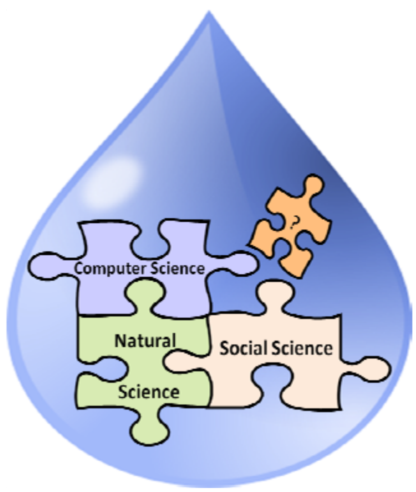
Synergy of Disciplines for Sustainability

Analysis of agent interactions in the transition management cycle to tackle the water scarcity issue

(Case Study: The Ebro River Basin, Spain)

By:

Maryam Nastar
nastar@acm.org



A thesis submitted in partial fulfillment of the requirements of
Lund University International Master's Programme in Environmental Studies and Sustainability Science,
LUMES, 2008

Supervised by:

Patrik Wallman, PhD
patrik.wallman@lucsus.lu.se

Lund University Centre for Sustainability Studies, LUCSUS
Geocentrum 1, Sölvegatan 10
P.O. Box 170, SE-221 00 LUND, Sweden
Phone: +46 (0)46 222 48 09
Fax: +46 (0)46 222 04 75

Abstract

Transition is a process of societal change and the consequence of shifting from an unsustainable to a more sustainable state by tackling persistent problems. Transition management is a framework concerned with long term and sustainability-oriented approaches focusing on conceptual learning, reframing and transformative outcomes. In this context, transition models are useful tools to represent the complexity of adaptive systems, and they can be used as learning tools to convey information between agents with different background in stakeholder meetings, and to enhance agents' collaboration.

By observing and participating in the implementation of the transition management framework in this case study, it is shown that there is a gap between idealized transition management and the implementation phase. This research analyzes the implication of applying the transition management cycle to the case of the Ebro River Basin, about the water management issues. In this respect, an agent-based modeling approach is employed to build a meta-model depicting the conflict arising from agents' interactions in tackling the water shortage problem. Accordingly, the agents' behaviors at the micro (individual) level, based on different paradigms regarding the water saving strategy, are analyzed and the challenges and the potential solutions are investigated.

One of the main challenges of implementing transition management is the lack of an interdisciplinary framework to capture the agent interactions at an individual level. This requires considering both weak and strong sustainability in the conceptual models. Stressing the importance of validating the outcomes of the transition model through diverse data collection methods, the developed conceptual model can contribute to bridging the transition management theories to the real world implementation phase.

Keywords: Transition Management, Agent Behavior, Water Management, Water Saving, Agent-Based Modeling, Meta-Model

Acknowledgement

I would like to express my special gratitude and appreciation to my supervisor, Patrik Wallman, for his immense support, which has given me confidence to face all the ups and downs during these months of research. His advice and encouragement has been a source of inspiration to carry out this study.

Sincere thanks to Lennart Olsson for providing the opportunity to take part in WP6 of the MATISSE project, and for precious documentations. I also thank Bodil Elmqvist and Pieter Valkering for their valuable feedbacks and critiques that have improved the quality of this study.

I wish to thank the LUCSUS staff, especially Ann Åkerman, Göran Ewald and Ingegerd Ehn for their help within the time this study was undertaken. My deep gratitude goes to my friends, particularly Golzar Ahmadi and Hitesh Soneji for their support and comments during the difficult days when the frustration level was high.

Last but not least, my deepest gratitude and love goes to my family who has stood firmly by my side until the last day of this journey from far away.

Table of Contents

List of Figures

List of Tables

Chapter 1: Transition Management in the Water Domain

Introduction

The lack of coordinated policy approaches of resource developments is one of the challenges in way of achieving sustainability (Annan, 2001). Most of the sustainable development approaches are “driven by short-term considerations rather than a long-term interest in sustainability” (ibid). Seeking to overcome the conflict between short- and long term objectives, the transition management cycle, as a framework used in one of EU projects called MATISSE, is designed to “propose procedures, methods and tools for better integrating sustainability into policy development processes and institutions” (MATISSE, 2008). In this sense, the transition management is a form of knowledge production emphasizing the process of change, and the relationships that lead the direction of transition (ibid).

The first chapter of the paper explores the stages of the transition management, namely the scoping, envisioning, experimenting and learning, in the water domain using the Ebro River Basin case study. Relying on the collaboration among the stakeholders, different techniques emphasizing participatory approaches in addition to conceptual models and computer simulations are employed in the case study.

In the second chapter, the theories behind transition management are explained, and the role of transition models as the learning tools in enhancing agents’ communications in the stakeholders’ meetings are demonstrated. Accordingly, the definition of the conceptual (meta) models is clarified.

Explaining the main challenges of the transition management cycle, the third chapter points to the gap between the process of implementation and the grounded theories. This chapter explores the factors preventing successful implementation of transition management in the way it is theorized. As it is discussed, one of these challenges is the lack of interdisciplinary works, which is particularly noticeable in the development of models.

Given the lack of interdisciplinary models, chapter four integrates the modeling techniques from computer science with the relevant elements from social and environmental sciences regarding the transition management cycle. In this respect, the procedure of building up a conceptual model, in an interdisciplinary way, is depicted. In doing so, the agent-based modeling approach is carried out to capture the social interaction of the agents in the case of the Ebro River Basin, and to depict how different perspectives clash with respect to water management issues. The main objective of developing the conceptual model is to capture and interpret the agents' interactions based on different paradigms by considering both the environmental and social aspects of the problem.

The last chapter of the paper discusses the potential solutions to address the challenges of agents' interactions. In this respect, the challenges and the opportunities regarding the agents' communications is included in the conceptual model (meta-model)[1]in the context of transition management is explained. At the end, this chapter examines how a model embedding multiple disciplines can be useful as a learning tool in co-producing knowledge, and can be helpful in implementing transition management as successfully as possible (*See* The Outline, Appendix 1).

Research Objectives and Questions

Like most plans and programs, the transition management framework is not immune from criticism. This paper intends to explore the gap between the idealized transition management and the implementation phase. One of the criticized issues in this context is the lack of an analytical framework to capture and interpret the agents' communications at the micro level (MATISSE, 2008). In this respect, one of the main objectives of this paper is to investigate agents' interactions through an agent-based modeling approach, and to illustrate it via a graphical language such as a meta-model. Assuming the oversimplified aim of the transition management cycle is to stress the notion of collaborative action, there is a need that agents compromise their self-interests, or change their behaviors (i.e. a farmer should change the irrigation pattern or change to a type of crop that consumes less water). This would raise a conflict between agents with divergent interests, and thus, conveying information, understanding individuals' behavior and strategy, and finding a synergic solution becomes a problematic issue itself. In short, there are different challenges in capturing agents' communications according to transition theories, which will be discussed in this research.

The research questions addressed in this study are:

- What is the role of models in the transition management cycle in the case study?
- What are the challenges of implementing the transition management in the case of Ebro River?

[1] The conceptual model, or meta-model in this paper is used to refer to a representation of a system and its components as well as the relationships between the factors and actors within the system. The definition of conceptual model and meta-model are explained in the second chapter thoroughly.

- How to build the conceptual model that can capture agents' interactions concerning water management issues in the case study?

- How can the conceptual model contribute to improving the transition management in the case study?

Research Design and Strategy

The research approach used in this study is based on inductive theory meaning that observations and derived findings lead to form new knowledge (Bryman, 2004). Aiming at acquiring insight and developing understanding of the essence of the problem, a qualitative strategy is employed in this case study. The qualitative approach is taken to understand the mechanism of societal systems through an examination of the researcher's interpretation of the case (ibid). The qualitative techniques for collecting data include interviews (conversational and unstructured), participant-observations (moderate and passive) and literature reviews (Yin, 2003). In this respect, the major part of collected data is based on two events.

The first event was the last stakeholder meeting of WP6 in Tortosa, Spain in February 2008. The experience gained from contributing to developing a computer simulation, and to promoting it to stakeholders in the meeting was useful to find out the weaknesses and strengths of transition models as means of conveying information from experts to non-experts. In addition, the experience of observing the process of participatory approach was helpful to have a better understanding of the cycle of transition management and its challenges. The second event was MATISSE final conference in Nice, France, March 2008. Attending at plenary sessions and panel discussions in addition to conducting open-ended interviews with (transition) experts were crucial to get a good grasp of theories behind the transition management cycle (*See* Table 2, Appendix 2).

Regarding water management issues and agents' interactions in the case study, the literature reviews, reports and publications concerning the Ebro river basin case were gathered. The analysis of agents' behaviors are discussed according to different paradigms and based on the primary sources.

Background

Spain is among the Mediterranean countries suffering from insufficient water supplies (Albiac et al., 2003). Located at the northeast of the country, the Ebro River Basin with an approximate watershed area of 85550 square kilometer is the largest basin in Spain (Alcazar et al., 2008). The climate change's impacts such as rainfall decrease and acceleration of sea level rise, and ongoing human activities such as agriculture, have made the water management issue complicated in the Ebro River Basin (Day et al., 2006).

Figure 1 The Ebro River Basin and Delta in Spain (UNEP, 2005)

Addressing the problem of water scarcity in the region, there have been different water management strategies. In 2001, the Spanish government proposed to transfer water from the Ebro basin in north to the catchments suffering from water scarcity in southeastern regions. The plan was financed with national and EU funds as the National Hydrological Plan, NHP (Downward and Taylor, 2007). The main strategies of NHP were limited to water supply increase through building new dams and infrastructure for irrigation areas and river canalizations (ibid). There have been many critiques raised by scientists exploring the negative impacts of NHP on the environment, especially "the deterioration of the lower Ebro river and delta" (Day et al., 2006). Finally, in 2004, and due to several campaigns, the NHP was cancelled, and replaced by Spain's Programa AGUA.

Following the EU Water Framework Directive (WFD) in promoting water saving through full cost recovery[1] by 2010, the Programa AGUA not only recognizes water demand reduction, but also emphasizes desalination as a means of increasing local water supply (Downward and Taylor, 2007). It is considered within the wider context of water management, as the New Water Culture (NWC) stressing proactive citizen participation and monitoring, reuse, and changing irrigation's patterns (Tabara et al., 2007). However, uncertainties regarding the impacts of increasing water tariff and the intensive energy requirements for desalination within the Programa AGUA have caused other NWC movements to focus on more participatory approaches to reduce water demand through conservation and more efficient use (ibid). In this sense, transition management is employed as the framework in the Ebro River Basin case to enhance the stakeholders' negotiation and collaboration in order to find a holistic solution to tackle the water scarcity problem. The aim of this framework is to gather diverse perceptions of the problem, to depict multiple scenarios of sustainable visions and to synthesize all the perspectives to deal with the water management issues (ibid).

Implementing Transition Management in the Ebro River Basin

To tackle the water management problem, the framework of transition management was applied in the Ebro River Basin as the case study of Work Package 6 (WP6) of the EU FP-6 research project MATISSE, Tools for Integrated Sustainability Assessment (MATISSE, 2008). It is important to note that, within the context of the MATISSE project, transition management was referred to as ISA, Integrated Sustainability Assessment. However, as there is no difference between the objectives of ISA and transition management and their processes of implementation are identical (Weaver, 2006), in this study transition management is the chosen terminology. Figure 2 illustrates the cycle of transition management which has been done in the WP6. In the following, the different stages of the process are explained.

[1] Basically prices for water supply and waste water collection and treatment

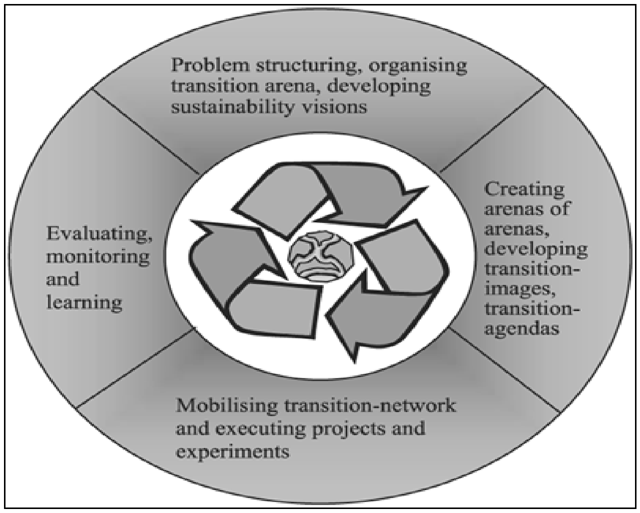


Figure 2 Activity clusters in transition management (Loorbach 2006)

Scoping stage

In the first stage of the cycle, the criteria to choose the relevant participants, who have a stake in the outcome of the process, are being documented. The goal of this stage is to have a balanced representation of diverse stakeholders in order to be able to reflect on the problem from different perspectives (Loorbach and Rotmans, 2006). In WP6, the set of criteria for inviting stakeholders was based on “water dependency” and “policy influence”. As a result, the participants were recruited from representatives of “New Water Foundation Culture, Birdlife-Spain (environmental NGO), Catalan Water Agency, Regional Council of Ebro Delta, Municipality, Farmers, and the Ebro Delta Natural Park” (Tabara et al., 2007). A series of participatory exercises were carried out to the stakeholders to represent their views about the problem. From a socio-economic viewpoint, increasing tourist pressure and crises of the agricultural sector, including decreased rice production, were perceived as the main issues. From an environmental perspective, salinization, subsidence of the land area, habitat loss, water contamination and delta regression were discussed mainly as the impacts of intensive agriculture, ecosystem fragility and deforestation. Another perception of the problem, related to both socio-economic and environmental issues, was the existence of “too many overlapping administrative bodies responsible for different parts of Ebro River Basin management” (Tabara et al., 2007).

