operational concepts which arise in building intelligent systems and semantic web systems for managing databases for water technology. It pays particular attention to problems of database labeling and retrieval of traditional water supply and sanitation techniques. The paper proposes an ontology-based flexible system architecture, looking at technological memories and cognitive multi-agencies as useful components of the system.

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