AQUASTRESS

Mitigation of Water Stress through new Approaches to Integrating Management, Technical, Economic and Institutional Instruments

Integrated Project

D5.3-3

REPORT: DESIGN AND APPLICATION OF VIRTUAL AND REAL TESTS – GENERAL FRAMEWORK, COMPARISON AND INSIGHTS GAINED

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Abstract

Deliverable 5.3-3

This deliverable discusses the notion of "option testing". It first presents the general framework used in the AquaStress project to test and evaluate water stress mitigation options. It reviews, analyses and compares three experiences in which virtual and real tests have been carried out: an integrated technology mitigation option (Tadla case study, Morocco), an economic option (Przemsza case study, Poland) and a procedural option (Vecht case study, The Netherlands). It does not present the results of these tests (these will be described in case studies' final reports) but focuses on the way in which the water stress mitigation options have been tested. For each case, the case context, the purpose of the mitigation option, and the objective of the test are outlined, followed by the test characteristics (level of field implementation, level of user involvement, risk of test damage, external factor consideration, and the risk of "false negatives" and "false positives") and the evaluation criteria used. The review makes clear that testing is very context-specific. It also suggests that the learning by (potential) option users involved in testing is an important co-determinant of the eventual outcome. The framework proposed in this document can support test designers in their reflection.

1. Introduction

This deliverable discusses the notion of “option testing”. It first presents the general framework used in the AquaStress project to test and evaluate water stress mitigation options. It reviews, analyses and compares three experiences in which virtual and real tests have been carried out. It does not present the results of the tests, which will be described in case studies’ final reports, but focuses exclusively on how the water stress mitigation options have been tested.

2. What is the overall aim of the AquaStress project?

The AquaStress project aims to define, test and evaluate mitigation options for water stress, in various sites which are representative of water stress problems across Europe and North Africa. According to the project’s description of work, “the mitigation of water stress at regional scale depends not just on technological innovations, but also on the development of new integrated water management tools and decision-making practices. The AquaStress project delivers enhanced interdisciplinary methodologies enabling actors at different levels of involvement and at different stages of the planning process to mitigate water stress problems”.

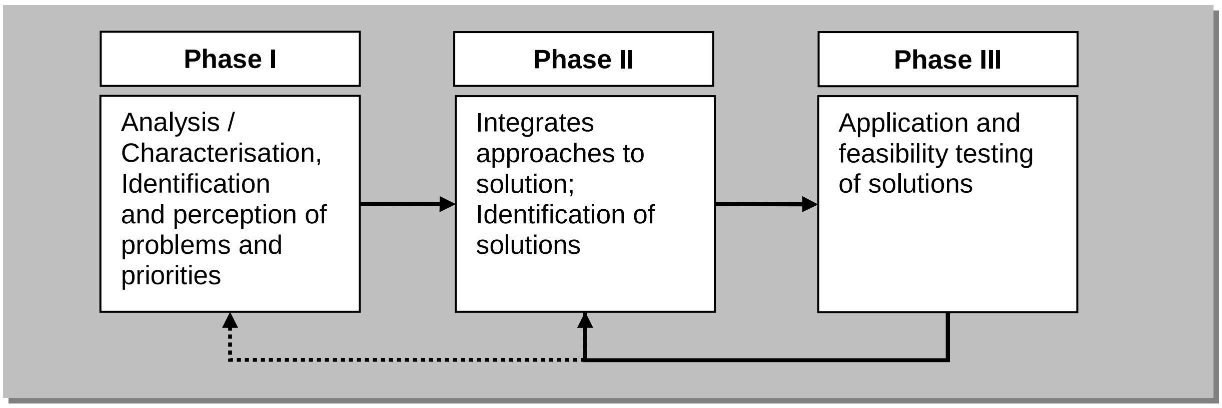


Figure 1: Phases in AquaStress

As shown in Figure 1, the overall AquaStress problem solving process follows three phases. The first phase aims to characterise problems. In the second phase, different mitigation options are identified. The third phase implies the test of these options, that is to say their controlled application. Basically, it is a way to confront these options with the system in which they will be applied in order to assess their relevance, and possibly to adapt and modify them to make them more appropriate.

3. Which options are tested in AquaStress?

Three main types of options are tested in this project:

Technology

Most of the water stress mitigation options considered in the AquaStress project are technical options. Although these options are physical artefacts (a water conserving device, for example), testing an innovative technology that is to be introduced in a complex system should not only focus on its physical consequences. Specific attention should also be paid to which inputs are needed to apply it, how the technology will be used, and which side effects it may produce in time and space and at different system levels.

Economic mechanisms

Economic mechanisms or economic instruments have the potential to alter water consumption patterns as to promote efficiency in water use. The economic mechanisms that may be applied include consumption quotas, water pricing, consumption taxes, pollution taxes, and permit systems. These mechanisms are developed and tested using economic models. These models are usually based on the assumption of rationality on behalf of water users and complete information on all parameters of the problem by all actors involved. When these conditions are not met (which is often the case), the models will not adequately predict actor behaviour. In such situations, practical field tests can help to assess the impact of the economic mechanism on individual and aggregate welfare as well as its effectiveness in coping with water stress. Field testing economic mechanisms is difficult because their implementation requires institutional changes that entail legislative changes.

Procedural methods

The third type of mitigation options studied in the AquaStress project is the introduction of an innovative procedure to improve decision making for planning or management. In complex socio-economic environments, there is no single “best” management mode, but rather a range of management modes that respond more or less effectively to different vested interests. Based on this observation, new procedures can be developed in order to reconcile divergent interests, find agreement between stakeholders, and improve the quality of decision-making. Procedural options are even more difficult to test than economic mechanisms because they involve institutional and political change, while pertinent theories are partial and value-laden.

The options developed and tested in the AquaStress project should be integrated. An integrated option is understood here as an option which has been developed taking into consideration all the relevant elements of the system that will impact or will be impacted by its application (Figure 2).

