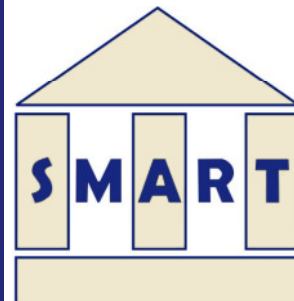


Integrated Water Resources Management in the Lower Jordan Rift Valley

Sustainable Management of Available Water Resources with Innovative Technologies



Work package 7, Deliverable D 706 & 707

ANNEX

Synopsis of the WP7 socioeconomic studies

Author ⁽¹⁾ Ingo Heinz

⁽¹⁾ Formerly of the University of Dortmund, Germany

December 29th, 2014

Corresponding author:

Dr. Ingo Heinz
Formerly University Dortmund
Bierstr.9, 58239 Schwerte
Ingo.Heinz@uni-Dortmund.de
++49-2304-74831

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FKZ 02WM1079-1086 and FKZ02WM1211-1212

Project Coordination:

Main Coordinator:	Assistant Coordinators	
Prof. Dr. Nico Goldscheider & Dr. Jochen Klinger Institute of Applied Geosciences, Karlsruhe Institute of Technology Adenauerring 20b 76131 Karlsruhe Germany Phone: +49 (0) 721 608 43096 Fax: +49 (0) 721 606 279	Prof. Dr. Martin Sauter Department of Applied Geology Göttingen University Goldschmidtstrasse 3 37077 Göttingen Germany Phone: +49 (0)551 39 79 11 Fax: +49 (0)551 39 93 79	Dr. Roland Mueller & Dr. Stefan Geyer Helmholtz Centre for Environmental Research (UFZ) Permoserstr. 15 04318 Leipzig Germany Phone: +49 (0)341 235 30 00 Fax: +49 (0)341 235 2885

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Introduction

This synopsis will provide an overview of the outcomes from the socioeconomic studies of Work Package 7 prepared for SMART II by pointing out their key messages. The purpose is to demonstrate the significance of socioeconomic issues in implementing the IWRM approach at the Lower Rift Jordan Valley. The 11 studies address a broad range and great variety of water-related domains, including:

- Population growth; production of foods and other goods,
- Employment of manpower; usage of land,
- Availability of water resources; water demands of agricultural, domestic and industrial users,
- Water scarcity; water quality and ecological services,
- Construction of water infrastructures; costs and benefits of water services,
- Water pricing and governmental water policies,
- Institutional and political situation; participation frameworks.

All these factors have to be considered in assessing and implementing IWRM strategies as they influence the utilization of water resources and vice versa. The following table shows the titles of the 11 WP7 studies and their corresponding authors; the numbers of the deliverables are set in brackets.

Cost benefit analysis of decentralized wastewater treatment and reuse in Jordan: An application in Maghareeb and Ma'addi (701 & 704)	Nele Lienhoop
Environmental and socioeconomic benefits of decentralized wastewater treatment (DWWT) in Palestine (702)	Abdelrahman Tamimi
Assessing the impacts of different water qualities and quantities on farmer income and their economic situation in Palestine (703)	Abdelrahman Tamimi
Assessing the impacts of different water qualities and quantities on farmer income and their economic situation in the Jordan Valley (703)	Amer Salman
Cost effectiveness of individual technologies, such as decentralized wastewater treatment (DWWT) and water reuse, managed aquifer recharge (MAR) and brackish water treatment (BRA) (705)	Nathalie Korf
Costs and benefits of alternative IWRM strategies and their financial feasibility at basin level in Palestine and the Lower Jordan Valley (706 & 707)	Ingo Heinz
Costs of different IWRM technologies in the West Bank (708)	Abdelrahman Tamimi
Social acceptability of different IWRM technologies in the West Bank (709)	Abdelrahman Tamimi
Institutional feasibility of alternative IWRM technologies in the West Bank (710)	Abdelrahman Tamimi
Assessment of multiple water qualities in Israeli municipalities (711)	Tami Milgrom
Participating framework for the decentralized wastewater treatment and water reuse for Jordan (712)	Mi-Yong Lee-Peuker

1 Cost Benefit Analysis of decentralised wastewater treatment and reuse in Jordan: An application in Maghareeb and Ma'addi (study 701 & 704)

SUBJECT OF INVESTIGATION

This report describes two cases for the cost benefit analyses (CBA) of decentralised wastewater treatment technologies and reuse (DWWT & R). In Jordan, the construction of decentralised treatment plants is planned to serve especially rural communities that do not have an adequate sanitation infrastructure (MWI, 2010).

The three options investigated in the cost benefit analysis (CBA) are:

1. Wastewater treatment and re-use through Sequencing Batch Reactors (SBR)
2. Wastewater treatment and re-use through Constructed Wetlands (CW)
3. Do nothing - Business as Usual (BAU).

The villages under investigations include: The Eastern part of Ma'addi, an agricultural village in the Middle Jordan Valley and the Maghareeb village, a suburb of the city Al-Salt (Fig. 1).

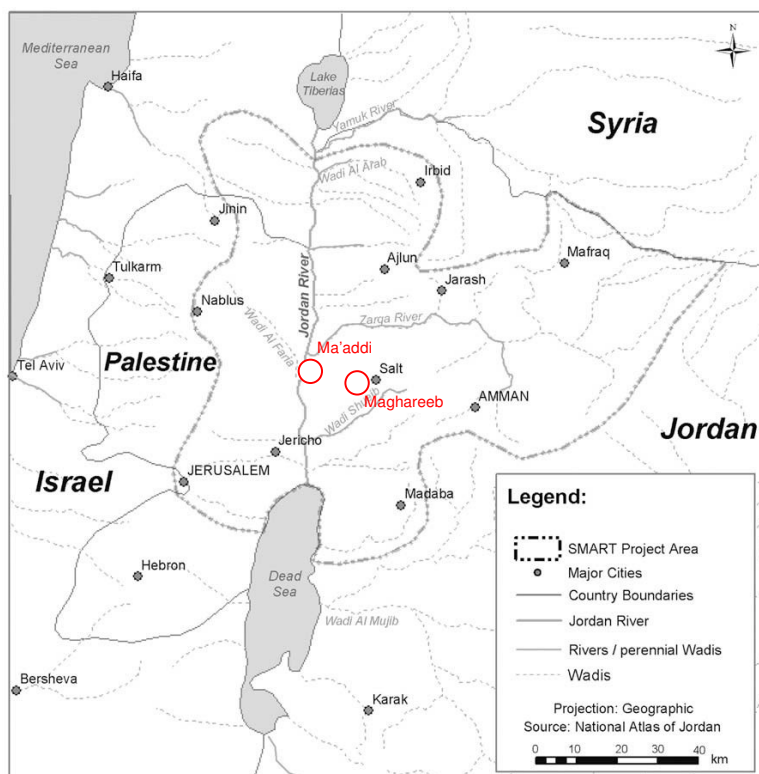


Figure 1: Location of the two project sites in LJRb.

Both villages have a sewage system in place and wastewater is collected in several shared cesspits that are owned and emptied by the respective municipalities. Both villages face problems with overflowing cesspits causing odour, groundwater contamination and diseases. Agricultural production in Ma'addi takes primarily place in greenhouses where a range of vegetables are grown. Agricultural activities in Maghareeb are dominated by olive tree plantations that do not require irrigation and fruit trees.

Applying the **CBA methodology** provides the opportunity to make a comparison between alternative projects. The investments in water infrastructure are generally of long-term nature (covering often more than 20 years), so that both the costs and benefits will be calculated in terms of **present values**. By using the present value analysis the time streams of future costs and benefits can be diverted ('discounted') to two single values. The difference between both is the **net present value (NPV)**: if greater than 0, the investment would be worthwhile. If there are several optional projects, the one with the highest net present value should be chosen.

Since not all costs and benefits can be quantified directly in economic terms, surrogates are to be used. A commonly applied approach is to estimate the amounts of money the people are ready to pay – the Contingent Valuation (CV) method. Typical examples of environmental problems are odour, groundwater contamination, insects, and health risks particularly for children.

It is assumed that costs for the two technologies **SBR** and **CW** do not vary significantly between the two villages, but that health and environmental improvements (benefits) are different according to the specific situation in the villages. For both treatment options, 500 person equivalents are assumed. The time horizon of the analysis is 30 years and corresponds with the lifetime of the technologies. Constant prices were computed to net out the annual inflation rate. Costs and benefits, that incur in the future, were discounted by using alternative discount rates of 3, 5 and 7%. The main types of costs and benefits are:

- Costs:** ▪ Construction and operation and maintenance (O&M) costs of the wastewater treatment plants
- Benefits:** ▪ Reduction in odour, health risks and environmental problems for households
- Increases in the productivity of agriculture due extra water for irrigation.

