KNOWLEDGE REPRESENTATION AND MEDIATION FOR TRANSDISCIPLINARY FRAMEWORKS: TOOLS TO INFORM DEBATES, DIALOGUES & DELIBERATIONS

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Abstract

In this paper we address the challenges of transdisciplinary practice and quality assurance by extended peer review, in terms of knowledge co-production, mediation and representation. Spaces for the articulation of plural narratives are explored, including the opportunity to deploy new information technologies. The TIDDD (tools to inform debates, dialogues & deliberations) is introduced in the context of the European Commission funded GOUVERNe project.

1. The Transdisciplinary Challenge

It is now recognised that fields of knowledge and scientific practice are, in many cases, no longer usefully divided into isolated compartments. This awareness leads to attempts to create bridges among several disciplines, and the emergence of inter-disciplinary and multi-disciplinary studies and projects. Already in the 1960's multi-disciplinary approaches were seen as an essential way to tackle practical problems, providing an impulse for the further development of systems thinking, integrated methodologies and operational research. On the late 1970's academic curricula everywhere reflected the recognition that societal issues have to be approached, framed, resolved and justified from a multiplicity of perspectives, some even recognising a transdisciplinary evolution (Nicolescu 1999). This is clear in addressing such problems as sustainability and, in general, environmental and health governance.

There are several definitions of *trans-disciplinarity* but it is generally described as a specific form of inter-disciplinarity in which boundaries between and beyond disciplines are transcended and knowledge and perspectives from different scientific disciplines as well as non-scientific sources are integrated (Flinterman *et al.* 2001; Klein *et al.* 2001). Gibbons and Häberli (in Gibbons & Nowotny (2001), page 68), refer to "joint problem solving", i.e. the idea that trans-disciplinarity involves more than simple juxtaposition,

rather it conveys integration of perspectives in the identification, formulation, and resolution of problems.

The above definition stresses the importance of **integration** of different scientific disciplines and non-scientific sources (and types) of knowledge. The latter is the characteristic feature that distinguishes trans-disciplinarity from other multi-disciplinary approaches. The concept originated from the increasing demand for **relevance, legitimacy** and **applicability** (which are aspects of quality) of academic research to the challenges of societal *problematiques* in a policy context.

In the growing literature on frameworks of scientific activity, transdisciplinary approaches emerge as an inevitable explicit or implicit alternative to the disciplinary structure. This is due to the nature of the issues addressed and also to the increasing variety of places where recognisably competent research is carried out, and where most likely, disciplinary research is inappropriate.

The so-called Mode-2 knowledge production (Gibbons *et al.* 1994; Gibbons & Nowotny 2001) refers to transient innovations research in which trans-disciplinarity as a different framework of intellectual activity along with context of application, stakeholder involvement, accountability, and quality control (in the sense of societal "value integrated" to define what quality science is) are key categories. Mode-2 is described as a logical response to on-going developments in the economy and technology at the expense of the established University disciplines and academic ideals.

As science-related policy issues have come to be recognised as complex and more inherently difficult of solution, the conception of the role of science has also developed and matured. Funtowicz (2006) describes the evolution of conceptual models of the relation between science and decision-making in policy processes. The "modern" model (perfection/perfectibility) where scientific facts (unproblematic, employed in rigorous demonstrations) determine policy progressed into four different models: precautionary (uncertain and inconclusive information), framing (arbitrariness of choice and possible misuse), demarcation (possibility of abuse of science) and the extended participation model. The latter recognises that due to "*imperfections in the deployment of science in the policy process, it becomes ever more difficult to defend a monopoly of accredited expertise for the provision of scientific information and advice. "Science" (understood as the activity of technical experts) is included as one part of the "relevant knowledge" is brought in as evidence to a process. The ideal of rigorous scientific demonstration is replaced by that of open public dialogue. Citizens become both critics and creators in the knowledge production process as part of an extended peer community. Their contribution is not to be patronised by such labels as "local", "practical", "ethical" or "spiritual" knowledge. A plurality of co-ordinated legitimate perspectives (with their own value-commitments and framings) is accepted. The strength and relevance of scientific evidence is capable of assessment by citizens. All sides come to the dialogue ready to learn, or else the process is a sham*" (Funtowicz 2006).