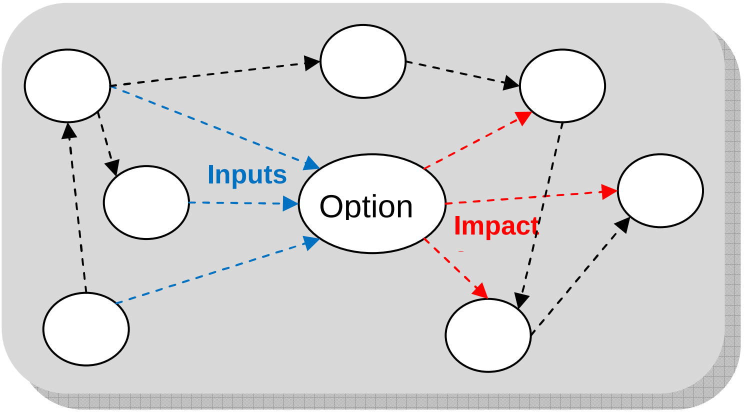


Figure 2: Links between a water stress mitigation option and different elements of a system

4. Why are options tested?

The mitigation options to be tested in the AquaStress project are proposed by experts. Testing the options gives the experts and other associated stakeholders the possibility to state at the end of the test why, and to what degree, the option is appropriate for a specific context, effective, efficient, and so on. The rationale behind option testing is that it will reduce the risk of implementing a mitigation option that is not appropriate for a specific context. A test should therefore provide relevant information about, for example, the technical feasibility, the economic viability, the social acceptability, as well as the environmental sustainability, of mitigation options. Comprehensive testing is needed because a mitigation option that is technically feasible may be socially unacceptable. Such testing requires that the mitigation option is tried out or otherwise assessed by its potential users and the people who will be impacted by it, in order to determine its various consequences. If these consequences do not meet certain explicit evaluation criteria, the option should be rejected or modified.

4.1 Testing and evaluation

In the AquaStress project, tests are developed and performed to assess the appropriateness of water mitigation options of all three types: technical, economic and procedural. The symbolic equation in Figure 3 provides a generic model of option assessment as an abstract function E that returns the evaluation vector that comprises different evaluation criteria, given the result vector of the test T that is carried out using a specific testing protocol, of a mitigation option O in a specific context C. The result vector comprises indicators for the "impacts" of putting an option O in place in context C as described in Jeffery and Muro (2005).

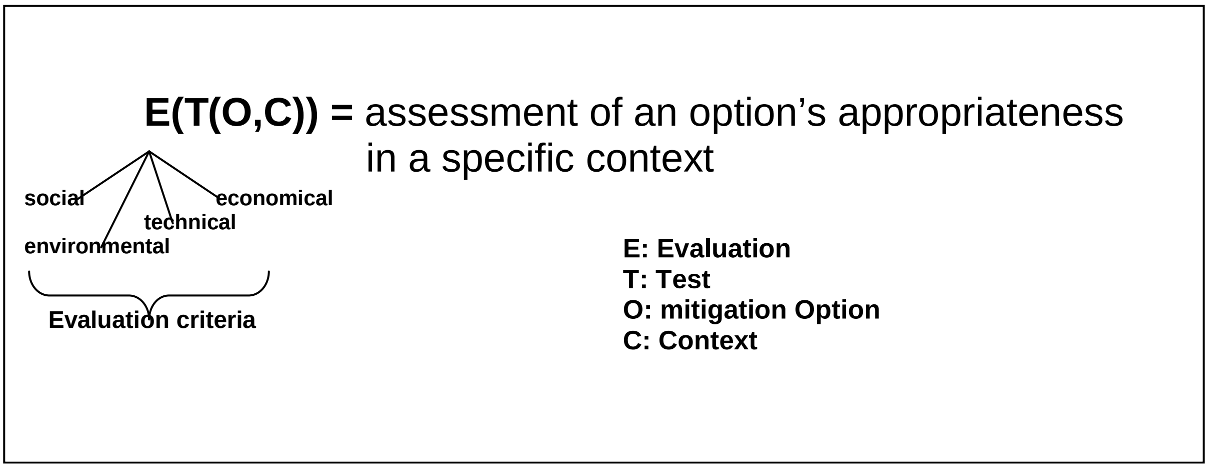


Figure 3: Abstract definition of option assessment as an abstract function

4.2. Evaluation criteria

The three categories of criteria—environmental, economic, and social—outlined in Table 8 of Jeffery and Muro (2005) are considered to be incomplete, as they disregard "technical" or "man-made" physical factors. When taking the systems approach to sustainability and assessment outlined in Foley et al. (2003) and Daniell et al. (2007), these factors provide important criteria for the assessment of water stress mitigation options. The introduction of a new technology such as, for example, drip irrigation is likely to have impacts on existing infrastructure in the region, causing modifications to or changes in the maintenance of dams and ducts and individual water fittings. Such an impact can not be readily measured directly using the indicators in Jeffery and Muro's "environmental" category, hence the proposal to add a fourth category of criteria: "technical". The four categories cover the following sub-categories of criteria:

- *Technical:* Feasibility (i.e. of option design, installation and maintenance), changes to existing infrastructure and technologies-in-use
- *Environmental:* Ecosystem health and biodiversity, carbon and nutrient balances, waste production
- *Economic:* Viability, efficiency, changes in micro and macro economic factors
- *Social:* Health, well-being, equity, governance, participation, acceptability

When evaluating an option, several criteria from each of these sub-categories should be chosen to ensure comprehensive testing.

5. How are options tested?

Given a comprehensive set of evaluation criteria, a test protocol must be designed that will produce data on the impacts of a water stress mitigation option when it is implemented in a specific context. When designing such a test protocol, the following design parameters must be chosen.

Level of field implementation

A mitigation option can be tested either virtually or in a real-world situation. A "virtual" test means that the mitigation option is placed in a controlled situation that reproduces the characteristics, components and dynamics of the real system in which the option could be implemented. Because these systems are complex, the controlled situation should consider social, environmental as well as economic, factors. Virtual tests usually involve the use models, but can also involve people, in particular for estimating the social consequences of an option.

A "real-world" test means implementing the option in the real system, but on a small scale (in space or time) only (or it would not be a test). A "real-world" test may cause real damage, as the impacts of the option are real, not simulated. On the other had, there will be less chances that unforeseen but important system impacts are overlooked, whereas such impacts may be ignored in "virtual" tests because simulation models are always incomplete representations of reality.

