Aquastress D2.2.3 - Key research priorities for and major knowledge gaps in Water Stress mitigation

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AquaStress

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

Integrated Project

D2.2-3

Report: Key research priorities for and major knowledge gaps in Water Stress mitigation

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Abstract

In this report the factual analysis is compared with the stakeholder perceptions for different test sites. Based on these findings the following general conclusions could be drawn.

To obtain a good insight in the bio-geophysical system as well as the socio-economic setting often data were inadequate. This made it difficult to assess the water stress. It also stresses the need for a good monitoring network. A number of sites indicated that the distribution of the amount of water over the different sectors is the main problem. In these cases, institutional and social settings are key, to come to acceptable solutions. Although environment is often mentioned, it is not a well represented stakeholder in most of the sites studied. Future problems that may aggravate water stress such as climate change, but also the impact of European policies are difficult to take into account by most stakeholders.

More knowledge is needed to be able to act fast when facing a crisis but also to predict

possible future problems. Not only adaptive management strategies should be developed, but also adaptive problem-threat-stress definition rules linked to these management strategies should be developed. Great care should be taken to make these as site specific as possible.

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1 Introduction

In D2.1.-3 a general overview is given of knowledge gaps to mitigate water stress. The major conclusion of this report was, that, as already has been mentioned by several authors (e.g. Bos et al.,1994), gaps in knowledge and thus knowledge needed at a specific location is largely dependent on the characteristics of such a location. Besides knowledge on the physical system governing the hydrological regime of a site and knowledge of possible technical adaptation measures, also the socio-economic setting determines the knowledge that is needed to ameliorate the water stress situation.

In this report the factual analysis (D2.2-2) is compared with the stakeholder perceptions (D2.2-1) for the different test sites (see Table 1). Based on these findings knowledge gaps are identified and key research priorities are summarized. In the next two sections a summary of the results is given based on the before mentioned deliverables. For a better understanding of the diverse situations, both of the biophysical system as well as of the socio-economic system, the reader is recommended to read the full reports of D2.2.-1 and D2.2-2. For the convenience of the reader in Chapter 2 the main findings of the stakeholder perceptions are summarised and in Chapter 3 this is done for the factual analysis.

Table 1: Overview of the test sites used within the AquaStress project, the available stakeholder data and special focus of factual data.

Site	Country	Special focus Factual data	Stakeholder perception
Guadiana	Portugal	(Semi-) natural ecosystems	Detailed
Flumendosa	Italy	Domestic	NA
Vecht	The Netherlands	(Semi-) natural ecosystems	Detailed
Przemsza	Poland	Industry	Detailed
Iskar	Bulgaria	Domestic Industry	Detailed
Limassol	Cyprus	Economic instruments	Limited
Merguellil	Tunisia	Economic instruments Agriculture	NA
Tadla	Morocco	Agriculture	Detailed

2 Overview Stakeholder perceptions

The definition of water stress as adopted by the AquaStress project is:

> *Water stress occurs when the functions of water in the system do not reach the standards[1] (of policies) and or perceptions (of the population) on an appropriate quantity and quality, at an appropriate scale and the adaptability for reaching those is not given.*

This definition does not always correspond with the perceptions of stakeholders. The next paragraphs are a summary of the perceptions as were retrieved from interviews and discussions with stakeholders in four of the test sites. For a good interpretation of these results it should be kept in mind that although efforts were made to involve a well balanced representation of all possible stakeholders, this was not always achieved (for example the Iskar test site). A broad explanation of that can be found under D2.2-1b

Guadiana

Based on the stakeholders interviews, water stress could be categorised in the following groups:

- Water scarcity due to droughts and climate change
- Ground water diminution due to the reduction of the run-off
- Water distribution problems
- No adequate water management

Within the interviews representatives of all sectors were involved: domestic sector (water distribution companies, water authorities), agricultural sector (farmers association and ministry of agriculture), industrial sector (indirectly the water utility delivering water to the tourist sector and a representative of the winery industry) and environment (indirectly the representative of two environmental NGO)

Water stress was generally attached to the perceived treat to their economies. Also climate change and an inadequate water management were considered the drivers for water stress. Those both factor influence the suffering of water stress in all water consuming sectors. What they mentioned as being water stress situation for them was as well reiterated as the impacts in the different sectors. It was stated that the area is one of the less developed (in economic sense) of Europe due to water scarcity and mismanagement. There is still a high emigration to the cities (Lisbon and Porto) and to foreign countries.

[1] Under “standard” should be understood the “level” needed for the whole ecosystem (understanding humans as a part of the ecosystem). Usually these standards are described by political bodies. Since ecosystems can not talk, the political bodies for ecosystems would be NGO as well as any scientific publication.

The agricultural sector reported a high difference in economic development in comparison to Spain due to the scarcity of water that the region suffers and also to the disinterest of the central government for the region. But the main problem is that Portugal still has only small reservoirs that cannot stand prolonged dry periods. And there is not special restriction on crop type by government, but on water quantity for farmers.

There is a conflict between agricultural and domestic supply (residents). Residents have priority. Sometimes, then there is conflict over who's next the agriculture or tourism (typically golf courses).

There is a high potential conflict between the future development of the agricultural sector towards irrigation and nature conservation. The biodiversity of the area remains very high due to the extensive agricultural practices of the area. It has been already recorded that in areas where the intensification of the agricultural sector has increased, a decrease in species numbers have occurred.

Comments by stakeholders on existing gaps in knowledge (in practice and research)

Regarding the lack of information or data in the Guadiana, the stakeholders answered following points:

- Lack of quantitative knowledge on water balance and soil mineral balance (soil saturation capacities).
- Lack of economic assessment. Disparity on numbers. E.g.:
    - Water cost in Lisboa: 2,000 €/person/yr; in Alentejo: 11,000 €/person/year
    - Water yield in Lisbon: 20,000 €/ha Lisbon; Water yield in Alentejo: 2,000 €/ha
    - is it worth the investment and the construction of such a big dam?
- There are no basin Integrated Management policies or initiatives.
- Lack on the description of the agro-environmental systems of the Guadiana Basin
- Lack of continuity of policies due to changes in government officials.
- Comments on the importance of supporting activities more ecologically friendly. And about problems to control activities that damage the environment.´
- Regarding biodiversity knowledge: The Guadiana belongs to the Mediterranean zone with a high biodiversity index. Intensive agriculture is the most damaging factor to the autochthon diversity. Example: Lameiro watering system.

