Development of a Scenario Management Tool (SMT) to map out possible socio-economic and environmental futures for the Dead Sea Basin/

Possible socio-economic and environmental futures for the Dead Sea Basin

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Summary

This paper summarizes the results achieved so far in the development of the Scenario Management Tool (SMT). The SMT is a part of an ongoing project entitled *"A Future of the Dead Sea Basin: Options for a More Sustainable Water Management"*. The main objective of the project is to establish the scientific basis for a "more sustainable than today" water management and water- related land management in the Dead Sea basin, and from this, to develop practical recommendations that can be used for strategic decision making.. The outputs of the project are expected to allow a better understanding of the interconnections between the human and natural systems and to provide sound basis for a better future water and land-related water management for the entire Dead Sea Basin. The project started by establishing 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. The Scenario Management Tool (SMT) is a PC-Based model that allows to establish, assess and document meaningful scenarios. It is an organizational model that incorporates a human knowledge- base and a logical framework. The outputs of the scenario management tool are a description of how socio-economic and environmental indicators might develop under different assumptions. These are the exogenous factors that will govern the behavior of the projects system models.

1. Introduction

The Dead Sea, *Arabic Al-Bahr al-Mayyit*, *Hebrew Yam HaMelah*, is a landlocked salt lake between Jordan, Israel and Palestine. Its total area is 898 km^2, while its perimeter is approximately 870 km. It lies some 1,339 feet (412 meters) below sea level-the lowest elevation and the lowest body of water on the surface of the Earth. The Basin is a unique habitat for wildlife and is a global cultural heritage site.

The Dead Sea Basin has been affected by the political and demographic changes in the region. The land cover is mostly open with little vegetation; this is a fragile ecosystem vulnerable to anthropogenic impacts (e. g. grazing, tourism and expansion of built- up areas). Several areas in the Dead Sea Basin have become degraded through deprivation of freshwater, through expansion of human settlements, and through inappropriate land use. Water shortage and land degradation are a problem all over the Basin and these are likely to exacerbate with population growth and changes in consumption trends. Consumption trends will most likely rise in the near future, especially if Palestinians in the Basin currently living below poverty line (including approximately 380,000 people) are given the opportunity to raise their material standard of living. Population increase and changes in consumption patterns are examples of driving forces modifying landscapes and ecosystems on the one hand and draining natural resources, especially water, on the other. Driving forces are societal trends and natural processes that either directly or indirectly via policies and feedbacks, cause land use/land cover changes and alter ecosystem functioning. They can have positive or negative socio-economic and environmental impacts. The intensity of negative impacts can be greatly mitigated by proper water and water- related land management.

The driving forces that were identified to have key impacts on the socio-economic and environmental conditions in the Dead Sea Basin were the role of agriculture in the region, the level of cooperation between Jordan, Israel and Palestine and the level of investment in new water and wastewater recycling and reuse projects. The dynamics of these driving forces will have a multitude of effects on the availability of water resources, allocation of water between the three countries, on water use and land use patterns, among other indicators of future development. The objective of this work is to develop a computer tool that parameterizes the relationships between the driving forces and their relevant sets of indicators in order to map out a set of possible socio-economic and environmental futures. This will serve as the foundation for the Dead Sea project team to develop practical recommendations for a "more sustainable than today" water management and water- related land management in the Dead Sea Basin.

The computer tool is a Scenario Management Tool (SMT) that allows to establish, assess and document meaningful scenarios. It is an organizational model that incorporates a human knowledge- base and a logical framework. A scenario is defined by a set of indicators that changes over time. However, not all combinations of indicators are meaningful. There are some indicators that are positively or negatively linked to each other. The practicability of a scenario management tool is that it is able to organize such bundles of parameters (= indicators of scenarios that change over time), and to translate assumptions about certain developments into meaningful quantitative parameters. In its simplest form, the outputs of the model are tables with numbers for all driving parameters (DP's) for all scenario years.

The main objective of this paper is to present the progress achieved so far in the development of the Scenario Management Tool (SMT). The specific objectives were:

- To define the driving forces and explain why they were selected
- To develop a conceptual and graphical model of the interconnections between the driving forces and the indicators as well as the interactions among the indicators and their feedback relations.
- To derive a methodological framework for scenario management tool development
- To present preliminary results observed from the simulation of the Scenario Management Tool

2. Definition of terms

Prior to describing the progress achieved in the development of the SMT, the definition of scenarios, driving forces and indicators is provided.