The revenues from selling treated wastewater to farmers are not considered as they represent **financial transactions** only.

RESULTS

The estimated costs of the two alternative DWWT & Reuse projects are shown in Table 1.

With regard to the benefits for the **households** a survey was undertaken in Ma'addi (89 households) and Maghareeb (94 households). The residents currently face the following environmental

problems: Odour, groundwater contamination, insects, risk for children and visual impact. Based on this data, **the willingness to pay per household** is estimated to 47.8 JD/yr in Maghareeb and 42.6 JD/yr in Ma'addi. The **aggregated environmental benefits** are **4,251 JD/yr** and **4,004 JD/yr**, respectively.

	SBR TECHNOLOGY	CW TECHNOLOGY
<i>TREATMENT PLANT</i>		
Construction Cost (JD)	185,768	161,374
Annual Operational Costs (JD/yr)	36,521	19,834
<i>IRRIGATION SYSTEM</i>		
Construction Cost (JD)	9,976	5,154
Annual Operational Costs (JD/yr)	157	24
TOTAL COST		
Construction Cost (JD)	195,744	166,528
Annual Operational Costs (JD/yr)	36,678	19,858

Table 1: Construction and operational costs of two alternative DWWT & Reuse projects

With respect to **health problems**, 19% of the surveyed households in Maghareeb and 13% in Ma'addi state that household members sometimes face health problems associated with wastewater. The most common diseases are: skin problems (increase in mosquito bites), diarrhoea and asthma (as a result of odours).

To estimate the **costs of diseases** the "Illness Approach (COI)" was applied. It is a survey-based method to assess the costs of health impacts in terms of citizens' expenditure on medical services, including consultation with the doctor, medicine, travel cost, and loss in income due to days off work. Further health benefits would be the reduction in the number of deaths and the avoided opportunity cost of lost time due to illness (loss in income that could have been earned). However, a household questionnaire in Maghareeb and Ma'addi revealed that no deaths can be associated to wastewater and that almost nobody misses work due to wastewater related diseases.

For Maghareeb, the average costs per doctor consultation and person were estimated to 17 JD and **the average costs per household** to 221 JD/yr, as households visit the doctor on average 13 times per year. Since 19% (N=17) of households consult the doctor, the **aggregated health costs** amount to **3,757 JD per year**.

Although the survey reveals that households in Ma'addi also face considerable health problems, the sample size was too small to provide valid estimates of health costs. Therefore it was decided to use the same costs per household of 221 JD/yr and to multiply these with **12 households** (13% of households in Ma'addi need to see the doctor as a result of wastewater related diseases). Hence, the aggregated health costs in Ma'addi amount to **2,652 JD/yr**.

With regards to the benefits in **agriculture**, the amount of treated wastewater made available for irrigation is 13,360 m³/yr from **SBR** and 10,979 m³/yr from **CW**. With this amount of additional irrigation water it would be possible to grow fruit on 13-16 extra dunums in Maghareeb (based on average crop water requirement of 838,9 m³/year for typical crops in the region) and to grow greenhouse crops on 25-30 extra dunums in Ma'addi (based on average crop water requirement of 442 m³/year for greenhouse crops).

It is assumed that the increase in yields results from the extension of cultivated land. Table 2 shows the parameters used for calculating the **economic benefits** due to the use of treated wastewater for irrigation. **Gross margins** reflect the increase in farmers' incomes ("profits") per dunum: together with the crop specific **water requirements**, the economic benefits due to the additional water supply for irrigation can be calculated – the **water profitability**. The values of gross margins were taken from the D703 study as mentioned above.

MAGHAREEB – FRUIT		
Crop water requirement: 839 m ³ /du/year		
Gross margin: 173 JD/du		
	<i>SBR</i>	<i>CONSTRUCTED WETLAND</i>
Treated WW (m³/year)	13,359	10,979
Increase in dunums irrigated (du)	15.9	13.1
Economic benefit per year	2,758	2,266
Water profitability (JD/m ³)	0.21	0.21

MA'ADDI – GREENHOUSE CROPS		
Crop water requirement: 442 m ³ /du/year		
Gross margin: 679 JD/du		
	<i>SBR</i>	<i>CONSTRUCTED WETLAND</i>
Treated WW (m³/year)	13,359	10,979
Increase in dunums irrigated (du)	30	25
Economic benefit per year	20,370	16,975
Water profitability (JD/m ³)	1.53	1.55

Table 2: Estimates of additional agricultural benefits per year

Obviously, the SBR technology yields higher economic benefits per year than the constructed wetland. However, with regard to the **water profitability** (= the economic benefit in relation to the volume of treated wastewater), there are no significant differences, i.e. **the economic value of one cubic meter additional water is nearly the same for both treatment technologies.**

There are **further economic benefits** that are to be considered: According to the literature, the costs of cleaning cesspits range between 1-2 JD per m³. This expenditure would be avoided if a wastewater treatment plant was installed and enters the CBA as a benefit. The overall avoided cost for a village with 500 inhabitants generating 13,359 m³ wastewater would amount to 20,039 JD per year, if an average cost of 1.5 JD per m³ is used.

For the **CBA of both treatment options**, the total costs (including the treatment and conveyance costs) must be compared with the total economic benefits by applying the present net value method. Three different discount rates were chosen to take different credit terms into consideration. The general formula for calculating the net present value is:

$$NPV = \sum_{t,i}^{T,N} \frac{B_{i,t} - C_{i,t}}{(1+s)^t}$$

where T is the time horizon, t the year t, i stands for different groups, such as households or farmers affected by the project and N is the number of groups. Another term for NPV is: *Sum of discounted benefits - sum of discounted costs*, by which the time streams of the future costs and benefits are calculated separately (Table 3).

	PV COSTS	PV BENEFITS		NPV	
	Million JD	Million JD		Million JD	
		Maghareeb	Ma'addi	Maghareeb	Ma'addi
OPTION 1: SBR	1.68	1.26	1.93	-0.42	0.25
<i>Min.</i>	1.35	1.22	1.90	-0.13	0.56
<i>Max.</i>	2.02	1.33	1.99	-0.68	-0.03
OPTION 2: CW	0.98	1.24	1.78	0.26	0.80
<i>Min.</i>	0.78	1.20	1.76	0.41	0.97
<i>Max.</i>	1.18	1.31	1.84	0.14	0.67

Table 3: Present values of costs and benefits and net present value of the two project options at the discount rate of 3%

Table 3 depicts the lower and upper estimations of the **present values of costs** and **benefits** as well as of the **net present values** for the two project options using a 3% discount rate. The time horizon of the analysis is 30 years and corresponds with the approximated lifetime of the technologies. Table 4 compares the net present value estimates under three different discount rates.

	NPV (3%)		NPV (5%)		NPV (7%)	
	Million JD		Million JD		Million JD	
	Maghareeb	Ma'addi	Maghareeb	Ma'addi	Maghareeb	Ma'addi
OPTION 1: SBR	-0.42	0.25	-0.36	0.13	-0.32	0.06
<i>Min.</i>	-0.13	0.56	-0.13	0.37	-0.14	0.24
<i>Max.</i>	-0.68	-0.03	-0.56	-0.08	-0.48	-0.11
OPTION 2: CONSTR. WETLAND	0.26	0.80	0.15	0.54	0.07	0.37
<i>Min.</i>	0.41	0.97	0.27	0.67	0.17	0.48
<i>Max.</i>	0.14	0.67	0.05	0.43	-0.01	0.28

Table 4: Net present values at the discount rates of 3, 5 and 7%

As the results show, in Ma'addi the net present value of the both wastewater treatment technologies is larger than zero. This means that **values added from the wastewater treatment** can be expected, i.e. both options would be **cost-beneficiary for the villagers in economic terms**. In Maghareeb, however, the net present values of **SBR** are mostly negative. This can be explained by the relatively low economic benefit in agriculture (Table 2) and the high costs of wastewater treatment due the high demands on the quality of reclaimed water in Jordan (Table 1).

Further, the benefits may be underestimated. For instance, the benefits from better groundwater quality accrue to people also beyond the borders of the villages and should be considered as well; the economic value of less diseases in terms of willingness to pay may be higher; and the application of the Contingent Valuation method to evaluate the environmental benefits is critical in low-income countries, where the willingness to pay and affordability are restricted.