Przemsza

Summarizing the results for this site it should be stressed that the Polish society is less afraid of natural environment contamination year by year. What is more the positive opinion about improvement in the protection of nature is systematically

strengthened. Although still many people are afraid of natural environment specially if they expressed their opinion about water resources and drinking water.

Further conclusions come form the interviews with the experts (journalists specialising water issues). They highlight the lack of understanding for the water management system by the Polish society. In their opinion, public opinion does not see links between the water in houses and natural water resources. On the other hand, the limitation of water use is noticeable. But the main reason why people reduce the water consumption is economical motive.

From the interviews one has to notice the varieties issues seen by the respondents according to the water situation in the region. Firstly, it should be stressed that there is enough water in the region, what was stressed by all respondents and can be confirmed by the hard data. Only one person mentioned the lack of water in the region touched by the drought (Beskidy Mountain – not the test site area), specially during the summer in 2006. In the test site area there is much water, even, what was emphasised by several interviewers, it is more then needed. A large amount of water is caused by two reasons:

- inhabitants become more economical since the economic transformation started in Poland,
- less consumption of water by the industry due to the process of closing down some heavy industry units.

The consequence of the surplus of water in the test site area is its high price because the waterworks enterprises need to maintain the infrastructure what is very expensive. Here one can notice a paradox: much water does not reduce the cost but it increases the price of consumption water.

Water quality is the second issue seen by the respondents as crucial. Few of them laid emphasis on the poor quality of drinking water (lack of drinking water from taps in houses as it can be drunk in Great Britain for example), others highlighted poor quality of surface water (rivers) and at the same time deprived quality of water for recreation. Most rivers and streams in the test site area are highly polluted, especially with bioorganic substances.

General perception of the water stress

Water stress is perceived by the respondents as a very serious problem in the region. The perception of water stress is different when we divide respondents into two groups: one with no close connection with waterworks who only perceive the problem of water consumption and the second group of those whose jobs are to deal with water issues. The first group concentrates on the water quality (i.e. clean and healthy water for consumers), specially drinking water and water for recreation. The second group concentrates on the consequence of mining industry for water resources in the region and waterworks.

Summing up three the most important problems concerning water stress in the test site, which are as follows:

- Quality of water (cleanness, possibility to drink without boiling it)
- Dysfunction of rivers for sustaining life supporting (i.e. water supply, transportation, recreation, landscaping, irrigation etc.)

- Dependence on inter-basin transfer of potable water.

Others problems mentioned by respondents during the interviews were:

- The necessity to build a water supply system for the whole region (rank 6).
- Lack of habitat diversity in the riverbeds (rank 4).
- Reduced self-cleaning ability of rivers (rank 4).
- The necessity to artificial lakes management and protection (rank 3).
- High price of water for consumers (rank 7).
- Salt water (surface water flow) (rank 7).

All respondents mentioned that there is low population's awareness of all the problems of water stress (1 – 2). The only one person (the representative of a local self-government and at the same time a nongovernmental organization) pointed out that the awareness of water stress can reach the grade four (4) on the proposed scale. It means that people in the region as long as they are not touched by the water problem they do not perceive threats to the water sources. This is why one of the respondents emphasised that taking into consideration the population of the whole region education about water resources and water system management is extremely needed.

The cause and effect chain of the problem (quality of water) one could draw as follows:

- The most important cause of all water problems in the region is mining industry development in the past and at the same time the process of urbanisation.
- The former communist regime which forced the mining industry development with no respect for natural environment.
- The problem has existed for at least 50 years.
- The problem affected the organisations on the average level (ranks 3-4).

- The problem affected the region on the average level (ranks 3-4).
    - Low value of riparian areas.
    - Local flood events.
    - Unused potential areas for investment.
    - Unused potential areas for recreation.
- Different social groups have been equally affected by the problem: consumers, private enterprises, tourists, industry.
- Generally all represented by the respondents organisations have reacted on the problem but differently in the chosen ways and strength of their activities. The less active in this field is the women organisation SOROPTIMIST and students' organisation.
- The effectiveness of the adopted approach was on the average level (rank 3 – 4).

- One person mentioned that the approach led to the new problem: lack of successful management plans for local catchment's areas. Representatives of non-governmental organisations did not mention any more problems appearing during their activities.
- Media in the most interviews are negatively perceived. They are interested only in very dramatic problems but do not take any responsibility for searching solutions.
- Generally, respondents may contribute to the mitigation of the problem but their success depends on the role of organisation they represent.
- The represented organisations may cause changes differently. Waterworks companies have great impact, but scientific and social organisations may not strongly influence effective changes in the test site area.
- According to the respondents' opinion they (what means the organisations) do not do all their best to solve the problem.

Iskar

The main threats for Bulgarian stakeholders were the difficulties to cope with floods and droughts in the same region and to have contingency plans for both, the industrial pollution doing directly to the river Iskar and the influences of that in the water quality, the mismanagement of the water resources in the city of Sofia and the losses in the domestic sector counting to a very high percentage of the water being delivered by the authorities.

From the outcome of the interviews, it was concluded that the Bulgarian test site would benefit the most from:

- Scenarios for the development of agriculture and strategies to guide it;
- Integrative strategies for water distribution from the Iskar dam to be prepared for droughts;
- Support in economic strategies to finance investments in water management;
- Enhanced cooperation and conflict resolution between agriculture, energy and industry concerns;
- Improved stakeholder awareness of use of water, pollution and prevention of wastage;
- Improved repair strategies for water supply network;
- Waste water treatment for upstream villages;
- Water treatment for industry;

Tadla

As the test site primarily involves the irrigation perimeter, the analyses was concentrated on the agricultural sector. The main problem perceived by the

stakeholders was a possible water shortage due to drought. However, it should be noted that as the main income is based on the production of sugar beets and this crop has priority in the allocation of water, some stakeholders did not perceived drought as a real threat.