In the same water problem solving process, an option can be tested both virtually and in the real world. For a more in-depth elaboration of the notions of "virtual" and of "real-world" test, see MacKenzie et al. (1999), Pinch, (1993) or Bijker (1995).

Level of user involvement

The involvement of users or stakeholders in a testing process can be done at different phases and with different intensity. Firstly, they may not be involved at all, or just informed about the test. Secondly, they could be consulted to hear their points of view. For example, they could provide information on constraints, needs and possible interests they have relative to the option during different participatory activities. However, in this case there is no guarantee that this information received will change the test. Finally, they can be actively involved in the testing process, working collaboratively with the implementers. In this case, the users or stakeholders take part in the experiment with the option, virtually or in the real-world, provide and exchange knowledge and take part in the decision-making processes throughout the test.

For more elaborate descriptions on types of participation with different stakeholders and throughout the different stages of the option testing process, see Arnstein (1969), Pateman (1970), Fischer (1990), Rocha (1997), Mostert (2003), Thomas (2004), Daniell et al. (2006) and Mazri (2007).

External factors consideration

The output of the test of an option into a specific context may result from the test itself, but can also result from non-controlled exogenous factors. Indeed, when designing and implementing a test, specific attention should be paid to any exogenous factors which might influence the results of the test.

In complex systems, the linkages between external factors and the observed results are difficult to establish. If such knowledge is lacking for the test site, a reference system or model may be used as standard for comparison. If no such standard is available, other methodological designs that systematically take into account the influence of external factors (e.g., experimental or quasi-experimental designs, see Mohr (1995) and Borland et al. (2004) for more information) may be used. However, such designs are complicated and expensive to implement, and often even practically unfeasible because it is impossible to replicate the test under different circumstances (Hohler et al., 2002).

Risk of test damage

Testing a mitigation option may jeopardise the current "real-world" system under water stress. For example, a "real-world" test of injecting treated waste water might cause a local deterioration of the quality of the groundwater. Likewise, a "virtual" test of a water rights trading system that involves stakeholders might antagonise certain stakeholders and hamper future negotiations. Therefore, when designing a test, the likelihood of producing negative consequences on the system as a result of the test should be estimated.

The degree of risk that a test poses to the system under consideration can be more or less rigorously analysed against a variety of criteria using formalised methods of "risk analysis". The following publications can be referred to for more information: ISO/IEC (2002), Standards Australia (2004), Renn (2006), Mazri (2007).

Risk of "false positives" and 'false negatives"

Last but not least, test designers should consider the consequences in case the test leads to a rejection of the mitigation option. The idealised separation in Figure 3 between impact assessment T according to an objective testing protocol and evaluation E using ex-ante defined criteria is only rarely achieved in practice, so careful thought must be given to the way test results will be aggregated and interpreted. Test designers must gauge the probability that the testing protocol will lead to the rejection of a good mitigation option or the acceptance of a bad mitigation option. Likewise, test designers should anticipate whether those who eventually decide whether or not an option will be implemented will deliberate as judges or as doctors. In the first situation, the test design should help to minimise the likelihood of rejecting a good option, in the second situation to minimise the likelihood of accepting a bad option. Mayo (1985) and Rindskopf and Saxe (1998) discuss the concept of "false positives" and 'false negatives" and related methodological issues in more detail, albeit in different application contexts.

6. Three experiences of mitigation option tests

Three examples of how mitigation options have been tested in the AquaStress project are described in this subsection. These examples focus on the modality of test and on the evaluation criteria that have been used to assess the adequacy of the proposed mitigation options in, respectively, the Tadla irrigation scheme in Morocco, the Przemsza river catchment in Poland, and the Vecht en Velt area in the Netherlands. The idea is not to discuss the results of the test (that is to say the adequacy of such mitigation option in such context), but rather to discuss and compare how the research teams have developed and implemented their tests, which questions they aimed to answer and to what degree their test fulfil the normative description of why an option should be tested. Each experience is described following the same framework: a brief context description, the description of the option, the modality of test and the evaluation criteria used in the test.

6.1. The Tadla case study: Testing an integrated technology mitigation option

6.1.1. Context

Moroccan agriculture is undergoing major political, socio-economic and environmental transitions. The different structural adjustment policies that took place in Morocco since the 1980s changed the political context for agriculture. This is particularly true for large-scale irrigation schemes, such as the 109,000 ha Tadla irrigation system, located 200 km south-east of Casablanca. In the past, these schemes were essentially state administered. The state provided water, determined the cropping patterns, provided services such as land preparation, and transformed and marketed most industrial crops (sugar, cereals, cotton). The recent state disengagement in agriculture entailed the liberalisation of cropping patterns (1994) as well as the privatisation of food-processing industries (2005). Industrial crops such as sugar beet are declining, while farmers are looking for alternatives (dairy production, horticulture…). In addition, there are environmental problems with the drop in groundwater tables, due to droughts in the early 1980s and late 1990s, linked with an increased exploitation of groundwater through more than 10,000 private tube wells.

In this context, small and medium farmers in the Tadla scheme - 80 % of farmers hold less than 5 hectares of land, accounting for 33 % of the total area - will face in the coming years a global water scarcity, a decrease in services from the irrigation administration, and a strong competition in the marketing of their production. Modernising the actual gravity irrigation systems should increase water use efficiency, improve crop yields through better irrigation and fertilisation, and reduce labour costs. However, existing modernisation programs, subsidising farmers to install localised irrigation systems replacing existing gravity irrigation, mainly reach the larger farmers. Small and medium farmers face several constraints, related to financial difficulties to invest (typically only 30-40 % of the investment cost is subsidised by the state), technical difficulties in installing and managing the system, and uncertainty of the land tenure status with numerous land heritage problems (Kobry and Eliamani, 2004). The underlying hypothesis of this case study is that collective action in the modernisation of irrigation systems can help smallholder farmers in overcoming these constraints.