A scenario is a story or a "scene". It describes a situation in common terms that represents what might happen in the future. It is not a prediction, but a way of putting a lot of ideas and possibilities together. A scenario is governed by a set of driving forces. Driving forces are societal trends and natural processes that either directly or indirectly via policies and feedbacks, cause changes in the system. The driving forces, by definition, should:

- have an order of magnitude on the system.
- be independent from each other; and
- have highly uncertain future development trends.

The driving forces affect the future behavior and development of several indicators. These are trend information of key socio-economic and environmental factors. The future behavior of key indicators would provide contexture images of possible futures.

3. Driving forces

The driving forces that were identified to have key impacts on the socio-economic and environmental conditions in the Dead Sea Basin were the role of agriculture in the region, the level of cooperation between Jordan, Israel and Palestine and the level of investment in new water and wastewater recycling and reuse projects. The criteria for selecting the driving forces were:

The role of agriculture in the Dead Sea Basin was considered as a driving force because (1) irrigated agriculture is the largest consumer of fresh water in the Dead Sea Basin, (2) it is independent from the other driving forces selected herein and (3) the future development trends of agriculture are uncertain as governmental policies concerning farmer subsidies and per sector water allocation can change erratically. Two possible future alternatives will be considered, the first assumes that the current trends observed for agricultural subsidies and fresh water allocation for the agricultural sector among others will continue into the future, the other will assume a lower level of support for agriculture such as lifting water subsidies for agriculture.

The level of cooperation between the three riparian countries is highly uncertain as there are several conflict-settlement proposals. It is also independent from the two other driving forces and would have a significant impact on the socio-economic and environmental futures in the region. Two possible future alternatives will be considered. The first is a situation of a unilateral disengagement of Israel from the Palestinian territories characterized by low levels of cooperation on all fronts and the other is an agreement reached through negotiations and characterized by high levels of cooperation.

Investment in water and wastewater projects will have magnitude of impacts on the socio-economic and environmental situation in the region. Indeed, the gap between water supply and demand in the Dead Sea region is widening and is expected to quadruple by 2025. Water and waste water projects such as the MED-DEAD and the RED-DEAD proposals as well as many other surface water harvesting projects can significantly impact water supply in the region. However, the level of investment in development projects is highly uncertain and can range from lower funding levels to higher funding levels to support development in the Basin.

4. Indicators of future development

The three driving forces discussed above will affect a large number of future development indicators. However for the purpose of simplicity, only the most sensitive indicators for the three driving forces were selected. Although the driving forces are independent from each other, an indicator can be impacted by changes of more than one driving force. A participatory approach identified the list of indicators and stories were told on the relations between the driving forces and the indicators. The indicators of interest in this study were:

- Future Industrial Water Demand
- Future Domestic Water Demand
- Future Agriculture Water Demand
- Future Tourism Water Demand
- Future Unfulfilled Wishes for water
- Future Level of regional Cooperation
- Investment levels in surface water harvesting projects
- Investment levels in wastewater treatment and reuse projects
- Investment level in desalination projects
- Investment levels in importing water from outside the region

- Return of Palestinian Refugees
- Israelis settling in the study area
- Government ability to enforce water policy

5. Role of the SMT

The role of the SMT is to produce a computer dynamic model that parameterizes the relations between the driving forces and the bundles of indicators. It is not necessary that the parameters are deduced empirically, they can be as well mental models with either a numeric output or a semi-quantitative (e.g. Low/Medium/High) output. The SMT will attempt to draw images of how the selected indicators might develop in the future until 2025 and at a time step of 1 year. It will basically answer eight what if questions. These are the eight possible combinations of driving forces. For example, how would the indicators in the future develop if the level of cooperation is low, the role of agriculture is high and funding for water projects is low?

The future images will actually be tabular data explaining the behavior of each indicator in the future until 2025 (Table 1). The spatial scale of analysis is on a regional level. The behavior of the indicators will be described for the Palestinian part of the Study area (RP), the Israeli part of the study area (RI) and the Jordanian part of the study area (RJ) - (Figure 6.1).