Also the declining ground water tables were indicated as a possible problem. This may be of a major concern as some of the stakeholders indicated that in their opinion a possible solution of a shortage in the water supply by the irrigation scheme, could be solved by drilling deep wells.

As described in D2.2-1 three stakeholders which had been taken in the range of possible stakeholders, did not perceive themselves being part of the issue of water stress. This result partly shows the institutionalised inequality of the experience of water stress. Since sugar beet is the prioritised crop for the irrigation scheme, the representative body of sugar beet cultivators is not stressed at all. The same applies to hydropower generation which actually benefits from agricultural water use since with water supply, electricity is generated.

Among those interviewees who saw their stake in the situation, a “blame game” can be observed to a certain degree. Farmers experience temporally defined water stress since a limited amount of water is above all provided during sugar beet water requirement. The administration sees agricultural practices not adapting to the naturally driven water scarcity.

3 Overview Factual Analysis

Guadiana

According to the River Basin Plan the main water quantity problem is the high annual variability of water resource and not the total annual quantity (River Basin Plan 2001). This conclusion is the logical prelude to the building of the Alqueva dam, to which it is the solution. With is very high storage capacity it should be able to keep enough water from wet years to cover a series of dry years. With the Alqueva dam, an irrigation infrastructure is planned that will allow a further extension of the agricultural sector. It is a political decision extending beyond the reach of water resource management whether the agricultural sector, with al the problems and environmental consequences associated, is the best option to increase welfare and economic development in this region. The Alqueva dam will change the water situation profoundly and though the first evaluations have taken place (e.g. special issue Estuarine and Coastal Ecosystems), it is too short term to draw conclusions. An integrated focus on water quality could benefit both environmental and domestic needs, especially if the effect of low flow velocities on eutrophication and thus water quality is taken account. However, the paradigm that a high variability is a problem, and the building of dams and reservoirs as solution to it, forms a threat to the natural dynamism that the aquatic ecosystems in this region are adapted to. The increase in exotic fish species is one of the most obvious examples of the negative effects of a more stable situation.

Flumendosa

In the Flumendosa-Mulargia system water scarcity related to droughts has determined several conflicts of use in particular between civil and agricultural

purposes where, according to the priority of use of civil sector, inevitably agriculture results penalised.

Moreover the existence of dams in the upper part of the catchment has a considerable impact on both water availability and water quality in the downstream plain; in fact after the reservoirs were built, the main source of recharge of the aquifer ceased, additionally the overexploitation of groundwater largely increased being the latter the only resource left for drinking, irrigation and industrial water supply in the coastal area, which is not supplied by the reservoirs system. As a result salinity has considerably increased in groundwater near the coast. Moreover surface water quality is very poor as a result of flood events supplying high loads of suspended solids causing low oxygen availability.

Conflicts arise also in the environmental sector, due to the flow rate management downstream of the dams, especially during dry periods. Minimal vital flow is required by national legislation, to assure the environmental features of the rivers, the ecosystem balance and the aquifer recharge. However adapting reservoir releases according to environmental flow requirements seems difficult to manage.

In the Flumendosa test site, the available resources can be assessed as follows:

- The average runoff has decreased from about 415 Mm3/y (1922-1972) to 210 Mm3/y in the years 1986 -2000. The latter value can be assumed as a minimum value for available surface water resources during droughts, while the average of 415 Mm3/y can be assumed as a maximum value.

- Groundwater availability in the area is limited to the Muravera coastal aquifer, while in the rest of the basin groundwater circulation is negligible due to the mainly impervious nature of the dominant lithologies in the watershed. Water abstraction for civil uses add up to about 100 l/s; moreover from May through August abstraction for irrigation are also practiced. The unbalance between recharge and exploitation is evident from saline waters intrusion.

Some indicators related to industrial use have been assessed. Water deficit is 14.2%. The added value per m³ of abstracted water is relatively high (410.6 €/m³) compared to that for agriculture (10.3 €/m³). Moreover contaminant load due to industry is very high (2.76 M t COD/€ GDP). Water use for industry in Sardinia is about 6.7 % (15 Mm³/y) relatively low compared to other sectors. Therefore, it can be concluded that industry is not a major water user on this island.

The Flumendosa potentially irrigated area administrated is 70 000 ha, what represents around to 40% of the total Sardinian irrigated area. Agriculture is responsible for 53% of the water consumption and only 55% of the agricultural water demand can be satisfied. The most important challenge regarding water consumption of the agricultural sector is to prevent water losses in the public infrastructures and to generalise the volumetric base pricing system. Conversely it is already recognized that the irrigation techniques are efficient since in Sardinia, micro irrigation and sprinkler represent 93% of the equipments.

Domestic sector demands make up approximately 45% of demand in the Flumendosa-Mulargia-Campidano area. Flumendosa hydraulic system supply water resources for civil purposes to a total population of about 700,000 inhabitants which increase during summer season of about 250,000 people. Within Flumendosa basin total population adds up to about 22,000 inhabitants with an increase of about 3,000 people during summer season.

Vecht

In the river basin of the Vecht, there is not a problem of water shortage per se, but a continual dilemma between excess water in winter and spring on one hand and water shortage in summer on the other. Groundwater dependent wetlands have dried as the groundwater table is structurally lowered several meters to improve growing conditions for crops in spring. However, groundwater tables in floodplains and former wetlands are still too high for intensive agriculture. Groundwater extraction for drinking water, industry and sprinkling is a further cause of the low groundwater tables. In summer, the groundwater table falls so low that crops experience drought and sprinkling is necessary. The low groundwater tables in the peat covered areas enhance decomposition of the organic soils causing a decrease of the surface level and consequently a further decrease of the groundwater table. However, any ambition to raise the mean level of the river or the groundwater table for ecological or other purposes meets with strong opposition of the farmers.

The predominance of agricultural land use in the region is reflected in the type of water quality problems experienced. Fertilizer run-off and seepage are mostly responsible for eutrophication of the surface and groundwater. However, emissions from points sources and households not connected to sewer systems also contribute. Still, the surface water is ecologically qualified as “reasonable” to “good” in some areas towards the west. All groundwater is qualified as in a poor state.

Overall, 36 of the 38 surface water bodies are at risk due to water quality problems and two of the 38 surface water bodies are possibly at risk. Thirteen of the 23 groundwater bodies are at risk and 10 of the 23 groundwater bodies are possibly at risk.

