The „Dead Sea“ Project: Is a More Sustainable Water Management in the Dead Sea Basin Possible?

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Summary

The Dead Sea basin plays a major role for regional economic development (industry, tourism and agriculture). This potential is threatened by the steady disappearance of the Dead Sea. Since around 1930 the water level of the Dead Sea has fallen by about 25 m, about half of this alone in the last 20 years. These causes for the decline are a direct result of the water management strategies of the riparian and upstream countries. Water from the natural inflows (the Jordan River and side wadis) has been blocked and diverted for urban and agricultural uses inside and outside the watershed. In addition, much water is pumped from the Dead Sea into evaporation ponds, which alone constitutes about 25 % of the present total evaporation rates. The decline undermines the potential as a tourist destination, despite the enormous investment in hotel and resort infrastructures in Israel and in Jordan. The decline also raises ethical issues about the exploitation of water resources by the present generations at the expense of the natural heritage in the future.

The „Dead Sea“ project aims to synthesize and assess existing physical and socio-economic data and to assess options for a better future. It will identify the patterns of water supply and use in the region, and the factors that control these patterns. The underlying assumption is that solutions for a more sustainable development than today scenario will not come from simply providing "more water for more development", but from a new land and water management system that is sensitive to social, cultural and ecological resources.

As a first step, the team has established a system model that combines the physical and social dimensions of water use. Data, information and knowledge between the human dimension (economy, sociology etc) and the physical dimension (hydrology, ecology, agricultural, water planning) are linked under changing scenarios. This identifies the key driving forces that determine water use. Preliminary results make already clear that current water usage is very unequal, and that it is obviously not based on strategic, rational or on socially equitable criteria.

1 Background

1.1 Lessons Learned from the “Jordan Valley” Project

The project builds upon a similar study in the region that was made during 1998-2001 in the Lower Jordan Valley. In this study, a project team with partners from Israel (IL), Jordan (JO), Palestine (PS) and Austria have established a harmonized data base and analyzed the water supply and use in the region. A description of this study and some results can be found on the project documentation website (http://system-forschung.arcs.ac.at/jowapubl/).

Results from this study (Orthofer et al. 2001) have shown that – contrary to what is usually thought – the Lower Jordan Valley has a per-capita water availability that much higher than in most regions of the Middle East. It is not a water-scarce region but the available water is unevenly distributed.

- Regionally water is unevenly distributed between the West and the East, and between the North and the South.
- Socially it is unevenly distributed between social groups in the West, namely between IL settlers and the PS population.
- Sectorally it is unevenly distributed because about most of the available drinking water is used for agricultural production in several regions while about 44,000 people in another region do not have access to drinking water to meet their domestic demand.

The conclusion of the “Jordan Valley” study was that it is not the scarcity of the natural resource itself that causes the apparent water shortage but the scarcity of proper supply and demand management. The project team had recommended a demand-side management approach that should be directed towards a better use of the available water. A “more sustainable system than today” water management would guided by setting priorities on the water use, and by utilizing the available water qualities according to their best use. Drinking water should be used with first priority to satisfy the domestic and urban demand. Remaining drinking water would then be used to make the best economic and societal use that would generate income and promote the quality of life. Agriculture, on the other hand, would be scaled to match the remaining water, mainly re-used urban wastewater.

The “Jordan Valley” study had a serious shortcoming. All assessments and recommendations were based only on “rational engineering-type” considerations and had no social feasibility assessment and no user participation. Therefore – while the engineers would recommend to replace agriculture through tourism or other services – there was no one in the team who would assess if the population was prepared for such changes and how such changes would affect the social fabric.

1.2 The “Dead Sea” Project

Following the lessons learned from the “Jordan Valley” project, the authors of this paper have tried to put together a new study design for assessing options for a sustainable water management the Dead Sea basin, working in close collaboration with social scientists and economist and with an intense participation of the users.

The project encompasses the development of a GIS-based database that contains harmonized and comparable physical, economic and social data, including consistent sets of maps that document the spatial dimension of current and projected water supply and demand sectors, and of land-use patterns that drive water supply and demand. It also will establish realistic development scenarios until the year 2020 with social, economic, technical and ecological constraints. The project team will also try to establish criteria for essential water requirements for nature & ecosystems, and to propose socially, economically & environmentally sound alternatives for irrigated agriculture.