In their work on *post-normal science*, Funtowicz and Ravetz (1990, 1992) have analysed how the presence of irreducible uncertainty and complexity in science-relevant policy issues necessitates the development of alternative problem-solving approaches, in which uncertainty is acknowledged and science is consciously democratised. In the extended participation model, through the co-production of knowledge, an *extended peer community* – see section 2 – creates a democracy of expertise in the context of post-normal science.

Jasanoff (1996) has argued that scientific knowledge is contextual and not independent of culture and values; it is co-produced by scientists and the society within which they are embedded. The contextualisation of knowledge production, as policy relevant scientific knowledge requires a transdisciplinary approach, both in terms of the integration of types of knowledge and of the mediation among sources of knowledge. Trans-disciplinarity is therefore unavoidable in the production of useful knowledge, it being implicit in the context in which knowledge co-production occurs or explicit in the integration of different types and sources of knowledge.

In transdisciplinary practice, interfaces among different types of knowledge and the articulation of co-production activities and uptake of co-produced knowledge in established institutional arrangements become key issues for operationalising such endeavour.

Each discipline has developed in an established conceptual and methodological framework, with its own scales, language, narratives, knowledge representation, knowledge mediation and communication. Moreover, *scientisation* has lead to the scientific internalisation of many societal issues, especially in environmental and health domains. This has occurred mainly through the creation of masses of quantitative knowledge and argumentations which, in many cases, do not help and can even worsen controversies (Sarewitz 2004), confusing framings and justifications when (urgent) action is required. Hence, transdisciplinary activities have to deal with a myriad of *knowledges* and perspectives that have to be mediated and articulated in appropriate ways.

In this paper, we concentrate on the post-normal science framework within which we have developed TIDDD or tools to inform debates, dialogues & deliberations, in order to operationalise the concept of quality assurance through an extended peer community. This is a coherent response to the need to extend the assessment of relevant knowledge to those who contribute to its co-production, outside the boundaries of disciplinary science.

2. Quality and Extended Peer Review – Post-Normal Science

When policy-relevant science is recognised as uncertain, complex and contextual, new approaches for knowledge production are necessary:

> *"The insight leading to Post-Normal Science is that in the sorts of issue-driven science relating to (...)* [complex societal issues]*, typically facts are uncertain, values in dispute, stakes high, and decisions urgent"(...) In post-normal conditions, such products the goal of achievement of truth or at least of factual knowledge may be a luxury, indeed an irrelevance. Here, the guiding principle is a more robust one, that of* ***quality****." (Funtowicz & Ravetz 1990)*

Box 1: Funtowicz & Ravetz (1985; 1990; 1992; 1993) have represented through the diagram in figure 1 how different types of problem solving strategies and practice correspond to different sorts of uncertainty (namely technical, methodological, epistemological) as well as, how they relate to the world of policy: *decision stakes* included "costs, benefits, and commitments of any kind by the parties involved".
"In post-normal science, when global environmental issues are involved, the stakes can become the survival of civilization as we know it or even of life in the planet" Funtowicz & Ravetz (*ibidem*) .

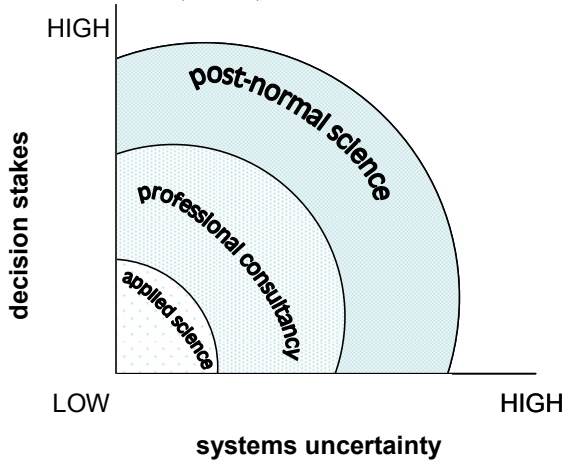

Figure 1: Three types of problem solving strategies by Funtowicz & Ravetz (1985; 1990; 1992; 1993)

The assessment of the quality of the knowledge inputs to policy issues by those extended communities are in many ways different from the review processes of research science, professional practice or industrial development (Funtowicz 2001). Each of those has its established means for quality-assurance of the products of the work, be they peer review, professional associations, or the market. However, for new controversial problems, the maintenance of quality depends on open dialogue between all those affected.