Envisioning stage

In the second stage, the definition of transition towards stabilization is discussed by the stakeholders, and different scenarios towards sustainability are developed (Loorbach and Rotmans, 2006).

Addressing the perceived problems as the result of the scoping stage, two pairs of scenarios were built after the preliminary sessions in WP6. Firstly, it was the technical-expert scenario with an emphasis on improving and reinforcing the biophysical capacity via technical solutions. Secondly, it was the socio-institutional scenario based on strengthening the social network, and enhancing the collaboration among stakeholders. Participants acknowledge that the integration of both scenarios is required to tackle the existing problem, and a more coordinated collective action is necessary.

Experimenting stage

The hypotheses made by the participants are tested in the third stage. The purpose of this stage is to measure to what extent the premises contribute to the sustainability goals (Loorbach and Rotmans, 2006). In WP6, in order to allow stakeholders to experience alternatives of action based on the mentioned scenarios, a conceptual World Cellular Model (WCM) was developed, and implemented as a role-play game. The purpose of the game was to "facilitate a structured dialogue" among participants and to "support reflexive learning" (Tabara et al., 2007). Thus, the focus in this part "was not so much on defining what the problem is, but rather on who has agency and responsibility" (ibid). In parallel to the role-play game, the development began on a hydrological simulation to represent the consequences of stakeholders' actions in the environment, e.g. irrigation and soil degradation via geographical information systems (GIS) and system dynamic techniques. The intention of this phase was to integrate WCM and a hydrological model as a computer simulation game, which is still under development.

Learning stage

Last, but certainly not least, is the stage of learning, monitoring and evaluating of transition management cycle. In this stage, the participants' activity and responsibility during the previous stages is being monitored. In addition, an evaluation is being conducted to rate the improvements and the hindrances with respect to the stakeholders' agreement on the objectives set in the previous stage (Loorbach and Rotmans, 2006). At the end of WP6, the most important learning experience of the previous phases was that the stakeholders' negotiations were not enough to achieve the sustainable visions shared at the second stage of the project, but also there is a need for participants to transform their practices. The next chapter describes some of the related theories and paradigms behind the concept of transition management.

Chapter 2: Theoretical Framework

Social Learning

Transition management is inspired by the concept of social learning theory, which has a long and diverse history of use. Focusing on the psychological aspect, Bandura (1989) explicates the social learning as a process of gaining knowledge through observation, imitation and modeling. As one of the foremost advocates of the theory, he refers to social learning as a process in which individuals learn from successes and mistakes of others instead of self trial-and-error practices (Bandura, 2003). Hence, the outcomes of the process of social leaning empower individuals to modify their behavioral patterns. In this sense, the social learning (which he names the social cognitive theory in his later works) is more an observational process rather than an experimental procedure (ibid).

From another point of view and in the context of sociology, the concept of social learning is rooted partly in the concept of "communicative action". In this sense, the goal of social learning approaches is to create space in which the actions can be coordinated based on the process of sharing different discourses (Rist et al., 2007). Habermas, the founder of the theory of communicative action, argues that human society can be influenced by humans' interactions mainly through negotiations and open discussions (Callinicos, 1999). Accordingly these atmospheres of dialogues can result in setting new norms and values in the society, and agents will nonetheless accept them if these norms appear reasonable to them (Habermas, 2005). In this respect, the social learning process can be considered as a social change brought by a new set of values in the society by means of individual's communications and interactions.

The above dimensions of the social learning's concept have had an influential impact in the recent interpretation of the process. Pahl-Wostl et al. (2007) describe the social learning process in terms of a multi-scale procedure on three levels: Firstly, the collaboration between stakeholders at the micro level with a short to medium time scale. Secondly, the meso level encompassing changes in actor networks with a medium to long time scale. Thirdly, it is the macro level with long time scale and changes in the governance structure. At this level, social learning is about a change in governance style from pure expert-based decision-making process to more collaborative and participatory process (Pahl-Wostl et al., 2007).

In short, social learning is a process in which participants convey their information concerning a common issue by discussions and feedbacks. Seeking to enhance the stakeholders' collaboration, the aim of the process is to build knowledge and take action collectively. In this respect, there is a need for an interdisciplinary framework that can address the uncertainty of ongoing developments during the whole procedure of social learning.

Transition Theory

Dealing with uncertainty is the key matter of concern with regard to the complex societal systems and sustainability issues. Degrees of uncertainty varies during the process of societal changes, where the structural characteristics of a society fundamentally change (Rotmans et al., 2001). Managing this process, so called transition, has a vital role to confront the complexity and uncertainty in the societal systems, and to tackle the problems. Inspired by the concept of the social learning process, transition management is a framework to "tackle persistent stubborn problems by steering them in a more sustainable direction, through a visionary, cyclical process of agenda building, learning, incrementing and experimenting" (Rotmans, 2005). To provide a better understanding of the transition management cycle, the notion of transition theory is briefly explained below.

In the context of sustainability, the transition theory can be described as an analysis of the dynamics of development from multi-phase and multi-level perspectives in order to influence the pathway of transition in a more sustainable direction (Geels, 2002, Rotmans, 2005).

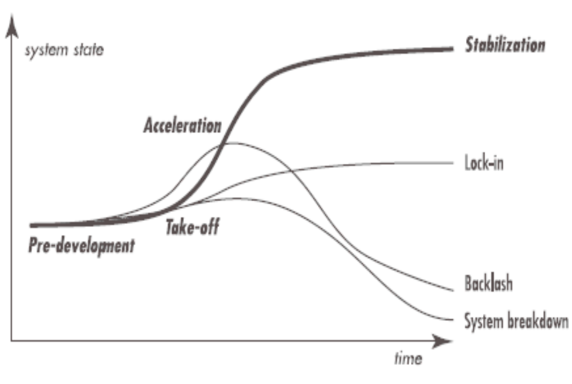


Figure 3 The different phases of a transition and different transition paths (Rotmans, 2005)

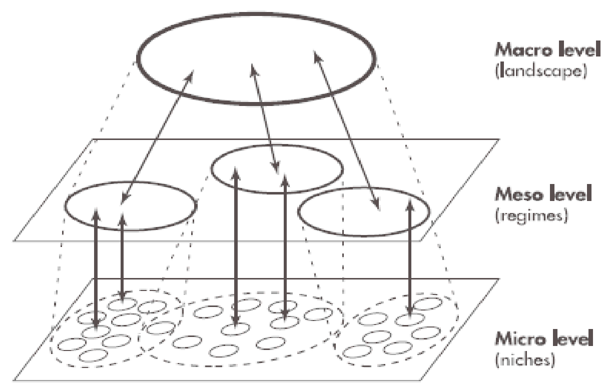


Figure 4 Multiple levels as a nested hierarchy (Geels, 2002)

Transition Theory from a multi-phase perspective

In this respect, a transition can be defined as “alternating phases of relatively fast and slow dynamics, which together form a strongly non-linear pattern where there is a shift from one dynamic state of equilibrium to the other” (Rotmans, 2005). This pattern (direction) is the consequence of shifting from one dynamic state of equilibrium to the other, and comprises four main phases (Figure 3). First is the *pre-development* stage where the marginal changes happen in the system’s background and do not have any impact on the status quo, at the micro and meso level. Second is a *take-off* phase in which the structure of the system starts slowly to change. Third is an *acceleration* phase where the new pattern of the system becomes visible because of accumulation of the changes in the previous stages. Finally, there is a *stabilization* phase where the rate of fluctuation is marginal, and the net effect of any changes is neutral. (Brugge and Haan, 2005, Rotmans et al., 2001).

Transition Theory from multi-level perspective

Regarding the multi-level perspective of the theory (Figure 4), transition can take place when developments at niche (micro), regime (meso) and landscape (macro) levels move in the same direction (Rotmans, 2005). Niches at the micro level, including organizations, individual persons or innovations, are instrumental in the take-off of the new regime (Kemp et al., 1998). Regime refers to rules enabling and constraining activities within communities, and it can change as a result of responses to niche pressure (Geels, 2002). The landscape consists of regimes (in which niches are embedded), and developments at this level are relatively slow corresponding to the broad societal trends (Rotmans et al., 2001).

Transition Management

The importance of employing a framework, to influence the direction of a transition, is because not all the changes and developments necessarily result in a more sustainable situation than status quo. This emphasizes the need of understanding the mechanism of change in culture, structure and practices in order to prevent bringing about the situation worse than the pre-transition state (Loorbach, 2007a). In so doing, transition management is an approach associated with the normative orientation of socio-economic processes to explore the causality behind the societal changes (ibid). Entailing both multi-phase and multi-level perspectives, the framework of transition management seeks to address the conflict between long-term imperatives and short-term concerns (Kemp and Loorbach, 2003). Following this, the implementation of the transition management cycle in the societal systems needs a full understanding of the mechanisms of complex adaptive systems.

The Complex Adaptive System

One of the most crucial concepts in the context of transition management is the complex adaptive system. In fact, a particular case of the complex systems dynamic is considered as a transition dynamic (Rotmans, 2005). A *complex system* consists of a large number of interacting components or sub-systems whose aggregate activity is non-linear. Within the system, the interaction between sub-systems at lower levels creates a new network or organization at the higher-level (Schweitzer, 2007). The components of the complex system are the objects with the capability of learning, so-called agents, and the objects without this capacity, called elements or artifacts. In an *adaptive system*, agents can change their way of interaction (their rules or their behavior) with other objects based on their learning capabilities (Brugge and Haan, 2005).

Hence, a complex adaptive system in this study refers to a system (environment) in which people (agents) make their own behaviors (strategy) based on the interaction with other elements (objects), and adjust their behaviors accordingly (adaptation) into more complex sets (ibid).

The Agent-Based Paradigm

The complex adaptive system has its roots in the agent-based paradigm. The interactions between agents, elements and their environment can be very complicated. It has been a new challenge to develop an approach that is able to focus on these interactions while taking into account the heterogeneity of ecological and social components (Bousquet and Le Page, 2004). Aiming at analyzing the properties of adaptive complex systems, an agent-based approach is used in the context of transition management to represent the process of social and environmental changes, and to illustrate the possible ways to influence the direction of changes towards a sustainable vision. In this sense, the agent-based paradigm can be described as a bottom-up approach in the complex adaptive systems to illustrate the formation of new structures (regimes) originated from lower levels (niches). In other words, discrete, spatially distributed agents evolve their strategies and rules as a result of interacting with other agents and elements of the environment by means of several feedback mechanisms (Schweitzer, 2007).

The process of adaptation varies based on the level (*See* Figure 4) of the agents' interactions, and it is often hard to deduce when the consequence of these interaction affect the entire system (Axelrod, 1997). Depicting the procedure of adaptation and its unexpected outcomes distinguishes the agent-based approaches from other methods, which investigate the social behaviors of the agents (ibid). Unlike the rational-choice based paradigms, in which the deduction forms from the certain assumptions, in the agents-based paradigm, it is not possible to deduce the outcome in advance, because the assumptions change during the adaptation process (ibid). Hence, in the context of the agent-based paradigm, some techniques (i.e. modeling and simulation) can illustrate the process of change, and to follow the patterns being shaped from agents' interactions. Accordingly, and in order to apply the transition management cycle in the case of Ebro River Basin, an agent-based approach is employed to depict the social and environmental interactions among agents, objects and their environment. The outcome of this investigation is shown as a conceptual (meta) model, which will be defined in the following.

The Conceptual model

In the context of transition management, the models are potentially crucial tools for understanding, assessing and supporting transition process (Whitmarsh et al., 2008). As mentioned earlier, in the stage of experimenting and learning of the transition management cycle (*See* Figure 2), stakeholders exchange their perceptions of the problem to enhance their knowledge of a shared issue. In doing so, the graphical tools such as maps, flowcharts, diagrams can be essential approaches to convey the information in a simple and an understandable way. Illustrating a complex system and its components by means of these visual tools, where a diverse range of stakeholders try to identify the relationships among different concepts, facilitates the communications between expert and non-experts (Darmofal et al., 2006). In this respect, the graphical tools should support both theories expressed by scientists, and the empirical data collected from the field works concerning the case studies. Following this, the conceptual model used in this study aims at illustrating the relationship between the facts of the reality and the theories trying to explain the causality behind them. In this sense, it can be interpreted as a *mediating model* which "stands between theory and physical world" (Morgan and Morrison, 1999).

From this perspective, the model neither purely derives from theory, nor from the empirical data. In fact, it is the combination of both, representing the relation between the theory and the reality (ibid). In other words, it is an analytical strategy, as Yin 2003 considers it a *logic model*, which "deliberately stipulates a complex chain of the event over time".