CONCLUSIONS

Decentralised wastewater treatment and re-use are needed to improve sanitation and agricultural production in rural areas and small communities in Jordan. The net present value calculations in this study include all major costs and benefits associated with wastewater treatment and re-use. A range of valuation methods were used to monetise the benefits associated with the environment, health and

irrigation in agriculture. The models and methods discussed in this study are principally applicable to any decentralised wastewater treatment projects. As the results show, in the village of Ma'addi the net present value of the both wastewater treatment technologies is larger than zero. This means that values added from the wastewater treatment can be expected. In the village of Maghareeb, however, the net present values of the SBR technology are mostly negative. This can be explained by the relatively low economic benefit in agriculture and the high costs of wastewater treatment due the high demands on the quality of reclaimed water in Jordan.

The usefulness of the cost-benefit analysis (CBA) is limited by certain limitations, particularly in Arab countries. The severe water shortages and poor sanitation facilities in the region practically leave decision-makers with little alternatives to choose from. Due to the indisputable need for low-cost solutions to improve the current situation cost effectiveness aspects are also of high relevance. Furthermore, decision on wastewater treatment and reuse in rural Jordan entails prerequisites beyond economic aspects. For example, an important requirement is that residents, mayors and tribes accept and support such wastewater reuse projects. Hence, a participatory approach that involves all affected parties in the planning process is essential.

2 Quantifying the environmental and socioeconomic benefits of the decentralised wastewater treatment (study 702)

SUBJECT OF INVESTIGATION

This study gives first an overview of the current situation on the wastewater management and the institutional bottlenecks in Palestine (West Bank and Gaza Strip) (chapter one). Then, it contains a detailed description of the decentralised wastewater treatment technologies (DWWT) (chapter two). In the next chapter presents the experiences gained from the application of different technologies in the West Bank and Gaza Strip with regard to the use of treated grey water and black water for irrigation purposes; recommendations and a few cost information for special water treatment systems are provided (chapter three).

The following chapter addresses the **benefits** from improving the wastewater treatment for a growing population in Palestine. The question is as to which positive impacts can be expected by transition from untreated and at primary level treated wastewater to a complete treatment at least at secondary level by 2020.

Even though numerous health-related, socioeconomic and environmental benefits are highlighted, they are **not evaluated directly in economic terms**. However, this can be done indirectly with respect to the potential alleviation of water shortage: The **reclaimed water can be used for agricultural irrigation, where economic benefits arise in terms of increases in revenues**. Further **economic benefits** are **cost savings in wastewater drainage** and **use of fertilizers**. Moreover, the **households save costs**, because they can reduce the consumption of freshwater, which was used for irrigation purposes before.

The sum of the economic benefits is compared with the **installation costs of different treatment techniques**. Finally, the **potential environmental benefits** from the reduced water pollution are evaluated in economic terms by assuming that the (unit) cost of wastewater treatment reflects the minimum willingness to pay for protecting the environment.

RESULTS

Wastewater situation

In Palestine (West Bank and Gaza), wastewater represents an annual volume of 66 million m³. Only 30% of this water is collected in a public sewer network and less than 7% is conducted to a water treatment plant. The virtual lack of a household wastewater collection network and hence of any pollution treatment, especially in the West Bank, forces each household to store its wastewater in cesspools holding both

black waters and grey waters. These cesspools are sized to take approximately one month's household waste, which amounts to 15 m³ to 40 m³ depending on the size of the family.

In terms of wastewater collection, the majority of households in **urban areas** are already connected to wastewater collection, with connection rates of up to 90%. However, connection is significantly less in **rural areas**; in addition, some **major cities (e.g. Jericho) remain without centralized wastewater collection**. Regarding wastewater treatment, the currently existing treatment plants in the **West Bank** are clearly inadequate to handle the amount of wastewater collected. Thus, in the West Bank, 93% (33.5 MCM/year) of produced wastewater is discharged untreated into the environment.

The wastewater treatment plants located in the **Gaza Strip**, which only function at moderate efficiency rates (40-60%), operate above their capacity and are need of upgrade and maintenance. 4.9 MCM/year of untreated wastewater and the (partially) treated wastewater is discharged into the environment. The lack of effective wastewater treatment has impacts on nature, biodiversity and groundwater quality and endangers public health. Assuming a standard that would correspond to the 1991 EU Urban Waste Water Treatment Directive, an additional 5.25 million inhabitants would need to be connected to at least secondary treatment plants, which would result in additional 87.9 MCM of wastewater being treated at least at secondary level

Water scarcity

In both the West Bank and the Gaza Strip, groundwater constitutes the main resource. Rainfall is the dominant source of water, of which 68% evaporates and the remaining 32% percolate into and thus replenish the aquifers. A small amount drains off as surface runoff. The main groundwater bodies underneath the **West Bank** comprise the Western Aquifer System, the North-eastern Aquifer System and the Eastern Aquifer System. This groundwater is mainly used for domestic and irrigation purposes by the communities in the West Bank and Israel.

The main aquifer system in the **Gaza Strip** is the Coastal Aquifer, which includes the Gaza Aquifer. Around 850 MCM of renewable water are available each year in the West Bank. While the **Jordan River** is the only perennial river in the West Bank, this water is unavailable as it merely consists of brackish water and Palestinians are denied access to it. **Groundwater recharge** provides a further 750 MCM of renewable water resources for the aquifers shared between Israel and the West Bank. Of this, around 694 MCM/year are estimated to be internally produced in the West Bank and 46 MCM/year in the Gaza Strip. The remaining water volume of 10 MCM/yr of groundwater flows from Israel into the Gaza Strip.

However, according to World Bank estimates, Palestinian abstractions only account for some 20% of the groundwater produced in the **West Bank** (between 138 MCM in 1999 and 113 MCM in 2007). No desalinated water is produced in centralized, public plants that feed into the water supply network.

However, there is some private and decentralized desalination to account for the deteriorating quality and increased salinity of tap water. Around 10 MCM of treated wastewater were reused in 2005.

According to the Palestinian Central Bureau of Statistics, in 2008, **a total of 308.7 MCM of water were provided for the Palestinian population in the West Bank and Gaza from all sources (wells, springs and water purchased from the Israeli water company Mekorot)**. This compares to 335.4 MCM in 2007 and 319.1 MCM in 2006. In 2008, **groundwater wells** are the largest source of water, which provided **225.7 MCM/yr or about 73% (of which 66.3 MCM in the West Bank and 159.4 In Gaza)**. This was followed by the **water purchased from Mekorot with a quantity of 57.8 MCM/yr**, and finally the **springs with annual discharge of 25.2 MCM**.

Out of 225.7 MCM pumped from groundwater wells, 120.3 MCM is used for domestic use (36.1 in West Bank and 84.2 in Gaza), and 105.4 MCM is used for agricultural use (30.2 in West Bank and 75.2 in Gaza).

Comparing the **use 308.7 of MCM of water provided for the Palestinian population in the West Bank and Gaza to the 850 MCM that are available indicates a water exploitation index** (i.e. total freshwater abstracted as a proportion of total renewable water available) **of 36% in 2007**. This indicates severe water stress. Israel abstracts substantial amounts of water from the aquifers that it shares with the West Bank. These abstractions clearly exacerbate the existing water scarcity problem. With a **population of 3.57 million** in 2005, **240 m³ of water are available per capita/year**. **Total water use per capita is 120 m³/year, of which 60 m³/capita/year are used for municipal water use**). According to FAO classifications, this indicates that the Palestinian population is living in conditions of **‘absolute water scarcity’**

The scenario 2020 assumes that the water use in the various sectors increases proportionally with population growth. The baseline estimates for 2020 assumes for the **West Bank an increase in the population from 3.94 million (2012) to 5.45 million (2020)**. Annual precipitation rates are deemed likely to fall in the eastern Mediterranean, decreasing 10% by 2020 and 20% by 2050, with an increased risk of summer which would exacerbate the problem of water scarcity

Cost and economic benefit of decentralized grey water treatment

The quality of the treated water, free in principle from faecal germs and close to Quality A, should allow the water to reuse on a wide range of crops, provided that drip irrigation is used. Nevertheless, Palestinian regulatory standards, based on those of the World Health Organization do not actually mention reusing reclaimed waters for irrigation of **vegetables**. From the viewpoint of the Palestinian Hydrologic Group (PHG) reclaimed grey waters should be used solely for arboriculture and fodder crops, although during the study it was in fact observed that an owner might irrigate vegetables on climbing plants (e.g. tomatoes, cucumbers, peas).

Depending on crop type and family size, the irrigable area would be between 100 and 500 m². For a family, the economic benefits from wastewater reuse include cost savings in:

- Wastewater drainage
- Use of drinking water that would have had to be purchased to irrigate crops
- Purchasing fertilizer, as treated waters provide plants with needed levels of nitrogen, for example.