Indicator 1: Tourist water demand under scenario 1			
Year	RP (MCM)	RI (MCM)	RJ (MCM)
2005	1	8	3
2008	2	9	6
2011	2	10	7
2014	3	12	7
2017	7	15	9
2020	10	15	10

Table 1. Expected tabular output from the SMT

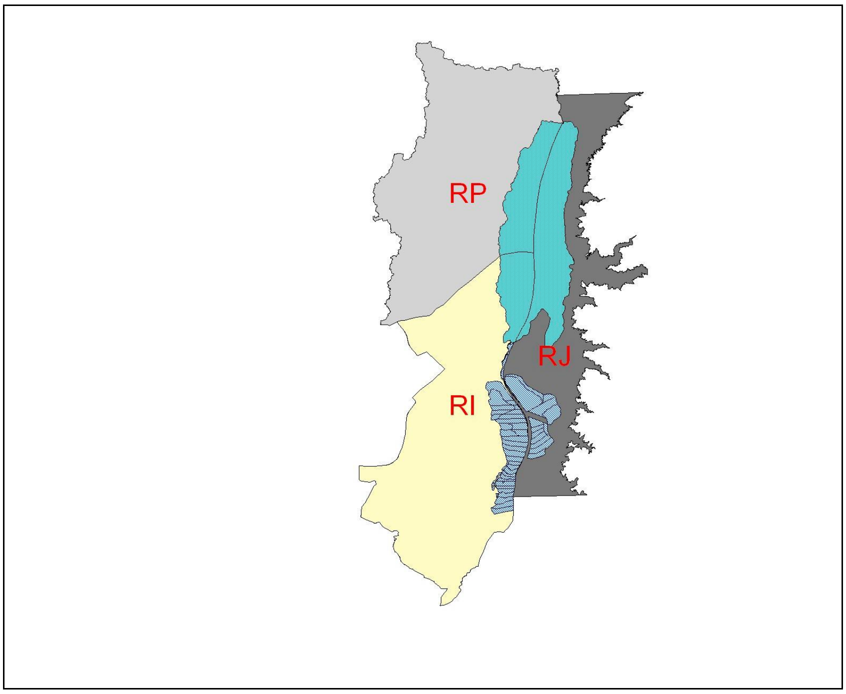


Figure 1. The Three regions of the Dead Sea Basin (RP: Region Palestine; RJ: Region Jordan; and RI: Region Israel).

6. Methodological framework for Scenario Management Tool (SMT) development

The methodology Framework to be followed in order to develop the Scenario Management Tool (SMT) is shown in Figure 2.