Quantitatively, shortage of water is not considered a main issue by the agricultural sector. However, ¾ of the nature reserves are experiencing drought. This is mainly caused by the improved drainage of the area combined with a lowering of the ground water table. The institution to solve this problem is the establishment of a new GGOR (Desired Ground and Surface water Regime), which has the possibility to determine new agreements on the surface and ground water levels.

Currently the determination of the GGOR, integrating the different land uses (agriculture, nature, urbanisation, infrastructure), is in process. This should lead to a maintenance, restoration or compensation of wet ecosystems and their ecosystem functions. Water quantity and quality should be closely matched with demands and there is a focus on decreasing drying of nature areas as well as water shortage in agriculture. The exact implementation of the GGOR remains still a major challenge, and will determine for a large extent what the future potential of the area will be for natural wet ecosystems.

The Velt and Vecht Water Board explicitly stated that river regulation and canalization (“stream morphology”) is the absolute main problem for the biological quality of the aquatic ecosystems in the basin, and that any improvements in water quality will yield marginal results without improving the overall “naturalness” of the rivers. Although improving the aquatic ecology is an important issue for the water board, the prevention of flooding remains a prerequisite.

Przemsza

The detailed analysis of the water resources and the water demand in the Przemsza test site shows that there is general water stress concerning water quality and water quantity. The water resources are not scarce however there is high demand and the

poor surface water quality puts limitations to its use for the different sectors including environment. Regarding the water demand the major user is industry (76%), followed by public water supply (13%). These two sectors also contribute very much to the water quality related problems since great amounts of not adequately treated industrial and municipal wastewater are discharged to water bodies. But also agriculture due to use of fertilisers has a negative impact on water quality.

The Upper Silesian Agglomeration with its major city, Katowice, is a typical example of a heavily polluted large urban area. Selective environmental assistance cannot rehabilitate these cities and concerted efforts among different sectors are needed. The process of stakeholder's dialogue should be viewed as an effective approach to engage stakeholders from different sectors in the decision-making process. Central to this process are informed decisions on the transfer of environmentally sound technologies and behaviour. In the context of domestic water stress, water quality issues need to focus on the treatment of highly polluted raw waters (i.e. BOD/COD, N and P concentrations, and in some areas where leaching from mine-waters has occurred, concentrations of B, Cd, Mn, Zn, and Sr). Water scarcity is not a major issue in the test site, although the threat of climate change may, in the future, increase the risk of extended drought in the region. Therefore, addressing the existing water quality issues should be considered as a priority as it will serve the dual purposes of improving water quality and securing future water supplies.

Limassol

There is a long history of growing water demand and increasing water shortage on the island of Cyprus and in the Lemesos area. Whereas groundwater initially was the primary source of water, surface water reservoirs have now taken over this role. The overabstraction has decreased groundwater levels and caused salinization problems in all coastal areas. In the Lemesos region the only aquifer not subject to salt water intrusion (Germasogeia) receives almost 80% of its water from artificial recharge. The dependence on surface water has increased the influence of the high annual variability in rainfall. A series of consecutive years with low rainfall (1997-2000) has recently created a sense of urgency for water resource related problems, and a series of adaptations and mitigation measures have been initiated. However, this urge for change seems to have decreased after a few wet winters that have reloaded all reservoirs. It is not clear what the current measures are to plan for similar droughts in the future and how to deal with the risks inherent to a system depending on a highly variable source.

The sectors most closely associated with the problem of water shortage are the agricultural sector, now using 70% of all water supply in a normal year, and the tourist sector, doubling its domestic water demand by 2020. Both have a peak demand in the dry summer months resulting in a direct conflict for the same water resources, however at a very different price per liter. To cover its drinking water demand, the tourist sector has an additional source of (costly) desalinated water. The economic structure of the desalination plants causes them to function even in wet periods, when the high-energy and costly process is not needed and is thus not optimal for a drought back-up. As the ground- and surface water resources are stretched to their limits, the options to increase the supply are limited to desalination of sea water and repeated use of freshwater. The management of water demand is left to market mechanisms in the industrial and domestic sector, with water tariffs reflecting real costs, while water prices in agriculture cover less than half of the costs.

This is a political choice with both positive and negative consequences, but in an agricultural sector which suffers from several stresses (lack of labour,…) and supports (subsidies,..) it is possible that a trade-off may be created between economic profitability and water use efficiency.

The water that is used is partly lost through evapotranspiration, but also returned to the water resources system loaded with unwanted chemicals. A large part of the industrial, domestic and tourist wastewater is still either discharged onto surface waters, or stored in a way that directly or indirectly threatens the quality of the groundwater. Over the coming decade, implementation of the WFD means Cyprus will have to increase its wastewater collection and sewage system capacity. This could be seen as a window of opportunity to extend and improve a recent solution to the water shortage developed during the drought, i.e. the re-use of tertiary effluent. The use of tertiary treated effluent as irrigation water was accepted when hardly any other water was available during the very dry years, but abandoned when the reservoirs were again filled with fresh water. Interviews with farmers showed that owners of large farms were more in favour than small farmers, who showed more distrust. Another problem was that salt concentrations of the water were sometimes too high. Alternatives to the use for irrigation are recharging of depleted aquifers or for a “grey” water system in domestic use (flushing of toilets,…).

The improvement and extension of the sewage system is not sufficient to solve all problems relating to water quality. Diffuse pollution sources from agriculture and solid waste landfills are a major cause of eutrophication. Wastewater production from mining and other industrial activities are a further source of pollution. Currently, however, hard data on pollution are scarce as many of the affected river stretches are qualified as “needing more investigation”. The implementation of the WFD will focus attention on the consequences for aquatic systems and changes in agricultural and industrial policies will be needed. As most of the currently protected areas (and presumably of most valuable nature) are situated upstream rather than downstream of the dams and of the most problematic river stretches, these seem to escape adverse effects. The Akrotiri wetlands at the peninsula seem to be hydrologically connected only through groundwater flows, through which pollution risk also threathens these nature areas. However, as they are not officially part of Cyprus, they were not included in the WFD report and information about the current status could not be found.