2 The Dead Sea Basin

The Dead Sea Basin is particularly appropriate for such a study. It has a size of about 44,000 km² and its watershed is shared by Israel, Jordan and Palestine (Figure 1). Details about the project can be found on the project website: http://www.dead-seaproject.org.

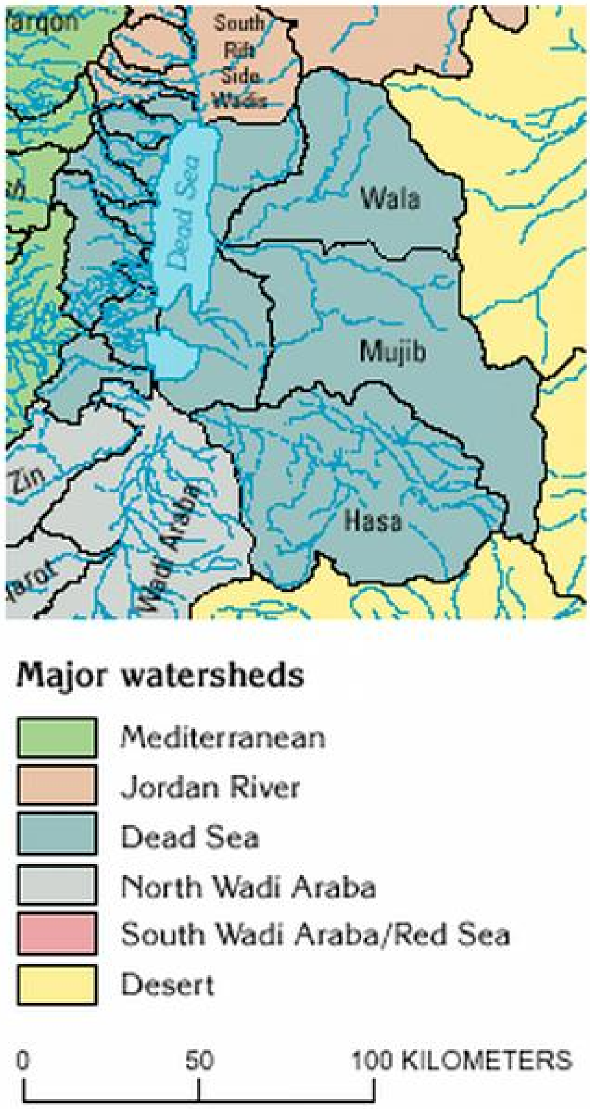

Figure 1. The Dead Sea watershed (from EXACT study: Assaf et al. 1998)

The basin plays a major role for regional economic development. Current economic activities in the basin are industrial (mineral extraction and water bottling), tourism and agriculture. The Dead Sea's mineral composition and the unique climate provide treatment for skin diseases, especially for psoriasis and atopic dermatitis (Schempp et al. 2000). The health and cultural feature plus the unique landscape have made the area attractive for tourism.

Besides the regional relevance, the basin has a global importance. Since 1998 there are efforts to promote the Dead Sea Basin as a UNESCO Man and Biosphere Reserve and a World Heritage site (Abu Faris et al. 1999) because it is a both a unique habitat for wildlife (particularly important around springs (e.g. Ain Fashkha, Ain Gedi, Wadi Mujib) and wadis and a global cultural heritage site with some of the world's oldest human settlements.

2.1 Physical Features

The Dead Sea is the terminal lake of the Jordan Rift Valley. Its surface is currently about 417 m below sea level which makes it the lowest point on earth. With a salinity of about 3,000 mg/l it is also the most saline water body in the world (Gertmann 1999). Rainfall is limited to winter months; it varies from about 500 mm/yr in the north-western highlands to less than 100 mm/yr in the valley floor (Isaac et al. 2000). Perennial storage in surface and underground water reservoirs is limited and vulnerable to pollution and depletion. Potential evapotranspiration in the valley floor is about 2,000 mm/yr, and actual evaporation from the Dead Sea surface is about 1,300-1,600 mm/yr (Stanhill 1984). The temperature is about 40°C in summer and 15°C in winter (Assaf et al. 1998). At the east and west there are steep escarpments, while in the north and south, the valley stretches gently upward along the Jordan River and along the Wadi Araba, respectively.