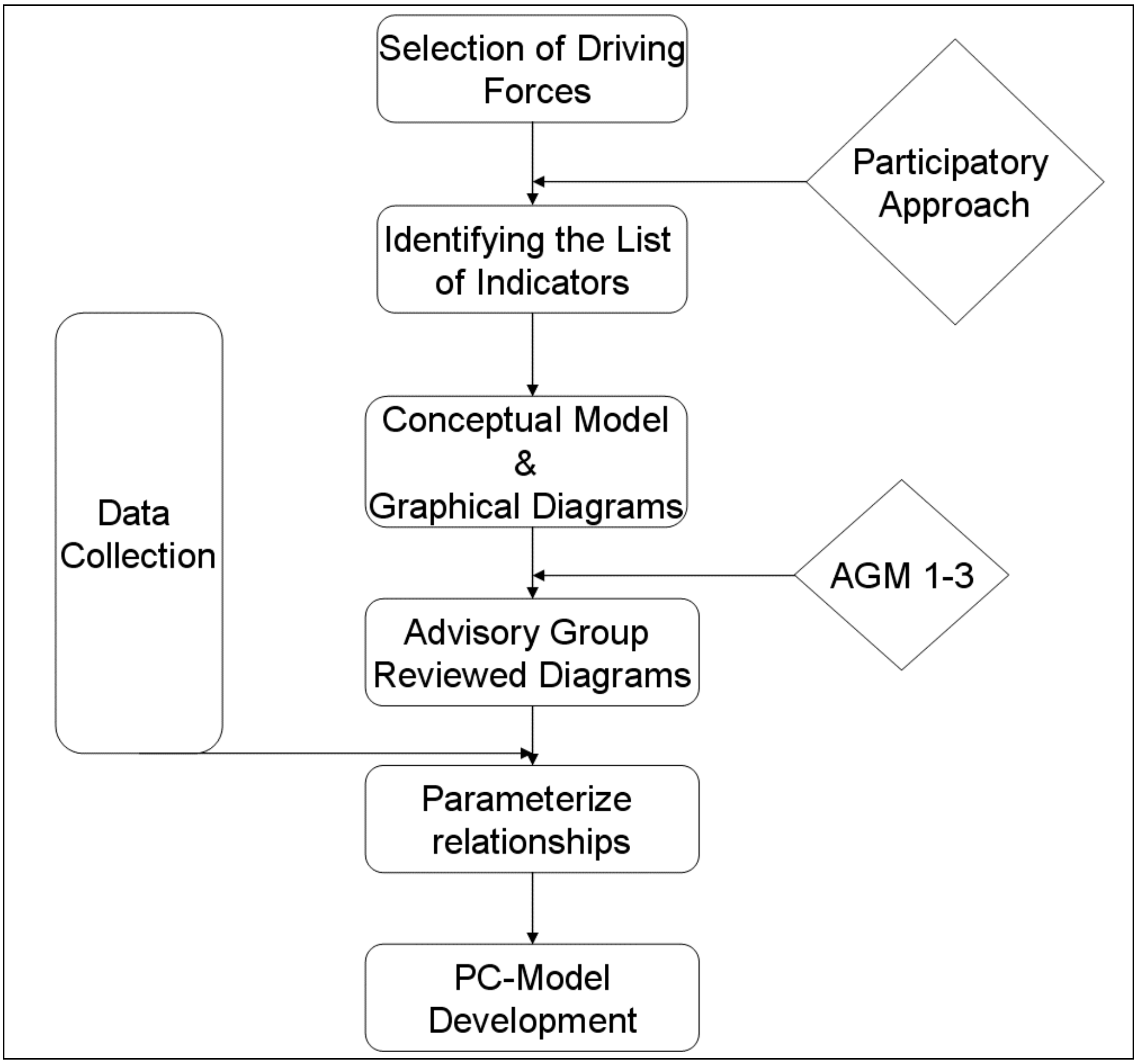


Figure 2 Flow Chart of the Methodological Approach

Work started by the identification of the driving forces with key impacts on the socio-economic and environmental futures in the study area. This was followed by the identification of a set of indicators most sensitive to changes in the driving forces. The list of indicators was reviewed by the project team. The Synergistic or antagonistic properties between the indicators and their driving forces were also identified.

The conceptual model and graphical diagrams were developed to narrate stories of how each of the driving forces affect the indicators and how these indicators interact. Graphical Diagrams were as well developed and are perceived as useful tools in *system thinking* approach. Moreover, graphical diagrams are very useful presentation tools and will be utilized in the Advisory Group Meetings where Scholars from the political, hydrological, environmental and planning sciences as well as policy makers will convene at a 1 day meeting to review the SMT diagrams. They will also be requested to assess the significance of the interconnections between the indicators and their driving forces on one hand and between the indicators on the other hand. The objective is to reduce the number of the causal loop diagrams within the SMT.

Parameterizing the relationships can be done empirically by observing trends, by quoting figures in literature, such as cost curve for desalination or can be mental-semi-quantitative relations such as more/less relationships.

PC-model development can be achieved either by combining VENSIM DSS software with VISUAL BASIC where the former can be designed to parameterize the relations and to answer WHAT IF questions and the latter can be customized to provide a user-friendly interface.

7. Conceptual Model

Conceptual models are narrative descriptions of the interconnections between the *Driving Forces and the Indicators* as well as the interactions among the indicators and their feedback relations.

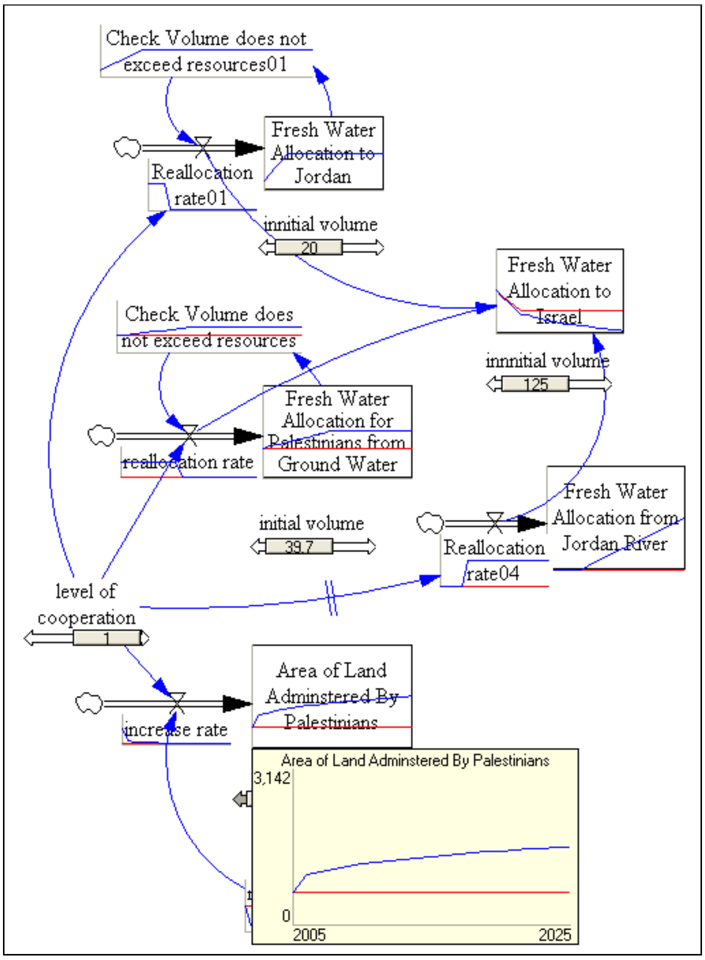
7.1 Level of Cooperation between Israel, Jordan and Palestine