Merguellil

The results of the factual analysis indicate at the national level the severity of the water scarcity problem, in terms of the lack of resources which the country is facing in general.

At this national level, efficiency of water use is relatively low, indicating that the economic return on water use is not optimized. This is measured in terms of the proportion of GDP generated by each sector of the economy, compared to that sectors share of water consumption. It is likely that the return on water use is higher within the case study site than it is at the national level.

The main problems arising in the Merguellil case study have been identified as:

- long-term groundwater overexploitation as a result of a sustained increase in water pumping,

- variable water requirements from different agricultural patterns in the upstream and downstream parts of the catchment,
- sources and quality of drinking water for the population living in the catchment, and competition for that required by coastal tourism.

Activities within the Aquastress case study have focused largely on irrigated agriculture, a fundamental issue in the whole of North Africa and semi arid zones in general. While good data exists relating to agricultural water use, little other data is available to date.

For the domestic sector the central conflict in the region is between the local use of water for agriculture by individual or grouped farmers and the supply of domestic drinking water for the region itself and the population along the coast. Although the industrial sector in the governorate of Kairouan uses just 1% of the total water demand, it is expected that development of local industries and population growth will lead to increasing industrial water demand. Limited finances to treat waste water may lead to problems related to water quality in the future. The agricultural sector is the main water user. Although there are some irrigation associations that share boreholes, most farmers operate their own wells. The economic need to conserve water means that most individually managed plots are well managed. Surface irrigation practiced in this way is >80% efficient, which is certainly not the case for surface irrigation practiced by irrigation associations. Fortunately, micro irrigation (90% efficiency) is set to replace surface irrigation in the near future. Nevertheless, the impact of micro irrigation on water saving is questionable. The reason for this is that because micro-irrigation is less labour intensive and more efficient, the area of land being irrigated has increased. Thus more summer crops are now being grown at the expense of winter production which is less profitable; in some parts of the basin winter crops account for less than 5% of total production. Besides this increase in irrigated area and change in cropping pattern, it is also unclear what the effect of the increased irrigation efficiency will have on the ground water recharge and thus on the water table depth for the region. The main water stress for the (semi-)environmental sector is caused by water scarcity, especially in the downstream part of the river basin. There has been a measurable degree of environmental degradation, as reflected in loss of habitats etc., but on the positive side, the relatively high score on capacity indicates that there is much potential for improvement through the investment of human and social capital. At the national level, Tunisia has been developing its people and institutions, and in many ways water management and policy at the national level is well developed. While this may be reflected at the case study site through the existence of organized water user groups, irrigation committees etc., there is need for participation in water management issues in general to be widened.

The problem in the catchment is to find a way to increase the volume of available water without reducing the present level of pumping. A number of options to achieve this aim have already been attempted or planned: Flow regulation, 'Artificial' recharge, Desalination plant, Water transfer, Restriction of borehole construction, Subsidies. Except for the unplanned recharge of the aquifer by the el Haouareb reservoir, non of these options seem to work well.

The use of modern irrigation technologies has been proposed as one of several possible solutions. Although this improved the irrigation efficiency, but also to an increase in the irrigated area. To solve the issue of long term groundwater

overexploitation, resulting from a widespread increase in pumping for irrigation and drinking water both in the catchment and coastal area, water metering has been introduced for Tunisia farmers to encourage greater efficiency. An economics instrument that can be used in combination with water metering, in the face of demand-supply imbalances is the introduction of water markets in which water rights, or permits, can be traded. The rationale behind water allocation through tradable rights is that in a perfectly competitive market, permits will flow to their highest value use. However, the use of tradable rights for groundwater is in practise complicated, since the impact of changes in the groundwater level on agricultural production and nature depends on location specific circumstances. If a further decrease of the environment is an objective, water trading should be combined with water valorisation. This allows to value the ecological functions of a river basin, using the so-called non-market valuation techniques that can estimate the mean willingness to pay by relevant stakeholders, in order to sustainable preserve such ecological services.

Tadla

The most important issue in Tadla case study concerns water availability for irrigation. At the beginning of the creation of the perimeter, the irrigated area was very small compared to the hydraulic capacity of the system. This lead to an excessive use of water and to an artificial recharge of the superficial aquifer. In some places of the perimeter it has even been necessary to drain lands.

With the development of the irrigated area, artificial groundwater recharge also reduces proportionally to the increase in the irrigation efficiency (lower consumption per hectare). In the same time, the aquifer did allowed to irrigate when there where restriction in the water allocation for the surface water. Surface and groundwater where then complementary resources. But drought become structural and the use of groundwater where the only solution to maintain the quantity of water at the field level. This leads to an increase in the investments in borehole and to groundwater depletion. Groundwater does not play any more its initial role of insurance against occasional draught.

The main problem comes from the reduction of the water allocation to the canal system that seems to be permanent now and induce behaviours consisting in drilling deeper and deeper, risking to challenge domestic consumption.

This situation justify most of the activities in Tadla case study aiming at (i) developing collective management of reservoirs or wells to facilitate conversion into drip irrigation and (ii) developing integrated water management solution aiming at least to develop tools to allow a conjugated surface and groundwater management.

The propensity to mitigate water stress in the agricultural sector is seriously challenged by the low financial capacity of farmers, the low level of education and the structure of the property that is very in-egalitarian.

Sectors issues in Tadla are then rather dissociated excepted regarding agricultural diffuse pollution and domestic pollution that have a significant impact on the domestic sector itself and on the environment.

The water stress issue in the domestic sector (low level of access to water) is due to 3 principal factors: (i) the rapid population increase that does not allow maintaining the level of connection to safe water and sewage infrastructure, (ii) the lack of public investment in this sector and (iii) the low possible contribution of water users to finance the services provision.

As a result, environment receives most of the impacts of water stress of other sectors: industrial waste water, nitrogen, phosphorus and phytosanitary pollution, low flows in rivers and the associated ecological damages…

The only sector where it seems possible to assess all indicators is agriculture. However, defining water stress thresholds for these indicators seems rather complex and / or a rather subjective issue. Concerning other sectors, most of the indicators can only be assess by stakeholder themselves what challenge the initial objective of comparison among test sites.