The economic evaluation is based on the following assumptions:

1. Water consumption per inhabitant per day: 80 liters, i.e. around 29 m³ per year
2. Proportion of grey water: 75%
3. Cost of drinking water: 4 NIS/m³ or 0.80 €/m³
4. Cost of draining 1 m³ of wastewater: 10 NIS/m³ or 2.00 €/m³
5. Savings on fertilizer: 0.3 €/m³ reused water.

Not only these cost savings, but also the **benefits for the environment should be considered**. These benefits are difficult to evaluate in economic terms. Therefore, as a surrogate, the unit cost of a water treatment plant can be used by assuming that this cost represents the price to pay (or the minimum willingness to pay) to prevent the pollution caused by 1 m³ of household wastewater. This cost is estimated to NIS 2.4 (€ 0.48).

On the basis of these assumptions, Table 1 indicates for a typical Palestinian family the **economic benefits compared with cost of wastewater reuse**.

For a family that drains its septic tank regularly, the cost of installing the systems studied here would pay off in around five years. From the societal point of view, the estimated environmental benefits should be considered as well.

	Euro
Capital cost per year	130
Drainage savings per year	435
Drinking water savings per year	174
Fertilizer savings per year	65
Total family savings per year	674
Environmental benefits per year	104
Value added per year	544 (648) *)
Water value per m ³ reclaimed water	25 (29.8) *)

*) Values in brackets with environmental benefits

Table 1: Cost and economic benefits of wastewater reuse for a typical Palestinian family

A cost-benefit analysis requires the annualised costs in order to calculate the **value added from wastewater reuse**. The lifetime of the grey water treatment facility for 10 persons (investment cost 2,000 €) is assumed to be approximately 30 years, so that annual capital cost would amount to 130 €/yr at a discount rate of 5%. Thus, the value added can be estimated to 544 €/yr and 648 €/yr, if the environmental benefits are taken into account. **The water value** related to 21.75 m³/yr grey water (i.e. 75% of 29 m³/yr) is 25.0 €/m³ or 29.8 €/m³, respectively.

CONCLUSIONS

A high percentage of Palestinian families in the villages especially the far-off ones live in poverty and low incomes. Most of these families depend on farming to ensure their basic needs of life. Because of the lack of water many use untreated grey wastewater to irrigate their farms and gardens without taking into consideration health and environmental risks especially to the children and women who are the direct user of this kind of water in addition to the social problems with neighbors because of the foul odors and insects, which ultimately affects the social bonds.

Grey wastewater treatment and reuse in the irrigation of gardens and farms is acceptable by the Palestinian families which helps ensure a good and durable source of water for agricultural use ensuring their basic needs from vegetables which are planted in the house garden with an area of 150 to 200 square meter, in addition to the reduction in pollution and sanitary problems caused by untreated grey wastewater. The PHG has implemented many grey wastewater treatment units in the Palestinian communities in addition to reclaim house gardens through providing the Palestinian families with irrigation networks and vegetable plants which can be irrigated with this kind of water according to the Palestinian and international standards. This helps in improving the healthy livelihood and conditions for poor Palestinian families.

However, reuse in Palestine remains to be very primitive and requires development mainly due to the lack of large scale infrastructure, social obstacles and public unacceptability. Farmers and households must be fully aware of the importance of reuse and how they can benefit from the treated wastewater by increasing the production and saving the costs that would in other case be spent on fertilizers and fresh water. At a discount rate of 5%, the value added from grey water reuse for irrigation purposes is 4 – 5 times higher than the annual cost. The unit value of the reclaimed water is with 25 €/m³ and 29.8 €/m³, respectively very high. It will be less at higher discount rates and shorter lifetime of the wastewater treatment facility.

3 Assessing the impacts of different water qualities and quantities on farmer income and their economic situation in Palestine (study 703)

SUBJECT OF INVESTIGATION

The analysis addresses the socioeconomic impacts of improvements in water supply of irrigated agriculture at the West bank. Of special interest is the availability of non-conventional water such as treated wastewater and desalinated brackish water as additional sources to mitigate water shortage. Increase in farmers' income is the main indicator for assessing the performance of water management activities. Pilot studies were carried out by conducting surveys at 15 communities.

RESULTS

With regard to the socioeconomic situation the study found out that a high proportion of people are engaged in agricultural production: 42.5% permanently and 17.0% temporarily. Agriculture plays a central role for the Palestinians in making a living from farming. Grains and vegetables are the main cultivations.

As the surveys showed, advanced irrigation techniques are being applied: 91.8% drip irrigation, 18.4% sprinkler, 13.5% furrow and 18.4% rain fed irrigation. The main water sources are springs with 46.9%, purchase of water from the Mekorot Company with 25.1%, private and public groundwater wells with 18.4% and 12.6%, respectively. Rain water harvesting is of minor significance due to the limited availability. Regarding the deficiency in water supply, more than 50% of the respondents are unsatisfied; however, there is a wide range of assessments (for instance, 84.6% in Jericho city and 7.7% in AZ Zubeidat).

The study focuses on the following water management options:

1. **Wastewater reuse.** The ElBireh treatment plant exists already and a further plant in Jericho is planned. A water volume between 1 and 3 million cubic meter per year is estimated that can be used for irrigated agriculture and artificial recharge.
2. **Desalination of brackish water.** This type of water can be used for agricultural and domestic purposes. The potential availability is approximately between 4 and 6 million cubic meter per year. It can be obtained by drilling a cluster of shallow wells, which are proposed to be located along the wadi Al-Qilt.
3. **Storm water harvesting.** A potential water volume of about 4 million cubic meter per year is estimated. The water is to be collected by a pond and small wadis can be used for harvesting.

Regarding the wastewater reuse option there are two hypothetical calculations comparing the costs of cultivating of alfalfa (e.g. seeds, pesticides, crop harvesting, energy, etc.) with the revenues. One of the example rendered economic losses and the other one net benefits.

The availability of land for expanding agricultural activities, provided the water needed would be supplied, was analysed: According to the survey carried out in the 15 communities, vegetables with 49% and fruits with 48% are considered as the most suitable cultivations.

CONCLUSIONS

As a comparison of the costs and revenues of different water management options shows, water harvesting is most economical for vegetables, banana, palms and green houses. With special regard to palms the other options such as drilling and rehabilitation of groundwater wells, desalination of brackish water, water transfer, artificial recharge and wastewater reuse are cost-beneficial as well. This is the reason why in Palestine many farmers started to cultivate intensively palm trees.

Wastewater reuse as a potential resource is important for the expansion of cultivated land. Desalinated brackish water is expensive, but could be useful if solar energy would be applied. However, brackish water blended with harvested rain water is the best option to use this resource. The use of treated wastewater and brackish water for palm cultivation is highly recommended due to high revenues and low demands on water quantity and quality.

4 Assessing the impacts of different water qualities and quantities on farmer income and their economic situation in the Jordan Valley (study 703)

SUBJECT OF INVESTIGATION

The objective of this report is to assess the economic impacts of different water types, such as freshwater (FW) and treated wastewater (TW) for agricultural irrigation. Water reuse is one of the major options to tackle exhaustion of natural resources and overuse of aquifers particularly at the Jordan Valley. Discharging of treated or untreated wastewater into the aquatic environment without any utilization should be minimised as far as possible. By that, considerable economic losses and environmental damages can be avoided.

In the Jordan Valley treated wastewater is being used. A prominent example can be found downstream of the King Abdullah Canal (KAC), where the effluents of the As-Samra treatment plant are stored in the King Talal Dam (KTD) and then mixed with the KAC freshwater. The blended treated wastewater (BTWW) is utilized for agricultural irrigation in the middle and southern part of the Jordan Valley. The upstream KAC freshwater is diverted in part for domestic users (mainly the city of Amman), in part for agricultural irrigation in the northern part of the Jordan Valley. The study aims to assess the economic impacts of water use for irrigation purposes at two sites: The upstream basin 10 (Northern Jordan Valley - NJV) and the downstream basin 22 (Middle Jordan Valley - MJV) provided with FW and BTWW, respectively. The key question is as to which of the two different water types are more cost-beneficial.

RESULTS

Results show that in general there is an increase in the productivity of vegetable crops that are irrigated with BTWW compared to those irrigated with fresh water during autumn and spring seasons. Consequently, the gross margins of crops irrigated BTWW were higher than those irrigated by fresh water. The *average profitability of one cubic meter* of one for vegetable crops irrigated by BTWW was 1.439 JD/m³, while it was 1.280 JD/m³ for those vegetables irrigated fresh water.