The conceptual model can also be considered as a meta-model for "visualizing, specifying, constructing and documenting the artifacts of distributed object system" (OMG, 2008). In this respect, the meta-models such as UML (Unified Modeling Language) and one of its extensions AML (Agent Modeling Language), are graphical languages consisting of a set of abstract syntax and semantic rules which illustrate the interaction among actors (agents) and factors (objects) within a system (ibid). Here, AML is the chosen tool to depict the issues of agents' communication related to social science, and the interaction of agents regarding their environment based on with respect to the Ebro River Basin case.

After defining the key concepts and terminologies related to transition management, in the next chapter its process is analyzed. Consequently, some of the challenges that create a gap between transition theories and management in practice are discussed. The outcome of this analysis will form the focus and system boundaries of the conceptual model, which will be explained thoroughly in the forth and the fifth chapters.

Chapter 3: Analyses of Transition Management

Imbalanced Representation of Stakeholders

As explained earlier, the goals of the first and the second stages of transition management are to identify the potential stakeholders, to bring different perceptions of the problem to the table and to delineate the problem. Defining a set of criteria to invite the relevant participants in addition to finding the proper strategies and incentives to encourage them to attend the meetings are the challenges of implementing the transition management. One of the flaws of the transition management implementation regarding stakeholders' meetings is that they are not always completely representative of potential stakeholders. Looking at different workshops within the MATISSE project, the majority of the participants in the meetings are either scientists and experts or people who are environmentally conscious (MATISSE, 2008). Increasing the awareness or co-producing knowledge for the people who are already motivated and willing to participate actively concerning social and environmental issues is not the objective of the transition management. As discussed in the MATISSE final conference in Nice, introducing the social and environmental insights into the economic and political decision making process requires the contribution of influential parties such as media, the business sector, policy makers and the ordinary people's representatives as well (Interview with Person 1; Plenary Discussion 1,4).

Like much of the other interdisciplinary research, the time constrains and the lack of financial incentives underlie the barriers to the meaningful stakeholders' meetings (Campbell, 2005). According to WFD plans regarding the River Basin Management, these obstacles should be addressed to secure the progress of the integrated projects (ENEA, 2006). In essence, creating incentives and implementing effective participatory approaches, to get stakeholders involved in the scoping and envisioning stages, are time-consuming tasks that should be provided by full financial supports. Hence, the possibility that the results of knowledge co-production can be affected negatively by the above limitations should be taken into account by the transition managers while the theories are being developed.

A Social and-Natural Science Gap and Bias Issue

As explained above, making the assumptions, upon which the models are built up, is crucial in the context of transition management and ABMs, which (making those assumptions) itself is a way of co-producing knowledge. In this sense, there is a need for integrating multiple disciplines and sciences in order to have a coherent framework for the model. However, this integration is not easy, and as a result, scholars with different academic background usually doubt the assumptions used in the models. For example, as a result of the lack of inter-disciplinary group work, some models of the workshops in the MATISSE project were overly culture-focused such as the Ebro River Basin case, whereas others were too technologically or environmentally concerned (Plenary Discussion 2; Interview with Person 2). As a result, the uncertainties arose regarding the effectiveness of ABMs in capturing the details of the complex systems in general. For instance, in MATISSE final conference, the representative of the EU Commission expressed his concern about the usefulness of transition management cycle as an essential tool in the policy-making procedure by mentioning that:

> *"…Today I heard a lot about confusion and discussion about theory … Perhaps wrapping up a project like MATISSE, they should be some reflection on implication of project on theoretical level… I think it's a challenge for the research community to be open to be clear about what ISA can or cannot do… and I think there is still a lot of confusion here …"* (Person 3, Panel Discussion)

Based on the observation during the MATISSE final conference, sometimes highly educated people tried to impose their ideas rather than to be open to other scholars' points of view. For example, during the presentation regarding the gap between theory and practice of transition management, the speaker pointed out that in reality there is not much difference between the cycle of transition management and other frameworks such as Impact Assessment. This argument led one of the founders of transition management quite provoked in the way that his response turned the scientific discussion to a tense atmosphere after he said:

> *"… I cannot imagine that you don't agree with me on this …."* (Person 4, Plenary Discussion 3)

Being biased towards their own way of thinking, especially on behalf of scholars, mislead the process of knowledge co-production. This is another challenge being faced during the implementation of transition management in the case studies.

Challenges of the Monitoring and Evaluating Stage

Implementing the last stage of transition management is vitally important because it indicates how much stakeholders have adjusted their perceptions and attitude towards the discussed visions and scenarios (Weaver, 2006). However, the monitoring and evaluating procedure is not implemented in the way it is idealized. In some cases, the workshops in the MATISSE project were able to accomplish this stage, and in those cases, it was done by means of questionnaires. The process of transition is long, and the cycle of transition management is being practiced many times during this period. Accordingly, having follow-up plans seems very essential to measure the participants' commitments to their promises beside questionnaires. These kinds of plans were missing from almost all the workshops.

In addition, the implementation of this stage is insufficient not only because of the lack of proper plans (which of course is related to allocation of time and money again), but also due to the hidden barriers. The fact that the progress of the project can potentially create new opportunities for further research (in addition to building a good reputation) may influence the process of evaluation towards unrealistic outcomes. Accordingly, a tendency to avoid getting negative feedback and risking the future of other projects might be formed as an invisible barrier by those who are participating in and working on the project (Interview with Person 5). Hence, there is a need to consider an external evaluation in the process conducted by people who are not involved in the project with more objective viewpoint (third-party evaluation).

Ambiguity of the Social Interactions of the Agents

The third stage of the transition management aims at testing the consistency and the feasibility of sustainability visions (scenarios) by means of different methods and tools. (Weaver, 2006). Exploring why and how societal systems transform, the transition theory and transition management rely on the agent-based paradigm and the tools to illustrate the social interaction of the agents (Brugge and Raak, 2007). Accordingly, Agent-Based Modeling (ABM) is one the techniques used in the context of transition management to simulate the behaviors of the agents in the complex adaptive system. ABM is one of the most appropriate techniques in illustrating the communication among components (agents and objects) of a complex system (Macy, 2002). It is an essential tool for representing how agents' social interactions at the micro level generate the new patterns (networks) at higher levels (ibid). The point of employing this method is to help stakeholders to improve their understanding of the complexity of the system, and empower them to tackle the problem as sustainably as possible. In order to benefit from ABM, and to demonstrate the bottom-up processes, it is crucial to correctly formulate and represent agents' behaviors according to real world actors. Nonetheless, there is not a generally accepted way of interpreting and modeling the complex social interactions by means of ABM tools during the implementation phase (Plenary Discussion 1). There are two main reasons behind this problem:

Firstly, it is due to a lack of knowledge with respect to the agents' behaviors (ibid). Based on the experience gained from the MATISSE project, many workshops suffered from lack of data about the agents' attributes (characteristics or behaviors), and facts about the environment and its components. Secondly, the lack of a clear analytical framework to interpret data is another problematic issue (ibid). Capturing the communications between the agents and the other elements in the models requires a conceptual framework upon which data can be interpreted. Hence, there is a need for identifying the potential and diverse aspects of agents' behaviors (i.e. social, political, economical and psychological perspectives), and to form an analytical framework. Lack of the availability of such an outline or skeleton, even by having access to the data and employing essential tools such as ABM, makes the process of formulating agents' behavior vague and challenging (ibid).

The ambiguity regarding social interaction in ABMs would be better understood by using an example. For an instance, in reality, a particular type of agents (i.e. representative of the farmers) would act/react towards another agent (i.e. representative of the environmentalists) in various ways depending on different interpretations of transition theory. Accordingly, the outcomes of models of the same interactions can be very dissimilar due to different assumptions. Hence, modelers need to be provided with a conceptual framework in which the transition theory and the embedded concepts are precisely defined.

In addition, the ambiguity of social interactions is related to the incompatibility between the theories of transition and the empirical evidence of the case studies. For example, in the context of transition theory, there is an emphasis on stakeholders' collaboration during the stages of transition management. However, not all the stakeholders attending the meetings are willing to collaborate. They do attend the meeting but not necessarily for general good will, or exchanging their beliefs and practices, but for their own benefits (Interview with Person 2). It seems a naive assumption that the agents would start supporting an action after hours and hours of negotiations, and transforming their practices to resolve the issues for the sake of cooperation (Plenary Discussion 1, 2; Interview with Person 2). Most of the time, individuals' interest clashes with each other when they are asked to support or search for an optimal strategy in reality. Therefore, there is a need for exploring the possible ways of building the trust among the agents, improving the collaboration and enhancing the negotiations in the context of transition theory. Equipping transition management with more analyses regarding agents' incentives for collaborations can bridge the transition theories to implementation phase, and boost the process of capturing and formulating agents' interactions.

Addressing the Ambiguity of Agent Interactions in the Ebro River Basin Case

WP6 as one of the work packages of the MATISSE project, concerning case study of the Ebro River Basin, faced most of the above challenges. As stated earlier, the current gap between transition theory and transition management raises many questions regarding the effectiveness of this approach to tackle the sustainability issues in the first place. Some issues, such as the allocation of time and money, in addition to the project management are very important technical subjects, but are outside of the scope of this paper. Here, the focus is on addressing the problem regarding the last barrier, the ambiguity of capturing the social interactions of the agents in the Ebro River Basin case. In doing so, this work-study emphasizes the practical ways of integrating different disciplines and sciences. Regarding the case study, the final aim is to build a conceptual model capturing the interactions of the agents with respect to social and environmental sciences by means of ABM approaches. Therefore, in this particular case, the plan is to integrate the modeling techniques from computer science with the relevant elements from social and environmental sciences with respect to the transition management cycle. In short, it seeks to benefit from critical analyses in order to minimize the gap between theory and practice. To make it simpler, let us assume that a modeler, an environmentalist and a social scientist want to make a conceptual model in this case study. Assuming that the starting point of the process is to look at the case study from the modeler's point of view, what should be considered in the conceptual model according to the others' academic stance? It is important to note that the factors considered in the building the conceptual model are in line with the computer simulation concepts such as Object Oriented Programming (*See* e.g. Bellifemineet al., 2007) in order to provide the possibility of converting the meta-model to a computer model (or game).

Chapter 4: The Components of the Conceptual Model

The purpose of this chapter is to delineate the system boundaries of the case of the Ebro River Basin from agent-based modeling, environmental, and social perspectives. As stated earlier, the goal is to illustrate the meta-model with a visual language, which can be understood by both modelers and non-modelers (environmentalists and social scientists here). In this respect, AML is employed as the tool for building the meta-model. Respecting the AML terminology, the components of the multi agents system are represented by a set of interconnected abstract entities namely agents, resources and environments, each of which has specific characteristics (Bellifemine et al, 2007, Cervenka and Trencansky, 2007). In this sense, agent is an autonomous entity capable of controlling his behavior based on the external or internal stimuli. In addition, the agent has the abilities of mobility, adaptability, interacting and learning within the environment (ibid). Resource is an entity representing a physical or an informational entity within the system. Environment represents a collection of agents and resources of a system in which entities exist and function (ibid). It is important to note that the term of environment will be used to refer to its AML terminology in the next sections while for environmental and socio-economic will be referred as natural environment and society, respectively.

In the following, the mentioned abstract entities (agent, resource and environment) and their features (attributes) within the AML context are explained. In Figure 5, the attributes of farmer as the agent, water as the resource and society as the environment are illustrated via one of the AML diagrams[1]. After introducing the entities, social and environmental aspect of these attributes are described.

[1] AML includes different diagrams, which are being used to represent the interactions among entities (component of the system). In this context, the diagram in Figure 5 is called a class diagram, illustrating the overall structure of a system including its components and the relationships between them. These components, in software engineering terms, are referred to as the classes. In this respect, each class has specific properties (attributes) and methods (operations). These classes can communicate with each other by sending a message through their methods, and they can modify the value of other classes' properties.