6.1.2. Mitigation option

The mitigation option proposed in this case study can be defined as the introduction of modern irrigation techniques (drip irrigation) through a joint irrigation project involving a group of smallholder farmers. A typical joint drip irrigation project is a combination of joint hydraulic infrastructures (storage basin, head station unit…) and individual field equipment (water meter, distribution tubing…). However such projects require not only a change in technology; they also require a profound organisational change. Indeed, conceiving and managing joint infrastructures require the group to find agreements. Such agreement needs to be built on a solid and shared knowledge of the actual situation and of the technical possibilities. In addition, individual expectations should be set against collective ones. This requires a form of social learning process among the group. If the conditions needed to realise this learning process are not met, the modernisation of irrigation schemes can lead to disappointing agronomic performances (Vidal et al., 2001).

6.1.3. Modality of test

Level of field implementation

Our testing methodology was first designed for farmers interested in the idea of developing a joint irrigation project. The first tool used to test the adequacy of this option in the Moroccan context was a role-playing game in which farmers would virtually experiment the different phases of the implementation of such project (Dionnet et al., 2006). This test was virtual in the sense that farmers did not experiment on their own situation. The semi-contextual gaming environment represented a typical irrigation plot of the Tadla irrigation scheme. This first test allowed the team to first assess the social acceptability of the idea of developing joint irrigation projects and to identify groups ready to commit themselves in such projects.

Then, for those groups committed in the modernisation of their irrigation system, an accompanying process was designed to support them in conceiving and implementing their project on the field. The implementation of a joint project by a pilot group of farmers is understood as a real test. Indeed, such group will give the research team the possibility to assess on the fly and on the field which consequences these projects have in the Tadla irrigations scheme.

Level of users' involvement

The option design was a collaborative process, with different local stakeholders such as farmers, the ORMVAT[1], the River Basin Agency, local experts in drip irrigation systems and Morocco, French and German researchers (AQS research members). Once it was decided to work on joint irrigation project, different farmer groups were asked to join the process and to participate in the virtual test. In this phase, the process was largely driven by the research team, who gained a lot of knowledge through frequent interactions with the different stakeholders and an intensive evaluation process toward the testing modality as well as the option relevance. Among the different groups, some showed an interest to pursue the testing process. They committed themselves to implement a joint irrigation project, which constitutes for the research team, a real test of the option. At this stage, the farmers experienced a more interactive position in the testing process. The research team provided supports to help farmers in the design and the implementation of their project. During this phase, farmers explored different scenarios consisting of crop systems and technical options and assessed them with their own criteria (economic, organisational, and others…). They also took initiatives to make changes in the approach itself, by providing inputs on the design of the tool used in this phase (essentially a policy simulation exercise), interacting

[1]Office in charge of the agricultural development of the Tadla irrigation scheme

directly with other farmers' groups involved in the process and by contacting the facilitating team regularly.

External factors consideration

Two external factors that were not taken into consideration during the virtual test had a positive influence on farmers' choice to modernise their irrigation system. The first was the level of State subsidies, which changed from 40 to 60%. The second was the restriction of water quota imposed by the ORMVAT due to an important drought. Because the farmers could then irrigate no more than 20% of their fields, they became more interested to change to drip irrigation systems which allow to considerably augment the irrigated area with the same amount of water.

The decision of one group to actually implement a joint irrigation project allowed a real test. This decision was taken after the drought occurred and the subsidies had been raised. Until now, no more additional factors of influence have been identified. This does not say that no other critical success factors were involved, but their existence will only become apparent when joint irrigation project are implemented with other groups. Failures in such additional cases may reveal additional necessary conditions for success, such as social relations, soil properties, etc.

Risk of test damage

No major environmental risk is linked to the usage of drip irrigation. This technology has been used for more than 10 years in the Tadla irrigation scheme with no actual negative effects. However, soil salinisation (recognised as the principal side effect of drip irrigation system) should be carefully monitored in the next years.

Farmers who change their irrigation system face economic risks in case of unsuccessful production or commercialisation Because the groups committed in the process are pilots groups, the support provided by the team tried to gather all the socio-economic conditions required for a successful implementation, and thus lower the risk taken by the farmers.

Risk of "false positives" and 'false negatives"

After the virtual test, our impression was that farmers were quite positive regarding the implementation of a joint irrigation project. However, only one group out of 5 decided to really commit to such a project. On the other hand, some farmers decided to implement individual projects. Thus, the relevance of this virtual test, for us, pertained much more to the appropriateness of the technology than to knowing whether the group was really interested to implement a joint project. On the other hand, for farmers, it gave them enough information to decide for themselves to choose this option or not.

6.1.3. Criteria of option impacts assessment

A joint drip irrigation project addresses two issues: (1) the introduction of a new irrigation system (in the case at hand drip irrigation system) and (2) doing this collectively. The test and the evaluation of this mitigation option were especially designed to address the second issue. In particular it aimed to answer the following questions:

- Which technical constraints and/or benefits are linked to the collective dimension of the infrastructures?
    - Water use efficiency
    - Flexibility of irrigation
    - Complexity of the drip irrigation system
- Which social constraints and/or benefits will follow from the collective management of these projects?
    - Adoption of a new irrigation technology
    - Equity of subsidies access
    - Well-being of the farmers
    - Expertise
- Which economic benefits can be reached by the farmers who join a joint irrigation project?
    - Initial infrastructure investment
    - Maintenance costs
    - Farmer incomes
    - Adaptability regarding market fluctuation
- Which environmental consequences these projects may have if they were spread in the Tadla irrigation scheme?
    - Soil salinity
    - Ground Water pollution
    - Water resource over-exploitation

In the case at hand, only the three first questions were addressed, at least partially by the tests. Because the real test is ongoing, and because the consequences of the development of joint irrigation project in the Tadla irrigation scheme has to be considered over several years, the test of this option will still be partial at the end of the AquaStress project.

6.2. The Przemsza case study: Testing an economic option

6.2.1. Context

The Przemsza river catchment is situated in a "central plains" ecoregion (WFD ecoregion type 14) in Upper Silesia (Wyżyna Śląska). Coal mining and heavy industry and the urbanisation linked to this economic development have strongly affected the region. Changes to the landscape caused by mining and creation of spoil heaps have made the area very susceptible to flooding. The land changes and floods have led to the formation of unique ecological habitats in the flooded areas, very rich in biodiversity. Moreover, the wetland is also of high recreational value to local residents.

