A FUTURE FOR THE DEAD SEA BASIN: OPTIONS FOR A MORE SUSTAINABLE WATER MANAGEMENT

Elements for Environmental Risk and Security

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Abstract

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. The Dead Sea is the terminal point of the Jordan River watershed. As such, it serves as a barometer for the health of the overall system. Its rapid decline reflects the present water management strategies of the riparian and upstream countries.

Elements pertaining to environmental security, whereby a sustainably managed environment provides for social, economic as well as environmental benefits are evident with regards the Dead Sea. The decline for example, undermines its 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 present generations at the expense of this natural heritage to future generations.

This paper provides a preliminary analysis of a European Union funded project whose aims are to synthesize and assess existing physical and socio-economic data and to assess options for a better future for the Dead Sea. 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 thereby providing security and stability across sectors and nations.

As a first step, the project 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, agriculture, water planning) are linked under changing scenarios. The model is an attempt to reflect the complexity inherent in the system through the mapping of human and physical connections. An understanding of these connections can lead to a more secure environment for both.

1 Background

1.1 THE “DEAD SEA” PROJECT

The project partners, from Israel, Palestine, Jordan, Austria and the UK, have taken an interdisciplinary approach in assessing options for sustainable water management in the Dead Sea basin. This is being done by working in close collaboration with engineers, ecologists, social scientists and economists and including intense participation of the public.

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 and ecosystems, and to propose socially, economically and environmentally sound alternatives for irrigated agriculture, the dominant water consumer in the region. Further details about the project can be found on the project website: http://www.deadseaproject.org.

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).

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 features 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) as it is a both a unique habitat for wildlife (particularly important around springs (e.g. Ein Fashkha and Ein Gedi) and wadis (e.g. Wadi Mujib) and a global cultural heritage site with some of the world's oldest continuous human settlements (e.g. the city of Jericho).

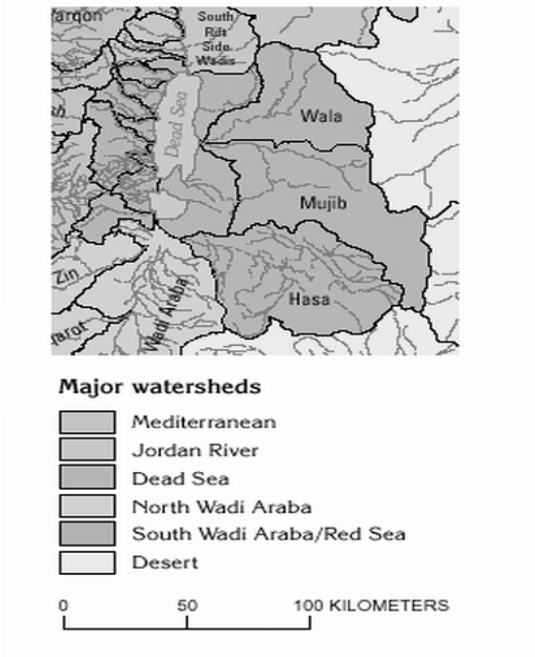

Figure 1. The Dead Sea watershed (from EXACT study: Assaf et al. 1998)

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 are 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, marshlands and wetlands at the northern and southern ends of the Dead Sea, the Wadi Mujib, the Ein 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 artificial evaporation ponds.