The post-normal science framework (Funtowicz & Ravetz, 1990; 1992; 1993; http://www.nusap.net – see also box 1), and its guiding principle quality, requires the participation of an extended peer community (Funtowicz & Ravetz 1990) engaged in dialogue and the resolution of the issues at stake. An extended peer community consists not merely of persons with some form or other of institutional accreditation, but rather of all those with a desire to participate in *extended peer review* processes for the resolution of the issue (Funtowicz & Ravetz 1990).). Since this context of science is one involving policy, we might see this extension of peer communities as analogous to earlier extensions of the franchise in other fields, such as women's suffrage and trade union rights.

New forms of dialogue and new mechanisms for introducing scientific issues to non-scientific contexts calls for radical changes in the design of interfaces between the scientific processes and products and the audiences to be engaged.

This extension of the peer community requires the design of new forms of integration and conviviality of different types of knowledge and possible justifications. On one hand the extended peer review process of *knowledge* scrutiny, may improve the knowledge database; yet, a different sort justification can be sought for such extended peer processes: *the building of a convivial society*. This view of the "integration" process — considered as an interactive (participatory, deliberative, etc.) social process with political, as well as cognitive and scientific dimensions — is, in itself, a way of generating high(er) quality policy evaluation, decisions and outcomes (Guimarães Pereira & O'Connor, 1999). Conviviality is the opposite of technocratic production, is the concept that recognises that *"people can do more than relinquishing the task of envisaging the future to a professional elite"* (Illich 1973).

Box 2: In case of local risk management much relevant knowledge can be drawn everyday experience gained personally by dealing with real world problems as well as encapsulated in social folklore and mores, about the nature of the hazards, thus providing invaluable insights for effective risk management. In the case of long-term future considerations, even if there is a consensus about plausibility of experts' scenarios indicating severity of a future problem (e.g. climate change) the willingness and ability of people to act for a common future depends a lot on the framing of options in terms that are meaningful for themselves in their social scene, and that are in conformity with the realities of past experience and practicable future initiatives (O'Connor in De Marchi *et al.*, 1998)

In these new forms of dialogue there are two contrasting notions of integration concerning knowledge reconciliation: on one hand integration can be conceived as the reconciliation of all knowledge within the terms of a single and internally consistent conceptual framework; on the other hand it can be seen as the reconciliation of perspectives and understanding as co-existing in society in their irreducible plurality (O'Connor in De Marchi *et al.*1998).

Extended peer communities are already being created, in increasing numbers, either when the authorities cannot see a way forward, or when they know that without a broad base of consensus, no policy can succeed. They are called citizens juries, focus groups, consensus conferences, or any one of a great variety of other names; and their forms and powers are correspondingly varied. But they all have one important element in common: they assess the quality of policy proposals, including a scientific element, on the basis of the science they master combined with their knowledge of the ways of the world. The contribution of relevant social actors in this case is not merely a matter of broader democratic participation and their verdicts all have some degree of moral force and hence political influence.

These extended peer communities will not necessarily be passive recipients of the materials provided by experts. They will also possess, or create, their own *extended facts*. These may include craft wisdom and community knowledge of places and their histories, as well as anecdotal evidence, neighbourhood surveys, investigative journalism and leaked documents. Such extended peer communities have achieved enormous new scope and power through the Internet. Activists scattered among large cities or rainforests can engage in mutual education and coordinated activity, providing themselves with the means of engagement with global vested interests on less unequal terms than previously.