The current regional flood control policies do not prohibit the mining industry from discharging mine drainage water into the river, or from creating spoil heaps. This will negatively affect the ecological habitats, and their biodiversity is therefore expected to decline.

The Przemsza case study focuses in particular on the issue of managing the trade-off between flood control and biodiversity conservation in flood induced wetlands. This is a complex problem with a large number of actors involved. The most important tension occurs between on the one hand the mining companies that are largely responsible for the flooding problems of the wider area due to landscape alteration and riverbank erosion. On the other hand there are the local residents that face flood risks but on the same time enjoy non-use values from the flood induced biodiversity

6.2.2. Mitigation option

One possible mitigation option that could be applicable in the Przemsza case study is the combination of imposing earmarked taxes on the mining industry to fund the compensation of flood damages, while at the same time levying a tax on local population to fund measures for the conservation of the species predominant in the wetlands. This way, the principle of “polluter pays” and “consumer pays” are both applied.

6.2.3. Modality of test

Level of field implementation

The test presented for the Przemsza case study can be classified as “virtual test” as it involves a projection of the consequences of a scheme of tax and levies, rather than observing the actual consequences of putting such a scheme in place via legislative changes. At present, this virtual test has been implemented only partially, focussing on the “willingness to pay” of households. Testing the consequences of applying the “polluter pays” principle for the industrial stakeholders can be done by presenting the tax scheme and discussing its consequences in an open dialogue. For the industrial stakeholders this means that they foresee in what ways they will probably change their operations in response to the new tax scheme. This information is then used to estimate the consequences for employment, productivity, and the environment. Alternatively, economic experts could estimate the possible effects of a tax for a selected representative sample and extrapolate from this information.

The “willingness to pay” test comprised a choice experiment was conducted to assess how stakeholders valued alternative “wetland management plans”. We refer to Birol et al. (2006a,b) and Birol & Cox (2007) for more details on similar applications of choice experiments. To obtain valid information, the attributes of the plans should be considered important by the stakeholders, and the levels for these attributes should be achievable with and without a proposed policy change (Bateman et al., 2003).

After discussions with scientists from different Polish universities and focus group sessions organised with the local population, four wetland management plan attributes were chosen:

1. *Surface and underground flooding risks*, defined as the predicted risk of flooding in the area in the next 10 years. At present, the risk of flooding is high, but it can be reduced by improving both underground and surface barriers.

2. *Biodiversity found in the wetland*, defined as the number of different species of plants and animals, their population levels, number of different habitats and their size in the wetland ecosystem in the next ten years. Although the biodiversity level is presently high, it is expected to decrease due to continuing mining activities. Prohibiting such activities and taking measures such as afforestation will lead to higher biodiversity levels.

3. *Access to the river bank for recreational purposes*, such as walking, cycling, and fishing. At present, access to the river is difficult because of concrete vertical walls constructed as an (unsuccessful) flood risk reduction measure. Demolishing these walls and re-canalising the river to its natural state would make it easily accessible for recreational purposes.

4. *Change in local household tax* (–10%, –5%, 0%, +5% or +10%). Taking the present tax level as base figure, the percentage change provided a suitable means to express how the wetland management plan would be financed.

Using experimental design techniques (Louviere et al., 2000) and an orthogonalisation procedure, a questionnaire was developed asking respondents to make 32 pairwise comparisons of wetland management plans. The choice experiment survey was implemented in March and April 2007 in the city of Sosnowiec, using in-house face-to-face interviews. Of the carefully selected sample of 200 households, 192 households agreed to be interviewed, providing data not only on their wetland management plan preferences, but also the households' social, demographic and economic characteristics, whether they used the river for recreation, and whether they had been affected by floods in the past ten years.

Level of users' involvement

Considering the households as the 'users' of a wetland management plan, these users have been involved first during the initial focus group meetings, then in the choice experiment survey.

Risk of test damage

Although the test is virtual, the direct interaction it involves with stakeholders may pose a socio-political risk. The discussion with stakeholders that is part of the test might evoke a negative reaction from the stakeholders as they will realise the need for additional taxation.

Risk of "false positives" and 'false negatives"

For the choice experiment, this risk is low, provided that an adequate sample is selected. Limited resources for testing may lead to a sample that is too small to be representative for the entire population (see also the remarks considering external factors).

Testing a tax scheme in an open discussion with industrial stakeholders may impair the validity of this test. In an open discussion, the participants (industry representatives) not only have full information about the proposed policies and their potential effects, but they can also observe the reaction of competing industries to this information. Knowing this, participants may behave strategically in order to influence the final outcome. For example, industrial stakeholders may harshly object to the levy of an additional believing that this attitude will eventually lead to a lower tax level. To mitigate the risk of strategic behaviour and still involve stakeholders, the test could also be performed using personal interviews while keeping private the information about the reaction of competing firms.

External factors consideration

For any analysis containing economic aspects it is important to avoid biases that may affect the conclusions. This would also be the case for a field test of economic options. Many factors could produce biases. It is desirable that the industrial stakeholders involved in the test constitute a sample that is representative of the financial health of the entire population of industrial enterprises. Focusing on the sub-sample of only the financially sound firms would very likely lead to overestimating the willingness of the industrial stakeholders to participate in a taxing scheme. The same principle holds for residential and other stakeholders. Furthermore, the timing of the field test is very important. The closer to a flooding episode this takes place the less reliable the results may be because a flooding episode will result in a positive bias towards implementing measures that will alleviate the problem.

6.2.4. Criteria of option impacts assessment

The impact of the application of the economic option can be assessed using the following indicators:

1. How well do stakeholders react to the implementation of the option?
2. What is the behavioural path they state they will follow?
3. How robust is their stated future behaviour to small perturbations to the economic option?
4. Are industries still viable after internalising through the tax rate the negative externality they create?
5. Is the tax rate stakeholders propose to be imposed on them sufficient to internalise the cost?