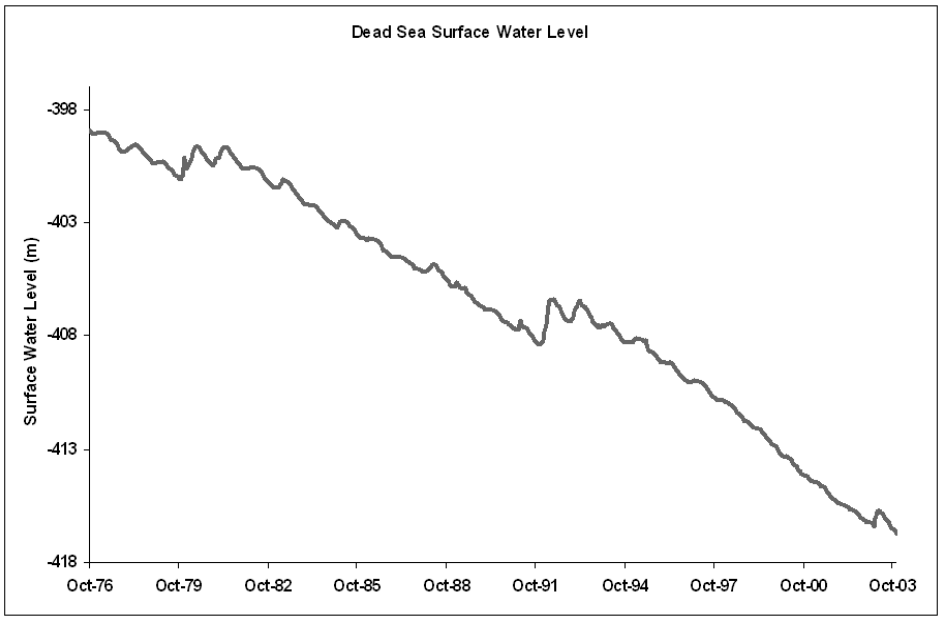

Figure 2. Decline of Dead Sea water level 1976-2003 (Data from IL Hydrological Service)

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 probably plays 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’s 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 of water are pumped out of the Dead Sea into evaporation ponds in the shallow southern basin. It is estimated that the salt industries contribute 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.

3 Elements of Environmental Security

3.1 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). These sinkholes are a serious threat to infrastructure development as they can cause, without warning, the collapse of roads, bridges and buildings. They also disrupt agriculture by making it unsafe to work with heavy machinery required for date harvesting. A number of date orchards have been shut down due to the threat of sinkholes.

Furthermore, the decline of the Dead Sea also affects the freshwater springs on its shores (e.g. Ein Fashkha, Ein Turiba) that support a unique biodiversity. The decline of the water level, in conjunction with the outbreak of the Intifada in September 2000, has also already had a serious effect on tourism. In Israel since 2000, international tourism to the Dead Sea has declined whereas domestic tourism in response to lower hotel and occupancy rates has flourished (Figure 3).

The current trend has a disastrous effect on 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 water 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 less for the Dead Sea.

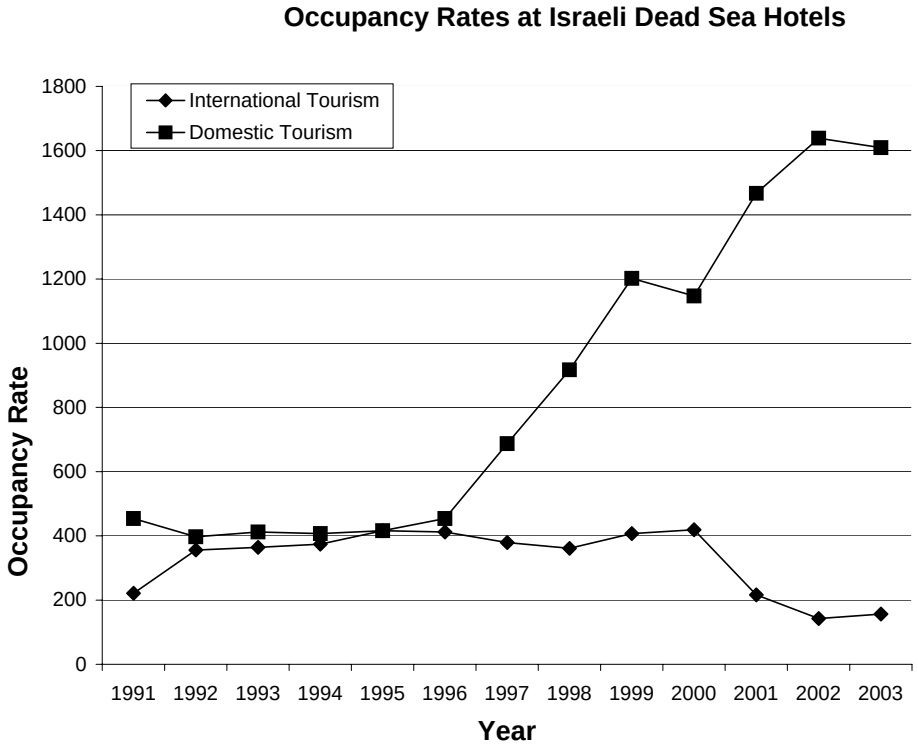

Figure 3. International and domestic tourism occupancy rates at Dead Sea hotels in Israel (Data from the Israeli Hotel Association).