Along with the regulatory, evaluative function of extended peer communities, another, even more intimately involved in the policy process, is springing up. Particularly at the local level, the discovery is being made, again and again, that people not only care about their own environment and health but can also become quite ingenious and creative in finding practical, mixed social and technological means for their improvement. In many cases, local people can imagine solutions and reformulate problems in ways that the accredited experts, with the best will in the world, do not find *normal*. This is most important in the phases of policy-formation, and also in the implementation and monitoring phases. Thus, in addition to extending the traditional processes of quality assessment, participants can enhance the quality of the problem solving processes themselves.

As stated earlier, transdisciplinary practise arose as a response to the increasing complexity of scientific knowledge production, and the need to re-establish an active dialogue among a plurality of disciplines and forms of knowledge (Nicolescu 1999). This requirement now extends beyond the inter-operability of methods and techniques coming from different scientific disciplines; it is in fact a quest for quality, not (just) excellence in scientific terms, or (just) reliable knowledge but robustness also in societal terms (Gibbons 1999). The aim of knowledge quality assurance by extended peer review is precisely to open processes and products of policy relevant science to those who can legitimately verify its relevance, fitness for purpose and applicability in societal contexts, contributing with "extended insights and knowledge".

Transdisciplinary practice and extended peer review face common challenges such as, for example, resistances and closure of institutional or established practice in research and policy, different conceptual and operational framings, knowledge representations and mediation (Guimarães Pereira & Funtowicz 2005). Both require processes of knowledge representation and mediation as the means to actually reconcile different types of knowledge, enhance the quality of policy processes.

3. Knowledge Representation & Mediation: Interfaces

In transdisciplinary literature, the issue of knowledge representation and communication is recurrent due to a perceived need to communicate more complex and dynamic insights,

exploring the use of metaphors, patterns and analogy (see e.g. Judge 1995). Knowledge representation and mediation becomes an issue when different sources and types of knowledge have to be "integrated in a framework of analysis" or have to be articulated in a same decision space. It often happens that the need to deal with a diversity of *knowledges* originates from those who are already used to a certain type of framing and the deployment of specific tools of assessment.

Traditionally, integration meant reductionism and the conversion of different languages into one single, mainly quantitative language (e.g. Cost Benefit Analysis or other mono-criterion evaluation techniques, such as multi-attribute theory). This tendency has persisted, despite the pitfalls of knowledge loss, poor scoping and increased controversy. The recognition of multiple perspectives has encouraged the use of frameworks trying to acknowledge and to operationalise a diversity of knowledge representations. Among such frameworks are, multi-criteria evaluation (see, for instance, Munda 1995), integrated assessment modelling (see, for instance, Alcamo *et al.*1994), multi-scale integration (Giampietro 2003). These attempts arise from the need to make comparisons, seek for trade-offs or even become Alephs - the place from where all dimensions could be seen at the same time, according to the poet J. L. Borges (in El Aleph written 1949 – see for instance Borges 2001) - regarding alternative courses of action, policy making options and foresight.

In transdisciplinary practice and extended peer review it is often the case that the framework in which knowledge integration and assessment occurs is that of research, characterised by concepts and tools that determine in a sense the ways in which knowledge has to be represented in order to be shared. Among others Giampietro (2003) talks about different narratives depending on who initiates the process, with which purpose, perspectives and values. Hence, the main challenges posed to transdisciplinary research, extended peer review and other attempts to integrate different knowledge sources and types are, on one hand, the creation of spaces for knowledge representation and mediation and, on the other hand, the creation of spaces for knowledge co-production. That is what we call interfaces between the relevant science and the relevant sectors of society.

We argue that such methodologies should ultimately provide spaces to make sense of a variety of bits of knowledge, recognising the legitimacy of, not only different types of knowledge, but also different ways of articulating them. It is not surprising then that transdisciplinary literature points to the use of metaphors, patterns, multi-media visualisation, isomorphism, analogies, and to methods that acknowledge diversity and complexity.

