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NETWORK ANALYSES FOR PARTICIPATORY EVALUATION OF CAPACITY DEVELOPMENT ON SUSTAINABLE SANITATION

Abstract
Is a priority for researchers to develop the sustainability science, through the integration of multiple disciplines in several scales. Socio-ecological systems under the theory of resilience are aiming to the adaptive capacity to change through the premise of "learning by doing". Evaluation is viewed as a process to steer and control programs and policies. Stakeholder participation is the key to create knowledge and learn together through an iterative process. Developing the capacity on the stakeholders to learn and take better decisions, it can conduct to a social learning process in a path to sustainable development. Integration and interrelation have they expression on the flow of information. The scientific discourse is on the need for better integration on sustainability science, but better tools are need to reflect this necessity on the practical field. We expose a graphical tool for network analyses to evaluate the interactions between huge amounts of information. If worth of information is on the relations, in graph database models many stakeholders and their activities are tracked in a network that is growing at the same time that the learning process. For the evaluation practice this is a potential because this tool allows recognizing patterns, social networks, analyse relations, detecting emergences or gaps in the knowledge creation. We illustrate the utility of this tool in the Millennium Development Goals, deeply jointed to sustainable development. The necessity to improve sanitation through capacity development in sustainability is a real problem that will need a huge effort that can be evaluated using graph database models.

Index

1 Introduction

Sustainability science is becoming a distinctive research field perceived as a top priority mission for science and technology (Kajikawa 2008). This is not yet an autonomous field or discipline, but rather a vibrant arena that is bringing together scholarship and practice, global and local perspectives from north and south, and disciplines across the natural and social sciences (Clark, Dickson 2003). There have been enormous efforts to try to bring sustainability into science (Kates, Clark et al. 2001) defining the focus on sustainability with terms as inter-, multi- or transdiciplinary (National Research Council 1999). Finally is recognized that the transdiciplinary assumptions is the most suitable for sustainability science (Kajikawa 2008). Two key properties to navigate towards sustainability are resilience and adaptive capacity: (a) Resilience is defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks. (b) Adaptive capacity is closely related to learning, and learning is central to the notion of adaptive management (Gunderson, Holling 2002). When change occurs, resilience provides the components for renewal and reorganization. In a resilient system, change has the potential to create opportunity for development, novelty and innovation (ibid.). Managing for resilience enhances the likelihood of sustaining development in changing environments where the future is unpredictable and surprise is likely (Holling 2001). A changing, uncertain world in transformation demands action to build the resilience of the social-ecological systems that embrace all of humanity (Folke, Carpenter et al. 2002). Adaptive management allows for social learning. Resilience-building management needs to be flexible and open to learning while increases the capacity of a social-ecological system to cope with surprise.

The pursuit of environmental sustainability is an essential part of the global effort to reduce poverty. This was confirmed at the turn of the millennium in two important declarations: the Millennium Development Goals (MDG) at the United Nations Millennium Summit in 2000 and the World Summit on Sustainable Development in 2002 where they provide global impetus to eradicate poverty and improve the environment (Schnoor 2002). This is reflected on the Goal 7 of the MDG as the title “ensure environment sustainability”. In our work we want to stress in the importance of the target 10: “Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation”. It is reported that the target on water and sanitation is a basic objective to achieve all of the other MDG, because is extremely related with the child mortality, diseases, maternal health, gender equality, literacy and hunger (UNDP 2006). We need to end with the up to down vision, and start a learning process between different actors (UNDP 2006). Social learning is needed to start a change towards adaptive management systems to sustainability (Pahl-Wostl, Craps et al. 2007)

Capacity development within sustainable sanitation it is a dynamic process where learning links up with live experience to improve outputs, processes and products (Keen, Brown et al. 2005). In the field of sustainable sanitation great efforts are leaded to capacity development and training with special emphasis on school sanitation (Rosemarin, Ekane et al. 2008). Better understand the interlinkages between social and natural systems will help us take the appropriate action to act in coherence with the natural system, this is a concept linked to resilience (Holling 2002). Explicit attention to learning in adaptive co-management and related approaches represents a necessary evolution if expected social, economic and ecological benefits are to be realized (Armitage, Marschke et al. 2008). Learning provides a basis for the joint action required to respond to social–ecological feedback (Folke 2006) Social learning in this context refers to the growing capacity of social entities to perform common tasks.