The historical Dead Sea consisted of two basins: the deep northern basin (which is now the only remaining Dead Sea proper), and the shallow southern basin from which the Dead Sea has retreated since 1978. The two basins were divided by the Lisan Peninsula.

2.2 Pressures on Ecosystems

The land cover is mostly open with little vegetation. Sensitive areas include the Lisan peninsula area, marshlands and wetlands at the northern and southern ends of the Dead Sea, the Wadi Mujib, the Ain Gedi oasis, and the Dead Sea itself (Fariz 2002). Lack of natural freshwater, expansion of human settlements, and inappropriate land use has affected these areas.

Waste waters from local domestic, agricultural, industrial and tourist activities flow directly into the Dead Sea. Raw sewage flows into the Dead Sea from Jerusalem-Bethlehem urban areas via the Wadi Nar (Kidron valley). Water shortage and land degradation are a problem all over the basin and these are likely to exacerbate with population growth (Rishmawi and Hrimat 1999).

2.3 The Declining Dead Sea

The most visible and most disturbing degradation is the decline of the Dead Sea water level and volume. Since around 1930 the water level of the Dead Sea has fallen by about 25 m, about half of this alone in the last 20 years (Anati and Shasha 1989; Assaf et al. 1998). In the past few years the rate of decline was 80-100 cm per year. The last available data from mid-2003 indicate a water level of -417 m (Figure 2). As a result of this decline, in the last 20 years the Dead Sea surface area has shrunk by about 30 %, and its north-south extent has shrunk from over 75 to 55 km (Anati and Shasha 1989). Since 1978, the Dead Sea has completely retreated from the southern basin, which presently consists only of artifical evaporation ponds.