The impacts of the level of cooperation can be classified into direct and indirect impacts. Direct impacts affect the return of Palestinians to the study area, population of Israelis in the study area, fresh water allocation, volume of trade, and area of land administered by the three riparian countries. Indirect impacts affect the Price of Desalinated water, volume of treated wastewater, Water allocated to the tourism sector (per country), Size of labor force in the tourism sector (locals), Value of investment in the tourism sector, number of tourists coming into the area; Human Development Index, woman status, National GDP, population counts in the three countries and volume of water imported from outside the study area.

A synergistic relationship exists between the level of cooperation and regional trade, return of Palestinian refugees and economically displaced people, fresh water allocation from conventional sources to Palestinians and Jordanian, regional tourism and water allocation to the tourism sector, HDI, volume of treated wastewater and volume of desalinated water. Antagonistic relationship exists between the level of cooperation and conventional fresh water allocation to Israel and settlers population in the West Bank.

A story of the impacts of the level of cooperation on each of the aforementioned indicators was narrated. For example, the area of land administered by the Palestinians is impacted by the different levels of cooperation. Within the low level of cooperation scenario, the Palestinians will not have full control over the Israeli declared natural reserves, military closed areas currently occupied by Israeli Military Bases and areas occupied by Israeli settlements and their master expansion plans. While the area of the Dead Sea Basin in the West Bank is approximately 1546 km^2, the areas of the Israeli Military Bases (476.78 km^2), Israeli declared natural Reserves (283.15 km^2) and Israeli Colonies' master plans (145.2 1546 km^2) sum up to 905.136 km^2. This leaves the

Palestinians with a total area of 640.8 km^2, which is approximately 41% of the total area of the Dead Sea Basin inside the West Bank. Moreover, Palestinians will have no control whatsoever over any stretch of the Dead Sea shore. Alternatively, a higher level of cooperation scenario assumes that Palestinians would gain gradual control over the entire Dead Sea Basin within the West Bank following the evacuation of most of the settlements. A land swap between the Israelis and the Palestinians for the settlements that will not be evacuated is assumed. The ratio for Land swap was not agreed upon but can range anywhere between 3:1 to 1:1 of Israeli Colony to new Palestinian land. Accordingly the land area under Palestinian Control for the high cooperation scenario would be approximately 1500 km^2. A system diagram for the impacts of the level of cooperation on some indicators is provided as an example (Figure 3) and table 2 shows the results of land controlled by Palestinians resulting from the parameterization and simulation of the system diagram.



Time (Year)	Land Area (km^2) under the High Cooperation	Land Area (km^2) under the Low Cooperation
2005	640.8	640.8
2006	995.252	640.8
2007	1071.17	640.8

2008	1129.86	640.8
2009	1178.56	640.8
2010	1220.57	640.8
2011	1257.73	640.8
2012	1291.19	640.8
2013	1321.71	640.8
2014	1349.84	640.8
2015	1375.97	640.8
2016	1400.4	640.8
2017	1423.37	640.8
2018	1445.07	640.8
2019	1465.65	640.8
2020	1485.24	640.8
2021	1503.94	640.8
2022	1521.84	640.8
2023	1539.01	640.8
2024	1555.52	640.8
2025	1571.42	640.8

Table 2. Area controlled by Palestinians assuming a low and a high cooperation scenarios

7.2 Level of investment in water and wastewater projects

Figure 3. System diagram and simulation model for two indicators, namely, area of land controlled by Palestinians and fresh water allocation for Palestine, Israel and Jordan.

Two levels of investment in wat … w level of investment where dono … to support other development secto … nd wastewater projects where donor contributions and national budgets are channels from other development sectors to solve the water crises.