There is a great need on technology change to better practices, and the question is: How can we measure the advance on the learning capacity of the stakeholders in sustainable sanitation? The core question proposed is how can today's relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning? (Kates, Clark et al. 2001). Participatory evaluation can bring one of the answers. Participatory evaluation is a process of self-assessment, collective knowledge production, and cooperative action in which the stakeholders in a development intervention participate substantively in the identification of the evaluation issues, the design of the evaluation, the collection and analysis of data, and the action taken as a result of the evaluation findings.

This paper presents a technique to do participatory evaluation through the stakeholder collaboration trying to track the process of social learning in the context of adaptive capacity. The first part analyses the linkage between social and ecological systems in the sustainable development discourse, and the urgency to work with the MDGs as a way to become environmentally sustainable. Secondly we go beyond the evaluation as a process on itself to work on sustainability and the recognition that better tools to integrate social into de ecological systems are need. In order to base this contribution on an established approach for the evaluation of sustainability, we rely on the field of participatory evaluation (Blackstock, Kelly et al. 2007). In Section 4 we present the social network analyses as a tool to deal with socio-ecological systems. Because sanitation has seen as a top priority in the sustainability and development discourse we want to apply our findings to this field. To evaluate the effects on capacity development process, we stress the importance on the stakeholders who participate also in the evaluation. The network structure allow us to do better analyses on the social learning process and track the advance of outputs and outcomes and better learn across the process.

2 Sustainable science and development

2.1 Socio-ecological perspective

Many disciplines have come to share the same goal: the path to sustainable development. The common mechanism is the integration, is the case of transdisciplinary research which characterized by a process of collaboration between scientists and nonscientists on a specific real-world problem. Knowledge and values from outside the realm of science are integrated into the research process. At the same time, the research process is opened up to the stakeholders, aiming at a mutual learning process (Walter, Helgenberger et al. 2007). This new approach necessarily needs innovative methodologies to monitor and evaluate the integration among environmental and social conditions to navigate a transition toward sustainability.

The resilience approach is another one that brings the social dimension into the ecosystem management for dealing with uncertainty and change (Folke, Hahn et al. 2005) into the context of complex systems theory. The term “social-ecological” (Berkes, Folke 1998) emphasizes the integrated concept of humans in nature and stresses that the delineation between social and ecological systems is artificial and arbitrary. The capacity to adapt to and shape change is an important component of resilience in social-ecological system (Berkes, Colding et al. 2002). In a social-ecological system with high adaptability, the actors have the capacity to reorganize the system within desired states in response to changing conditions and disturbance events (Walker, Holling et al. 2004). Adaptive management proceeds by a design that simultaneously allows for tests of different management policies and emphasizes learning as we use and manage resources, monitoring and accumulating knowledge on the way, and constantly adjusting the rules that shape our behavior to match the dynamics and uncertainty inherent in the system. In other words, those participating in adaptive management expect to continually monitor the system they are managing, and in doing so they expand and enrich their understanding of the dynamics of the system (Folke, Carpenter et al. 2002). The continuous monitor is the goal for sustainable assessment.

In addition to scientific information, the adaptive capacity it requires the involvement of resource users, decision-makers and other interest groups in resource management (Gunderson, Holling 2002). Ecological knowledge and understanding of resource and ecosystem dynamics among resource users and other interest groups, its incorporation into resource-use practices and institutions, its temporal and spatial transmission and transformation, and its re-creation through cycles of crises and re-organization needs to be nurtured to counteract the creation of social-ecological vulnerability. Quantitative and qualitative data about the core set of socio-ecological systems variables of heterogeneous costs and benefits between governments, communities, and individuals and to lead to improved policies. (Ostrom 2009) How are the mechanisms to bring this desired stage to the practical field? There is a recent work reviewing tools for participatory tools in natural resources management that illuminate the possibility to share it depending on the context (Lynam, Jong et al. 2007) .There are many theories and theoretical research about it but in times of change as we are now, more practical tools to integrate this knowledge are needed.