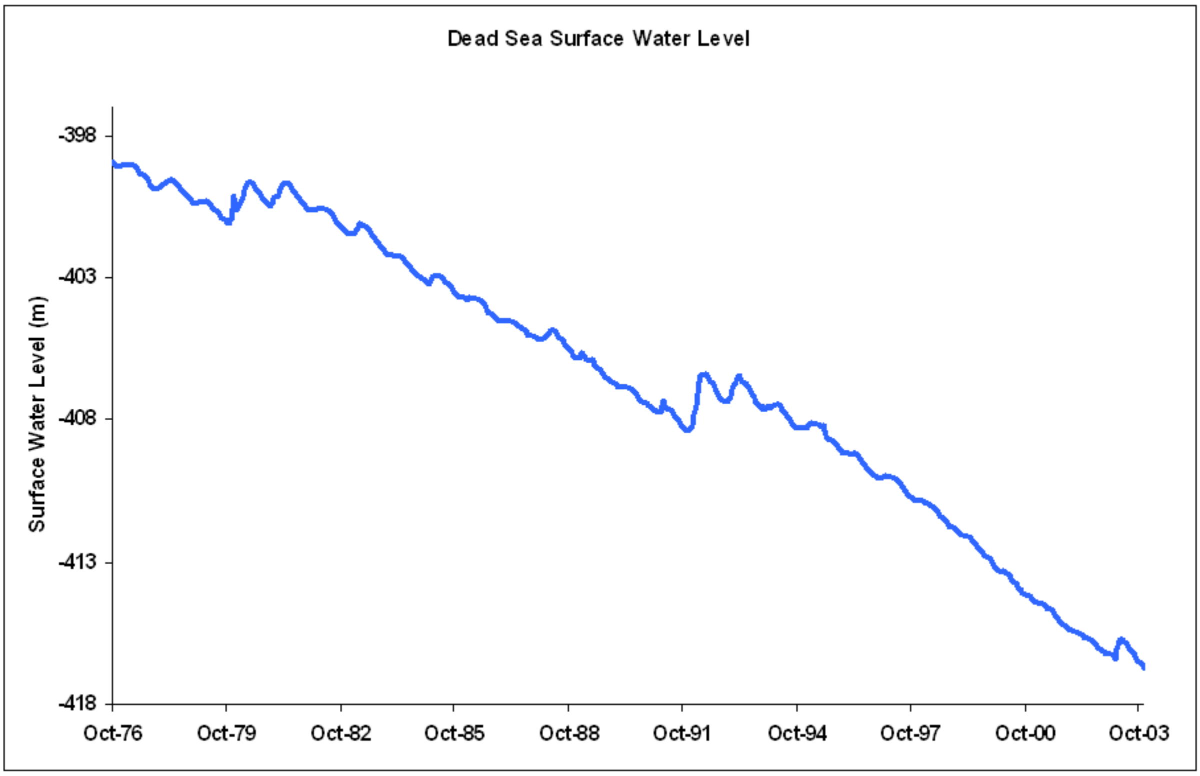

Figure 2. Decline of Dead Sea water level 1976-2003 (Data from IL Hydrological Service)

The reasons for this decline are well-known:

- First and foremost, the decline is a direct consequence of the declining freshwater input: this includes decreasing discharge from the River Jordan, increasing water use from natural springs and side wadis, and extensive use of aquifers that provide secondary water input (Klein 1985). Of all these factors, the River Jordan plays probably the biggest role. Insofar the Dead Sea's steady disappearance is a direct result of the water management strategies of the River Jordan riparians. While 100 years ago the River Jordan discharge into the Dead Sea was about 1200-1300 million cubic meters per year (MCM/yr) of freshwater, it has been reduced to about 900 MCM/yr by the 1940's and now is not more than 100-200 MCM/yr of saline and polluted water (Hillel 1994; Rabi 1997; Al-Weshah 2000; Orthofer et al. 2001; Shavit et al. 2001). The main reason for this decline is that water from the Upper Jordan River as well as water from the Lower Jordan River tributaries (e.g. Yarmouk, Zarqa) has been blocked and diverted for urban and agricultural uses inside and outside the watershed.

- On top of the reduced freshwater input, more than 200 MCM/yr water are pumped out of the Dead Sea into evaporation ponds in the shallow southern basin. It is estimated that the salt industries contributes 25 to 30 % of the present total evaporation rates (Wardam 2000).

It is not clear whether the Dead Sea water level has now come to equilibrium between the reduced surface and a reduced evaporation, or if it will continue to decline.

2.4 Consequences of the Decline

As a result of the lowering of the water level, the adjacent aquifers are seriously affected (Yechieli 1996). Sinkholes have opened up along the shoreline, caused by lowered water tables and groundwater over-exploitation (Bowman et al. 2000; Baer et al. 2002). Furthermore, the decline of the Dead Sea also affects the freshwater springs on its shores (e.g. Ain Fashkha, Ain Turiba) that support a unique biodiversity. The decline of the water level has also already had a serious effect on tourism.

The current trend has a disastrous effect of the future situation. The growing population in all three countries will increase the pressure for the freshwater that currently remains unused. The possible re-settlement of returning Palestinian refugees will also increase demand in Palestine. Palestinians demand as part of a regional water agreement that more water should be allowed for the Lower Jordan River and that this additional water should be usable for the Palestinian population. This, of course, means that the Dead Sea would not benefit.

For the next few years, there are plans for the further tourism and industrial development of the area including the construction of over 50,000 new hotel rooms (Meunier 1999). In all three countries, development policies have disregarded impacts on the environment, indigenous people and small farmers. Essential water needs for nature were neglected; policies lacked incentives to promote local forms of environmental security and equitable access to natural goods and services. Water is increasingly allocated to the urban sector and to large-scale agriculture on the expense of the needs and rights of the rural and indigenous people. Consequently, the rural poor and indigenous are overexploiting land resources to sustain their livelihoods.

The declining Dead Sea undermines the potential as a tourist destination, despite the enormous investment in hotel and resort infrastructures in Israel and in Jordan. For the fledgling Palestinian economy, the present state of the Dead Sea suggests that it may never have the opportunity to develop what should have been one of its more attractive tourist locations that could provide critical employment to a growing workforce.

Furthermore, the decline of the Dead Sea raises ethical issues regarding the exploitation of present generations of water resources at the expense of the natural heritage in the future. Many would argue that it represents an intolerable violation of the rights of future generations.