In the next few years, there are plans for increasing 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 at the expense of the needs and rights of the rural and indigenous people. Consequently, the rural poor and

indigenous communities are overexploiting land resources to sustain their livelihoods.

The declining Dead Sea undermines its 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 by present generations of water resources at the expense of the natural heritage for future generations. Many would argue that it represents an intolerable violation of the rights of future generations.

3.2 NEW WATER FROM THE PROPOSED 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 that would connect 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 that will occur due to the mixing of the waters from the two seas.

This project is yet another example of engineering hegemony rife in the region. Yet, ultimately it is not a solution as it ignores the social and environmental impacts that such a project may cause and rather allows for the status quo to continue whereby water is diverted from the upper Jordan basin by both Israel and Jordan. If true environmental security is to be achieved then all elements need to be

taken into consideration i.e.: social, environmental and economical concerns must be incorporated.

3.3 SCENARIO DEVELOPMENT AS A MEANS OF ASSESSING RISK AND SECURITY

The project will develop realistic development scenarios for the Dead Sea basin for the period 2000-2020. These scenarios will consider social, economic, technical and ecological uncertainties and constraints. It was particularly important to develop socio-economic indicators to describe the social dimension of development as this is often not taken into account by planners and policy makers. 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.

These have been defined according to three driving forces impacting the region. These are: regional cooperation, investments, and the role of agriculture (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 than today” water management.

These driving forces can then be used to map out potential risks and securities for the Dead Sea basin. For example, if regional cooperation improves in the near future a likely result is an increase in development in the tourism and agricultural sectors. The former due to a more stable political climate and the latter due to a return of Palestinian refugees to Palestine. This bodes well for the security of the region but it may place an added burden on local water resources thus increasing the risk to the Dead Sea itself. From this simple example one can see the inherent complexity in such scenarios.

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 harvesting • Efficiency of municipal & irrigation networks • 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 in agriculture • Investment in agricultural sector • Available labour force for agriculture • Protected area

Table 1. Driving forces and parameters for scenarios (Source: Orthofer et. al., 2004).