A promising development of this sort of knowledge conviviality is the creation of contexts of co-production of knowledge, entailing different types of knowledge organisation for non-scientific contexts, experimented in sustainability issues (see for instance, Guimarães Pereira & O'Connor 1999). We advocate that, as in extended quality

assurance, transdisciplinary practise requires a new type of skill, enabling the creation of multiple interfaces between scientific and non-scientific *knowledges*.

Hence, we need a new sort of narrative different from science propaganda or public understanding of science; a narrative about *knowledges* interfaces and the engagement of those concerned in the science relevant societal debates, rooting the extended scientific debate in the broader cultural milieu.

4. Institutional Arrangements

Broader involvement does not happen spontaneously, it requires adequate structures and organisation. The accountability being asked of science implies a sort of co-evolutionary process in the development of societal institutions develop and knowledge production systems (Gibbons & Nowotny 2001). The transdisciplinary literature refers to "agora" (Kleiber 2001), as the place where integration of different disciplines could occur; it strongly emphasises the need for creating appropriate structures for transdisciplinary work to be carried out, including changes at the educational level, appropriate resources, etc.

Societal involvement in transdisciplinary research or extended peer review has to be conceptualised beyond the reductionist and ambiguous quantitative analysis of social statistics [from surveys and/or economical and social models] and embrace actual engagement of relevant societal actors and deployment of their actual *knowledges*. This is not a merely methodological issue but also an institutional one. It requires fundamental transformations in institutional cultures.

The creation of appropriate structures for post-normal practice, extended dialogue and co-production of knowledge requires that complexity is addressed in public *fora,* and hence purposeful communication and mediation settings, as described in section 3. Institutional adequacy has to be considered, and specifically, social settings have to be created, designed and organised to favour such extensions of extended engagement in knowledge production processes.

Eventually, new professionals have to be incorporated and specifically "institutional ears" have to be created so that there is actual uptake of knowledge produced ensuring its articulation with assessment procedures, etc. and the desired institutional culture changes.

5. Trans-disciplinarity at Work: Case Study on Groundwater Resources

The project GOUVERNe[1], aimed at the development and pilot implementation of a user-based scientifically validated process and informatics product for the improved governance of groundwater resources. The Joint Research Centre activities in this project dealt mainly with the organisation of the available knowledge about two groundwater resources case studies in Europe (see Guimarães Pereira *et al.*, 2003a and Guimarães Pereira *et al.* 2003b; Guimarães Pereira *et al.* 2005).

The methodology developed within a post-normal framework. It is based on the concept of quality assurance by extended peer review, as a normative procedure to construct the knowledge base upon which a debate about water governance options could start in both case studies. What we called the "GOUVERNe process" was strongly based on transdisciplinary principles, combining hybrid methodologies, integrating social research methods with evaluation tools, such as multi-criteria evaluation.

5.1 The GOUVERNe Process

Knowledge scrutiny in the GOUVERNe process was strongly based on social research. That was the means to ensure that knowledge other than scientific-technical was available in the knowledge base to debate on possible futures for groundwater resources and the associated river basins of the two case studies (in France and Greece). The institutional cultures faced in these cases studies are fundamentally different. Whilst the case study in France developed in a region where there is some endeavour to start a dialogue about the water governance issues, the case study in Greece develops in a highly conflicting context where relevant social actors are not encouraged to engage in dialogue.

The involvement of relevant social actors was done from the very first framing step which ensured that, early in the process, their perspective, concerns and ways of representing the issues were accounted for. The research framing acknowledged and shared by the relevant community helps to avoid the so called Type III error, of addressing the wrong problem, and enhances the scoping phase (i.e. focuses the work of collecting relevant information). The extended involvement also means that the issues addressed are shared and are dealt at the appropriate depth.

Clearly, if the experts involved in the process are the only "digesters" of the available knowledge (even if the process is *inclusionary*), their research framing and

[1] Project no. EVK1-1999-00032: a Shared Cost Action financed by DG RTD, under FP 5. GOUVERNe stands for Guidelines for the Organisation, Use and Validation of information systems for Evaluating aquifer Resources and Needs. Online. Available: http://neptune.c3ed.uvsq.fr/gouverne/ and http://alba.jrc.it/gouverne.

representation will be paramount. This is why, the quality check by the relevant community throughout the whole process is essential for compliance and effectiveness, and why the process of creating socially robust knowledge (Gibbons 1999) is a continuous *inclusionary* process of those concerned. In GOUVERNe engagement of relevant social actors was done at several steps of the process. This is fully in line with the concept of quality assurance by an extended peer community as described in earlier sections of this paper.