The data availability does not allow to quantify most of the selected indicators even if the reader can make its own judgement especially reading the domestic special focus (see AquaStress D2.2-2). The main findings and recommendations for the water stress related to the domestic sector were:

- Municipal wastewater effluents should be controlled, particularly in regions overlying vulnerable groundwater sources. Incentives are also required to promote sustainable farming practices for reducing agricultural pollutants entering groundwater sources used for drinking water.
- Further feasibility studies into wastewater reuse are required including social and institutional receptivity, economic feasibility, and necessary policy mechanisms to promote implementation.
- Investment at the national level has been used successfully to improve rural water infrastructure, and improve conditions for the rural poor. However, national investment has by-passed urban poor. At the same time, private involvement in urban areas has led to some improvements for some socio-economic groups, but according to some reports the urban poor have (again) been by-passed.
- The experience of market failure due to the existing gap between investment needs and economic capacity means that procedures for further introduction of the private sector in developing countries need to be returned to, in order to avoid similar problems relating to equity in the future. Two suggestion are that ‘the market needs to be entirely built before being efficient’ and ‘continuous monitoring of the paying capacity of different urban social groups’ could give direction in developing future strategies in managing these problems.
- There is a requirement for the introduction of mechanisms to regulate private sector involvement in the water sector.

For sure Tadla is a real water stressed case study because water availability does not allow any more to reach the standards defined by the past for agriculture, water quality is deteriorating challenging domestic sector activities and ecological functions and adaptability conditions to reverse this system seems to be absent or hardly accessible at present time.

4 Stakeholder perception versus factual analysis per sector

The European Water Framework Directive (WFD) is an example of the problems that arise when bringing trans-boundary strategies to the local level. The implementation of the WFD faces different difficulties arising from the universe of countries that have signed this legal framework. An example of this is already visible in the on March 2007 published map on heavily modified or artificial water bodies. The information to produce this map was obtained through submissions of the different countries in accordance with Article 5 reports of the WFD. Differences in the countries' perceptions have shown that e.g. Portugal and Spain have different perception on the shared river basin. Even the Rhine and Oder basin are under different categories depending on the different political border in which they flow. The implications of that are also differences in the perception of problems not only at the national but even trickling them down to the local level. All EU directives have to be translated into national law and, furthermore, need a national or regional execution on the ground. Thus, the EU requires improvements on how stakeholder perceptions are assessed, how it responds at a European scale to stakeholder driven demands. These responses need to be consistent with a host of European environmental, social and economic policy and legislation.

Within WB2 we have analysed perceptions of the stakeholders involved in our test sites using a framework (see Figure 1). This framework was presented in D2.2-1. The main goal was to characterise the actual perception on water stress in phase 1 and to use the information to inform researchers and participants in the project so that in phase 2 a reframing and reassessment of water stress can take place and a more accurate situation of the problem and even a more precise combination of mitigation options for water stress can be implemented.

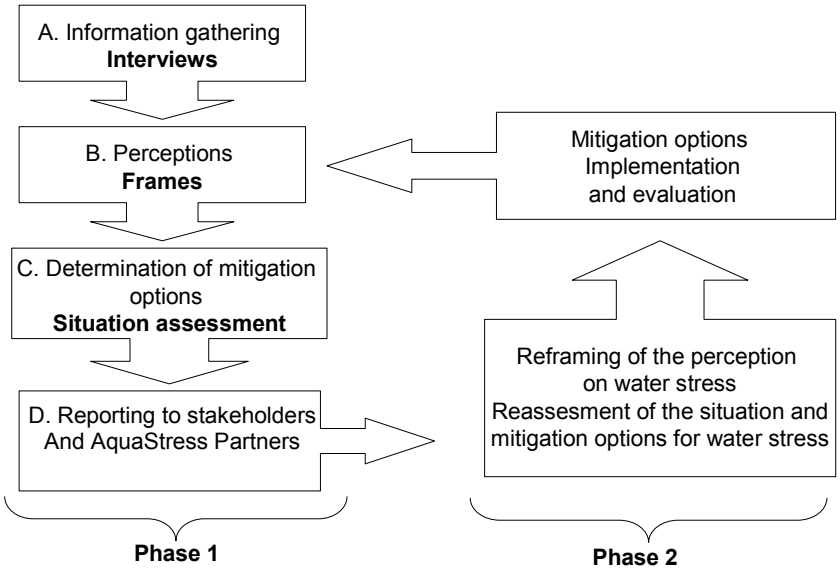

Figure 1: Framework for the analysis of water stress (out of D2.2-1).

The main outcome of using this framework was to be able to characterise the disparities in perception of the problems that were first defined by researchers when proposing the AquaStress project. Furthermore we investigate current practice of how to deal with water stress in different sectors. With the results of the framing of

the situation in the different test sites we were able to characterize the situation for the test sites in which our work was deeper: Guadiana, Vecht, Bulgaria and Morocco.

Table 2 gives an overview of the scientific framework as defined at the start of the project, the factual analysis and the stakeholder framework. As an example: stakeholders from the Bargerveen Area – corresponding to the test site Vecht in the Netherlands – did define the problem from different views giving an almost impossible common definition of water stress. So the perceptions differ from “to high water levels for the agricultural water sector” to “to low water levels for the nature protecting sector” (see Table 2).

The Vecht case study is not an isolated one in the project. Examples of the disparities reflected in D2.2-1 gives us enough reasons for suggesting that the factual analysis is far from local stakeholder perceptions and the reality of the test sites. There are major knowledge gaps in the concept of water stress and the local level and therefore it is very difficult to address the problem properly and to implement the suitable mitigation options for water stress. Key research priorities are consequently the in-depth study of perceptions related to water stress and the standardisation of those perceptions to be able to cope with water stress under different conditions.

Table 2: Overview of the water stress issues in the different test sites based on: the scientific framework as defined at the start of the project (Table 6.1 DoW AquaStress), the factual analysis and the stakeholder framework.