3.4 SYSTEM ANALYSIS AS A TOOL FOR ASSESSING RISK AND SECURITY

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

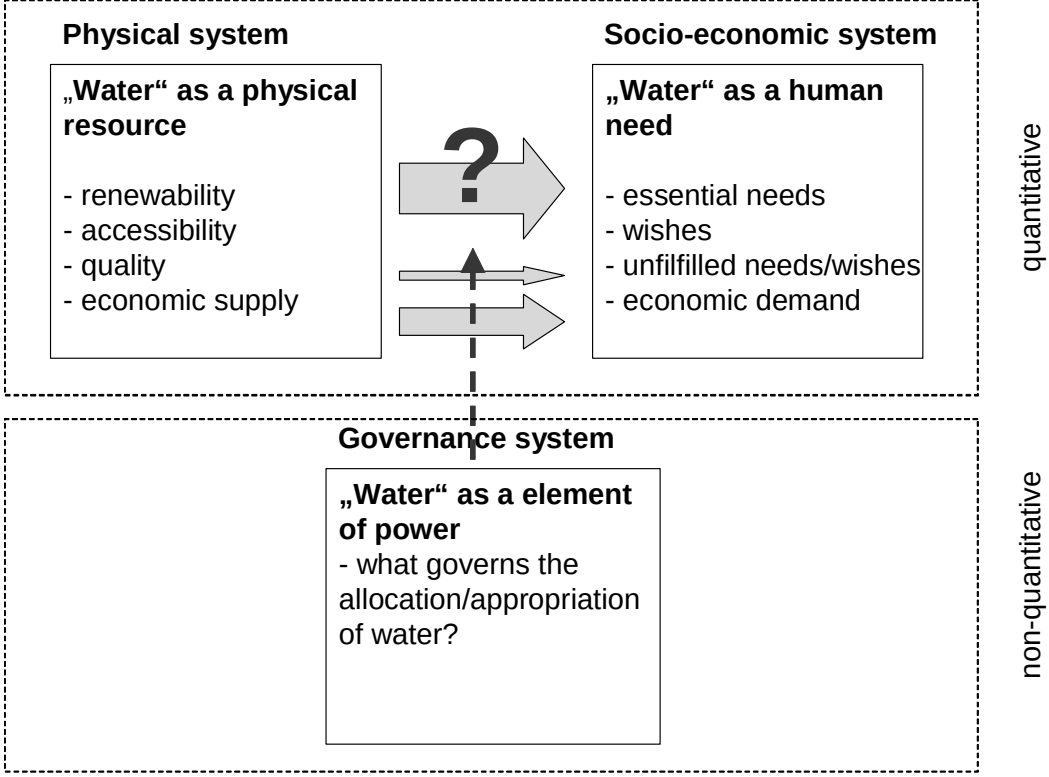

Figure 4. Interrelation of system analysis components (Source: Orthofer et. al., 2004). *Note: The physical system determines the availability of water in different quality categories, the socio-economic system deals with factors that determine the water wishes for different uses, the water governance 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 that are available. Water of low quality can be used for irrigation whereas water of higher quality is used for domestic purposes.

- Socio-economic system:

This includes the analysis of social and economic issues of water wishes and water use. A wish for water is how much water a person/sector wants over and above what is necessary. Water for basic human services is defined as a need for water. Once this need is met, any further want for water is a wish for water. These wishes for water may be fulfilled or unfulfilled depending on the capacity of the person or institution to fulfil them. Water wishes

can be satisfied (“fulfilled”) or not (“unfulfilled water wishes”) through the economic system (“demand”) or through informal systems. Issues that influence wishes for water include gender powers, traditions, health, perceptions, rights, equity, and the role of communities, employment, benefits and income generation/distribution. The socio-economic system analysis thus identifies the factors that determine the water wishes for different uses (agricultural, municipal, domestic, tourism, industrial) including water for nature.

- 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 Israel, Jordan and Palestine, 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 do not.

Figure 4 describes how these three systems are connected and how they influence one another. In order to minimize risk and maximize security one cannot look at these three elements separately. Consequently an integrated system perspective is crucial in understanding risk and security. The question mark in figure 4 indicates the inherent uncertainty that exists in any system. One can never completely remove uncertainty but a system analysis allows one to identify its source and work towards its reduction.
Within the “Systems Thinking” approach, a balanced system needs to have a negative feedback loop. This is the case with limited local water supply because in the long run more water availability will again result in more water wishes (Figure 5).