What emerged from the processes of knowledge scrutiny is that activities and options explored together by those concerned, had great advantages in terms of enhancing the final process of dialogue, compared with those activities structured solely by "experts": what becomes available as knowledge base to support the ongoing dialogues is perceived as a *co-produced result* and issues are then more easily appropriated by all those engaged.

One of the main research issues of this process was how to *articulate* different values and perspectives, as well as different representations of knowledge which may be presented through alternative narratives (language, framing, scales of measurement, numerical models, etc). GOUVERNe is about knowledge integration, while trying to keep diversity which in the interpretation of the researchers was the creation of a space: where different types of knowledge articulated in different sets of semantic rules, with different codes, different scales of evaluation, etc. could be represented through several formats implying various degrees of specialisation; where no *a priori* "integrative methodology" was applied as the means of sharing knowledge, the integration being made through dialogue and interactions.

This entails the effort to produce a sort of knowledge platform that is accessible to all those involved and promotes conviviality of different *knowledges*, including tools that help with the process evaluation, capturing plurality and diversity and avoiding the pitfall of reducing them to something plausible but meaningless. This was explored through the use of Information and Communication Technologies (ICT) and in particular multi-media knowledge representation.

5.2. Building Spaces for Conviviality: The TIDDD Concept

A major development within the GOUVERNe process was the realisation, the design and prototype implementation of a new concept tool: TIDDD (Tools to Inform Debates, Dialogues & Deliberations) deploying new ICT. The main characteristics of this tool can be defined as "tools that inform and mediate processes of debate, dialogue or deliberation which involve social actors of a governance, policy or decision process". Mediation of knowledge in this case entails **organisation, communication** and **exchange** of a plurality of sources and types of knowledge (Guimarães Pereira *et al*. 2003b; Guimarães Pereira *et al.* 2005). In the case of GOUVERNe, there was a great deal of disciplinary knowledge, such as climate, geological and hydrological, as well as socio-economical, regulatory, etc.

Scenario drivers to debate about future options were devised together with the social actors. Hence, as some modelling tools were used to characterise possible futures, there had to be some work on "translating" that information in order to use it as input for the models. TIDDD's aim is the creation of convivial contexts of exploration, and "discovery", where representations of knowledge come from different actors in the form of consistent narratives, aided by a multiplicity of supporting materials, namely multi-media formats, metaphors, etc. In TIDDD some pieces of information were represented through different media in order to reach different people involved. TIDDD can integrate other sources and types of knowledge that may emerge during the process, which is done through the available multi-criteria evaluation tool.

Quality assurance through extended peer review of TIDDD contents and design is one of the basic principles of this tool, since its main aim is to provide socially robust knowledge in contexts of societal debates, and even scientific controversy. This is achieved through upstream engagement of the relevant community in the implementation of the knowledge base available in TIDDD, where the social actors check all developments and ensure that contents and design are suitable to start the debate on groundwater resources futures.

5.2.1 The GOUVERNe TIDDD

TIDDD are a product and a process. The knowledge scrutiny that has to be carried out is an important feature that distinguishes TIDDD from other platforms. It includes not only the science content that can be used to assess a particular issue, but also a whole process of social enquiry with relevant actors which, in this case lead to the co-production of scenarios, co-production of perspectives and options. Hence, main governance issues, as well as main actors – and therefore the types of audiences that could take part in the aquifer governance – have been identified, prior to the development of the TIDDD (Courtois et *al.* 2001; Corral Quintana et *al.* 2002).

The TIDDD developed for GOUVERNe consists of several modules[2]. Figure 1 shows the general architecture of the TIDDD.