2.5 New Water from Red-Dead Canal

There is concern in the region about the threat of a disappearing Dead Sea (EcoPeace 1998; Coussin 2001), but very little progress. Most options for solving the environmental and economical problems focus on the provision of „new water from outside“, particularly through a canal between the Red Sea and the Dead Sea (“Red-Dead Canal”). This 240 km conduit is expected to replenish the missing inflow, use the gravity pressure for desalination through reverse osmosis, and for production of electricity. Costs are estimated to be around 3 billion dollars (Pearce 1995). Among the questions which remain unclear are the environmental impacts of the canal, e.g. the chemical changes of the water.

3 Preliminary Results

The “Dead Sea” project has started in early 2003. Currently a number of activities are ongoing, and a few preliminary results are already available. Some of these results are presented in detail at the MEDAQUA’04 workshop (Gebetsroither et al. 2004; Rishmawi et al. 2004; Trottier 2004). This presentation will summarize the overall status of results.

3.1 Data Harmonization

The three regional partners are in the process of establishing a harmonized data base with data that relate to water supply and use. While many data have been collected, only few of them are already in harmonized format (Figure 3).

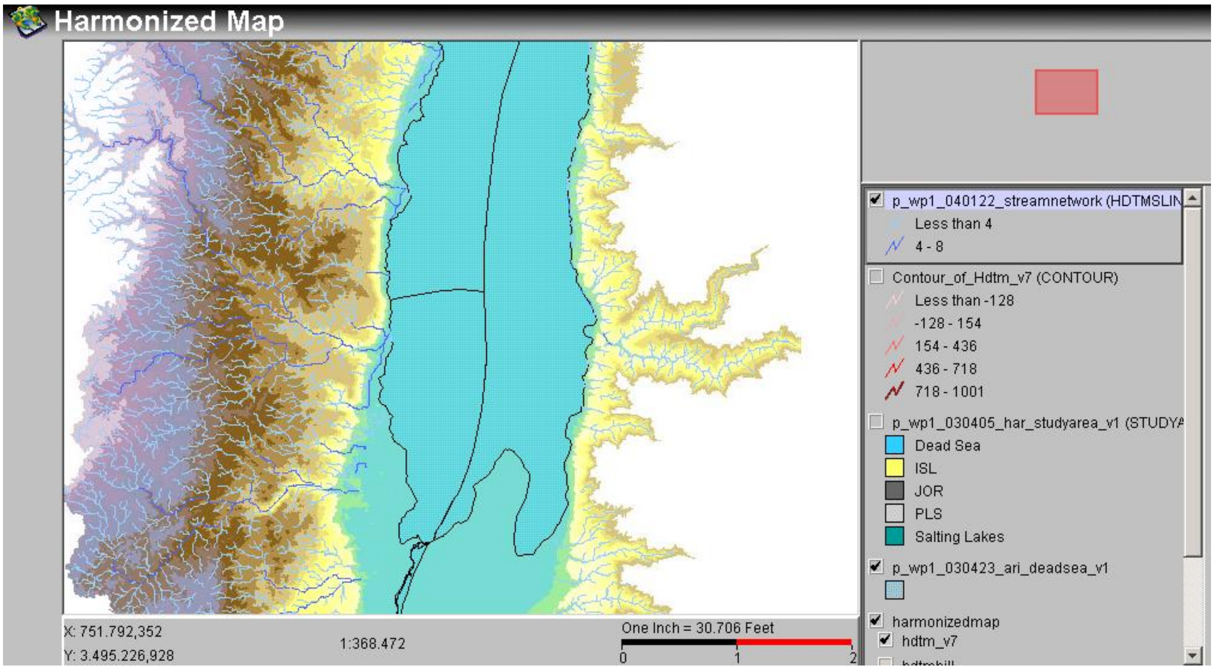

Figure 3. Example of a harmonized map of the region accessible through a web-GIS: administrative borders, Dead Sea water body, contour lines, surface water bodies and wadis

It is expected that by the end of 2004, there will be about 20 GIS datasets that contain information about water sources (e.g. rainfall, wells, springs, surface water) and water usage patterns (e.g. population, land use, irrigated areas).