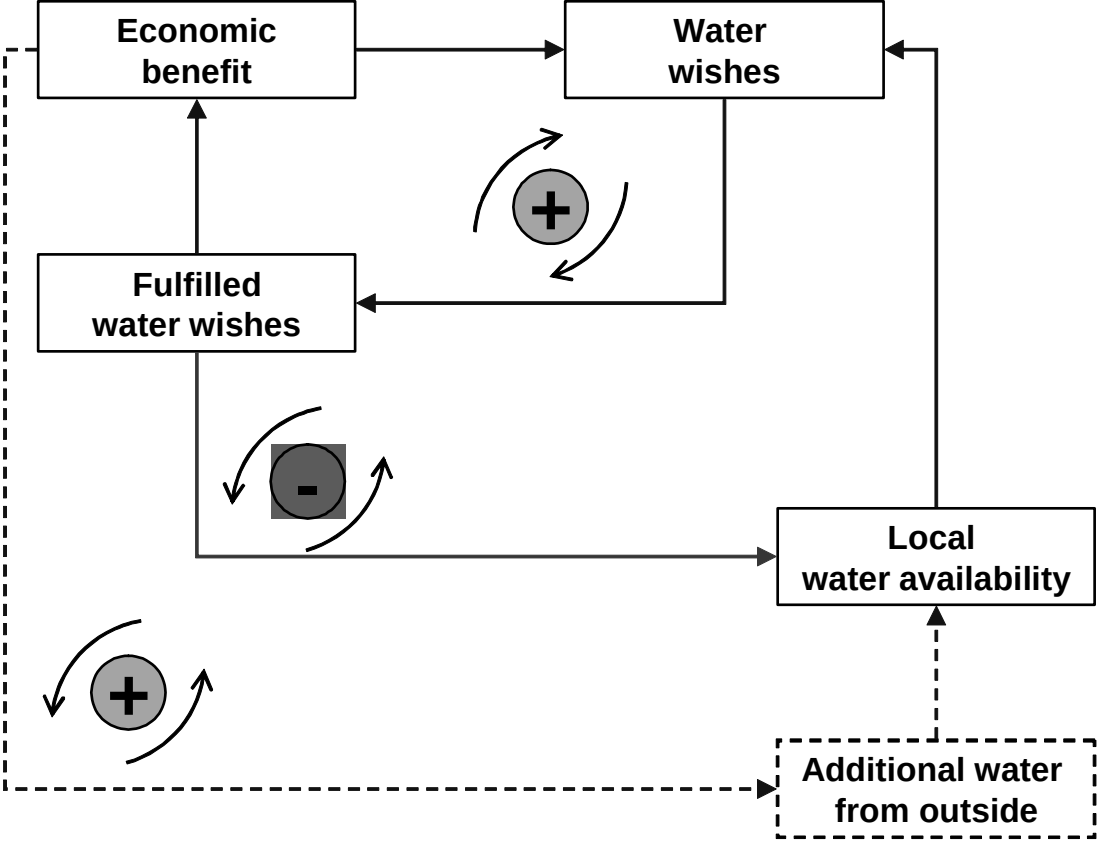

Figure 5. Aggregated causal-loop diagram for water use.
Note: In the local system (solid lines) the positive feedback-cycle (in black: more "Fulfilled water wishes" result in more "Economic benefit" and more "Water wishes") is counterbalanced through negative feedback loop (in gray: more "Fulfilled water 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 i.e.: the system is determined by pressure points from within and outside the system.

4 Conclusions

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

Given the fact that nature has made the Dead Sea the terminal sink of all freshwater sources in the Jordan River basin any withdrawal of water in the basin could be considered non-sustainable in terms of ecological 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 than today water management. An understanding of risk and security, and a means for quantifying them, are vital elements for the success of the project. Nonetheless, many questions remain unanswered:

- What is the carrying capacity of the system and its 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 the 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?

In finding answers to these questions water management in the Dead Sea basin and elsewhere must be based on systemic solutions such as allocation priorities for different water qualities plus changes in water usage patterns. Solutions for 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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6 References

Abu Faris, H., G. Bromberg, G. Fariz, S. Hoermann and M. Turner (1999). Moving Towards a Dead Sea Basin Biosphere Reserve and World Heritage Listings. Friends of the Earth Middle East, Amman, Jordan. Nov 1999. http://www.foeme.org/docs/dsbio.htm.

Al-Weshah, R. A. (2000). The Water Balance of the Dead Sea: An Integrated Approach. Hydrol. Process. 14: 145-154.

Anati, D. A. and S. Shasha (1989). Dead Sea Surface-Level Changes. Israel Journal of Earth Sciences IJERAK 38(1): 29-38.

Assaf, K. K., M. Ben-Zvi, J. S. Clarke, H. El-Naser, S. Kesslerm, M. N. Landers, M. F. Nuseibeh and C. J. Wipperfurth (1998). Overview of Middle East Water Resources. Water Resources of Palestinian, Jordanian, and Israeli Interest. Compiled by USGS for the EXACT Middle East Water Data Banks Project. US Geological Service, ISBN 0-607-91785-7. http://water.usgs.gov/exact/overview/index.htm.

Baer, G., U. Schattner, D. Wachs, D. Sandwell, S. Wdowinski and S. Frydman (2002). The lowest place on Earth is subsiding - An InSAR interferometric synthetic aperture radar) perspective. Geological Society of America Bulletin 114(1): p. 12-23.

Bowman, D., D. Banet-Davidovich, H. J. Bruins and J. Van der Plicht (2000). Dead Sea shoreline facies with seismically induced soft-sediment deformation structures. Israel Journal of Earth Sciences 49(4/2000): pp. 197-214.

Coussin, O. (2001). Wild and stunning and shrinking fast. The Dead Sea region is being undermined by industry and tourism. But is anybody paying attention? Ha'aretz English Edition. Tel Aviv, Israel. Thursday, 1 Feb 2001.

EcoPeace (1998). Final Symposium Report. Symposium on Promoting an Integrated SustEinable Regional Development Plan for the Dead Sea Basin, Amman, July 1998, EcoPeace - Middle East Environmental NGO Forum.

Fariz, G. H. (2002). Ecology of the Dead Sea Biosphere Reserve, Friends of the Earth Middle East. 2002.

Gebetsroither, E., A. Afaneh, C. Lipchin and D. Lehrer (2004). An analysis of the feedback structure driving water dynamics in the Dead Sea region. Presentation at MEDAQUA'04 INCO-MED Water Conference, 14-15 Jun 2004, Amman, Jordan.