The *yield of cereals per dunum* that are irrigated using BTWW are higher than those irrigated by fresh water, the average yield for cereals irrigated using BTWW was 1.41

ton/dunum in MJV, while it was 1.29 ton/dunum for those irrigated using fresh water in the NJV. Moreover, the yield of winter and summer vegetables planted in the MJV and irrigated using BTWW is higher than those vegetables in the NJV which are irrigated with fresh water. For instance, the average yield of tomatoes in the MJV was 7.78 ton per dunum, while it was 5.99 ton dunum for tomatoes planted in the NJV. The average overall yield for winter vegetables was 3.05 ton/dunum in the MJV and 2.66 ton/dunum for NJV. Other results can be found in the case of fruits: the yield of all kinds of citrus irrigated by fresh water (1.85 ton/dunum) was much higher than those irrigated by BTWW in the Middle Jordan Valley, where it was only 1.28 ton/dunum. The other fruits exhibited the same manner as vegetables: the yield of the fruit trees irrigated by BTWW was 1.27 ton/dunum and 1.13 ton/dunum of those irrigated by fresh water in the NJV.

One of the main outputs of the analysis concerns *water consumption*. The total water consumption for irrigation water in the NJV was around 78 MCM fresh water; about 71% was used for citrus fruit trees. The water consumption of winter vegetables was about 44 MCM BTWW, which represent 35% of a total water use, while the citrus used 19%, other fruits 19%, summer vegetables 15% and cereals 12%.

Furthermore, *water content in crops* produced is estimated. The average of water content of all crops irrigated with fresh water in the NJV was 484 m³/ton. However, the average water content of cereals in the NJV was 590 m³/ton, and 147 m³/ton and 160 m³/ton for winter and summer vegetables, respectively. The water content in the produced crops in the MJV was higher in the case of cereals (632 m³/ton), winter vegetables (327 m³/ton) and fruits (925 m³/ton), while it was slightly lower in the case of summer vegetables due to the prevention of summer agriculture during drought periods.

The third indicator is *water productivity* which can be considered as the inverse of the water contents; it measures the productivity of one cubic meter of water in kilograms of crop production. The crop groups with high water productivity are the vegetables, where one cubic meter water can produce winter vegetables of around 10 kg both in NJV and MJV, and about 8.0 kg and 11 kg of summer vegetables in the NJV and MJV, respectively.

Table 1 shows the *returns, costs and net profits* for the different crop groups in the MJV and in the NJV. The main results showed that most of the crops registered higher net profit for those that are planted in the MJV (199 JD/dunum), which are irrigated by BTWW compared to those planted in the NJV and irrigated with fresh water (188 JD/dunum). It is worthwhile mentioning that citrus is considered as the only exceptional case which has registered higher net profit in the NJV (208 JD/dunum).

The last indicator was the profitability of the water for each crop group in the NJV and MJV. As the results show, the average profitability of all crops per cubic meter of BTWW was 0.518 JD/m³ in the MJV and 0.477 JD/m³ in the NJV (Tab. 1).

For all crop groups the higher profitability per one cubic meter was for the winter and summer vegetables. This can be applied for all vegetables irrigated by BTWW. On the other hand, the fruits have the lowest in water profitability regardless of the type of water.

Finally, the costs of irrigation water related to the total production cost range between 7% for fresh water and 9% for BTWW, for example, in the case of fruit trees (Tab. 1). The water costs are determined by the price and the amount of water quantity consumed; however, in the Jordan Valley there is no price discrimination between fresh water and BTWW.

Water Source	Crop	Cereals	Winter Veg.	Summer Veg.	Citrus	Other Fruit Trees	Average
Fresh (NJV)	Total Return (JD/Dunum)	310	584	475	571	525	493
	Total Cost (JD/du)	208	345	293	363	317	305
	Net Profit (JD/Dunum)	102	239	182	208	208	188
	Profitability (JD/m ³)	0.267	0.942	0.642	0.241	0.293	0.477
	Percent of Water Cost	10%	3%	4%	9%	10%	7%
BTWW (MJV)	Total Return (JD/Dunum)	360	675	581	393	601	522
	Total Cost (JD/du)	243	398	357	259	359	323
	Net Profit (JD/Dunum)	117	277	224	134	242	199
	Profitability (JD/m ³)	0.264	1.04	0.835	0.158	0.293	0.518
	Percent of Water Cost	11%	6%	4%	13%	10%	9%

Table 1: Total Returns, total costs and net profits (JD/du), profitability per cubic meter (JD/m³) and percentage of water expenses to the total production costs for different crop groups irrigated by fresh water in the NJV and irrigated by BTWW in the MJV

CONCLUSIONS

As the results show, agricultural crops produced by using blended treated wastewater (BTWW) have higher yields (kg/du), lower water consumption and higher productivity (kg/m³) compared to those produced under fresh water.

With increasing water scarcity, the Jordan government will divert more fresh water from agriculture to domestic uses, because of the growing population. The supply of treated wastewater (TWW) will rise after implementing the Disi and Red-Dead water conveyance projects. The additional TWW can be used not only at Jordan Valley, but also in the Highlands, where ground water is overexploited.

5 Cost effectiveness of individual technologies, such as decentralised wastewater treatment (DWWT) and water reuse, managed aquifer recharge (MAR) and brackish water treatment (BRA) (study 705)

SUBJECT OF INVESTIGATION

The study addresses technologies to recharge existing water resources in the Lower Jordan River Basin:

- Decentralized wastewater treatment (DWWT)
- Managed aquifer recharge (MAR)
- Brackish water treatment (BWT).

These technologies aim to providing a water quality, which is suitable for reuse in agricultural irrigation. Water quality A is defined by the Jordanian Standard 893-2006 particularly for the irrigation of cooked vegetables and playgrounds. By applying the cost effectiveness analysis (CEA) the three different technologies will be ranked. However, the analysis does not focus on certain communities in the Lower Jordan River Basin. Instead, it offers a decision tool for any location in the study region. Depending on the specific local conditions, the most cost-effective technologies are to be selected.

Two DWWT systems are considered: Sequencing batch reactor (SBR) and Vertical flow constructed wetlands (VFCW). Both are suitable approaches to sufficiently treat wastewater. In this case, SBR consists of a preliminary treatment, a primary septic tank, a buffer tank, and a sequencing batch reactor (SBR). Constructed wetlands are artificial wetlands or swamps, which operate like biofilters and hence remove pollutants from the wastewater.

The cost-effectiveness analysis (CEA) presented here intends to compare the various technological solutions to mobilize additional water resources. The CEA focuses on treatment technologies designed for 5000 person equivalents in line with the SMART project's aim to serve villages and semi-urban settlements with about 5000 inhabitants (p.e.). A further common feature is that the technologies are to be applied in towns and villages where large centralized plants are not feasible and thus decentralized systems are preferable.

In contrast to the cost benefit analysis (CBA), the CEA is applied, if it is difficult or not possible to assess the **impacts** of water projects in economic terms. Instead, physical units are used, such as water quantities, reduced pollution or environmental benefits. The cost-effectiveness ratio (CER), is calculated as follows:

$$CER = \frac{C}{E}$$

where C means the cost and E the effectiveness of a water project.

Since the investments in water infrastructure are generally of long-term nature (covering often more than 20 years), the **costs** can be calculated in terms of **present values** by using a suitable rate of interest ('discount rate'). The costs can vary significantly over the years, and it is important to consider at which years such changes occur. By using the **present value analysis** the time streams of future costs within the planning period (usually equal to the lifetime of the project) can be diverted, i.e. 'discounted' to a single number.

Another calculation method refers to the **annualised costs**. The annual cost is computed by multiplying the present value of the investment with the capital recovery factor. By using this factor the yearly amount of money required to return the investment (i.e. initial capital cost) over the project life can be determined. Again, discount rates are used. The yearly maintenance and operation costs (O&M) are to be added to the annualised capital cost. In this study, the second approach will be applied. The annual water volumes generated will be related to the annual cost. By that, the different technologies can be compared in terms of **cost per cubic meter (unit cost)**.

In the process of data collection, different sources were used. These include technology providers, Jordanian plants, and literature. A major effort was undertaken to collect viable data. In March 2011 a field trip to Jordan was undertaken to collect cost data from different plant operators. Between June and September 2011, German technology providers were interviewed. Meetings and interviews in 2009 with Jordanian responsibilities resulted in a detailed set of cost data for material prices to calculate construction costs of the technologies.

The assumed life-times of the plants are based on literature and empirical data: SBR about 25 years, VFCW about 20 years, MAR about 30 years and BRA about 15 years. Since interest rates are uncertain, it was decided to use alternatively the following three discount rates 3%, 5% and 7%.

The CEA applies cost data that are general costs for the Lower Jordan River Basin. If decision-makers use the CEA for a particular location, adjustments regarding the cost data will be necessary.

RESULTS

The following table shows the results of the analysis for SBR and VFCW, the three basin MAR solution with pre-treatment in a central plant and brackish water treatment. All treatment options are designed to supply 5000 p.e.