2.2 Sustainability evaluation

Sustainable development requires a process of dialogue and ultimately consensus-building of all stakeholders as partners who together define the problems, design possible solutions, collaborate to implement them, and monitor and evaluate the outcome (Hemmati 2002). There is broad consensus that the major goal of evaluation should be to influence decision-making or policy formulation through the provision of empirically-driven feedback (Trochim 2006)(Beywl 2006), therefore is an inherently political process (Markiewicz 2005). Evaluation supports two important functions for society: steering and control, both of them inherently political. On the one hand evaluation is seen as a tool for learning and steering interventions (formative evaluations), while on the other hand evaluation is equally often used for control and legitimizing political decisions and priorities (summative evaluations). Formative evaluations are conducted for the purpose of finding potential areas of improvement for an evaluand. These evaluations aim at allowing learning in the evaluand and producing relevant information, sometimes also carried out by program staff as internal evaluators.

We want to focus on the evaluations that faithfully involve the evaluand on the process, as a way to learn together. We are referring to participative, cooperative or empowerment evaluation. Participation is therefore one of the key principles of good governance, along with transparency and accountability. Participation actually implies increased transparency by fostering exchange of information, as well as a higher measure of accountability of decision-makers to the public (Blackstock, Kelly et al. 2007). Local stakeholders often possess local, traditional and context specific knowledge that increases understanding of the issues (ibid). Through involvement of stakeholders, values of the interested parties become clearer, this provides legitimization for the decision and generates social learning. In a parallel way to the growing of sustainability science, transdiciplinary research and social-ecological systems a new paradigm is growing from the integrated sustainability assessment sharing principles by researchers and practitioners working on diverging networks in the sustainability research field. This include, as on the other approaches the interdisciplinary point of view, the use of complex systems theory and the co-production of knowledge in a interactive process among the stakeholders involved that ends on a learning process where innovation is the key (Rotmans 2006). In this point we want to see the approach as a whole, even though they receive different names from each academy or specific research streams.

For the evaluation practice, a huge number of tools have been developed to conduct assessments, including indicators, models, surveys, cost-benefit analyses and cost-effectiveness studies, but it is difficult to know how and when to combine these in carrying out sustainability assessments (Herwijnen 2008). Assessment approaches also differ in their application –whether to policies, programs, or agreements; to the national, regional or international levels; or to particular sectors. In addition to the methodology itself, the procedures for conducting the assessments are important to sustainable development – particularly transparency and the involvement of all stakeholders. Another aspect to consider is the presentation of the assessment results to policy-makers and communication to stakeholders in clear and understandable terms. One of the main limitations is the lack of interrelation between variables, instead of the standardization efforts done with the Global

Reporting Initiative (GRI 2000). It's clear the common intention to the multi-stakeholder approach to learn together, but there is a lack on the practical representation and reporting of this tendency. The desirable tools should be flexible, easy to adapt, up-to-date and suitable to be combined so that one tool can cover blind spots of another tool. A shift in the impact assessment approach is needed towards a process-oriented, integrated approach that entails more the stakeholder involvement/qualitative exercise logic than current practice.

We need new tools and instruments rooted in a new paradigm that enable us to assess quantitatively the multiple dimensions of sustainable development, in terms of multiple scales, multiple domains and multiple generations. New tools will response to an interlinkage of existing ones and improvement of existing integrated sustainability assessment tools and the developing of new ones under the characteristics of co-evolutionary, stakeholder-oriented, explorative, and more integrated (Rotmans 2006). Recent research elucidate from the stakeholders perspective, how sustainability is a situation in which relevant agents continuously learn to collaborate from the common good. The research also shows how set two different views at odds, this are the "socio-institutional" and the "technical-expert" perspective, and necessarily to path to sustainability is the integration of them (Tàbara, Roca et al. 2008)

2.3 Capacity development

Adequate country capacity is one of the critical missing factors in current efforts to meet the MDGs, and sustainable development for extension. Development efforts in many of the poorest countries will fail, even if they are supported with substantially increased funding, if the development of sustainable capacity is not given greater and more careful attention. This is now widely recognized by donor organizations and partner countries alike, as articulated in the 2005 "Paris Declaration on Aid Effectiveness" (OECD 2006).