The level of investment in water wastewater projects is assumed to have significant impacts on the following set of indicators:

Quantity of desalinated water; Price of desalinated m3 of water; Volume of treated and reused wastewater for agriculture, tourism (landscaping) and industry; Amount of treated wastewater; Price of wastewater treatment; Water allocated to the domestic sector (per country);Water allocated to the tourism sector (per country) Volume of water inflowing from Red-Dead Canal Volume of water imported from outside sources (e.g. Turkey); Capacity of NEW dams in the region, Quantity of rainwater harvested per country; Irrigation network efficiency; Municipal network efficiency; Amount of money invested in campaigns/programs informing people of the potential of Wastewater; and Measure of population using at least one water saving device (WSD).

A synergistic relationship exists between the level of investment and Municipal and agricultural network efficiency, freshwater networks coverage, volume of wastewater treated, volume of wastewater reused, volume of Brackish and Sea water desalinated, volume of rainwater collected in Dams, establishment of the Red-Dead canal and Volume of water imported from outside (e.g. Turkey). However, the scenario management tool for the Level of Investment behaves differently from that for other driving forces, where money is allocated for different water and wastewater projects according to assumed prioritization criteria. The first priority for the allocation of funds goes to increasing freshwater network coverage, increasing the efficiency (reducing water losses) in existing municipal and agricultural water networks and for wastewater treatment and reuse. Figure 2 presents the system diagram for the allocation of funds for the aforementioned water and wastewater projects. Only when those projects are implemented to satisfactory results (e.g. reducing water losses in municipal networks to 20%), additional investment would take place in building new dams, desalinating water and in water awareness campaigns.