Specific treatment costs in JD/m³

Discount rate	0.03	0.05	0.07
SBR	0.53	0.60	0.68
VFCW	0.62	0.70	0.79
MAR, infiltration, three basins	0.03	0.04	0.05
MAR, infiltration & treatment, three basins	1.19	1.41	1.65
BRA	0.59	0.61	0.64

As the table shows, the decentralized technologies VFCW, SBR and BRA do not differ significantly in terms of their cost-effectiveness. The specific treatment costs to produce one cubic meter of water quality A range from 0.53 JD/m³ (SBR) and 0.59 JD/m³ (BRA) to 0.62 JD/m³ (VFCW). The two MAR options, however, differ considerably from the other technologies. The least cost-effective option is MAR (treatment & infiltration) with 1.19 JD/m³ and the most cost-effective option is MAR (infiltration) with 0.03 JD/m³.

The high specific treatment costs for MAR (treatment & infiltration) can be ascribed to the treatment costs of the central wastewater treatment plant Deir Alla that was selected as an example for providing a water quality that would be suitable for infiltration purposes. Note, that pre-treatment in a centralized treatment plant before infiltration can be substituted by smaller decentralized low-tech treatment plants that generate water quality below standard A. Combining such plants with infiltration basins would result in water quality A at a lower cost. MAR (infiltration) turns out as the most cost-effective option, because it assumes that a treatment plant is already in place. Thus, solely an addition of the infiltration basins is necessary and the additional costs arise from the infiltration step.

A closer look at the core technologies SBR, BRA and VFCW shows that treatment with SBR systems have a slightly lower treatment costs per cubic meter than BRA and VFCW. This can be explained by the comparatively simple treatment systems with a high removal capacity and sedimentation rate when processing wastewater. **Surprisingly, VFCW turn out to be the least cost-effective option of the decentralized technologies, although the distance between the specific treatment costs for constructed wetlands and the other technologies is only marginal. The higher costs are mostly due to substantial land requirements and the amount of filter medium needed for the wetland.** However, we refrain from condemning VFCW as too expensive since different constructional alternatives and adjustment to in-situ conditions might result in another picture. Critics claim that VFCW is generally less cost-effective for large villages with 5,000 p.e., and may be more viable for smaller p.e. - values. However, a comparison of investment and O&M costs for small treatment plants

(4 to 50 p.e.) shows a similar pattern as the results presented here, where constructed wetlands are listed as comparatively expensive, even though only used as finishing treatment.

As expected, costs increase with rising interest rates.

CONCLUSIONS

The CEA can be used in decision processes that involve the determination of the most cost-effective or beneficial technological option to mitigate water scarcity. In order to make the analysis applicable to different locations in the Lower Jordan River Basin, we decided not to focus the analysis on one or two specific locations. Instead, our analysis presents general cost estimates that are generally applicable to the entire region. This point is very important when using the CEA results in single villages or specific locations, because construction costs are likely to vary according to the bedrock conditions. Decision-makers should therefore check, whether our assumptions for construction costs of the technology options are applicable to the village under considerations and make adjustments if necessary. The results can only guide decisions for villages or communities with about 5,000 p.e.

Depending on the location, not all technology options might be feasible. For example, BRA is only an option if brackish water is available in sufficient quantities. Furthermore, MAR are only feasible if the hydraulic conductivity of the underlying soil is within useful parameters. If the resulting infiltration rate is too low, this option should not be considered in a water resources management plan for a specific location. It is also important to keep in mind that until now, infiltration of treated wastewater for groundwater recharge is illegal in Jordan.

6 Costs and benefits of alternative IWRM strategies at basin level and their financial feasibility (study 706 & 707)

SUBJECT OF INVESTIGATION

Water problems

The study focuses on two areas: The *Jericho basin in Palestine* and the *Eastern Lower Jordan River Valley*.

The *basin of Jericho* is divided into three sub-areas with different utilization of water resources, infrastructures and water demands: a) Jericho east sub-area, b) central sub-area with the Jericho City and c) Jericho north sub-area (Fig. 1). At each of them with specific problems, water management options have been identified, that are supposed to be appropriate in improving the water situation. In the near future water supply problems will aggravate if no measures would be undertaken. In areas, where

agriculturally used land could be extended, more water is needed. In other areas, growing population and additional commercial activities will increase the municipal water demand. Furthermore, the sanitary infrastructure is poor as no wastewater treatment plants exist. Cesspits are in use, by which the water bodies are seriously polluted.

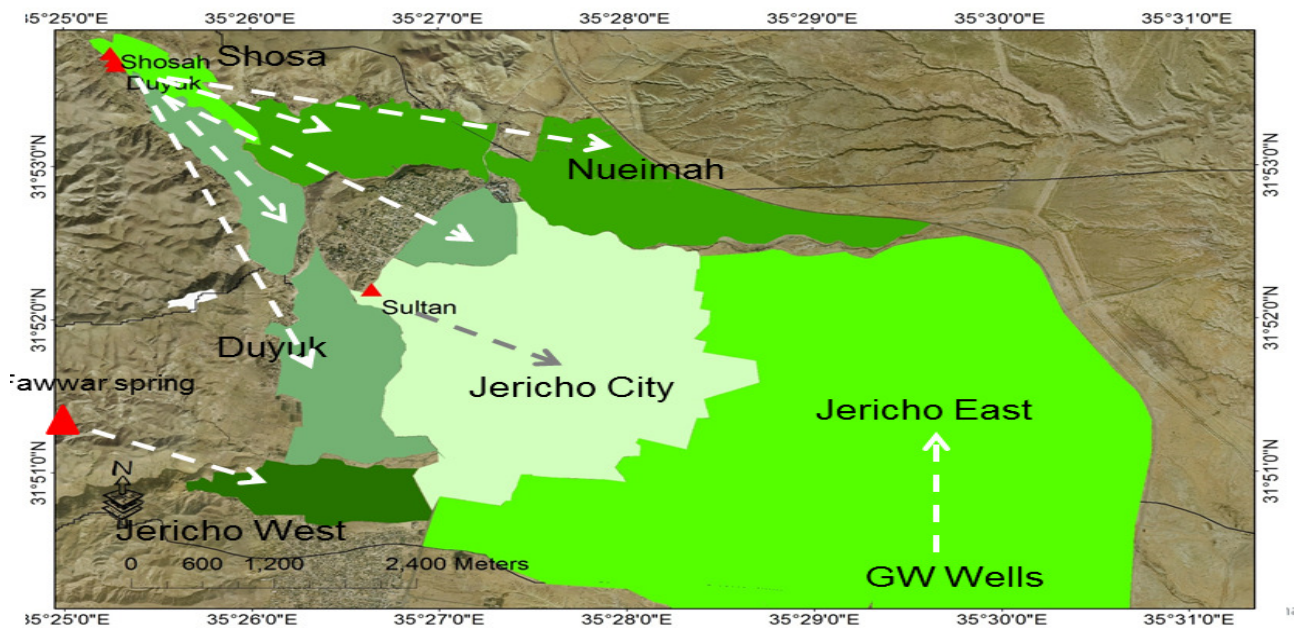


Figure 1: Three Jericho sub-areas

The *Eastern Lower Jordan River Valley (LJRV)* is one of the most water scarce areas in the Middle East. This situation is caused by the high water demand for irrigation and the limited water availability. Further influencing factors are the unfavourable climatic conditions, such as high temperatures and declining precipitations. On the other hand, this area is the ‘food basket’ for Jordan and a major source for the drinking water supply of the city of Amman and other municipalities (Fig. 2). Thus, IWRM concepts are urgently needed for more efficient use of water resources.

RESULTS

Water management options

At the *Jericho east sub-basin*, groundwater wells are concentrated and only extensive agriculture exists. Most of wells are not working due to the poor water quality and deep water levels. Salinity is the main problem and salinity increases with falling water levels that causes sea water intrusion from the Dead Sea. Various assumptions regarding the expansion of agriculturally used land and declining water availability will render different prospected developments of water shortage.