Capacity development involves much more than enhancing the knowledge and skills of individuals. It depends crucially on the quality of the organizations in which they work. In turn, the operations of particular organizations are influenced by the enabling environment – the structures of power and influence and the institutions – in which they are embedded. Capacity is not only about skills and procedures; it is also about incentives and governance (OECD 2006). The terrain where capacity development involves decision making process and institutional strengthening is where sustainable assessment can contribute to learn on the process. It is the contrast between the increasingly recognized importance of capacity and the difficulty of achieving in the practical field is that has stimulated the preparation of this paper.

2.4 Social learning process

Adaptive governance focuses on experimentation and learning, and it brings together research on institutions and organizations for collaboration, collective action, and conflict resolution in relation to natural resource and ecosystem management. The essential role of individuals needs to be recognized in this context; their social relations and social networks serve as the web that ties together the adaptive governance system (Folke, Hahn et al. 2005). Learning is inextricably linked to the development of relationships among the actors that constitute adaptive co-management processes, as well as facilitating a common (Keen, Brown et al. 2005). These new scopes which create opportunities for adaptive co-management to self-organize and learn in the process stress also the need to be carefully tested and evaluated.

The Integrated Sustainability Assessment goes towards a social learning process, where stakeholder learns from evaluators and where the evaluators learn from the users. This can be realized by taking three principles as starting point: (1) setting up a cyclical and iterative framework, in which learning, interaction and feedback are crucial elements, where past learning experiences form the basis for best practice rules, (2) Seeking the environment of stakeholders at an early stage and in a structured manner, by actively engaging them in the improvement and development of assessment tools (3) building up a user community by using notions of co-development and reflexive mutual learning with potential users, varying from policy makers to practitioners and scholars (Rotmans 2006).

3 Analysis and exploration of social-ecological systems

In a world connected by networks that enable instant transmission of voices, images, and data, environmental science is changing in ways that bring researchers, students, decision-makers, and citizens closer than ever before. Realizing the potential of this connected world depends on building an infrastructure, both technological and human, that enables effective interaction. This potential is actually developed; there exist plenty of applications that afford social and ecological interaction.

In our work, we try to improve this stream, subsection 3.1 argues that if the information required for sustainability evaluations resides on relational data model, this imposes difficulties for decision making based on exploration of the relationships among the data, such as paths, neighborhoods, patterns and, definitely, all queries based on entities that are interconnected satisfying a given constraint. That means a low performance on time and cost. We suggest the use of Graph Database Models (GDMs). In subsection 3.2 we introduce an example where GDM can be applied for capacity development evaluations. In subsection 3.3 we suggest a technology that implement de GDM to solve the main difficulties of the system as a tool for sustainability assessment, as they are: i) the continuous growth of the data sources, ii) the need for a versatile querying system that allows Information Retrieval queries ranging from keyword search to the complex mining of patterns in graphs, and iii) the need to integrate data coming from different sources to enrich the answers to complex queries over incomplete databases.

3.1 Why a graph data model? Limitations of relational data model for the study of interlinkages

The development of huge networks such Internet, geographical systems, transportation or automatically generated social network databases, has brought the need to manage information with inherent graph-like nature (Angles 2008). In these scenarios, users not only keen on retrieving plain tabular data from entities, but also relationships with other entities using explicit or implicit values and links to obtain more elaborated information. In addition, users are typically not interested in obtaining a list of results, but a set of entities that are interconnected satisfying a given constraint (Martinez-Bazan, Nin et al. 2007), also and most network research is based on a representational formalism borrowed from graph theory. (Butts 2009)

The term “data model” or "database model" has been widely used in the information management community: it covers various meanings. In the most general sense, a database model is a collection of conceptual tools used to model representations of real-world entities and the relationships among (Angles 2008). The differences between graph data models and the relational data model are manifold. For example, the relational model is geared towards simple record-type data, where the data structure is known in advance (airline reservations, accounting, inventories, etc.). The schema is fixed, which makes it difficult to extend these databases. It is not easy to integrate different schemas, nor is it automatable (ibid.).