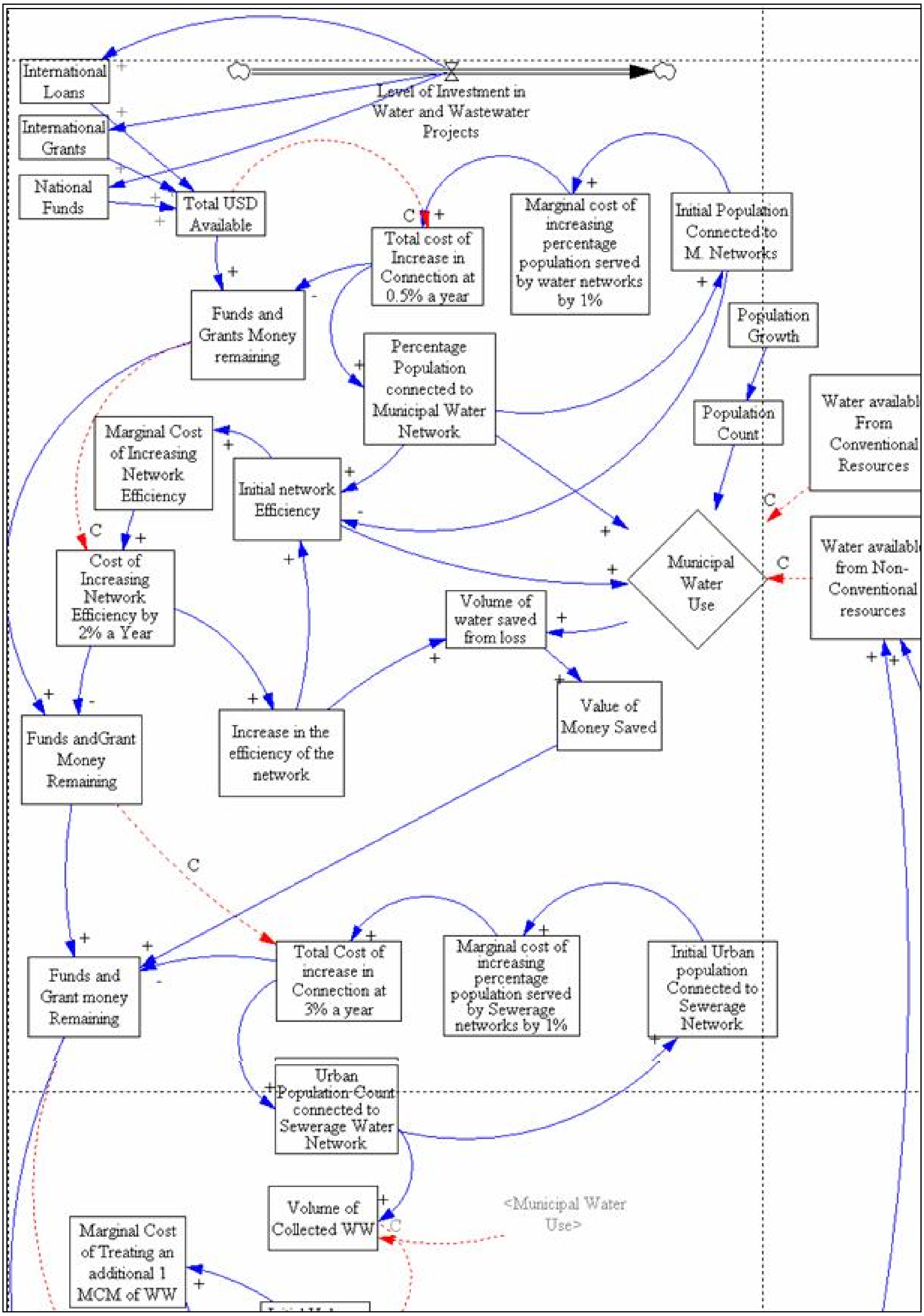


Figure 4. A part of the system diagram for the level of investment and the allocation of money for water and wastewater projects.

7.3 Role of Agriculture

Agriculture is the larger consumer of fresh water in the Dead Sea Basin. Indeed, approximately 55% of freshwater allocated to the Palestinian population in the Dead Sea basin is used for agriculture. Similarly, 55-60% and 65-70% of water is consumed by the agricultural sector in Israel and Jordan. While the agricultural sector overall contribution to GDP in Jordan and Israel is only 2%, the agricultural sector in both countries is heavily subsidized. The contribution of the agricultural sector to the Palestinian overall GDP is about 8%. Subsidies to the agricultural sector for Palestinians take place in the form of cheap water prices.

Agriculture has historically enjoyed a privileged place among Israeli decision-makers. Explanations for this were somewhat self- evident during the 1950s and1960s when agriculture provided some 30% of the country's GNP and most of the top political leadership had either immediate or historical connections with agricultural communities. This ideological and cultural bias provides some explanation for present water policies, which today are frequently inconsistent with economic and environmental considerations. To begin with, the economic contribution of agriculture to Israel's economic profile has fallen to 3% of GNP and 2% of overall employment. Crop subsidies nevertheless remain high for certain crops. Large- scale water diversions for agriculture have also left a hydrological legacy of dry streams and depleted aquifers. Part of the reason can of course be attributed to the political elites who continue to dominate government decision-makers. Senior politicians and government officials are disproportionately affiliated with the agricultural sector, affecting their decisions about water allocation, pricing and distribution. The political patronage of Israel's top leadership to agricultural interests continues and they remain protected in recent years regardless of party affiliation.

Two levels for the role of agriculture are considered for the purpose of this study, namely agriculture is still perceived to play an important role characterized with a continuation of current water allocations for agriculture and other forms of subsidies and agriculture plays an insignificant role in the Dead Sea Basin characterized by lifting the subsidies for the agricultural sector.

The level of support for agriculture is assumed to have significant impacts on the following set of indicators:

- Water allocated to the agricultural sector (per country)
- Quantity of over-abstracted groundwater
- Size of protected areas
- Income per CM of water used in Agricultural
- Size of labor force in the agricultural sector (locals)
- Value of investment in the agricultural sector
- Value of subsidies given to the agricultural sectors
- Value of water subsidies to agriculture

Synergistic relation exists between the role of agriculture and the total value of farm subsidies and water subsidies to farmers. A higher value of farm and water subsidies reduces the value of investment in the agricultural sector and thus the role of agriculture is assumed to have an antagonistic relation with the value of investment in agricultural modernization and development. Antagonistic relation exists as well between the role of agriculture and agricultural water prices, income per cubic meter of water used in agriculture. Figure 5 shows the synergistic and antagonistic relation between the role of agriculture as a driving force and its relevant set of indicators.