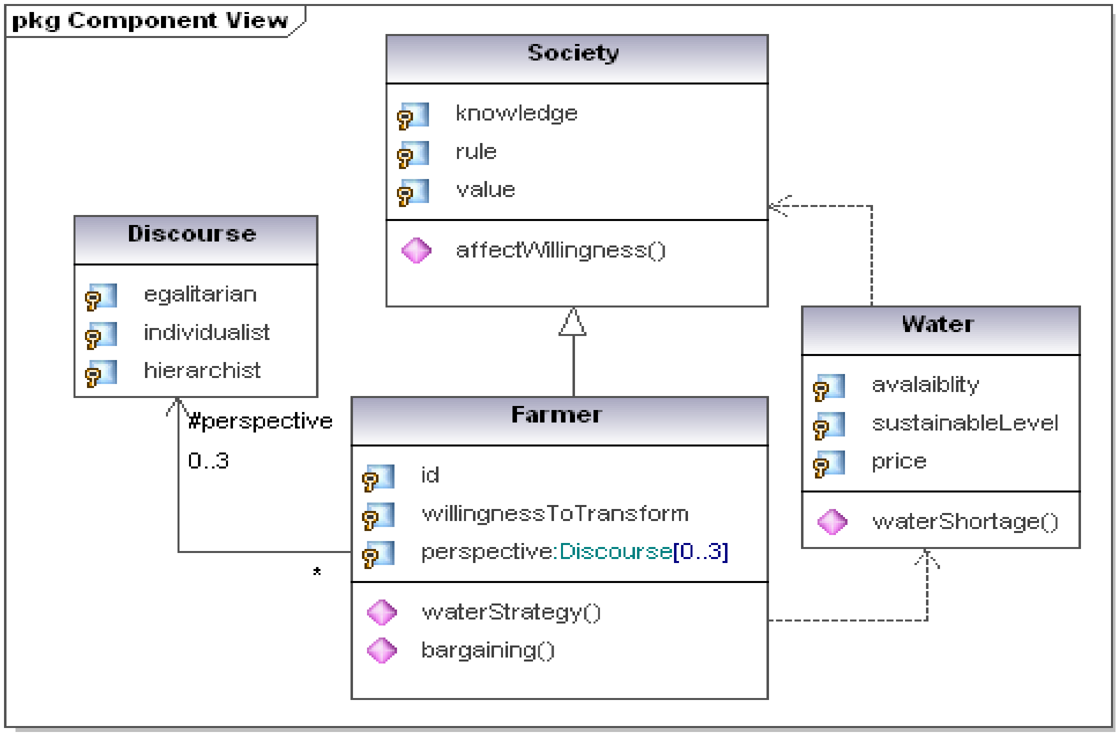


Figure 5 The overall view of the components of the system (Class Diagram)[1]

Agent: Farmer

From a modeling point of view, it is nearly impossible to map each individual in reality one by one to the virtual agents in the model associated with complex societal systems. Therefore, the specific types of agents are assumed, i.e. a farmer, electrician, policy maker, etc. to represent particular characteristics of a group of people. Defining the type of agents will be easier if the agents' level of the communication is clarified. According to the transition theory, there are three levels of agents' interactions (*See* Theoretical Framework). In this meta-model, the focus is only on niche (micro) level as depicted below:

[1] The relationship between each farmer and discourse is defined 0 to 3 meaning that each agent can have 0, 1, 2 or 3 perspectives. For example, according to collected data, one can consider himself X percent egalitarian, Y percent individualist or Z percent hierarchist. The collected data in this respect can help to find out the potential dominant perspectives in the region.

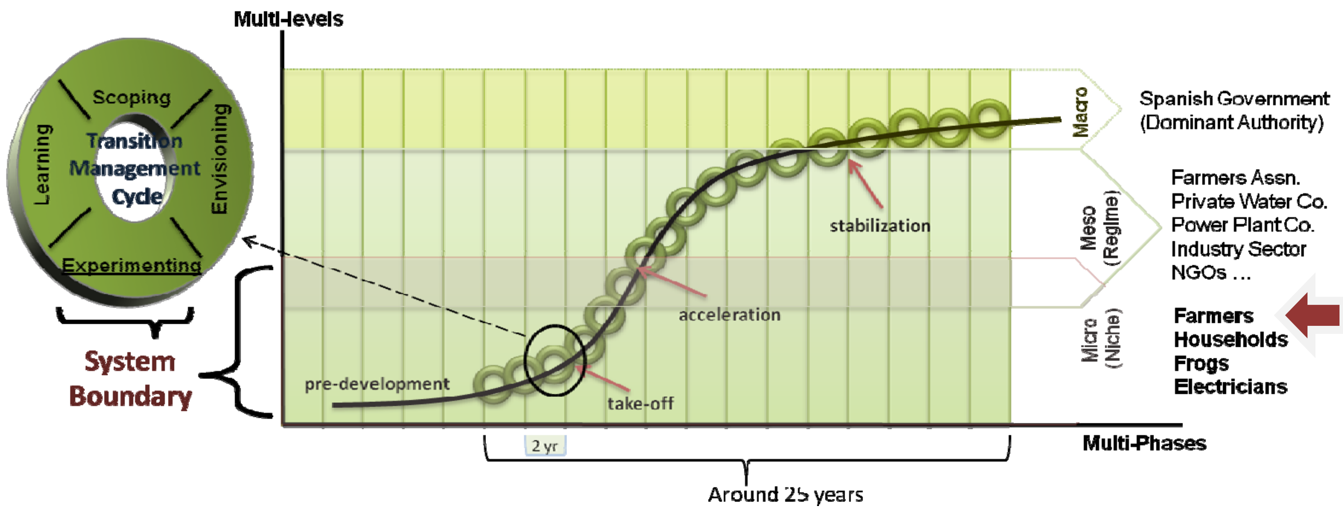


Figure 6 The levels of agents' interactions in the context of transition theory

Capturing the interactions between all types of agents even only in niche level requires a vast investigation of different social and environmental issues. In this paper, only the communication between farmers (as one of the most important actors in the niche level), is captured. The goal is to show the implications of farmers' behaviors during the negotiations regarding the water management. In this sense, it is assumed that each farmer is concerned with two attributes, "perspective" and "willingness to transform", and two operations, "bargaining" and "water strategy "as listed below.

1. Farmer Attribute: Perspective

Among a variety of social paradigms elucidating the agents' perspective of the world, the cultural theory categorizes the agents' perceptions of the environment to three major discourses, namely hierarchism, individualism and egalitarianism (Verweij et al., 2006).

According to the hierarchist's point of view, the natural resources of environment are controllable, and there is enough time to come up with the innovative plans to deal with environmental problems especially by means of technological breakthroughs (ibid). The experts' opinion regarding the environmental management is the key issue, and government regulations should advocate technological optimization to fulfill human needs (ibid). Hence, artificial groundwater recharge, artificial surface reservoirs, desalination and importing or transferring water are all possible ways to deal with the problem of water shortage (Hoekstra, 2000).

An Individualistic viewpoint believes in managing the natural resources through market-based mechanisms. From this perspective, agents should follow their own self interests and maximize their benefits because it is the only way that the whole system can succeed (Verweij et al., 2006). Hence, in the case of water shortage problem, the demands should be managed by means of pricing water based on free market rules. The higher the prices are, the less the demand will be. Water privatization and cost effective investments in water supply or conserving techniques are desirable strategies (Hoekstra, 2000).

On the other hand, from egalitarian's perspective the natural resources are limited, and barely manageable if human beings do not change their selfish viewpoint of maximization (Verweij et al., 2006). Everyone should have the equal access to resources, and voluntary considerations and precautionary principles are the appropriate methods to manage the usage of the environmental resources (ibid). Accordingly, reducing demand by means of technology through water reuse and efficient irrigation patterns, in addition to shifting the social preferences via participatory techniques, from maximization to optimization are desired (Hoekstra, 2000).

2. Framer Attribute: Willingness to Transform

The main reason to include "willingness to transform" as one of the farmer's (agent) attributes is based on the outcome of WP6 pointing to "lack of agents' willingness for transformation" as a barrier preventing system change (Tabara et al. 2007). The notion of this attribute is also addressed in the context of transition management where the outcome of social learning attempts at increasing agents' capacity or knowledge to make changes in their behavior. However, as mentioned earlier, in reality, agents oppose the change, and although they can realize the need for change, they prefer others to change their behaviors. Following this, the elements affecting agents' behaviors in different ways are explained later in this chapter. In this regard, it is assumed that the elements can affect the farmers' willingness to transform are society's attributes such as rules, values and knowledge.

3. Farmer Operation: The water management strategies

The water management concerning the water shortage problem can be categorized in two major categories consisting of three strategies as shown below:

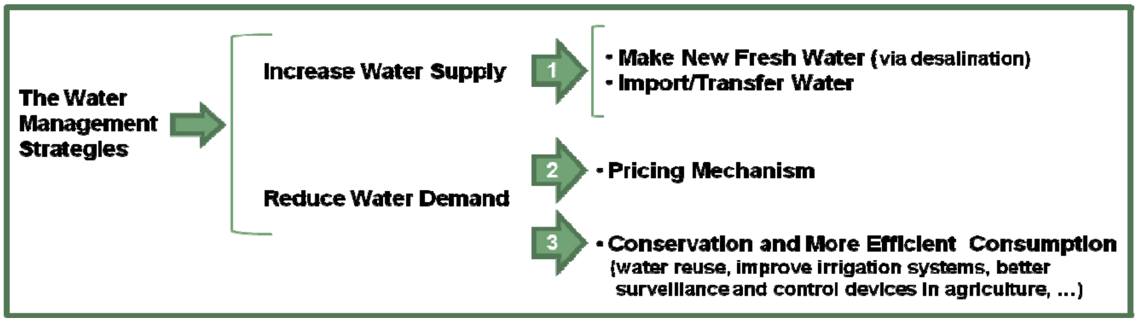


Figure 7 The major water management strategies regarding water shortage problem

According to the cultural theory's postulation of agents' beliefs in the water domain, it is assumed that a farmer with a hierarchistic viewpoint supports the first strategy, while an individualist farmer is in favor of the second, and an egalitarian farmer follows the third strategy (Hoekstra, 2000). There are several studies (Albiac et al., 2003, Berbel and Gomes-Limon, 2000, Day et al., 2006, Downward and Taylor, 2007, ENEA, 2006) explaining the benefits and the challenges of each strategy which are not being discussed thoroughly here. In the case of the Ebro River Basin, and within the system boundary of this section, the emphasis of the transition management is on the third strategy where the problem of water shortage is addressed through participatory approaches to reduce demand (*See* Figure 7). The third strategy is in line with Integrated Water Management (IWM) which attempts to improve the level of coordination between a diverse range of agencies sharing different responsibilities for the management of water (Watson et al., 2007). In this respect, IWM promotes a collaborative-oriented approach to tackle the formal rules, structures and norms impeding the active engagement of agents to deal with the water management issues (ibid). The third strategy is also under the umbrella of the WFD in which the participation of various government departments and stakeholder groups are required for river basin and management (WFD, 2007). Along with the WFD and IWM, the third strategy focuses on bottom-up approaches to stress the notion of agents' coalition in the cycle of transition management. Following this, the meta-model, Figure 9, depicts the situation in which the dominant farmers' practices are based on the third strategy aiming at reducing demand through conservation and more efficient consumption, preferably via voluntarily actions. Hence, the goal is to illustrate the issues regarding practicing this strategy, and to scrutinize the possible solution addressing the problem associated with water saving approaches. The further investigation regarding the first and the second is out of the system boundary of the metal-model. However, the reasons behind excluding these strategies are explained briefly in the following:

First Strategy: Increasing Water supply… Why not?

The process of importing/transferring water from somewhere with a water surplus or making more fresh water through desalination –removing dissolved minerals including salt- is extremely costly and energy intensive (Villiers, 2000). In addition to environmental impacts (*See* background section), transferring water from Ebro River to Mediterranean regions in southeast of Spain is not economically and socially sustainable either (Albiac et al., 2003, Raluy et al., 2005). Firstly, the cost of transferred water is not affordable for farmers to pay due to their insufficient crop profitability (Albiac et al., 2003). Secondly, transferring water from one basin to another can potentially provoke social tension between different territories (Raluy et al., 2005). The other alternative for increasing the water supply, desalination, is even more energy intensive than transferring water plan (i.e. Spanish NHP) based on the results of the comparative life cycle analysis (ibid). Taking into account the environmental impacts (i.e. CO_2 emission) and energy consumption during the production and delivery phase, desalination techniques are currently cannot be considered as "sustainable" strategies (ibid).

Second Strategy: Reducing water demand through pricing mechanism… Why not?

Water pricing management has been suggested by many researchers as a means of demand reduction. Basically, the emphasis is on removing water subsidies and treating water as an economic good according to market rules (Villiers, 2000). The proponents of the approach argue that "free market" brings supply and consumption into balance. Nevertheless, there are three main problems associated with water price mechanism in this case study (Berbel and Gomes-Limon, 2000). First, it is very probable that farm income decreases (especially in rural areas) because of cutting subsidies and higher water price before reducing demand remarkably. Simply there is a possibility that farmers will go broke (ibid). The second, there are limited alternative crops in the region to be used in agriculture sector with lower water consumption. Considering the limitation and the required technological investments to switch to new replacements, this would result in loss of employment. In this case, farmers might be forced to change their business to be able to survive (ibid). Finally, the free market-based approaches in water management restrict the accessibility to water in the first place, instead of preventing water waste. In this sense, there are several examples in which water pricing causes the poor to get poorer as "they can't pay the newly inflated rates", while the rich get richer (Villiers, 2000).

4. Farmer Operation: Bargaining

In the context of agents' collaboration, bargaining is an inevitable coordination cost which refers to "operational dependence between the activities of the different actors" (Lozano, 2007). It is very probable that the interaction of agents with different perspectives leads to a conflict because of their incompatible interests, needs and beliefs. The underlying notion of bargaining drives the agents to discuss the possible ways of reaching the common goals beyond their personal needs (ibid). Thus, bargaining is considered as one the most important operations that farmers are capable of practicing. During the process of bargaining, there is a trade-off between individuals' perspective and the common goals. The detail of the procedure is explained in the next chapter.