In the relational model, the query language (SQL: Structured Query Language) cannot explore the underlying graph of relationships among the data, such as paths, neighborhoods, and patterns. The relational data model is now more than 30 years old. It's good for a number of scenarios and can handle certain types of data very well. But it isn't perfect. For data that is semi structured and/or network oriented, the relational database offers poor runtime characteristics. Furthermore, it forces a static development cycle and is of little help to those who have to live with a domain model that is constantly changing, even after deployment. This translates to wasted development time and money.

Graph database models are applied in areas where information about data interconnectivity or topology is more important, or as important, as the data itself. In these applications, the data and relations among data are usually at the same level. Introducing graphs as a modeling tool has several advantages for this type of data (Angles 2008):

- It allows for a more natural modeling of data. Graph structures are visible to the user and they allow a natural way of handling applications data, for example, hypertext or geographic data. Graphs have the advantage of being able to keep all the information about an entity in a single node and showing related information by arcs connected to it (Paredaens, Peelman et al. 1995).
- Queries can refer directly to this graph structure. Associated with graphs are specific graph operations in the query language algebra, such as finding shortest paths, determining certain sub graphs, and so forth. Explicit graphs and graph operations allow users to express a query at a high level of abstraction. It is not important to require full knowledge of the structure to express meaningful queries (Abiteboul 1997).
- For implementation, graph databases may provide special graph storage structures, and efficient graph algorithms for realizing specific operations (Angles 2008).

3.2 Network Analysis to sustainability evaluation

The dramatic progress of researchers from disparate fields plunging into network analysis needs to be tempered by awareness of the potential dangers of misapplying fundamental assumptions. Appropriate use of network analysis depends, however, on choosing the right network representation for the problem at hand. What factors should be considered when choosing a network representation, and what are the consequences when this choice is poorly made? The choice of individual humans as nodes in studies of friendship, or kinship, networks and the use of individual publications in citation studies are examples in which this assumption is well-justified (Butts 2009). Seems appropriate realize network analysis over bibliographic databases

Bibliographic databases also are a clear example where a more complex querying system would be beneficial. In these scenarios, the user might not be only interested in finding a specific author or publication, but to analyze the relationships within a group of authors or publication, to understand the relevance of an specific paper or any other implying the exploration of the relationships between entities (Martinez-Bazan, Nin et al. 2007). The field of capacity development could be seen as an extension of bibliographic databases in different formats of information necessary to develop the capacity of the stakeholders; we can add any kind of unstructured information as: social media (information blogs, videos), reports, e-learning courses, slide presentations, or other information sources that reported on the status of ecological systems. All this data become bigger and more distributed, more intuitive ways of navigating or exploring the associated information become necessary.

3.3 DEX: High-Performance Exploration on Large Graphs for Information Retrieval

In this subsection we present DEX as a possible technology based on GDMs, DEX is developed by DAMA-UPC[1]. In Figure 1 we can see the database structure for the case of *Bibex*, a bibliographical database, where relations are authors writing scientific papers. Queries are one authors or keywords and exploring the graph one can obtain related information and statistics. DEX is basically characterized by three properties: (i) data

[1] DAMA-UPC, the DAta MAnagement group at Universitat Politècnica de Catalunya (UPC) is part of the Computer Architecture Department (DAC). http://www.dama.upc.edu

structures are graphs or any other structure similar to a graph; (ii) data manipulation and queries are based on graph oriented operations; (iii) and there are data constraints to guarantee the integrity of the data and its relationships. DEX affords the efficient implementation of four basic features of network research: *link analyses, pattern recognition, social network and keyword search*, afford realize different kinds of queries for graph exploration.