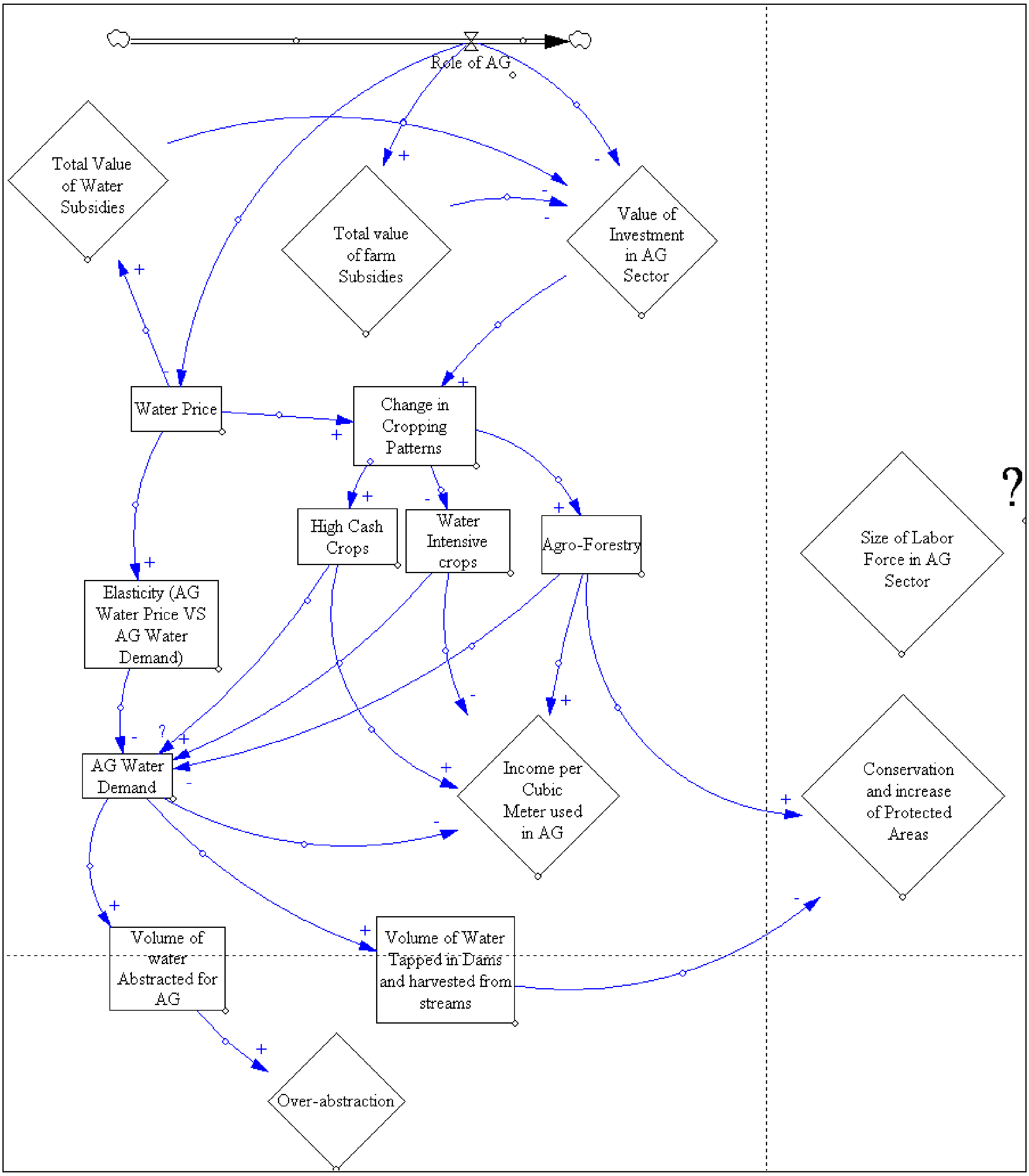


Figure 5 Role of agriculture driving force and its impacts

8. Conclusions

The objective of the work is to develop a Scenario management Tool that allows to establish, assess and document meaningful scenarios. This paper presented the progress achieved in the development of the scenario management tool. This included the identification of the driving forces that have a significant impact on the future socio-economic development and the ecological sustainability in the Dead Sea Basin. It is obvious that there are several other driving forces that impact the Dead Sea Basin such as climatic change and population growth. However, only the most uncertain of driving forces and the driving forces with a very high impact on the future of the region were selected. The selection of the driving forces was followed by the identification of relations (antagonistic and synergistic) between the driving forces and indicators of future development. Although it is impossible to map the entire complexity of the system and to identify all the relations, the research team attempted to identify the most significant relations. The process of identifying driving forces and how these impact the future behavior of indicators is an iterative process that is taking place through consultations with experts by using the system diagrams. The system diagrams are currently being used to build the simulation models in the software VENSIM DSS. This includes the parameterization of relations between the driving forces and the indicators. Tests of model behavior or sub sector behavior under different assumptions will be run in order to ensure that the developed models adequately represent the system at hand. These reality checks can be explicit or they may be implicit mental simulations and analysis based on the research team own understanding of models and the modeling process.

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