[2] The TIDDD software was developed using Macromedia ® Director Shockwave Studio ®, version 8.5 (http://macromedia.com). Geo-referenced data is accessed through a Map Server, which has been developed using Map Server COTS CGI (http://mapserver.gis.umn.edu/doc.html). The latter was developed by Intecs HRT: http://www.intecs.it, a partner of the GOUVERNe project.

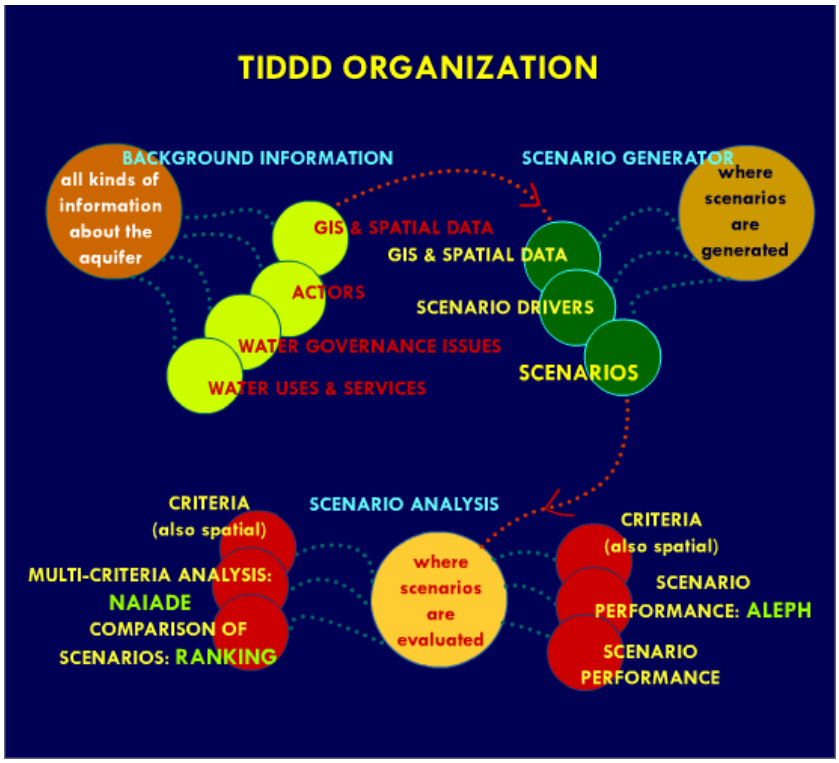

Figure 1. Map of the TIDDD available in the software, showing its functionality and linkages of modules. The software can be requested from the authors of this paper.

As an experience, it starts by introducing the user to the region of concern (1). Then through a menu the user can access several types of base information (2); governance issues, relevant social actors, uses of water and hydro system services, geo-referenced and other spatial information, etc. The user may also choose to explore scenarios by generating them through a scenario generator of plausible futures (3). This works by combining different trajectories of the drivers (factors that will influence the ways in which the future will unfold) that have been identified for the case study. For each scenario there are a number of criteria that can be visualised. From these the user may choose to assess the performance of each scenario alone (4) using the ALEPH system (Guimarães Pereira *et al.* 2003b), taking into account thresholds of suitability, or may compare scenarios using multi-criteria evaluation, namely through the Novel Approach to Imprecise Assessment and Decision Environments (NAIADE) method (Munda 1994; Munda 1995).

Both ALEPH and NAIADE provide the means for visualising different types of information, hence coming from different disciplines and different sources. NAIADE is a discrete multi-criteria method which features mixed information types and conflict analysis. Because it operates within fuzzy contexts, any attempt to reach a high degree of precision on the results tends to be somewhat artificial, and therefore a *pair wise* linguistic evaluation of alternatives is used. This is done by means of the notion of fuzzy relations, based on "semantic" distance between linguistic qualifiers (the distance between qualifiers like "good", "better" etc.). Conflict analysis in *NAIADE* is done by

constructing an "equity matrix", which gives a linguistic indication of the groups of interest' judgements for each of the alternative actions. So, NAIADE supplies the user with two pieces of information: a ranking of the alternative actions based on the selected decision criteria, and a second (normally different) ranking of the "acceptability" of these alternatives by the stakeholder groups.