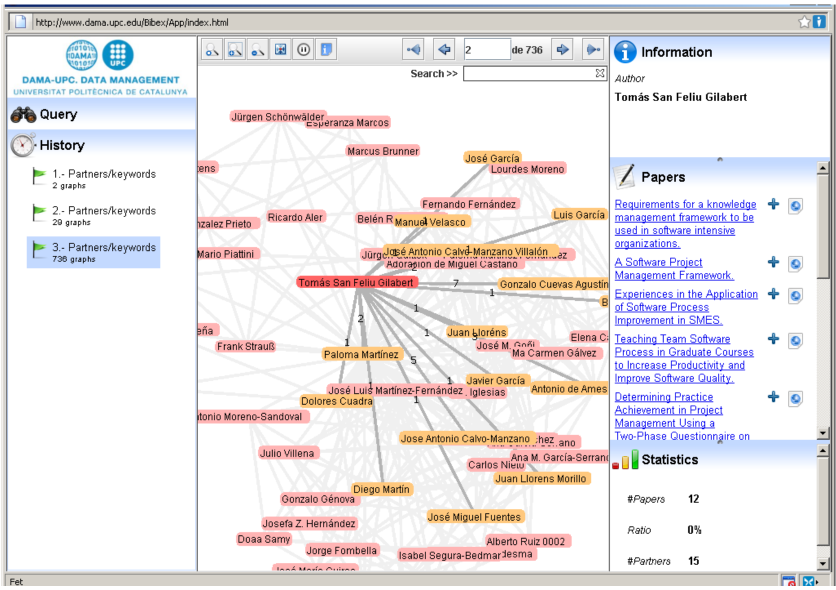

Figure 1: Shape of the DEX developed by DAMA (www.dama.upc.edu/bibex)

In *Link Analysis* we are interested on exploring the relations between the nodes of the graph, navigating the edges between them, i.e. To get all the information of a sustainable sanitation conference, the result is a graph where you can visualize, different kinds of relationships to this conference (board directors, assistants, topics, scientific panel, publications, relations among stakeholders established thank to this meeting, etc).

Social Network is focused on the relationship between different groups of nodes with the same affinity. Let us consider all the technical experts in our database who have participated in the same sanitation project to form a group in a social network. Specifically, we define a partnership as the relationship between two capacity development experts who have performed in the same project. Additionally, we impose two restrictions to this query. First, we restrict just to items tagged as "sanitation projects". Second, we restrict the participation as a "technical expert". We apply these two conditions because (i) we want to increase the query complexity rather than always exploring everything and, (ii) our database contains a lot of items extracted from NGO, blogs, journal database, etc that could provide unrealistic relationships between technical experts.

Pattern recognition defines a different kind of queries, where a lot of potential graphs can be created and explored, but only a few of them will qualify because they mach a certain pattern. A query could be, i.e. Find all the responsible that have worked with the same technical expert in three different sanitation projects made in a period of time of five years. This is a complex query that not only requires the pattern detection but also involves several data filters like project role, sanitation or project.

Finally we'll describe *Keyword search*. In others queries the user knows the schema or at least part of it, i.e. we assume that the user has knowledge on how the data is structured. However, this assumption may be unrealistic in some scenarios like the WEB or documental database. In this last DEX is also suitable to perform a keyword search, where the user is assumed not to know anything about the organization of the data. In conventional databases models like the relational model, this time of search requires a full indexing of all the string columns and it becomes unfeasible due to the high cost in terms of storage size and performance. DEX can take advantage of dictionaries and compressed structures (Martinez-Bazan, Nin et al. 2007). A query could be, i.e. Return all the context information of all the entities containing the tags Biogas production, expert John Smith and Country India.

4 Network analysis for sustainability assessment

We introduce a perspective, where integration in sustainability assessment, should be done helped by network analysis. As we have seen in the Section 3, the DEX allows us to explore the reality though interlinkages. These interlinkages can be from different types of stakeholders, spatial scales, deliverables, outputs and outcomes. There is also another scale that normally is very difficult to deal with: the temporary scale. Networking can show us different relations and the change between them across the time. This is a big potentiality to generate knowledge during the process. When we explore the global picture with our tool, we can elucidate the state of the main stakeholders, their synergies, and with the appropriate assessment, we can learn about the process. As in social network analysis there is the possibility to take centrality measures and core/periphery fitness. These measures are relevant to the sustainability science research as the focus in on the socio-ecological relations, and the participation of multiple actors in the process as researchers, practitioners and people from around the globe.

The development of tools as DEX that implements GDM is new in the sense that is based on relations, and all the ecology science is also based on relations. In natural ecosystems, the key is on the information transmission, the speed of this variable is fundamental for the well-functioning of an ecosystem. In sustainability science we can use also this comparison to view the human system under the ecological perspective, as the resilience theory do, and we can see information transmission as the worth of the process. When we need retrieval information, now we do exploration based on multiple relations through a huge amount of information structured at multiple levels. The fast we find the right information for our problem, the best we can function in our system. This can improve visibly the learning process in sustainability science.