The project team considers data harmonization particularly important, because of the many data that are available only few are comparable. Simply having available data from the three countries in a comparable and unified format is a value in itself.

3.2 Scenario Development

The project will develop realistic development scenarios for the Dead Sea basin for the period 2000-2020 that consider social, economic, technical and ecological chances and constraints. It was particularly important to develop socio-economic indicators to describe the social dimension of development. Activities have focused on establishing appropriate methods and tools for scenarios. First results have shown that it is necessary to define a limited number of development indicators.

A scenario management tool has been developed that allows to translate overall aggregate development trajectories (e.g. “green tourism”, “more water imports”) into concrete scenarios with the appropriate parameters. Three main driving forces of change have been defined: regional cooperation, investments, and the role of agriculture (cf. Table 1). These three driving forces will be categorized into two levels each (high/low), so that in the end there would be eight scenario options. These scenarios options will be discussed with the regional development authorities and communities. One of the final scenarios will reflect “current/no major changes” situation, i.e. with low level of cooperation and investments, and with a high role of agricultural activities. At least two of the final scenarios will be adjusted to a situation that will reflect a “more sustainable” water management.

Driving Forces	**Parameters**
A. Level of Cooperation	• Land administered by PS • Population - IL population & return of PS refugees • Volume of trade • GDP and HDI • Availability & price of desalinated water, treated wastewater, water imported from outside • Water allocated to tourism sector, local labour force in tourism, number of tourists coming into the area
B. Level of Investment	• New dams • Rainwater harvest • Efficiency of municipal & irrigation network • Water allocated to the domestic & tourism sector • Volume/costs of wastewater & reused wastewater for agriculture, tourism (landscaping) and industry • Availability & costs of water from Red-Dead Canal
C. Role of Agriculture	• Subsidies for agriculture (water & general) • Income per unit of water used agriculture • Investment in agricultural sector • Available labour force for agriculture • Protected area

Table 1. Driving forces and parameters for scenarios.

3.3 System Analysis

The purpose of the system analysis is to understand the complexity of interconnections of the water management system and its driving forces. This allows to identify options for system changes. The system analysis has three elements (Figure 4).