The test results to date imply that the local population has a significant willingness to pay for biodiversity conservation and access to the river for recreational purposes. The data collected with the choice experiment also allowed putting a cost figure on flood damage and loss of biodiversity. It is expected that the mining industry can pay these estimated cost as taxes.

6.3. The Velt en Vecht case study: Testing a procedural option

6.3.1. Context

The Netherlands has a long tradition in water management. The first water boards (*Waterschappen*), responsible for dike maintenance and groundwater level management, and authorised to levy taxes to finance water works, date back to the 13th century. *Velt en Vecht* is the name of a water board in the Eastern part of the Netherlands (on the border with Germany), covering an area of 900 km^2 in the catchment area of the river Vecht. The area is mostly rural; half of the 200 thousand inhabitants live in the towns Coevorden and Emmen (province of Drenthe), and Hardenberg and Ommen (province of Overijssel). This case study focuses on the process of defining a desired groundwater and surface water level regime (*Gewenst Grond- en Oppervlaktewater Regime*, or GGOR for short) for this area.

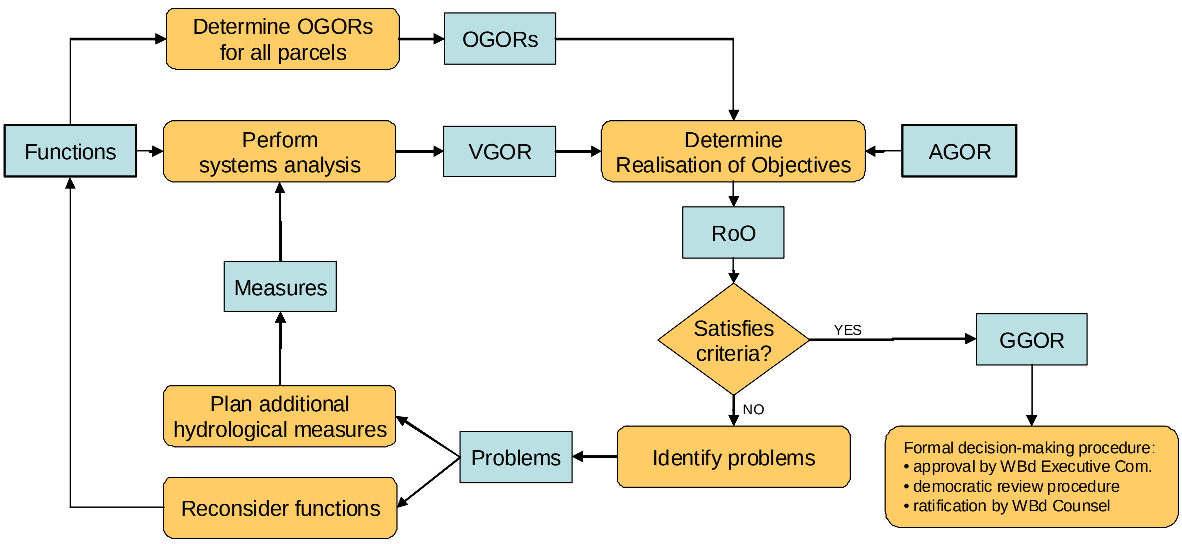
To face structural changes in the type and scope of water management issues (climate change, sea level rise, sinking soil, urbanisation), the Dutch national government and the three umbrella-organisations of the local administrative bodies (provinces, water boards and municipalities) decided to coordinate their water policy development and reached a national administrative agreement on water (*Nationaal Bestuursakkoord Water*, or NBW for short). The NBW highlights that the Dutch national government, the provinces, the water boards and the municipalities each have specific responsibilities in bringing and keeping the regional water system up to standards. The water boards are responsible for the hydrological measures for retention, storage and evacuation of water. The provinces must ensure integrated assessment and anchor this in their provincial policy and regional planning documents, the municipalities must do the same by means of their zoning plans. The national water authority (*Rijkswaterstaat*), the provinces and water boards must jointly see to the coherence between the primary and regional water systems to avoid that problems are shifted to others, rather than solved locally.

The NBW defines mandatory targets for safety and water nuisance (water surplus issues) and defines procedures for dealing with irrigation, desiccation and salinisation (water shortage issues), pollution and clean-up of water bodies and soil (water quality issues) and lack of ecological variety. The NBW emphasises the potential of synergy with plans in other policy domains (agriculture, housing, the environment, cultural heritage, industry, infrastructure) and the need to comply with bird and habitat regulations.

The procedure of particular interest for the *Velt en Vecht* case study concerns the definition of the GGOR for one specific area: the *Bargerveen*. This area of 21 km^2 of peat bogs harbors a type of living high peat that is unique in Europe and has been designated as Natura2000 area. For such areas the water board must submit a GGOR for approval by the province concerned (Drenthe) by the end of 2007.

6.3.2. Mitigation option

The water boards and the agency responsible for implementing the rural development policy of the Dutch ministry of agriculture and nature conservation (*Dienst Landelijk Gebied*, or DLG for short) have agreed on a general procedure for determining a GGOR. This procedure (called *Waternood*) is summarised in Figure 4. Central to the procedure is an iterative process of defining and assessing alternative ground- and surface water regimes, eventually converging on a regime that satisfies the aggregated criterion that the regime realises a certain percentage (typically 70%) of the theoretically best performance, given the land use functions of the (clusters of similar) parcels of land in the area for which the regime is established. If this criterion cannot be satisfied for the present land use functions using the available means for water management, changing land use and/or taking hydrological measures may be considered. The NBW requires water boards to define the GGOR in close cooperation with municipalities, groundwater managers and stakeholders, but it does not specify any particular level of participation on the ladder of Arnstein (1969).



Explanation of terms:

- functions: refers to land use functions. Most relevant in for the Bargerveen area are nature, agriculture, recreation, and housing.
- AGOR: *actual* groundwater and surface water regime (result of monitoring networks)
- OGOR: *optimal* groundwater and surface water regime (one for each land use function)
- VGOR: *expected* groundwater and surface water regime preliminary (used as tentative scenario)
- RoO: realization of objectives. For areas combining land use functions with different water requirements, the optimal conditions will not be achieved, and by consequence the RoO will be less than 100%
- criteria: the OGOR that results from the process is screened not only on the RoO, but also on other criteria, e.g., no more than 10% income loss due to water surplus in agriculture. The criteria and threshold values are to be defined by the water board.