Resource: Water

In the case of the Ebro River basin, water is "part of the identity of people", as pointed out by Day et al., 2006, due to its high impact on farmers' economic and social activities such as rice cultivation, fishing, hunting, etc. (Day et al., 2006). Unfortunately, there are several water issues in the Ebro River Basin mainly in the category of water quality deterioration and water scarcity (Albiac 2003; Day et al., 2006; Downward and Taylor 2007). Accordingly, several attributes can be considered for water based on different issues. However, the focus of this paper is only on the water scarcity problem, and the related water management strategies. Among diverse attributes in this respect, only three major ones are assumed within the system boundary of the conceptual model, which are availability, price and sustainable level of water. The reasons for choosing these attributes are their relationships to farmers' perspective and how farmers choose their water management strategy. These relationships are illustrated in Figure 9 with the comments boxes (orange rectangles). To put it in another way, it is assumed that in the case of a water scarcity problem, a hierarchist farmer considers water availability and his water needs to choose his water management strategy (the first strategy). An individualist farmer looks at water price (and chooses the second strategy) while an egalitarian farmer takes the sustainable level of water into account to address the water shortage problem (and selects the third strategy) (Hoekstra, 2000). Another assumption in Figure 5, is sending a message to the environment[1]

[1] In the context of AML, this means that when water data, which is being read from database (from different areas), indicates that there is not enough water in the region (which can be an absolute number or relative number compared

(in ABM terminology) when the threat of water scarcity is recognized (this will be determined based on available database regarding the quantity of water in different locations). This operation is being done by a water shortage function, as illustrated with the water operation.

Environment: Society

From the agent-based modeling point of view, the environment is a complex entity containing the space and all the other objects such as agents and resources (Cervenka and Trencansky, 2007). The environment is used to model different aspect of the complex systems including the principles and the processes (ibid). In the case of the Ebro River Basin, the environment refers to system consisting of farmers, their attributes and operations in addition to water resource (Ebro River). In this sense, it can also be referred as the society in which agents function. Like the other entities, the society has its own attributes and operations explained below.

1. Society Attribute: Knowledge

The knowledge of society symbolizes the details of the environmental and socio-economic factors existing in the system. It is included as one of the society's characteristics due to its significant role to empower agents with knowledge. As stated earlier the process of transition management is a way of producing knowledge. In this respect, the agents' communications, negotiations and discussions can reveal the new facts regarding the system. Hence, the agents' collaboration amplifies the knowledge of the natural environment and society. Respectively, the more agents know about the society and its complexity, the more strategies or actions they are able to take

2. Society Attribute: Rule

In the conceptual model, the rules represent water legislations and laws (including taxation, monitoring, etc.) which can potentially support the water saving plans. The formation of these rules is based on bottom up approaches as the result of agents' bargaining. These rules are supported by the regime agents (institutions, organization and other networks), and eventually affect the agents' behaviors. The need for shaping these regime practices will be explained in the next chapter, however,

---

with previous years), then this information regarding the water scarcity spreads out in the environment, and all of the farmers have this information.

how they would be formed, and what drivers and barriers they might create is out of the scope of this research.

3. Society attribute: Status

This attribute indicates the environmental status of the natural resources such as the condition of the Ebro basin and delta. Therefore, the delta deterioration, loss of biodiversity, water scarcity, climate change, etc. affect the status of the environment negatively.

4. Society attribute: Value

It is assumed that within each environment (society) there are common values and that all the agents recognize their importance in their lives. These values emanate from the concept of “functionings” in Sen’s work (2001) reflecting “the various things a person may value doing or being” (Greig et al., 2007). For example, being a respected member of the farming community or preserving natural heritage are the values, which farmers may take into consideration concerning transforming their practices.

5. Society operation: Affect Agent’s Willingness

This operation has a virtual weight, which is accumulation of all the society’s attributes including knowledge, rules and values. (Virtual Weight = knowledge + rules + values of the society). In other words, there is a set of factors in the society, which can influence agents’ behaviors. The aggregation of these factors is the impact that the society can have on agents’ actions. This impact is symbolized by the virtual weight of the society. Therefore, the more laws are enforced, or the more values and knowledge are created with respect to the society, the more impacts the society has on agents’ willingness to transform. Based on the unsustainable situation in this case study, it is assumed that none of these elements are influential enough to affect the agents’ actions, hence the initial value for the virtual weight is considered to be zero before agents’ negotiations. However, when agents start bargaining and negotiating, then the attributes of the society (knowledge, rules and values) begin to shape. Accordingly, the virtual weight of the society starts to increase, and as a result, the more influentially it affects agents to transform their former behaviors.

In table 1, the assumptions used in the meta-model based on different AML, environmental and social aspects are summed up.

Table 1 The assumptions used within the system boundaries of the meta-model

The components of the system with respect to the agents' interactions at micro level	
Water Issue :	**Water Scarcity in the Ebro River Basin**
The focused water management plan :	**The third strategy (Demand reduction through efficient irrigation & consumption)**
Specific Problem :	**The issues associated with the third strategy (Free Riding)**
Agent type : Hierarchist :	**Favorite water management: 1^{st} Strategy, Triggered by: Water Availability**
Agent type : Individualist :	**Favorite water management: 2^{nd} Strategy - Triggered by: Water Price**
Agent type : Egalitarian :	**Favorite water management: 3^{rd} Strategy - Triggered by: Water Sustainable level**
Element affect agents' behaviors :	**The society's operation (Affect Willingness to Transform)**
Virtual weight of the society's operation :	**Zero by default (at the beginning)**
Elements concerned with virtual weight :	**Rules, Values and Knowledge (Attributes of the society)**
Elements affect attributes of society :	**Agents' (farmers) bargaining (Operation of agent)**
Trigger of Agents' bargaining operation :	**Water Shortage Problem**
The source acknowledging water shortage problem :	**Local water database (by means of GIS tools)**

After the declaration of entities, their attributes and operations, the next step is to represent the agents' interactions via one of the AML diagrams. The relevant diagrams for this case study ` are use-case diagram and activity diagram. The purpose of the first diagram is to promote a picture of the issues within the system, and the second diagram illustrates the details regarding the issues, such as the way of communication between the entities. In this sense, and considering the system boundaries of the Ebro River Basin case, the use-case diagram is shown in Figure 8.

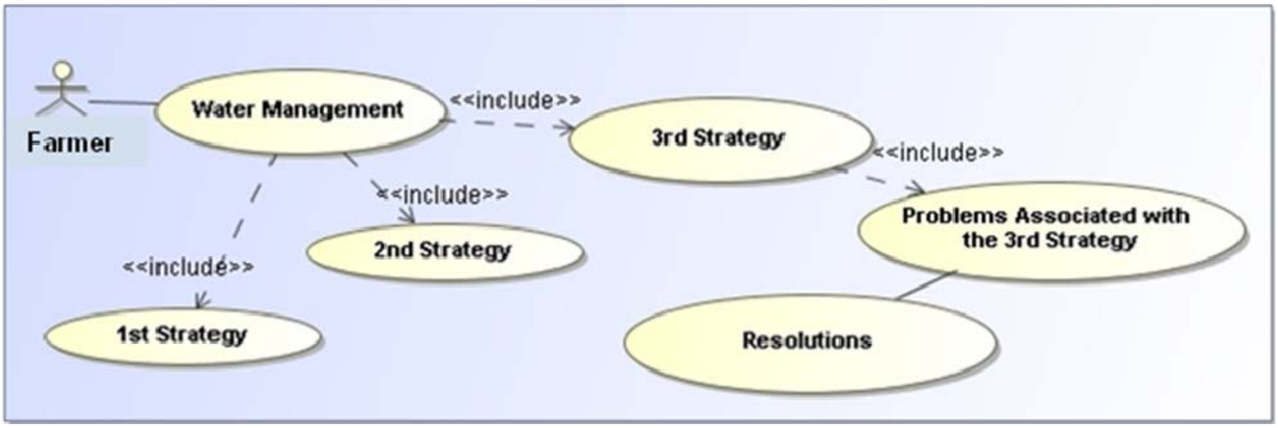


Figure 8 Demand reduction via conservation and efficient consumption (Use-case Diagram)

As mentioned above, the goal of the third strategy is reducing demand through less water consumption via reuse of water and efficient irrigation. However, this approach provides the opportunities to other farmers (who have the tendency to use more water) not to change their water management practices. The problematic issue arising from practicing the third strategy is a classical problem of "free riding" concerned with bargaining and collaborative action (Lozano, 2007). For an example, while egalitarian farmers reduce their water consumptions, the hierarchist and individualist farmers will take advantage of this opportunity to use more water. As a result, the efforts of egalitarian farmers to resolve the unsustainable water management issues will not pay off, because other types of farmers do not cooperate in water saving plans. As depicted in Figure 9, this scenario eventually results in more social and environmental damages.

To tackle this problem, the WP6 highlighted the willingness of the agents to transform as they key element to overcome the issue of free riding. The project demonstrated that the progress of water saving plans was heavily reliant on agents' willingness to actively participate in these programs. Oversimplifying the outcomes of the WP6, the approaches used to make all the agents transform their unsustainable practices, were heavily reliant on the cultural influences. As criticized in the third chapter, too much of the attention went to the notion of culture as the main driving force, which can change agents' behaviors. This study certainly acknowledges the notion of culture in affecting agents' behaviors. However, it also promotes other concepts and theories, which potentially can resolve the issue of free riding. In the next chapter, potential solutions regarding this problem is explained and illustrated via the meta-model. In Figure 9, the workflow of the components of the system bringing about the problem of “free riding” is shown.

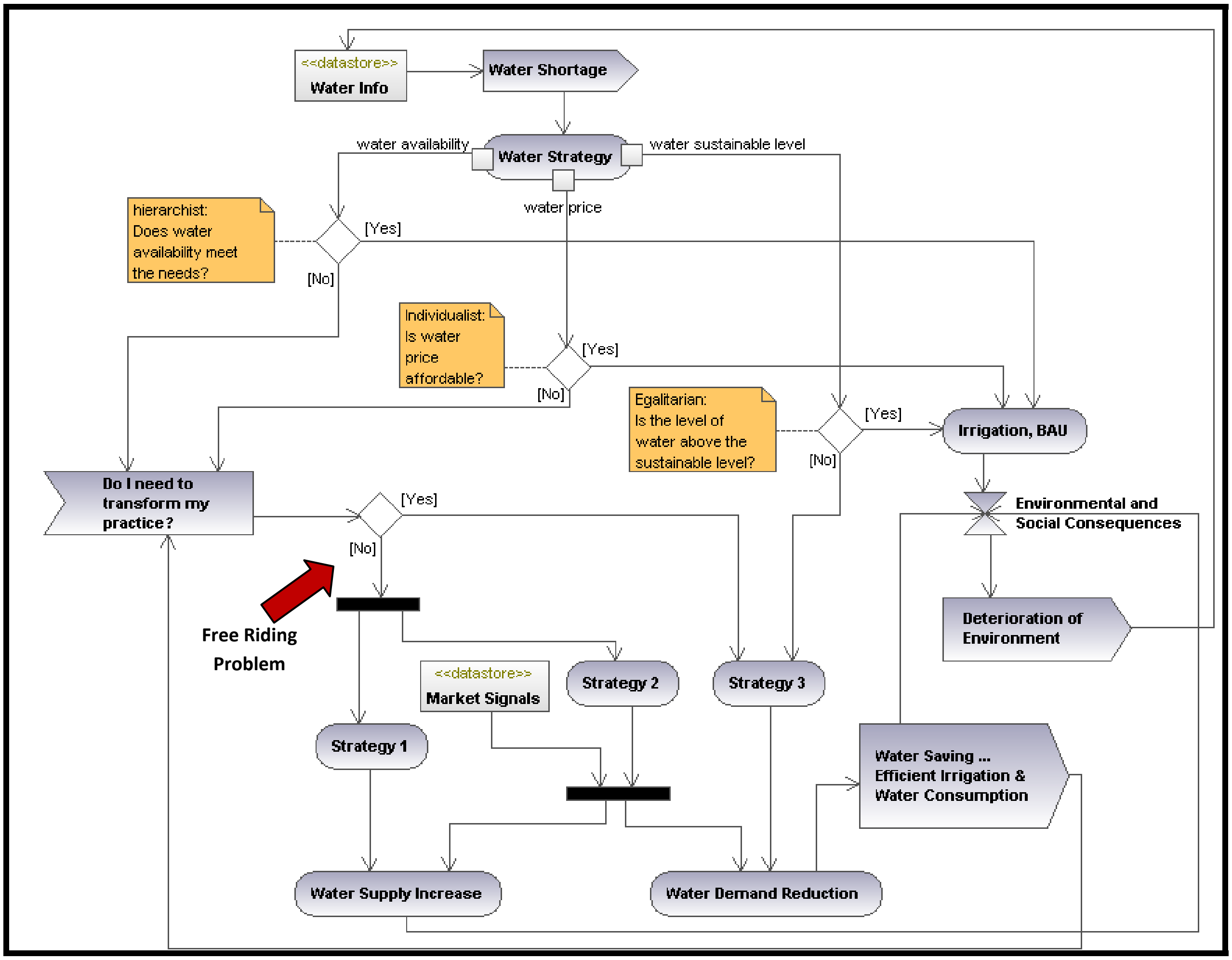


Figure 9 The free riding problem associated with 3rd strategy (Activity Diagram)

Chapter 5: Bringing Disciplines Together for Water Management

The reason underlying to investigate the problem of free riding (associated with water saving plans) from different angles is to boost the implementation of transition management in this case study. One of the challenges, creating the gap between theories behind transition management and its implementation in WP6, is due to the assumption that agents will adapt their behaviors to the new water culture because of social learning process. This assumption is valid if the agents' behaviors rely mainly on cultural influences. Nevertheless, in reality where the economic incentives are the main driving forces in most cases, the cultural influences cannot affect the willingness of agents to transform as successfully as theorized. Hence, the assumption used in this paper to capture and investigate agents' interactions under the promoted water saving plans is based on both non-cooperative and cooperative behaviors.