4.1 Applications on sustainability science

Prior research has been exploring the societal effects on transdisciplinary research (Walter, Helgenberger et al. 2007). The model used for Walter links outputs and outcomes of transdisciplinary processes via the impacts using a mediating variables approach. Outputs are considered immediate results of the transdisciplinary project on a procedural and on a product-related level: meetings, hearings, workshops as well as reports, publications, and other tangible results. If we want to apply DEX tool for outputs registration, we can make use of social media, known as the interactive website environment. There we can collect information of activities and automatically update our knowledge system. To properly measure the outcomes, you need a methodology mixing methods quantitative and qualitative, but also related to the role of the stakeholders. With the aim to integrate all this information and make it useful, using DEX tool we can relate quantitative with qualitative data to generate possible scenarios. Finally impacts are defined in social impact theory as cognitive or physical consequences of a program. We have focused on cognitive impacts as stronger feeling of belonging to the local community and better knowledge about current problems of the community (Walter, Helgenberger et al. 2007). Related to the impact evaluation, there is a series of operations that we can explore on our data. We can analyze the same information under different points of view, depending on the relations.

The table 1 is constructed thanks to the Walter’s classification on impacts on society under eight titles. We propose a new way to look at them, through the DEX tool scope and their four main characteristics: link analysis, social network, pattern recognition and keyword search. We highlight the advantages that the network thinking can bring to the impact evaluation on the social aspects.

Type of impact	Impacts *Definition*	Efficient features implemented by DEX			
		Link analysis *Focus is on the relationship between the entities of a virtual network*	**Social network** *Relationship between different groups of nodes with the same affinity*	**Pattern recognition** *A kind of queries that qualify graph that match to a certain pattern after an exploration.*	**Keyword search** *Return all the context information of all the entities containing the keyword*
Process	**Network building** *Describes the extent to which the participant are able to connect to new people and institutions as a result of the process*	Discover dependence and interference	People that had met during the process	Identification and characterization of increase/decrease of network cut-points, dependences, interferences	Network, collaboration, agreement
	Trust in others *Trust in inter-organizational personal relationship is an individual's behavioral reliance on another person under a condition of risk*	Kinds of relationships	Kinship, friendship, partner, vote, support, citations, beneficiaries, etc	Detect relations of power, budgets, beneficiaries, research, etc...	Trust, believe, hope
	Understanding of others *Participant's ability to take on another person's perspective of the problem*	Knowledge dialog maps to detect consensus	Support campaigns, shared lexicon, continuity in the activities	Detect participants that just are socialized with a closed network.	Understanding, support,
	Community identification *Sense of belonging*	Memberships	Mailing lists, membership, etc	Detect excluding collectives (i.e: be a member of a collective restricts to belong to another)	Same lexicon
Products	**System knowledge** *Knowledge about the current state of the problem*	Activities, projects and programs	Organization from a goal perspective.	Report problems, risks on the social media, press, journal, etc	Types of problems
	Goal knowledge *Referred to the personal goals, interests, and preference structures of the participants*	Discover interests	Specifics interests	Interests that remain over the years	Specific terms, technical language
	Transformation knowledge *The knowledge about how to transition from the current to the target situation*	Assumptions, new items in risk response plan, engagements, skills	Faced problem, skills, engagements.	Impacts of activities in other forms of knowledge: papers, blogs ... Detect capacity development references in a project memories or project risks response plans.	Types of skills
Prod &Proc	**Distribution Knowledge** *How often results of the project were the subject of public or private discussions*	Public or private discussions of participants	Publications, social media, centralization of the network.	Knowledge emergence (members with skills not previously capacitated), detect key assumptions, success projects cited, capacity development.	Key assumptions

Table 1: Application of GDM to impact evaluation on societal effects in transdisciplinary research, based on (Walter, Helgenberger et al. 2007)

Instead of transdisciplinary research has applied the social perspective on the stakeholders, and we have tried to bring it to the graph's structure, there are many other applications for using this tool. In sustainability programs it's possible to elucidate trust networks, through the analyses of references shared together or the e-mail communication. There is a potential in Geographical Information Systems to integrate spatial data with social data. GDM its priory used for networks on knowledge management, where you can analyze the knowledge distribution among the stakeholders.