ALEPH maps each scenario's performance according to a number of criteria. Through real time exploration, users can initiate an informed debate about the water governance issues. All sources of information presented are shown along with other kinds of useful information in relation to their reliability and uncertainty. This activity corresponds to one of the key aspects of TIDDD developments: the knowledge quality assurance process.

All modules are fully integrated through the same interactive multi-media interface. Different information formats are available and are fully harmonised with the tools for scenario generation and evaluation. An appealing Internet browser style was adopted to be tangible to less skilled computer users, featuring extensive navigation aids to suit less expert usage. The same information is available in different formats, so that accessibility is eased. Through the multi-criteria module, new scenarios, as well as new criteria can be defined and introduced during a session with stakeholders. This is important since it allows prearranged scenarios to be discarded and replaced by others or simply other options to be considered.

5.2.2 Quality Assurance in GOUVERNe

The Quality Assurance of TIDDD is not only about the software, or the scientific models or scientific information deployed by the software system, or about the usage context, but rather about the combination of all. That is, the quality assurance goes beyond software quality assurance or scientific quality assurance. It addresses aspects related to communication of science to non-scientific audiences and the use of these types of tools in participatory contexts (Guimarães Pereira *et al.* 2003b).

The QA process developed through group sessions, in this case focus groups[3] but other formats can be used such as workshop sessions, Internet based assessment, where in all cases participants are invited to evaluate the ICT tools they are interacting with. The evaluation is based on a set of criteria (adopted by the facilitators or moderators) related to user and societal needs, system functionality and operability, quality and reliability of the information provided, models or analytical frameworks deployed, user interface, etc.

[3] Focus groups are group interviews. A moderator guides the interview while a small group – usually 8 to 12 people – discusses the topics that the interviewer raises. The moderator is a well-trained professional who works from a predetermined set of discussion topics. These groups have a flexible organisation, as the objective is to promote interaction and discussion.
See for instance: Morgan (1998).

The users are also asked to make recommendations for modifications or improvements. These recommendations are complemented by the moderators' based on their own observation of the user's interaction with the applications.

TIDDD usage within participatory contexts has revealed how it enhances or hinders the conditions for an effective dialogue among stakeholders in water issues. The major issue arising was about the amount of information provided. Whilst specialists of the water sector (scientists) considered the available information as overwhelming, non-scientists (still relevant actors) considered that the information provided was very relevant and confirmed that the principle of progressive disclosure of information is very valuable. Also, the latter observed that the current tools for scenario analysis available through the TIDDD need further refinement in terms of interface. Their potential usefulness was recognised but they still seem to be too much oriented for an expert usage. Finally, the section on quality assurance available in the TIDDD is considered a key feature to reassure those involved in participatory processes.

6. Final reflections

TIDDD like tools are interfaces of mediation between policy spheres and other sectors of the society. This mediation is done with the help of *experts*, but what comes out of the GOUVERNe process is that a new class of expert is emerging, *experts* in creating contexts for co-production of knowledge, *experts* in mediation of different types of knowledge, perspectives and values, and eventually *experts* in making scattered non-organised pieces of relevant knowledge intelligible to the organised and sometimes poorly flexible institutions: in a sense transdisciplinary *experts*.

Trans-disciplinarity practice and extended quality assurance processes are about conviviality of different *knowledges.* It is hoped that tools like TIDDD can help to create the spaces where co-production and integrations take place. The GOUVERNe TIDDD are in fact a transdisciplinary platforms.

Finally, transdisciplinary research entails more than "just" acknowledgement of different perspectives, it requires "language" harmonisation and social, cultural and political contextualisation. Transdisciplinary work requires more than "just" articulation of disciplinary work; it requires institutions, cultures, histories to be reflected in the methodological approaches adopted to address a specific *problematique*, since contextual *uniquenesses* do show on the ways people interpret events and respond to those and also on the relationships that can be established with the research community.

Acknowledgments

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