Free riding problem: A rational or an immoral issue

As depicted in Figure 9, farmers' willingness of transformation is connected to the problem of free riding, meaning that the more opportunities for being a free rider, the less willingness to transform will be. This issue is investigated from two points of view: first as a rational behavior, and second as an unethical action. As a rational choice, the problem can be simply explained by the classical game theory of "Prisoner's Dilemma", (*See* e.g. Axelrod 1997 and Appendix 3) in which agents have the opportunity to have a better gain by betraying. For example, in this case, the farmers with individualistic and hierarchist perspective may ignore the voluntary limits because they know that there is a high possibility that egalitarian farmers will reduce the water demands anyway. Therefore, the way they behave is quite rational, because they can benefit from the situation more by not transforming their practices.

On the other hand, betraying, cheating, or not respecting the agreements (i.e. voluntary limits) are unethical behaviors in many conditions. In this sense, the free riding issue can be considered as an action undermining the values of the society in favor of personal interest. Accordingly, this problem can occur in the absence of a set of established values (set and agreed as a result of agents' negotiations), and their potential impacts on agents' behaviors. In other words, a hierarchist or individualist farmer is willing to be a free rider (based on his own interest) because he does not recognize the society's values, and consequently he is not willing to prioritize these values to his own perspective.

Respectively, the potential solutions to address the free riding problem are categorized from two major points of views. The first resolution is based on the rational choices paradigm assuming that farmers are fully rational, and they choose the strategy which can give the highest expected utility over time (Axelrod, 1997). Hence, if choosing the free riding strategy can be made to bring about lower gain, farmers will avoid being free riders. The second potential solution is corresponded to irrational choices [1] implying that there are other elements that can affect farmers' behaviors rather than calculating the losses and gains, which are based on the individuals' interest and benefit.

Resolution 1: The Emergence of the Nash Equilibrium

One reason underlying the free riding problem is that farmers with either hierarchist or individualistic perspective do not have enough motivation to transform their practices. In other words, these types of farmers do not recognize the necessity of water saving practices through collaboration and active participation, because the self-interest is the main driving force affecting their practices. Hence, as the actions of these free riders are being justified according to their rational choice paradigm, one possible solution is to demonstrate that being a free rider or following self-interest maximization is not actually rational. The irrationality of being a free rider can be explained by the classical example of "the tragedy of the commons" (Hardin, 1968), that results from self-interest maximization. If either of hierarchist or individualist type of farmers attempts to be a free rider, then their strategies (either the first or the second strategy) block each other in the way of maximizing self-interest, which results in the tragedy of the commons. Simply the more free riders because of hierarchist or individualistic behaviors, the less water will be available for distribution. Of course, according to the rational choices paradigm that will not happen, if increasing water supply is viable, if the water resources are being allocated by a perfect market and if the population (water demand) is stable (Lozano, 2007). As mentioned in the fourth chapter, none of these conditions is present in this case study. Without these conditions, maximization is not the optimal strategy for the agents, and behaving as a free rider cannot be considered as a rational choice. This argument is in accordance with the Nash Equilibrium's theory

[1] The "irrational" choice is a terminology used in the neo-classical paradigm to refer to a choice, which does not prioritize economic considerations to other factors.

based on which, unilateral maximization of self-interest is not the best choice (ibid). Conversely, maximization without considering others' strategies will result in less payoff. Hence, the optimal decision can be reached if an agent considers other agents' decision before making his own decision (ibid). In essence, the concept of the Nash Equilibrium highlights the influential role of collaborative strategy in reaching higher gains for the different agents. In other words, it emphasizes the benefit of cooperative behaviors rather than non-cooperative actions. From this point of view, the third strategy follows the Nash Equilibrium's theory where its focus is on active participation in water management. In this respect, the water saving approaches such as setting new limits for water consumption, changing the agricultural practices or crop patterns, and consuming less water by employing new technologies are promoted (EU Water Saving Potential Report., 2007).

Nevertheless, acknowledging the necessity of collaboration is not enough on its own. It is also crucial to secure active participation to keep the Nash Equilibrium, and to ensure that agent do not abuse or cheat at the system (Downward and Taylor, 2007). Hence, monitoring approaches like GIS or Earth Observation Satellite techniques are the useful means of providing information on water usage in different areas (Jochum, 2007). Thus the farmers, who try to deceive the system by using more water than the agreed limits, should be sentenced based on the laws being implemented by the authority (regime). In this respect, the foundation of water policy and legislation should be formed by agents through consultations or complaints procedure and the courts (WFD, 2007). Accordingly, the transparency in establishing legislations, and in enforcing laws in good faith, is crucial at regime (authority) level (ibid). Although investigation regarding the regime practices is not within the system boundary of the conceptual model, it is important to point out the role of regime practices at niche's behaviors. In this context, the WFD 2007 recognizes the role of States in providing a rational basis for the river basin management.

In short, the Nash Equilibrium logic is helpful to understand the necessity of collaboration to reach a higher gain (i.e. optimal water accessibility) in comparison with the situation in which farmers follow their own strategy disregarding others' practices. The above scenario of reaching the Nash Equilibrium portrays the farmers as the non-cooperative, competitive and greedy agents who follow their self-interest at any price (based on the rational choice paradigm). Thus, the goal of proposing the first resolution was to show that, attempting to maximize one's own benefits, and disregarding the water-saving strategies can have a lower pay-off than participative behaviors. The second resolution, however, investigates the free riding problem from outside of the rational choices paradigm. In this sense, the focus is on other influential factors of system (society) like the value and knowledge, which can change agents' behaviors. In the following the perception of these values and knowledge, and the mechanism through which they can influence the agents' practices are described

Resolution 2: Fostering a Sense of Responsibility towards Society's Values

Sharing Values, Why?

The problems of water management, including the free riding issue, are connected with diversity of perspectives attempting to deal with the problem based on different beliefs and values (Hoekstra, 2000). In line with the cultural theory and Social Learning Theory, the cycle of transition management aims at combining the all-opposing viewpoints and constructing a new set of values not by merging the existing values, but by making new ones (*See* theoretical framework). The cultural theory suggests that between these extremes (hierarchism, individualism and egalitarianism) "there is the possibility of constructive dialogue" (Verweij et al., 2006). The outcome of these dialogues and negotiations can make a new set of values, which can be shared among the agents. The question that may arise here is what could motivate agents to negotiate or collaborate with each other, instead of making their own rational choices? According to the Cultural Theory, the reason behind the willingness to negotiate and dialogue, for making the shared values, arises from that agents' dissatisfaction regarding their beliefs and value (Hoekstra, 2000). This dissatisfaction, itself, originates from surprises – the discrepancy between the individuals' values and their ordinary and practical lives, which are not aligned with their idealized perspectives (ibid). Facing the flaws and contradictions in their perspectives, agents collaborate and look for new alternative values by means of dialogues.

In many respects, this argument corresponds to the theory of communicative action, suggested by Habermas, which aims at reaching agreement that ensures "the symmetrical distributions of opportunities and capacities of expression" of all agents (Rist et al., 2007). Stating that agents should not despair the reasons, Habermas favors a tendency towards inter-subjective understanding or consensus (Callinicos, 1999). He argues that human beings are "embodied agents whose physical structures and biological needs constitute inescapable parameters of and forces within social life" (ibid). Hence, the willingness to build up a new set of norms and values is a part of agents' nature as they are agents capable of reasoning rather than purely rational agents.

How shared values drive the agents' behaviors?

Along with the above theories exploring the notion of society's (system) values, Sen (2005), points to the role of *commitment* to the shared values, which can affect agent's behaviors. According to Sen's postulation of commitment, the influential factor bringing about the transformation in agents' behaviors is connected to their sense of responsibility regarding the shared values (Sen, 2005). This commitment is not due to the contribution of the system's values on agents' own living standards, but because of the ethical incentives related to agents' power (ibid). In this respect, the more powerful (in terms of political and civic rights) an agent is, the more responsibilities he has regarding his environment and its elements. Accordingly, agents are ethically responsible for the consequence of their action concerned with the other agents and elements in the system. For instance, in the case of Ebro River Basin, the farmers should be concerned about biodiversity loss in the Ebro delta not necessarily because of the potential benefits that bird species in the delta can have in their lives. They should be concerned because they have this power to save endangered species by preventing delta degradation associated with their unsustainable water management. Hence, if farmers do no change their practices, they are responsible for exterminating the bird species in the delta.

How to foster a sense of responsibility?

In order to foster a sense of responsibility and commitment, one potential effective option would be raising awareness and knowledge. Often agents are not aware of the consequence of their actions, and empowering them with knowledge might be very essential to change their practices. This awareness is the outcome of the process of social learning being practiced in the cycle of transition management. According to the theories behind transition management (*See* theoretical framework), observation, imitation and adaptation during the process of social learning eventually lead to agents' behavioral change in the complex adaptive systems.

The impacts of knowledge empowerment and awareness on enhancing farmers' commitment to practice water-saving plans can be investigated from diverse aspects such as social cognitive perspective or observational learning. From a psychological insight, the connection of knowledge empowerment and behavioral change can be investigated under a broader concept connected to "regret-based" learning. From this point of view, after knowledge empowerment, agents might think that they would have behaved differently if they had known about the consequence of their actions in advance (Cohen, 2008, Ku, 2008). Hence, in order to prevent being regretful again, they will transform their formal actions eventually. Some recent research done in this respect indicates that regret-based learning have potentially more influential impacts on agents' behavior than formal economic-based learning approach (ibid).

The Resolutions in the Meta-Model

The first resolution in the meta-model is being illustrated by linkage between the "willingness to transform", the farmer's attribute, and "affect willingness" the society's operation. Following this, the Nash Equilibrium will be achieved if the virtual weight of environment's operation, which is assumed zero by default, increases. As explained above, the water laws and monitoring can potentially increase this virtual weight through affecting the "rule" attribute of the environment.

Regarding the second resolution in the meta-model, the attributes of the society that can affect the willingness of farmers to transform are knowledge and values. The theories mentioned in the second resolution section are helpful to understand the importance of these attributes and how they can influence farmer's willingness to transform. In this sense, the virtual weight of society's operation corresponds with the values and knowledge attributes through sense of responsibility and awareness.

The potential solutions discussed in this chapter, to resolve the free riding problem and to encourage the agents' transformation towards efficient water consumptions, are illustrated in Figure 10, as can be seen within the red circle. Addressing the issues by considering both "rational" and "irrational" choices would be better formulate the agent interactions in the context of transition management concerning water saving plans.

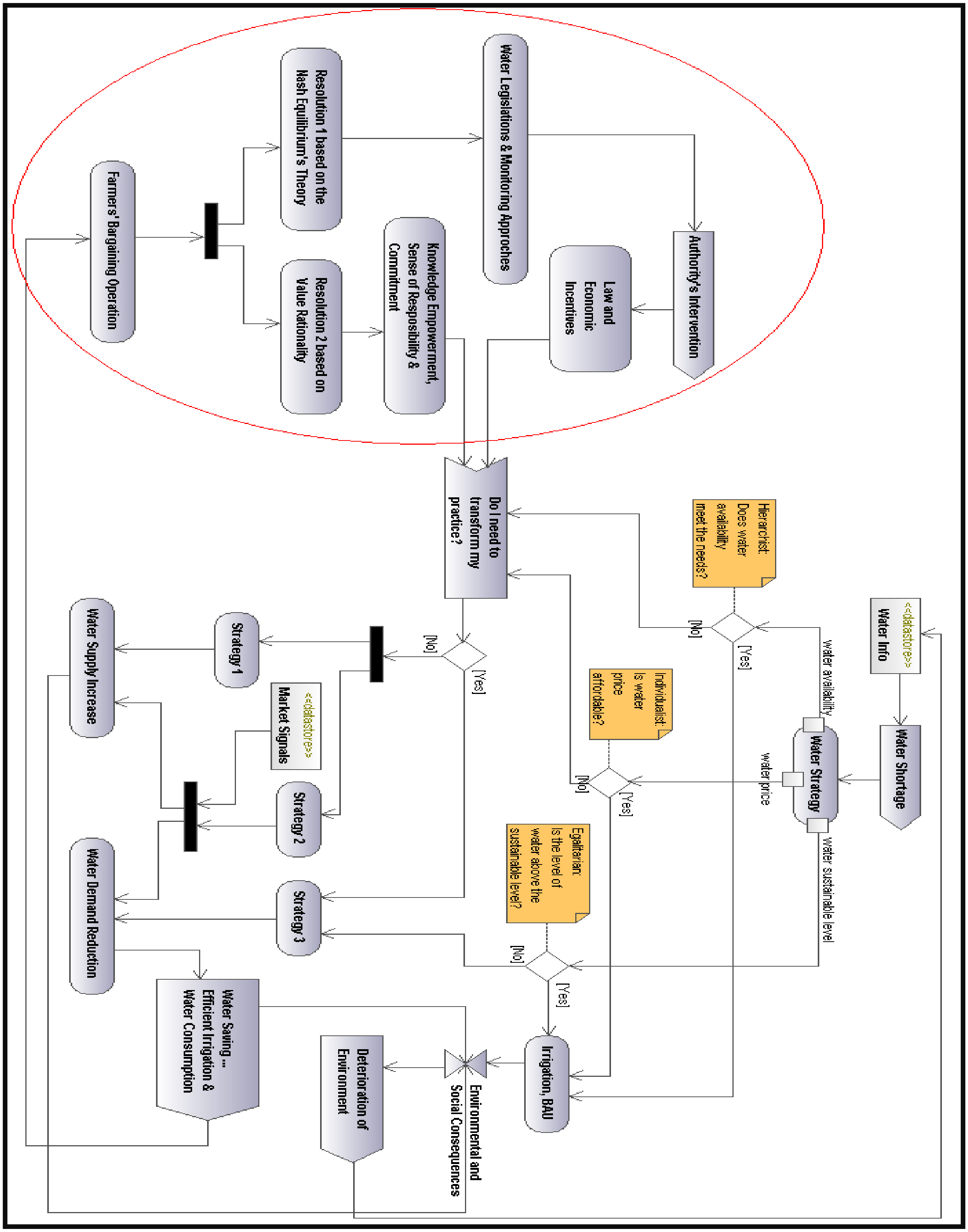


Figure 10 Potential solutions respecting the free riding issue

Resolutions in the Context of Sustainability

In line with transition management framework as a sustainability-oriented process, the discussed resolutions in the context of water-saving practices are mainly concerned with two concepts of sustainability, namely weak and strong sustainability. Weak sustainability concept is used to refer to "sustainable income" (Harris et al., 2001). Regarding this case study, the weak sustainability approaches are used to sustain the farmers' income, which relies on the amount of water consumptions. Accordingly, the social and environmental aspect of water management issues will be taken into consideration if they have impacts on farmers' income. On the other hand, respecting the strong sustainability concept, environmental depletions and damages cannot be easily substituted by manufactured capital (ibid). Hence, the center of water management plans should consider social and environmental aspects independently from economical considerations. In the following section, the linkage between the resolutions and these concepts of sustainability is explained.