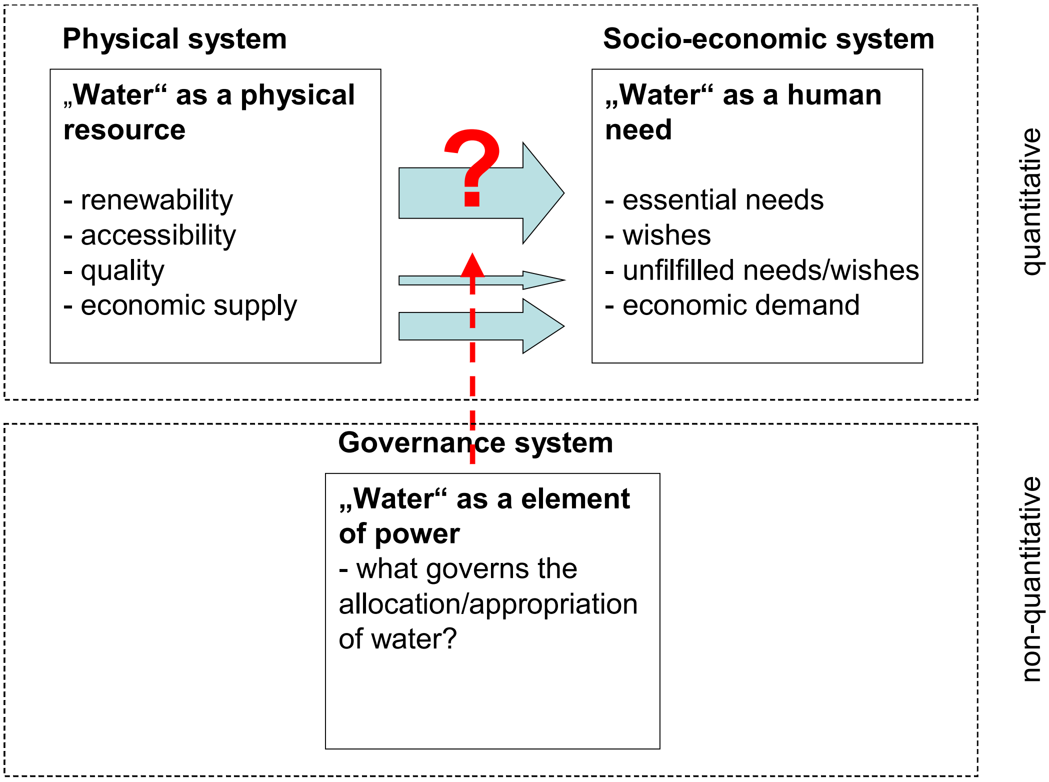

Figure 4. Interrelation of system analysis components.

Note: The physical system determines the availability of water in different quality categories, the socio-economic system deals with factors that determine the water wishes for different uses, the water governance system analyzes why some social groups have their wishes fulfilled and others don't.

- Physical system:
  This focuses on the physical dimension of water supply and use and the consequences on the environment (particularly nature, land/soil, and groundwater). The analysis also addresses the regional dimensions of the supply-use chain, and the exchange of water between the Dead Sea Basin and the region outside the basin. In the end, the physical system analysis identifies the factors that determine the availability of four different water quality categories through the economic system (“water supply”) and in the informal system (“informal water availability”).
- Socio-economic system:
  This includes the analysis of social and economic issues of water wishes and water use. Issues that are addressed include gender powers, traditions, health, perceptions, rights, equity, the role of communities, employment, benefits, income generation/distribution. Empiric data has already been collected to support the analysis. Finally, the socio-economic system analysis identifies the factors that determine the water wishes for different uses (agricultural, municipal, domestic, tourism, industrial) including water for nature.

Water wishes can be satisfied (“fulfilled”) or not (“unfulfilled water wishes”) through the economic system (“demand”) or through informal systems.

- Governance system:
  The analysis includes policies on national and regional levels, including institutional aspects of water governance and driving forces for policy changes. Other issues that are included are: traditional water rights, water policies in IL, JO, PS, players, role and power of stakeholders, international dimension, and conflicts of interest. In the end, the water governance analysis will analyze the factors that determine why some social groups have their wishes fulfilled and others haven’t.

Preliminary results from the system analysis indicate the problems associated with the supply-side water management: Within the “Systems Thinking” approach, a balanced system needs to have a negative feedback loop. This is the case with limited local water supply. In the long run more water availability will again result in more water wishes.