Gertmann, I. (1999). The Hydrography of the Dead Sea 1999-2000. National Institute of Oceanography, Israel. Oceanographic and Limnological Research (IOLR), Haifa.

Hillel, D. (1994). Rivers of Eden. New York, NY - Oxford, UK, Oxford University Press: 355 pp.

Isaac, J., N. Hrimat, K. Rishmawi, S. Saad, M. Abu Kubea', J. Hilal, M. Owawi, G. Sababa, M. Awad, F. Ishaq and I. Zboun (2000). An Atlas of Palestine (The West Bank and Gaza). Applied Research Institute Jerusalem (ARIJ), Bethlehem.

Klein, C. (1985). Fluctuations of the level of the Dead Sea and climatic fluctuations in the country during historical times. Symposium: Scientific Basis for Water Resources Management, September, 1985, Jerusalem, Israel, International Association of Hydrological Sciences.: http://water.usgs.gov/exact/overview/p4144.htm.

Meunier, J. (1999). Keeping the Dead Sea Alive: Toward a Regional Environmental Management Plan, International Development Research Center (IDRC) Project number 97-0217-01. September 24, 1999. http://www.idrc.ca/reports/read_article_english.cfm?article_num=519.

Nowitz, R. (1980). The Dead Sea as a Centre of Development. Kidma, Israel J. of Development 19(5 (3)): 38-38.

Orthofer, R., R. Daoud, B. Fattal, M. Ghanayem, J. Isaac, H. Kupfersberger, A. Safar, E. Salameh, H. Shuval and S. Wollman (2001). Developing SustEinable Water Managemenent in the Jordan Valley. European Commission, DG Research, Final Project Report Project ERBIC18CT970161. August 2001.

Orthofer, R., C. Lipchin, J. Isaac and R., Daoud. (2004) The Dead Sea Project. Presentation at MEDAQUA'04 INCO-MED Water Conference, 14-15 Jun 2004, Amman, Jordan.

Pearce, F. (1995). Raising the Dead Sea. New Scientist: p 33-37.

Rabi, A. (1997). Ecological resources of the Dead Sea basin and their sustEinable use: problems and cooperation between the countries of the basin. International Conference on Transboundary Protected Areas as a Vehicle for International Co-operation, Somerset West, South Africa, 16-18 Sep 1997, UNEP World Conservation Monitoring Centre.

http://www.wcmc.org.uk/protected_areas/transboundary/somersetwest/somersetwest-57.html.

Rishmawi, K. and N. Hrimat (1999). The use of high resolution satellite images to monitor the changes in the rates and directions of desertification in the southeastern part of the West Bank. The Second Palestinian Geographic Conference, Jerusalem.

Rishmawi, K., J. Isaac, D. Lehrer and A. Afaneh (2004). Possible socio-economic and environmental futures for the Dead Sea Basin. Presentation at MEDAQUA'04 INCO-MED Water Conference, 14-15 Jun 2004, Amman, Jordan.

Schempp, C., H. Dittmar, D. Hummler, B. Simon-Haarhaus, J. Schulte-Montig, E. Schopf and J. Simon (2000). Magnesium ions inhibit the antigen presenting function of huma epidermal langerhans calls in vivo and in vitro. Involvement of ATPase, HLA-DR, B7 molecules, and cytokines. Journal of Investigative Dermatology 115(4).

Shavit, U., R. Holtzmann, S. Segal, A. Venghosh, E. Faber, I. Gavrieli and T. Bullen (2001). Water Sources and Quality Along the Lower Jordan Valley, Regional Study. Water Resources Quality: Preserving the Quality of our Water Resources., H. Rubin et al. (eds.), Springer. Berlin Heidelberg New York: 127-148.

Stanhill, G. (1984). Evaporation From the Dead Sea. A summary of Research till Sept. 1984. Mediterranean Dead Sea Project.

Trottier, J. (2004). Realistic Water Management Policy Recommendations in the Dead Sea Basin. Presentation at MEDAQUA'04 INCO-MED Water Conference, 14-15 Jun 2004, Amman, Jordan.

Wardam, B. (2000). Lowest Point on Earth is Getting Lower. Jordan Times, 22 Mar 2000. Amman, Jordan. March 22, 2000.

Yechieli, Y. (1996). Influence of the Changes in Dead Sea Level on the Groundwaters Around. Israel Assoc. Water Resources - Dead Sea Valley and Arava Meeting.