Resolution 1 and the weak sustainability

Regarding the first resolution, the Nash Equilibrium was proposed to emphasize the importance of collaborative actions by means of law and monitoring approaches. The formula of the Nash Equilibrium is suited and applicable for the cases in which a phenomenon can be confined in mathematical functions, which is not a problem for economic aspects (Lozano, 2007). In addition, there is an inevitable need for an authority to implement the rules and monitor the system in order to make the equilibrium workable. The controversial questions arising here are whether the water management issues should be addressed from an economic perspective or not, who has the authority to implement the laws, and how "democratically" that authority is formed (ibid).

The focus of the first resolution is on the agents' economic gain and loss, and the optimal strategy would be based on cost and benefit analysis for water management according to the Nash Equilibrium's theory. The Nash Equilibrium's theory of optimization corresponds with the concept of Brundtland's report of sustainable development where agents should attempt meeting the needs of present while they consider the consequence of their actions on the next generation. In this respect, the first resolution is in line with the weak sustainability approaches where the human's economic needs are the center of attention (Sen, 2005). The advocates of weak sustainability do not overlook the necessity of collaboration, but they bind it to economic constraints to approach sustainability objectives within the paradigm of rational choices. Respecting this, the intention is to internalize the externalities (i.e. social and environmental aspects of the sustainability issues) within an economic framework. Compared with the current unsustainable situation in the Ebro River Basin, this resolution might seem a noteworthy idea, however, estimating social and environmental costs are extremely difficult and controversial (Albiac 2003; Raluy et al., 2005).

Resolution 2 and the strong sustainability

As mentioned above, the doubts about the effectiveness of the Nash Equilibrium, to address the problem of water management, brought about introducing another potential solution from sociological perspective. Following this, the formation of norms and values through constructive dialogues and negotiations was investigated. Notwithstanding, it is important to note that the success of constructing dialogue and negotiations rely on certain conditions. Providing the requirements for dialogic atmosphere, agents should respect others' perspectives, attempt to understand other viewpoints, honestly acknowledge the problems associated with their practices and not be afraid of expressing their own perspective (Rist et al., 2007). In short, agents should recognize the need for co-operation and collaboration in the first place, otherwise reaching agreements regarding the values and norms does not seem very realistic in a non co-operative situations.

The approaches of the second resolution of dealing with the water management issues correspond to the concept of strong sustainability where agents' values and the possibilities of achieving those values, are taken into account (Sen, 2005). Respectively, the advocates of strong sustainability acknowledge the role of institutions (regime practices) to establish enforceable legislation in addition to the role of a stronger sense of commitment to the society's values to tackle the environmental problems (ibid). Following the WFD public participation plans, the second resolution advocates the water saving strategies by balancing the interests of various types of agents in the river basin management (WFD, 2007). As mentioned earlier, considering farmers as the reasoning agents, they will change their behaviors towards the legislations if reasonably well argued (Habermas, 2005).

Containing both weak and strong concepts of sustainability, the conceptual model supports the possibilities of representing either or both resolutions; one relies on the Nash Equilibrium, and the other is driven by system's values and knowledge. The outcome of the first argument is represented by rules of the society, and the impact of the second approach is shown by the value and knowledge of the system. As explained separately, the virtual weight of aggregation of society's rules, value and knowledge affect the willingness of the farmer to transform his former practices to the third strategy, which is based on water conservation and efficient consumption. Estimating which one of these solutions can resolve the problems associated with water saving practices (i.e. free riding problem), or in other words, which element (rules, value, or knowledge) influences the farmer behavior more than the others, is open for discussion. The reason for avoiding predicting the future scenario derives from the idea behind agent-based paradigm and approaches, which aim at depicting unexpected results (*See* theoretical framework). Finding out whether these resolutions can be applied at the same time, or which one has a more influential impact is only attainable by gathering immense quantities of accurate local data regarding the agents, their attributes and functions. In this sense, the meta-model is an essential analytical framework, which can be used to collect required data, and to interpret it in a systematic way. As mentioned before, the meta-model is built up based on the agent-based modeling techniques making it feasible to be implemented via computer simulations tools. Hence, it is also possible to convert the meta-model to computer game/model in order to represent the outcome of agents' interactions regarding the water management issue based on the collected data.

Limitations

There are different levels of limitations in this study, which should be considered before drawing conclusions. First, it is important to note that the critical analyses regarding the application of transition management are based on the outcomes of WP6 and other case studies done in the MATISSE project. The reason to choose WP6 as the case study is to provide a suitable context for answering the research questions and not because of an unusual or extreme case in some ways (Bryman, 2004). In this regard, one of the main criticisms of case study (as the research design) is the fact that findings cannot be generalized in other similar cases (ibid). Following this, the issues associated with WP6 should not be considered as the representatives of all of implementations of transition management. There are also other case studies such as Dutch Waste Management in which a complete cycle of transition management was successfully enriched (Loorbach, 2007b).

Second, there are the limitations associated with modeling approaches. As mentioned earlier, the main point of using modeling techniques is to simplify the complexity of a system. This requires concrete assumptions in capturing and representing agents' behaviors in the meta-model. For example, the agents' reaction towards the question of "willingness to transform", in Figure 9, is illustrated by YES or NO, to show the issue of free riding. However, it is very unlikely that agents respond restrictedly as YES or NO in the real world cases. In a sense, this is an oversimplification of a farmer's behavior, which might not represent the agents' interactions precisely. Nevertheless, this simplification does not change the fact that the problem of free riding, as discussed earlier, can happen disregarding the accuracy of agents' responses.

Third, in order to illustrate the complexity of a system closer to the real world examples, the more types of entities (agents, resources and environments) are needed before converting the meta-model to a computer simulation. In addition, more attributes and operations for each of the entities should be considered to enhance the accuracy of the modeling by representing more detail of the system.

Conclusions

The transition models are useful tools to represent the complexity of the adaptive systems, and they can be used as learning tools to convey information between agents with different backgrounds in stakeholder meetings, and to enhance agents' collaboration. Simply, graphical tools such as maps, graphs, simulations or games are more understandable and convincing than numbers and figures for agents to grasp the complexity of the society and the environment. Accordingly, this requires an analytical framework upon which the transitions models can be built up, and to represent the agents' behaviors based on different stimuli regarding the water management issues.

In capturing the agents' interaction in the context of transition management in Ebro River Basin case, the social and environmental pillars of sustainability are currently the center of attention. Consequently, the law (institutional) and economic aspects of sustainability are not taken into account sufficiently when the agents' communications are investigated. This is one of the main challenges of implementing transition management, particularly when it comes to capturing the agents' interactions in the transition models at individual level. Thus, there is a need to equip the transition management cycle with more of analyses and instruments concerning the economic and institutional aspects.

The conceptual model (meta-model) developed illustrated how different aspects of sustainability concerning agents' behaviors can be captured to address the unsustainable situations in the Ebro River Basin. Taking the limitations of the conceptual model into account, the meta-model acknowledges the importance of interdisciplinary approaches (i.e. agent based modeling techniques) to co-produce knowledge. However, the effectiveness of meta-model (as the base for computer modeling, simulation, etc.) heavily depends on the availability of data regarding the agents and their attributes. In other words, validating the outcomes of a model relies on the inputs being fed from agents through interviews, surveys, questionnaires and other methods of data collecting.

In order to bring the aspects of sustainability together, the agents' interactions are illustrated in the meta-model according to "rational" and "irrational" choice paradigms. This includes the law and economic pillars of sustainability in addition to social and environmental aspects, respectively via Nash Equilibrium's theory and value-bases rationality. Along with the concepts of sustainability in managing transition, there is a need for considering both approaches of weak and strong sustainability in transferring from an unsustainable situation to a sustainable level. In this case study, the application of weak sustainability can be a take-off point for transition, and it can be developed towards strong sustainability approaches in the next iterations of transition management. This not only can achieve weak sustainability in short-term and strong sustainability in long-term, but also bridge the theories behind transition management to the real world implementation phase.

Recommendations for Further Research

The investigation regarding agents' interactions needs further research with respect to the role of institutions at regime level. As mentioned in the discussion section of the paper, the agents' interactions at micro level can form new regime practices, which consequently influence the agents' behaviors (*See* Figure 4). However, it is crucial to study how these regime practices evolve. The importance of studying the formation of institutions at regime level is concerned with the drivers and the barriers that they create for social change (Foxon, 2002). While these drivers can lead the direction of transition to a stabilized-sustainable situation, the barriers can drive it to the "lock-in" or "backlash" situation (*See* Figure 3). Respectively, there are the possibilities of a "non-ideal" or "reverse" transition after take-off point (Rotmans, 2005). Hence, it is important to capture the process of formation of regime practices with regards to their impact on micro and macro levels. In doing so, the focus will be on the institutional pillar of sustainability and on research regarding the interactions between institutions, organizations and networks.

References

ALBIAC, J., UCHE, J., VALERO, A., SERRA, L., MEYER, A., TAPIA, J. (2003) The economic unsustainability of the Spanish national hydrological plan. *International Journal of Water Resources Development* 19**,** 437-458.

ALCAZAR, J., PALAU, A., VEGA-GARCI'A, C. (2008) A neural net model for environmental flow estimation at the Ebro River Basin, Spain. *Journal of Hydrology,* 349**,** 44-55.

ANNAN, K. (2001) Secretary-General Outlines Vision for Building Secure Future in Report. *World Summit on Sustainable Development.* [Accessed 25th May 2008]. Available from: http://www.un.org/News/Press/docs/2001/sg2074.doc.htm

AXELROD, R. (1997) *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*, Princeton University Press.

BANDURA, A. (2003) On the Psychosocial Impact and Mechanisms of Spiritual Modeling *International Journal for the Psychology of Religion,* 13**,** 167 - 173

BELLIFEMINE, F. L., CAIRE, G., GREENWOOD, D. (2007) *Developing Multi-Agent Systems with JADE*, John Wiley & Sons, Ltd.

BERBEL, J., GOMEZ-LIMON, J.A. (2000) The impact of water-pricing policy in Spain: an analysis of three irrigated areas. *Agricultural Water Management,* 43**,** 219-238.

BOUSQUET, F., LE PAGE, C. (2004) Multi-agent simulations and ecosystem management: a review. *Ecological Modelling,* 176**,** 313-332.

BRUGGE, R. V. D., HAAN, J. DE. (2005) Complexity and Transition Theory. *Lof der Verwarring.* Rotterdam, Dutch Research Institute for Transitions, Erasmus University Rotterdam,.

BRUGGE, R. V. D., RAAK, R.V. (2007) Facing the Adaptive Management Challenge: Insights from Transition Management. *Ecology and Society,* 12.

BRYMAN, A. (2004) *Social Research Methods*, Oxford University Press.

CALLINICOS, A. (1999) *Social Theory*, Polity Press.

CAMPBELL, L. M. (2005) Overcoming Obstacles to Interdisciplinary Research. *Conservation Biology,* 19**,** 574-577.

CERVENKA, R., TRENCANSKY, I. (2007) *The Agent Modeling Language - AML: A Comprehensive Approach to Modeling Multi-Agent Systems*, Birkhäuser Basel.

COHEN, M. D. (2008) Economics - Learning with regret. *SCIENCE,* 319**,** 1052-1053

DARMOFAL, D. L., SODERHOLM, D.H., BRODEUR, D.R. (2006) Using concept maps and concept questions to enhance conceptual understanding. *Frontiers in Education, 2002. FIE 2002. 32nd Annual,* 1**,** T3A-1-T3A-6.