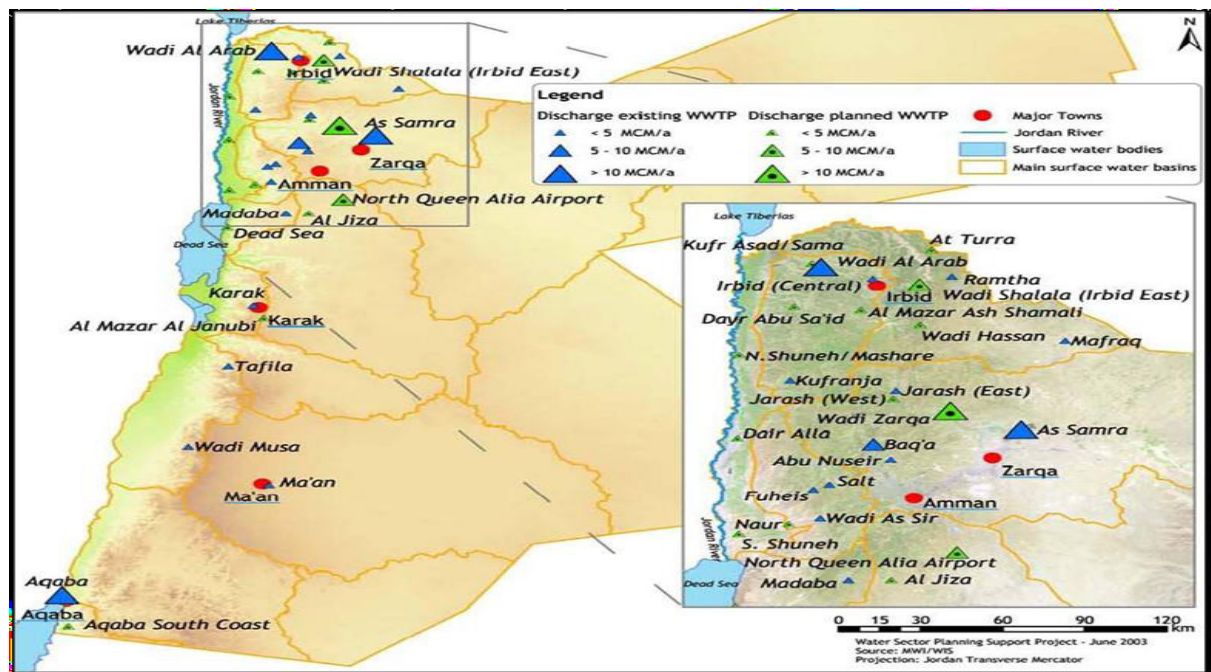


Figure 2: Lower Jordan River valley

By using the WEAP model, the water demands could be projected in the period from 2012 to 2030. Together with the declining groundwater availability the increase in demand will lead to growing *water deficits* (Table 1). The **desalination of brackish water** would improve the water situation. But also **wastewater reuse** and **rainwater harvesting** are to be considered.

At the *Jericho central sub-area* with the city of Jericho, there are domestic, agriculture, commercial and public water users. Currently, this area is supplied with water from the Ein Sultan Spring that produces about 5.5 Mm³/yr. Population is expected to grow rapidly in the next decades, so that the water demand will increase. The arable land is currently not fully used and the expansion of agriculture would only be possible if additional water resources will be available. Thus, the total *water deficit* will rise in the future (Tab. 1). The following options to tackle this problem are considered: **Rehabilitation of groundwater wells; transfer of Duyuk spring water rights from agriculture to the municipal users; storm water harvesting from Al Qilt watershed; demand management and rehabilitation of water distribution networks.**

Jericho sub-areas	Water demand (MCM/yr) 2012 – 2030	Water deficit (MCM/yr) 2016 - 2030
East sub-area	2.6 – 5.0	1.2 – 4.0
Central sub-area	3.7 – 7.0	0.6 – 4.0
Shosa / Duyuk and Nueimah sub-area	2.5 – 7.0 1.4 – 4.0	1.2 – 5.0 0.8 – 3.0

Table1: Water demands and deficits at the Jericho sub-basins

At the Jericho Shosa / Duyuk and Nueimah sub-area there are villages that depend on agriculture as their main source of income. The water sources are the three adjacent Shosa, Nueimah and Duyuk springs. The major water use is irrigation. The domestic water users are mainly farmers living in the villages. The yearly discharge of the springs varies due to different climate conditions. In the period from 2012 to 2030, the projected water demand will grow both at the Shosa / Duyuk site and the Nueimah site. Together with the declining spring water availability, this will lead again to *water deficits* in the future (Tab. 1). As water management options will be considered: **Rainwater harvesting from the Nueimah watershed and replacement of open channel with closed pipe distribution networks to decrease water losses.**

At the LJRJV, the water consumption will be relatively stable within 2012 – 2030 and will range approximately between 280 MCM/yr and 300 MCM/yr. The reason for that is the water scarcity that does not allow growing activities particularly in agriculture – the main user at this basin. Due to the yearly changes in precipitation and increasing water needs of agricultural and municipal users, including the citizens in Amman and neighbouring localities, there is a permanent *water deficit*, which varies from 80 MCM/yr to 140 MCM/yr. The purpose of the **Disi conveyer project** is to pump water from Disi fossil aquifer to Amman and other governorates over a distance of about 300 km. The aquifer lies beneath the desert in southern Jordan and north-western Saudi-Arabia. The project will be finished by the end of 2013. The additional water supply will amount to around 100 Mm³/yr. It will mitigate the water shortage for Amman and surroundings but not completely resolve the water deficit. Furthermore, it will positively affect the overexploited groundwater resources by slowing down the dramatic decline of their water levels. A further measure is the construction of the **Kufranjeh dam** to utilize the runoffs flowing into the Jordan Valley and Dead Sea. It will be located at the south of wadi Shueib with a storage capacity of 5 Mm³, and will operate presumably in 2015. The water will be used mainly for agricultural irrigation in the southern Jordan Valley. Further options are more **use of reclaimed water by construction of three further wastewater treatment plants** and to **enhance the efficiency in agricultural irrigation.**

Impacts of water management options

At the Jericho area, by means of the proposed water management options the water deficits can be resolved. As the results of the study show, the economic benefits exceed the costs in the most cases. For example, at the Jericho east sub-area a maximum of additional water supply of 6.3 Mm³/yr can be provided.

On the other hand, the projected water deficit will increase from 1.2 MCM/yr in 2016 to approximately 4.0 MCM/yr in 2030, if no measures will be undertaken (Tab. 1). This means, that not all the management options considered are to be implemented at the same time. Thus, the different options are to be prioritised according to their effectiveness.

In Table 2, the economic efficiency of the three options are compared in terms of their values added – defined as the annual surplus of the benefits over the costs per cubic meter extra water. **The water reuse option can be considered as the best one, followed by rainwater harvesting and desalination of brackish water.**

	Unit values added USD/m ³ *)
Desalination of brackish water	0.76
Rainwater harvesting from Al Qilt	1.11
Water reuse	2.06 **)

*) Values at 100% use of capacity; water losses in the networks not considered

***) Cost savings due to replacing cesspits (indirect benefits) are included. The value will be higher, if only the cost of upgrading the treatment technology to comply with the quality requirements will be taken into account.

Table 2: The economic efficiency of water management options at the Jericho central sub-area

At the *Jericho central sub-area*, a corresponding ranking can be made: The option rehabilitation of water networks and demand management have the highest values, while the option rainwater harvesting has the lowest.

For both sub-areas, time-referenced cost-benefit analyses were performed. The aim is to identify the most cost-beneficial time sequence of water management projects within the planning period 2012 – 2031. For the Jericho east sub-area, by applying the values added in Table 2 the time intervals with different combinations of options can be determined, if the water supply shall meet the continuously growing water demand in agriculture. The combinations A, B and C represent the most cost-beneficial IWRM strategies (Tab. 3, Fig. 3).

The shape of the curve in Figure 3 are dependent on several influencing factors such as the costs, domestic water prices, water profitability in irrigated agriculture and the growth rate of crop

production. For example, if the water profitability in agriculture is increasing, the curve will be shifted upwards. This means that each of the water projects should to be implemented earlier.