Site	Initial Scientific frame	Factual Analysis	Stakeholder frame
Guadiana	• Stable water resources, in average. Although water availability is, on average, enough to attend to water uses, Guadiana's basin has been mostly affected by droughts (11 extended droughts on a 50 year period), some of those periods with no affluences from Spain, when some major local deficits occurred. • Water shortages, aggravated in the summer and irrigation period; high urban water supply and irrigation losses; groundwater overexploitation due to water deficits. • Impacts on ecosystem degradation (surface and groundwater pollution; low or even no flow on dry years on bordering stretches) and on regional economy. • No urban water supply problems • The surface waters are considered inadequate to the various uses, mostly due to the pollution caused by Spain and also by national	• The Alqueva dam will change the water situation profoundly. However, too short term to draw conclusions • Using about 95% of the total amount of water used by society, the agricultural sector is the only sector where water quantity is an issue. • The most decisive factor influencing farmers decisions seems to be the CAP and the amount of subsidies received rather than production or crops with high market value. • Current priorities in case of drought are sufficient to prevent quantity problems in the domestic and industrial sectors for most of the Guadiana basin. • An integrated focus on water quality could benefit both environmental and domestic needs • The paradigm that a high variability is a problem, and the building of dams and reservoirs a solution to it, forms a threat to the natural dynamism that the aquatic ecosystems in this region are adapted to.	• Miss management of the distribution of water • Inter temporal (seasonal) water scarcity, • Groundwater depletion (all sectors) • Salt water intrusion in the southern part of the Guadiana *Future problems*: • environmental problems caused by the Algueva dam. The Algueva dam will make the region highly dependant on this single water resource. The inflow of the reservoir depends on the agreements on the water releases between Spain and Portugal. • Pollution is not caused by Spain but more due to the diffuse pollution sources within the Portuguese border

Site	Initial Scientific frame	Factual Analysis	Stakeholder frame
	agriculture, with groundwater parameters often not acceptable for drinking water use	The increase in exotic fish species is one of the most obvious examples of the negative effects of a more stable situation.	
Vecht	• High level of institutions • No particular problem description • Flooding can be a problem in the wet season and drought in the dry season.	• Low groundwater levels have resulted in drying of important wetland and groundwater dependent nature areas. • The river regulation and hydromorphological measures to increase drainage and flood protection are the major problems for the biological quality of the river, despite the low to reasonable water quality • Retaining the water in the area as long as possible, with adapted land use planning to minimize damage to agriculture is seen as the final challenge. • Water quality is a continuous concern.	Clear description depending on the back ground of the stakeholders: • *Nature protection* (Staatsbosbeheer, Natuur Monumenten, …): ground water level lowering because of farming practises • *Farmer organizations* (Ministry of LNV, LTO): high groundwater tables, growing conditions less than optimal, which forced farmers to install costly technical solutions (draining and pumping). No real water stress if all technical solutions were applied, but causing economic burdens (i.e. stress) • *Tourist sector*: water stress caused by disagreement between farmers and nature organizations, causing institutional water stress. For example wet camping places, flooded bike tracks, dry meadows with unattractive vegetation.
Iskar	• Non-rational use of the regulated water volume of Iskar reservoir,	Intermittent drought/floods (~eight year cycle) is considered one of the main causes of water stress.	• Scenarios for the development of agriculture and strategies to guide it;

Site	Initial Scientific frame	Factual Analysis	Stakeholder frame
	• the trend to drought, • the high percentage of drinking water losses in water supply network (about 50%), • the usage of potable water for industrial needs and river pollution due to uncontrolled disposal of domestic and industrial wastewaters and waste. • The multipurpose usage of the waters of Iskar reservoir (drinking water supply, industrial water supply, irrigation, energy production) determines its complicated management.	• Water quantity problems, i.e. irregular water supply during the year (either high flow of low flow), dissipation of drinking water and high demand of water from the Iskar reservoir • Water quality problems are the result of domestic and industrial waste water discharges and by agricultural nutrient loadings.	• Integrative strategies for water distribution from the Iskar dam to be prepared for droughts; • Support in economic strategies to finance investments in water management; • Enhanced cooperation and conflict resolution between agriculture, energy and industry concerns; • Improved stakeholder awareness of use of water, pollution and prevention of wastage; • Improved repair strategies for water supply network; • Waste water treatment for upstream villages; • Water treatment for industry;
Przemsza	• Surface waters are polluted due to inadequate water-sewage management policy in towns in the Przemsza catchment, industrial sewage drops and agricultural pollution. • Quality of groundwater used for municipal purposes is good. • Waters returned to surface waters	• The main sectors influencing water stress are industry and domestic water supply. • The high demands and the subsequent distribution of water between the industrial sector and the domestic water suppliers is the main cause for water stress. • The added value per m^3 water supplied is considered low.	• Quality of water (cleanness, possibility to drink without boiling it) • Dysfunction of rivers for sustaining life supporting (i.e. water supply, transportation, recreation, landscaping, irrigation etc.) • Dependence on inter-basin transfer of potable water.

Site	Initial Scientific frame	Factual Analysis	Stakeholder frame
	from mines are excessively saline. • Water resources quantity is in a better state than water quality, and is result of water retention reservoirs and reduced water demands for municipal and industrial purposes. • The water sector at the regional scale in Poland is still dominated by governmental agencies.		
Tadla	• The sustainability of the exploitation of groundwater resources is questionable. • The groundwater quality is heterogeneous, and some farmers irrigate with saline water. • There is concern on its adverse impact on soils and groundwater. Groundwater levels are going down, prompting farmers to exploit the captive aquifer with questions on its sustainability. • The viability of farms not having access to groundwater is threatened due to severe restrictions in surface water supplies. • Despite technology, farmers use more water than they did 10 years ago and technical innovations are not	• The main concern is water availability for irrigation. • The main problem comes from the reduction of the water allocation to the canal system that seems to be permanent now and induce behaviours consisting in drilling deeper and deeper, risking to challenge domestic consumption. • The propensity to mitigate water stress in the agricultural sector is seriously challenge by the low financial capacity of farmers, the low level of education and the structure of the property that is very in-egalitarian. • The water stress issue in the domestic sector (low level of access to water) is due to 3 principal factors: (i) the rapid population increase that does not allow maintaining the level of connection to safe	• Anarchic development of pumping stations which results in an increase in groundwater outtake. • The state cultivate or propagate the cultivation of cropping patterns with a high water demand • Precipitation decrease in combination with a bad surface water management would lead to groundwater overexploitation. The State would not sufficiently control groundwater outtake • Climate and lack of financial means to invest in irrigation technology • Miss management of water resources • “there is no culture of a good valorisation of water”; farmers do not manage water well