Figure 4: Schematic representation of the *Waternood* procedure

The *Waternood* procedure can be seen as a procedural option for water stress mitigation. *Velt en Vecht* is one of the first water boards to actually implement this procedure (the time period for GGOR definition set in the NBW is from 2005 to 2010). Wanting a GGOR with broad support of stakeholders, the water board has decided to implement this process in participatory fashion, and invited us to take part in its design, implementation and evaluation.

6.3.3. Modality of test

Level of field implementation

Testing procedural options is a challenge. Being a social artifact, a procedure takes concrete form as it is implemented. Initially, we proposed a virtual test of the GGOR procedure using a role-playing game that would allow participants first to familiarise themselves with the GGOR procedure, and then to experiment with establishing AGORs and defining alternative GGORS. Such a test would inform the researchers about the information needs of the actors involved, it would inform the water board about the trade-offs to be made, and it might surface previously unnoticed stakeholder interests that would allow creative "package deals".

The idea of the using a game was presented to the water board (Rougier et al., 2006), but *Velt en Vecht* opted for a real test, arguing that such a virtual test would either be too hypothetical and not produce useful new insights, or be so realistic that the distinction between virtual and real negotiations would be marginal. The stakeholders already had a long history of negotiations about the ground water level, as the *Bargerveen* area is the locus of strongly competing interests: high peat can flourish only when its base is submerged, so the responsible nature conservation agency (*Staatsbosbeheer*, or SBB for short) insists on high ground water levels, whereas the farmers who cultivate the fields immediately south of the peat insist on low ground water levels, as do (to a lesser extent) the people with houses close to the bog. The GGOR would be like the next round in a decade-long negotiation process, and the water board trusted that the combination of the Dutch decision making culture and the experience of the consultant who would be hired to act as process manager would lead to a successful implementation. Thus, the *Bargerveen* case became a real-world test for a participatory GGOR procedure. Working closely together with staff members of the water board and the consultant, our testing methodology involved designing and monitoring the overall process (laid down in a Plan of Approach), specific steps in it (meetings, workshops) and the tools used during these steps (maps, models, other supports). We evaluated each event, sharing our direct observations and using questionnaires to monitor appreciation of participatory approach by stakeholders, and used the progressive insight to prepare for the next step.

Level of users' involvement

When the GGOR is seen as a procedural water stress mitigation option, its users are the actors who implement it: the water board, the farmers and nature conservation organisation SBB. Additional stakeholders are the local residents, neighbouring municipalities, German water authorities, the provinces and the Dutch ministry fro agriculture and nature. From the onset, the first priority was to get these stakeholders involved and committed to the process. The process as designed by project group (water board officials, consultants, AQS research members) put much emphasis on formation of a "sounding board group" and on close interaction with representatives of both farmers and SBB. The sounding board group was consulted with respect to the plan of approach and intermediate results. Hydrological knowledge was developed in interaction between experts, but shared openly with all stakeholders.

Risk of test damage

Even though establishing a GGOR for the *Bargerveen* area can be seen as a small scale test (less than 5% of the total *Velt en Vecht* area), the stakes for all parties involved are high. If the ground water level is raised to maximise the growth potential for high peat, the fields south of the bog will become unsuited for most, if not all, types of agriculture, while the housing conditions near the bogs are likely to deteriorate as well. Conversely, if the GGOR favours agriculture, the nature conservation agency will probably fail to meet the Natura2000 goals for which it is held responsible. The stakes for the water board are high because the GGOR may require costly technical measures.

Although the stakes are high, the risk of test damage is limited because, notwithstanding the participatory approach that has been taken, the water board still is the GGOR decision-making authority. If no workable consensus is reached among actors, the water board can decide unilaterally for a GGOR that is at least technically and financially feasible. Thus, the risk of testing the participatory approach "real-life" is limited to the financial and political risk of decision process failure. Financial because the water board bears the cost of the participatory process (stakeholder meetings, consultant fees), political because the water board is expected to have defined a GGOR for the *Bargerveen* area — ready for approval by the Province — by the end of 2007, and will be held responsible for delays.

External factors consideration

Two categories of external factors can be distinguished: political and physical. The process of defining a GGOR is part of a wider policy context, the complexity of which depends on the local situation. The *Bargerveen* case is largely dominated by the diverging interests of agriculture and nature conservation, and therefore most sensitive to policy decisions at the municipal, provincial and national level that directly relate to agriculture, nature conservation, or to land use in general. These factors are difficult to anticipate because policy decision processes are opaque and unpredictable. Therefore, also the lack of certainty due to "pending" policy decisions is an important external factor.

The area for which a GGOR is defined is part of a larger hydrological system, the complexity of which can also vary considerably. Compared to the political environment, the hydrological context is more structured (largely due to a system hierarchy defined by policy makers!) which affords taking into account external physical influences. For the *Bargerveen* case, an important factor in the physical context is the uncertain outflow of water from the high peat area towards the neighbouring, much lower fields in Germany.

Risk of "false positives" and 'false negatives"

As the GGOR procedure is tested for real, the question whether the test results are "valid" is academic: the outcome of the process (the GGOR that is eventually constituted) will be a political fact; defining an alternative GGOR via some other procedure is not an option. For a virtual test (e.g., experimenting with the procedure in a role-playing game) the question would have been much less academic, as the decision to implement the option would then have been informed by the test results.

Whether the outcomes of the *Bargerveen* field test can be generalised for other areas in The Netherlands for which a GGOR has to be established is doubtful because, as for any social artefact, the effectiveness of a procedural option is very much context-dependent. Thus, even if the participatory GGOR procedure seems to work out well for the *Bargerveen* case (i.e., process and outcome are appreciated by decision makers and other stakeholders), this does not mean that it will be likewise successful for other areas. Likewise, an apparent failure of the procedure does not imply its inappropriateness for other areas.