DAY, J. W., MALTBY, E., IBANEZ, C. (2006) River basin management and delta sustainability: A commentary on the Ebro Delta and the Spanish National Hydrological Plan. *Ecological Engineering,* 26**,** 85-99.

DOWNWARD, S. R., TAYLOR, R. (2007) An assessment of Spain's Programa AGUA and its implications for sustainable water management in the province of Almeria, southeast Spain. *Journal of Environmental Management,* 82**,** 277-289.

ENEA (2006) European Network of Environmental Authorities: Making the Structural and Cohesion Funds Water Positive. Official Publications of the European Communities. [Accessed 25th May 2008]. Available from: http://ec.europa.eu/environment/integration/pdf/final_handbook.pdf

EU WATER SAVING POTENTIAL REPORT. (2007) Part 1. Ecologic, Institute for International and European Environmental Policy. [Accessed 25th May 2008]. Available from: http://ec.europa.eu/environment/water/quantity/pdf/water_saving_1.pdf

FOXON, T. J. (2002) Technological and institutional 'lock-in' as a barrier to sustainable innovation. Imperial College Centre for Energy Policy and Technology (ICCEPT). [Accessed 25th May 2008]. Available from: http://www3.imperial.ac.uk/pls/portallive/docs/1/7294726.PDF

GEELS, F. W. (2002) Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy,* 31**,** 1257-1274.

GREIG, A., HULME, D., TURNER, M. (2007) *Challenging Global Inequality: Development Theory and Practice in the 21st Century* Palgrave Macmillan

HABERMAS, J. (2005) Equal Treatment of Cultures and the Limits of Postmodern Liberalism. *Journal of Political Philosophy,* 13**,** 1-28.

HARDIN, G. (1968) The Tragedy of the Commons. *Science* 162**,** 1243-1248.

HARRIS, J. M., WISE, T., GALLAGHER, K. (2001) *Survey of Sustainable Development – Social and Economic Dimensions*, Island Press.

HOEKSTRA, A. Y. (2000) Appreciation of water: four perspectives. *Water Policy,* 1**,** 605-622.

JOCHUM, M. A. O. (2007) Input to First Interim Report "Water scarcity and drought". *Water policy in the European Union; Communication on Water Scarcity and Droughts.*

KEMP, R., SCHOT J., HOOGMA, R. (1998) Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management,* 10**,** 175 - 198.

KEMP, R., LOORBACH, D. (2003) Governance for Sustainability Through Transition Management. *EAEPE 2003 Conference.* Maastricht, the Netherlands, MERIT and ICIS.

KU, G. (2008) Learning to de-escalate: The effects of regret in escalation of commitment. *Organizational Behavior and Human Decision Processes,* 105**,** 221-232.

LOORBACH, D., ROTMANS, J. (2006) Managing transitions for sustainable development. *Understanding Industrial Transformation: Views from Different Disciplines* Springer Netherlands.

LOORBACH, D. A. (2007a) Editorial: Governance for sustainability *Sustainability : Science, Practice and Policy,* 3**,** 1-4.

LOORBACH, D. A. (2007b) Transition Management: new mode of governance for sustainable development Erasmus University Rotterdam.

LOZANO, R. (2007) Collaboration as a pathway for sustainability. *Sustainable Development,* 15**,** 370-381.

MACY, M. W., WILLER R. (2002) From Factors to Actors: Computational Sociology and Agent-Based Modeling. *Annual Review of Sociology,* 28**,** 143-166.

MATISSE (2008) Methods and Tools for Integrated Sustainability Assessment *MATISSE Ending Conference.* Nice. [Accessed 25th May 2008]. Available from: http://www.matisse-project.net/projectcomm/index.php?id=833

MORGAN, M. S., MORRISON, M. (1999) *Models as Mediators: Perspectives on Natural and Social Science*, Cambridge University Press.

OMG (2008) Catalog of OMG Modeling and Metadata Specifications. Object Management Group. [Accessed 25th May 2008]. Available from: http://www.omg.org/technology/documents/modeling_spec_catalog.htm

PAHL-WOSTL, C., TABARA, D., BOUWEN, R., CRAPS, M., DEWULF, A. , MOSTERT, E., RIDDER, D., TAILLIEU, T. (2007) The importance of social learning and culture for sustainable water management. *ECOLOGICAL ECONOMICS,* 64**,** 484– 495.

RALUY, R. G., SERRA, L., UCHE, J., VALERO, A. (2005) Life Cycle Assessment of Water Production Technologies - Part 2: Reverse Osmosis Desalination versus the Ebro River Water Transfer *International journal of life cycle assessment,* 10**,** 346-354.

RIST, S., CHIDAMBARANATHAN, M., ESCOBAR, C., WIESMANN, U., ZIMMERMANN, A. (2007) Moving from sustainable management to sustainable governance of natural resources: The role of social learning processes in rural India, Bolivia and Mali. *Journal of Rural Studies,* 23**,** 23-37.

ROTMANS, J., KEMP, R., VAN ASSELT, M. (2001) More evolution than revolution: transition management in public policy. *Foresight - The journal of future studies, strategic thinking and policy* 3**,** 15-31.

ROTMANS, J. (2005) Societal Innovation: between dream and reality lies complexity. Rotterdam, Erasmus Research Institute of Management.

SCHWEITZER, F. (2007) Browning Agents and Active Particles; Collective Dynamics in the Natural and Social Sciences Springer Berlin Heidelberg.

SEN, A. (2005) Why Exactly Is Commitment Important For Rationality? *Economics and Philosophy,* 21**,** 5-14.

TABARA, J. D., ROCA, E., MADRID, C., VALKERING, P., WALLMAN, P., WEAVER, P. M. (2007) The Integrated Sustainability Assessment of Water. Lessons from the Ebro river basin. *Deliverable D6.9, MATISSE, Final report.*

UNEP (2005) Publications Freshwater in Europe Major European Watersheds Ebro. [Accessed 25th May 2008]. Available from: http://www.grid.unep.ch/product/publication/freshwater_europe/ebro.php

VERWEIJ, M., DOUGLAS, M., ELLIS, R., ENGEL, C., HENDRIKS, F., LOHMANN, S.,NEY, S., RAYNER, S., THOMPSON, M. (2006) Clumsy Solutions for a Complex World: The Case of Climate Change. *Public Administration,* 84**,** 817-843.

VILLIERS, M. D. (2000) *Water: The Fate of Our Most Precious Resource*, Houghton Mifflin Books.

WATSON, N., WALKER, G., MEDD, W. (2007) Critical perspectives on integrated water management. *Geographical Journal,* 173**,** 297-299.

WEAVER, P. M., ROTMANS, J. (2006) Integrated Sustainability Assessment, Why? What? How?

WFD (2007) Introduction to the new EU Water Framework Directive. European Water Policy. [Accessed 25th May 2008]. Available from: http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm

WHITMARSH, L., SCHILPEROORD, M., BERGMAN, N., HAXELTINE, A., KOEHLER, J., ROTMANS, J., NYKVIST, B. (2008) Developing New Tools for Integrated Sustainability Assessment. *Deliverable D9.6, MATISSE, Final report.*

YIN, R. K. (2003) *Case Study Research: Design and Methods*, SAGE.

Appendix 1

As it has been explained in the paper, the transition management framework can be an essential tool to tackle sustainability issues such as the water management problems. Accordingly, one of the main objectives of this study is to examine how to improve the process of transition management by bridging transition theories to implementation phase. Figure 11 illustrates the relationship between chapters with regards to transition management.

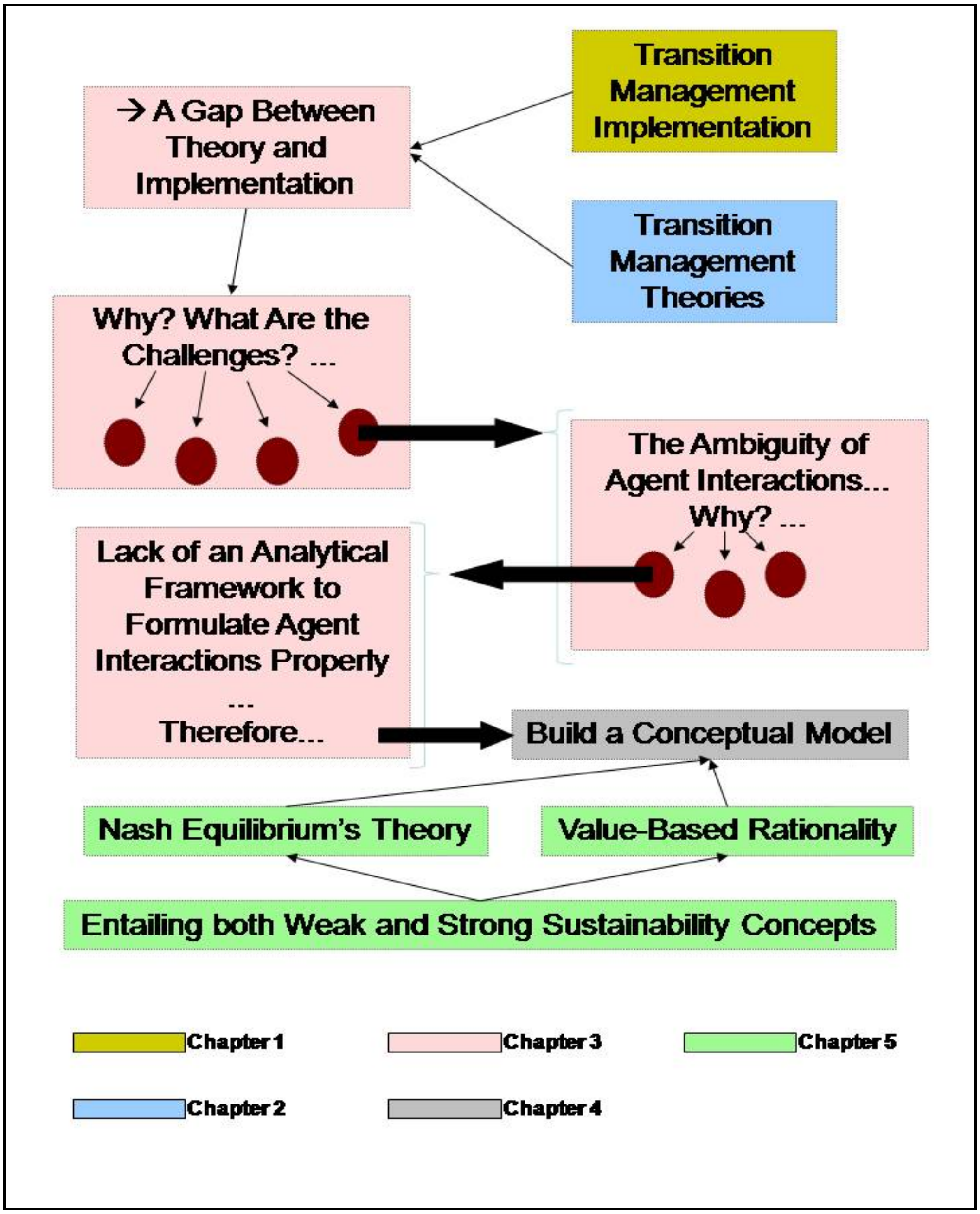


Figure 11 The outline of the paper

Appendix 2

Table 2 The guideline to Interviews, Plenary Sessions and Panel Discussions in MATISSE Final Conference, March 2008, Nice, France:

	Name and Surname	Position in the MATISSE Project *	Where to find the recordings on the CD?
Person 1	Lorraine Whitmarsh	Member of WP7 and WP9 Research Group	Recording #1&2
Person 2	Marina Fischer-Kowalski	Member of WP8 Research Group	Recording #3&7
Person 3	Peter De Smedt	EU Responsible Scientific Officer	Recording #8
Person 4	Jan Rotmans	Project Coordinator	Recording #10
Person 5	Anonymous	Anonymous	Off-the-record
	The Title of Panel /Plenary Discussion *		**Where to find the recordings on the CD?**
Panel Discussion	How (post)-normal was MATISSE? Panel: Peter De Smedt, Lennart Olsson, Alex Haxeltine		Recording #8
Plenary Discussion 1	What models and scenarios should be invested in the future?		Recording #3
Plenary Discussion 2	Discussion regarding the water case study and Interview with David Tabara, Pieter Valkering, , Patrik Wallman by Alex Haxeltine		Recording #5
Plenary Discussion 3	WP2: results, dissemination and future discussion by Andrew Jordan		Recording #10
Plenary Discussion 4	The strengths and pitfalls of ISA and how to conquer the world by Jan Rotmans		Recording #10

* *See MATISSE Project at:* **http://www.matisse-project.net/projectcomm/**

WP2: An analysis of ISA-related Tools in their Policy Context

WP7: Environmental Technological Change (Hydrogen Case Study)

WP8: Interlinking and Improving Existing Tools for Integrated Sustainability Assessment

WP9: Developing New Tools for Integrated Sustainability Assessment

Appendix 3

The Prisoners' Dilemma Matrix; The outcomes of prisoners' decision [1]

	X Betrays	X Denies
Y Betrays	**Both Serve 5 years**	**X Serves 10 years, Y Goes Free**
Y Denies	**Y Serves 10 years, X Goes Free**	**Both Serves 1 year**

[1] Cited from: LOZANO, R. (2007) Collaboration as a pathway for sustainability. *Sustainable Development,* 15**,** 370-381.