Site	Initial Scientific frame	Factual Analysis	Stakeholder frame
	adopted by a majority of them. • Water users associations do not assume much responsibility in water management. Questions related to farmers' participation in the formulation and application of water saving policies, and the scope for collective action in water saving at the grass roots level need to be taken up to ensure a more sustainable water use for a viable irrigated agriculture	water and sewage infrastructure, (ii) the lack of public investment in this sector and (iii) the low possible contribution of water users to finance the services provision. • The environment receives most of the impacts of water stress of other sectors: industrial waste water, nitrogen, phosphorus and phytosanitary pollution, low flows in rivers.	• No adaptation by farmers to the water situation, i.e. by cropping pattern change or the utilisation of new technologies

When looking at deep to the descriptions and the public perception of the problems regarding water stress, we realised that the definition for water stress can not be only understood as water scarcity. Therefore, in the actual situation of our test sites, it is difficult to attach a policy to the problem of water stress. Water stress is one of the phenomena, under the fluctuation margin of climate change, in which we realised, that definitions *per-se* must adapt to the changes in time. The characterisation of water stress depends deeply not only on the bio-climatic and geographic conditions of an area but also on the socio-economic and political circumstances of this particular area. Also, when characterising water stress, the results delivered by research reports and the results produced by models influence the perception of water stress bringing sometimes with the same data and results, different observers to different perceptions of the same problem.

Additionally, some areas in Europe, as our case study the Guadiana, will suffer in the near future an "induced" water stress. As today's influences through European programmes (e.g. common agricultural policy subsidising particular crops like olive trees), the creation of a "new" water stress situation has appeared for which the locals do not have the traditional copping patterns. This implies that under the former conditions and the production and consumption pattern that area would have been able to adapt to e.g. changes in the water household. Consequently, not only a new definition of water stress is needed, but also an adaptive matrix of the problem definition including the institutional problem definition, stakeholder perceptions, influencing policies, consequences and the different adaptive management strategies (see Figure 2). We believe that in this way social systems will be capable to adapt to the new threats of climate change and to find easily mitigation options that would alleviate if not mitigate water stress.

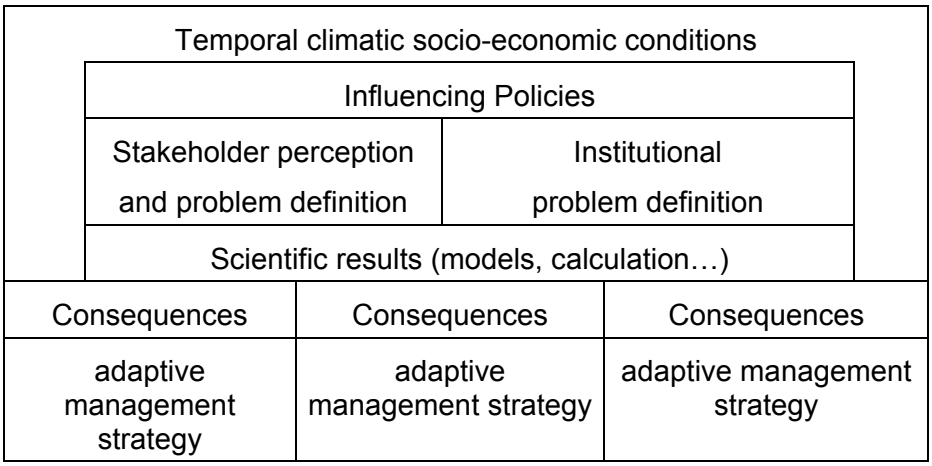

Figure 2: Adaptive matrix of problem definition (Manez, forthcoming).

Due to the extent of the project and the limitations in time, this research line will be out of the scope for the AquaStress project. Nevertheless, a need on this research topic appears essential to be able to act fast when facing a crisis but also to predict possible future problems. The vision would be to have not only adaptive management strategies but also adaptive problem-threat-stress definition rules linked to the management strategies. Our belief is that a good mutual understanding of the problem and causes can greatly help to derive a solution against much less costs.

5 Conclusions

Comparison of the initial scientific frame as was described at the start of the AquaStress project , the factual analysis and the perceptions of the stakeholders interviewed showed the large difference between the different sites. Some findings may be generalised as follows:

- To obtain a good insight in the bio-geophysical system as well as the socio-economic setting often data were inadequate. This made it difficult to assess the water stress. It also stresses the need for a good monitoring network.
- A number of sites indicated that the distribution of the amount of water over the different sectors is the main problem.
- In these cases, institutional and social settings are key, to come to acceptable solutions.
- Although environment is often mentioned, it is not a well represented stakeholder in most of the sites studied.
- Future problems that may aggravate water stress such as climate change, but also the impact of European policies (CAP, bio-fuels etc.) are difficult to take into account by most stakeholders.

The agricultural sector as the biggest water user in most sites, is compared to other sectors like households or industry, confronted with a huge quantity of types of agricultural water uses, each type having potentially a different impact on water stress. Furthermore, the agricultural sector is characterized by a relative instability of its components over space and time (intra-annual and inter-annual variations).

Beyond the difficulty faced to address the plurality of determinants, there are generally gaps in the data availability, both at the local scale as at scales that do not correspond to administrative units. These gaps can concern physical characteristics like soils structures, hydro geological parameters, as well as socio-economic ones like education level, employment, farm revenues.

As a consequence it is also difficult to assess the impact of a change on a large scale for example changing furrow irrigation to drip irrigation on the water availability for other users of the same physical water system.

To enable the development of integrated perceptions of the water stress mitigation options also adequate data on the biophysical boundaries of the catchment involved are needed. The latter can greatly help in the process to transform perception based into more objective based integrated options. Insight in the area of influence, both for the physical as for the administrative level it is important when developing mitigation options. It should be noted that these areas are not fixed and may change in time.

More knowledge is needed to be able to act fast when facing a crisis but also to predict possible future problems. Not only adaptive management strategies should be developed, but also adaptive problem-threat-stress definition rules linked to these management strategies should be developed. Great care should be taken to make these as site specific as possible.

6 References

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