4.2 Evaluating sustainable sanitation

To illustrate our approach with a specific research field on sustainability we want to focus on sustainable sanitation. We have chosen this case, because is a sector that reflects the interplay between human culture and appropriate technologies requiring stakeholder involvement in the planning and implementation steps (Rockström, Axberg et al. 2005). Also because is stressed the importance of capacity building in the sector at the individual, organizational and institutional levels in order to lift the sanitation sector into the era of sustainable development. Adequate integrated sustainability assessment with stakeholder involvement from the beginning of the program should be mechanisms to improve environmental sustainability in the world.

To move the world toward greater equity and sustainability, in September 2000 world leaders endorsed eight Millennium Development Goals at the UN Millennium Summit and confirmed that pursuit of environmental sustainability is essential to poverty reduction. There was formally assumed that poverty eradication, changing consumption and production patterns, and protecting and managing natural resources where requirements for sustainable development. Environmental sustainability is essential to achieving all other Millennium Development Goals (UN Millennium Project 2005). Many structural changes should be done in the governments. But one part of the solution could be in improving access to and use of knowledge. These have to be achieved with the stakeholder's involvement in the process. We want to present here the MDGs as an application of the socio-ecological systems theory. If we want to solve the world's real problem as poverty and inequity are we must see the interconnections between humans and nature, society and ecosystems.

In order to provide a global focus was declared the International Year of Sanitation in 2008. To strength the efforts and create a common place for exchange, the Sustainable Sanitation Alliance was created in January of 2007. This is a common to provide capacity and knowledge within sanitation. This is a coordination platform where more than 100 partners share their experiences and learn together. Institutions, universities, enterprises, NGOs, governments and individuals work together for a sustainable development approach.

The programme theory shows us that with the appropriate capacity development on the organizations we can create social learning going towards sustainability development. Especially multi-laterals agencies and donors share the formative evaluation perspective, and expect some impacts on society with their programmes on sustainable sanitation. With the DEX tool we can collect many sources of information from the first moment when de programme is launched. This is a potentiality, because normally in the evaluation stage there is a lack of resources to collect data properly. Collecting data form scratch can show us trends on the process. Always there is a key stakeholder who centralizes many projects, or a gap on the knowledge acquisition. With simple network measurements we can register it on time and learn about the findings.

We have reiterated on Section 2 how important is collaboration and integration of local knowledge with researchers to make steps together to a better sustainable future. With GDM we can explore these relations (through publications, seminars, projects, conferences, conversations, etc.) and have a test on the relations development. We can assess the impact on the local habitants simply going through the network structure of the process.

5 Concluding comments: learning by doing

Is widely expressed on literature the need for an integration of social ecological systems but a few tools can achieve it efficiently. While huge amounts of information are generated at multiple levels the need to deal with uncertainly is on the desk of decision makers and politicians. There is a call to work together among researchers, practitioners and local inhabitants.

We suggest that GDM improves the quality of sustainability assessments to deal with the learning process and social learning. Their main feature is that data model can hold the interrelationships between the elements more efficiently than relational databases. Appling the DEX technology - one of the technologies that implements GDM -, we can retrieve information from the global World Wide Web to the local documents and dump it in a graph data warehouse system, and allows us to make basic network operations that can bring us more information about the stakeholders interactions: link analysis, pattern recognition, social network and keyword search. This approach is not a close tool; it should be seen as a new perspective on the data collection, store and query analyzing.

Our aim is to provide tools that efficiently (in terms of time, money and personal work) could help on the relations among practitioners and researchers that they need for evaluate sustainability into the sustainable science paradigm. We can see how the access to the focused information into a fast way is a key factor to develop better practices among a learning process. Under the scope of interrelations, GDM can achieve the goal of learn through the capacity building process. Should be desirable that a tool as described here, could bring better practice on participatory evaluation, thanks to the facility how the system can retrieve information from multiple fonts.

The multiple scales and the capacity to extend the knowledge system as it grow up during the learning process makes it a valuable tool on the sustainability evaluation practice.

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