6.3.4. Criteria of option impacts assessment

The actual impacts (in terms of water stress mitigation) of a GGOR can only be determined some years after the new regime has been implemented. A participatory process is difficult to evaluate ex post (Rowe & Frewer, 2003; Van Duijn, 2007), and even more so ex ante.

The evaluation addresses two issues: (1) defining a GGOR and (2) doing this in a participatory fashion. In particular it aimed to answer the following questions:

- What are the environmental and economic consequences alternative ground water and surface water management regimes?
    - Various ground water level indicators (average, seasonal extremes, ...)
    - Development potential for living peat
    - Suitability for different agricultural functions
- To what extent does the GGOR process address the various stakeholder interests?
    - Potential for realising Natura2000 objectives for the *Bargerveen*
    - Economic viability of the farms
    - Cost-effectiveness of hydro-technical measures
- How do the actors involved appreciate the participatory GGOR process?
    - Transparency (of the political agenda, procedures and planning, and their own role in the process)
    - Openness (to new ideas, new actors, new interests)
    - Content (availability and quality of information)
    - Progress (in defining the problem, identifying and evaluating options, working towards a decision)
    - Fairness (impartial process management, equity)

Impacts were assessed for different ground water and surface water levels using hydrological models that visualised the consequences for individual parcels. The environmental and economic consequences were operationalised as the overall % of the maximum attainable “land use performance” (100% being the performance under an optimal water regime for the given land use).

The GGOR procedure itself does not include assessment of the consequences of measures in terms of economic viability of the farms; to date, these impacts have not been quantified.

The appreciation of the GGOR process by the actors involved was evaluated using questionnaires and interviews during the process. The results provided feedback to the process manager and the steering group.

Table 1: Three examples of mitigation options tested in the AquaStress project:

		Joint Irrigation projects	Tax & levies scheme	GGOR definition
Name of the option		**Joint Irrigation projects**	**Tax & levies scheme**	**GGOR definition**
Country		Morocco	Poland	The Netherlands
Purpose of the option		To mitigate water stress by organising farmers to collectively modernise their irrigation system	To obtain funds to finance measures that help maintain environmental conditions while mitigating flood risk	To mitigate water stress by improving SW and GW level definition
Object of test		Integrated innovative technology	Economic mechanism	Procedural methods
Objective of the test		To assess whether the organisation of farmers is relevant regarding the introduction of water saving technologies	To assess whether stakeholders behave in accordance with the "rational choice"-based economic model used while design the option	To assess whether the participatory process used to define the GW level improves the quality of the decision that is taken
Modality or testing	Level of field implementation	High, the option is tested for real, virtual tests are carried out during the process	Low, the option is tested virtually using models, stated choice experiments	High, the option is tested for real, virtual tests are carried out during the process
	Level of users involvement	High, pilot groups of farmers are involved in the process	High, local stakeholders are asked to reveal their response to the option	High, local stakeholders are involved in the process
	Risk of test damage	Medium, the pilot groups of farmers who choose to change their irrigation system take economic risks in case of unsuccessful results	Low, the stated choice methods do not have real consequences for the stakeholders involved	Medium, the level of participation is *consultation*; the decision remains with the Water Board; some political risk in case no consensus is reached; no major environmental risks
	External factor consideration	State subsidies and water quota in times of drought	Biases in sampling are avoided	Pending decisions in other policy arenas; hydrological variables
	Risk of "false negatives" and "false positives"	Results of virtual test suggest more adoption than in real life	Test outcomes may be invalid due to strategic behaviour of participants	Does not apply to case (outcome = real decision); generalisability to other cases is limited
Evaluation criteria	Technical	+++	-	++
	Environmental	+	-	++
	Social	+++	++	++
	Economic	++	+++	++

7. Discussion

The three examples of how mitigation options have been tested in the AquaStress project are summarised in Table1.

Although the tests are still under way, a meaningful global assessment and comparison can still be made.

A first observation is that the choice between real or virtual testing logically determines the consideration of external factors, the risk of test damage, and the risk of “false negatives” and “false positives”. Unanticipated external factors – changes in subsidies and water resource availability in the Tadla case, pending policy decisions (notably about the precise objectives for nature conservation in the Vecht case) – will only reveal themselves in a real test. Although this would seem a positive feature of real tests, it does not mean that it enhances the validity of the test outcome: the external factors may not be the same for different application sites, and therefore the test outcome may not generalise. For virtual tests, the risk of test damage is by definition low as these tests are supposed to provide a safe environment. On the downside, virtual tests have the risk of rejecting an option that would have worked well in practice or of accepting an option that will not work well.

Considering the evaluation criteria that have been used in the three tests, it is clear that these are quite case-specific across all three categories (technical, environmental, social, economic). The second column in Table 1 suggests that testing an economic option for its impact on stakeholder behaviour naturally focuses on social and economic criteria. Indeed, assessment using technical and environmental criteria would require testing the technologies that would be put in place (cf. the Tadla case).

Testing an option in a participatory context means that the perceptions of the participating stakeholders will be influenced by the test. The impressions during simulations and the opinions collected during debriefings and/or questionnaires may not adequately reflect these perceptions. Researchers may conclude that an option is quite appropriate while the users who were directly involved in the test may retain another image, or vice versa. As the Tadla case illustrates, intended users may decide not to implement an option that during the virtual test seemed to be favourable to them. It is difficult to say whether this invalidates virtual tests, as the participants may have more information about their own specific situation and thus assess it better. This suggests that user involvement in virtual testing, but also potential users from other possible application areas in case of real testing, is beneficial because such involvement allows the participants to learn directly, obtaining knowledge that would not be transferred via the test report containing the observations and conclusions made by researchers.

Like any design task, developing a test for a water stress mitigation option involves trade-offs. In addition to the tensions identified in the previous paragraph, designers will always have to consider the cost of implementing a test as well. Scalable cost factors, such as the number of stakeholders participating in the test, the number of replications of simulations, and the sample size for surveys and questionnaires, will typically pose a trade-off between cost and test validity. Although the proposed framework does not provide decision rules to make such tradeoffs, it supports reflection by identifying a number of important design parameters.

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