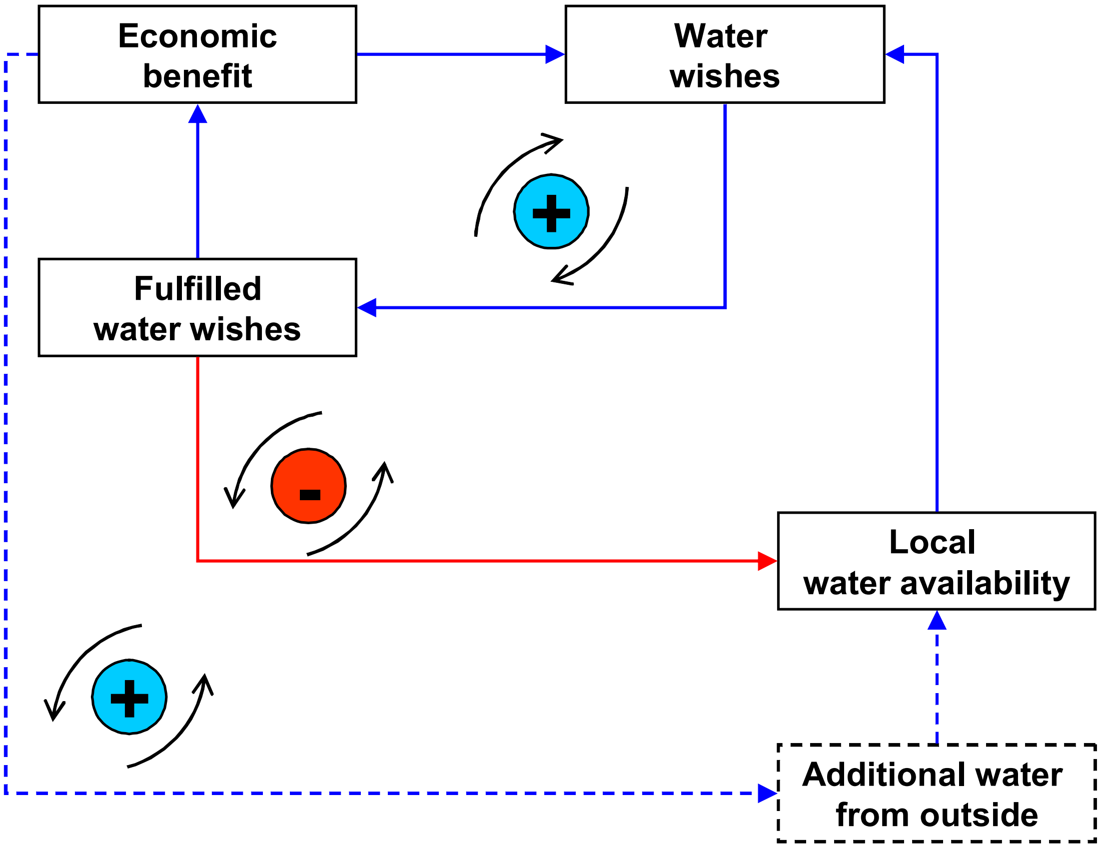

Figure 5. Aggregated causal-loop diagram for water use.
Note: In the local system (solid lines) the positive feedback-cycle (in blue: more „Fulfilled water wishes“ result in more „Economic benefit“ and more „Water wishes“) is counterbalanced through negative feedback loop (in red: more “Fulfilled water wishes” result in less “Local water availability”). The availability of additional water from outside (dashed lines) bypasses the negative feedback and creates a new positive loop: In the long run, more water supply leads to more water wishes.

3.4 Participation

The project partners intend to stimulate public participation through several focus group meetings in all three countries. A common methodology for these meetings has been developed. In May-June 2004 the first of such focus group meetings are being held.

4 Conclusions

Future regional stability will depend on an economic development, to which the Dead Sea region will be able to make an important contribution. This will require cooperation between Israel, Jordan and Palestine. The region has a high potential for economic development, particularly for tourism. Water is one of the most important limiting factors for development (Nowitz 1980).

Given the fact that nature has made Dead Sea the terminal sink of all freshwater sources in the basin water regime any withdrawal of water in the basin could be considered non-sustainable in terms of ecologic sustainability.

A "more sustainable than today" water management should be possible. The "Dead Sea" project will contribute to provide an assessment of strategic options for such a more sustainable water management. However, many questions remain still unanswered:

- What is the carrying capacity of the system and environmental resources?
- What is the impact of land use changes on the hydrological regime of the region? How can land use be optimized for a more sustainable water usage system?
- What are the competing interests and what are underlying factors for them?
- What are the essential water and land needs of nature that are required to preserve key processes?
- Are there possibilities to (partly) restore the natural inflow into the Dead Sea through a change in water management in Israel and Jordan?
- Do we have economic and technology development alternatives?
- How can tourist sector, industrialization processes and modernization of agriculture be developed without threatening the quality of the environment of people's livelihoods and well-being?
- How can sustainable development plans provide incentives to promote local forms of environmental security and equitable access to goods and services?

By addressing these questions the "Dead Sea" project team hopes to contribute to a better future.

For many regional and global policy makers the proposed Red-Dead Canal seems to be a "nearly perfect" solution to balance the Dead Sea water level, to maintain industrial activities, to promote tourism, and to produce freshwater. In a systemic view, it might well be that the Red-Dead project could alleviate some of the region's urgent problems. But it is already clear that in the long run an increase of freshwater supply will not be useful for an improvement of the situation.

The water management must be based on systemic solutions such as allocation priorities for different water qualities plus changes in the water usage patterns. Solutions for a more sustainable development will not come from simply providing “more water for more development”. Sustainable development will have to be sensitive to social, cultural and ecological resources as well.

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