IWRM strategies	Combinations of water management options
A	Wastewater reuse
B	Wastewater reuse + rainwater harvesting
C	Wastewater reuse + rainwater harvesting + desalination of brackish water

Table 3: IWRM strategies at the Jericho east sub-area

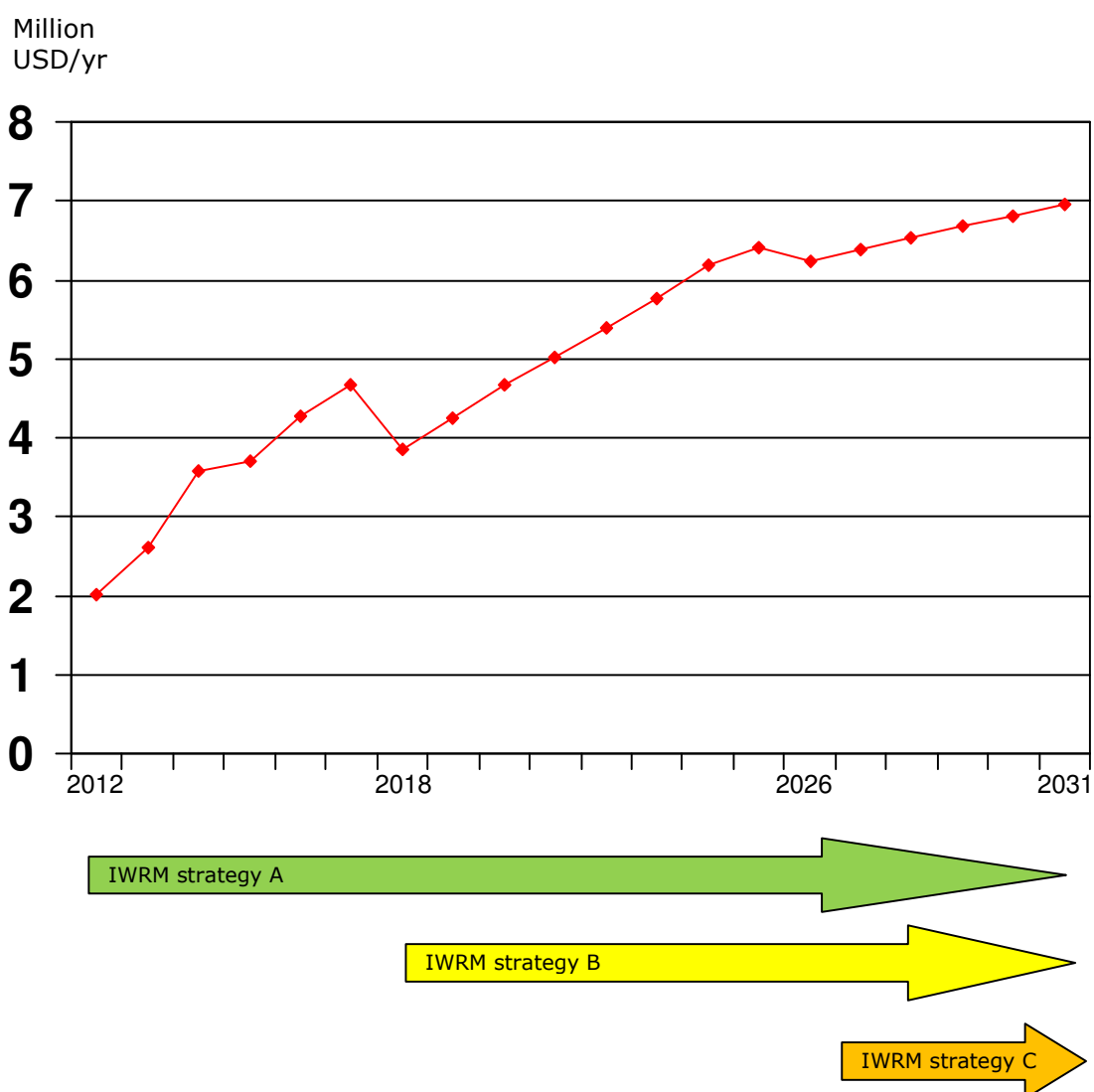


Fig. 3: Values added of IWRM strategies within 2012 and 2031 at the Jericho east sub-area

Such time-referenced cost-benefit analyses provide guidelines for water managers, who want to decide when different water projects should be constructed and which capacity they should have to perform the most cost-efficient IWRM strategies. Inter alia, they have to consider the projected water demands, the changes in water availability, the costs of water projects and the values of water (municipal water prices and water profitability in agriculture).

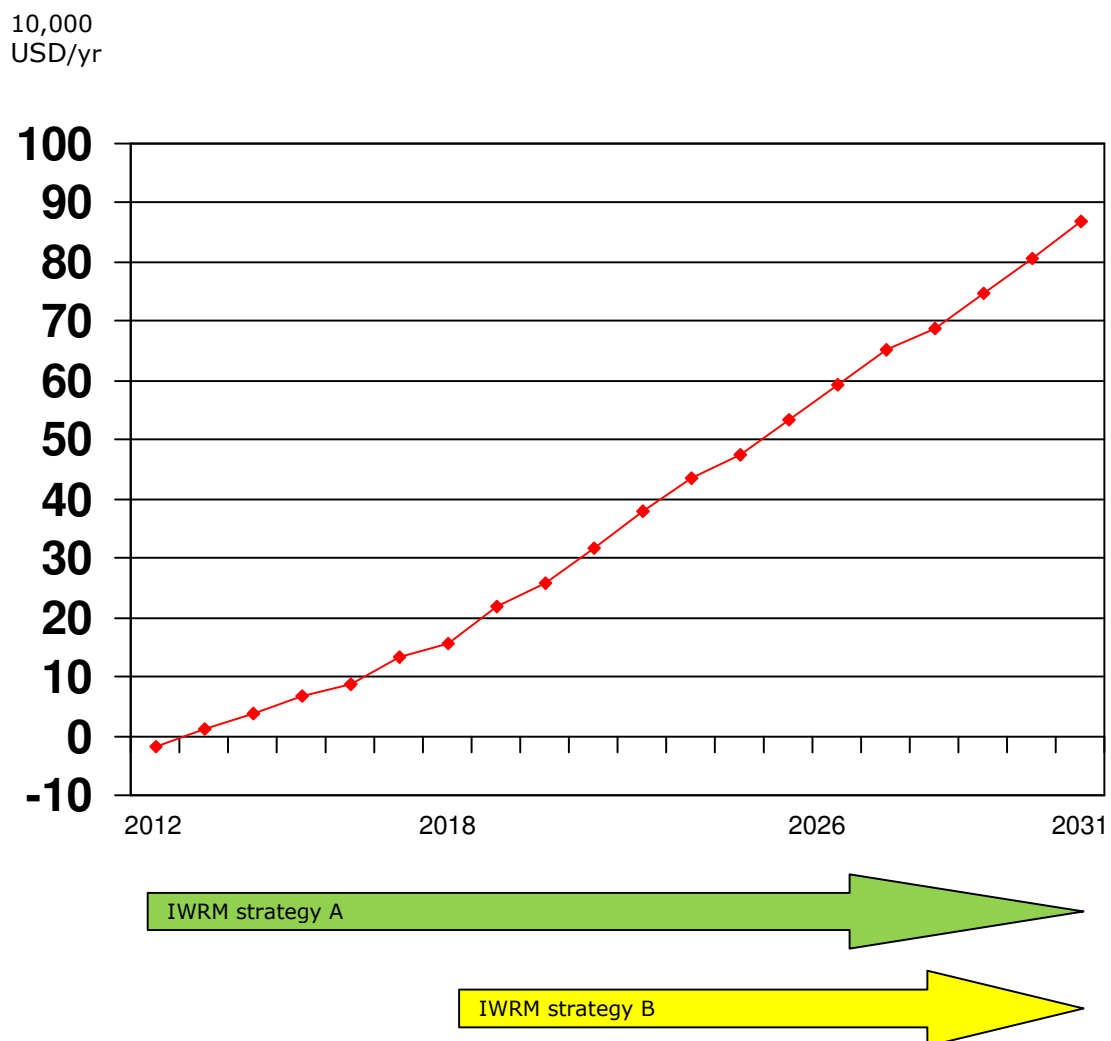


Fig. 4: Values added of IWRM strategies within 2012 and 2031 at the Jericho central sub-area

Figure 4 shows in conjunction with Table 4 the results of the cost-benefit analysis for the *Jericho central sub-area*.

IWRM strategy	Combination of water management options
A	Demand management + rehabilitation of networks
B	Demand management + rehabilitation of networks + intersectoral water transfer.

Table 4: IWRM strategies at the Jericho central sub-area

At the *Jericho Shosa / Duyuk and Nueimah sub-area*, the values added of replacing open channels with a pipeline network are higher than the values added expected from storm water harvesting. However, even if both options would be implemented, the water needs in irrigated agriculture - the main user at the Shosa / Duyuk and Nueimah areas – will exceed the water supply within the planning period 2012 - 2030. Consequently, both options should be implemented soon and a prioritising is not useful.

A similar situation can be found at the *LJRV*, where **all the options considered are to be implemented in order to mitigate the water shortage** years, so that further measures will be needed in the future. In Table 4, the estimated values added of the three options are compared. The water reuse projects have the highest values added, followed by the Kufranjeh dam and improvement in irrigation efficiency.

	Cost (Million US\$/yr)	Benefit (Million US\$/yr)	Value added (Million US\$/yr)	Value added (US\$/m ³)
Kufranjeh dam *)	1.7	6.3	4.6	0.84
More irrigation efficiency	6.8	10.0	3.2	0.16
Water reuse **)	1.3	9.4	8.1 / 9.1	1.07 / 1.2

*) Southern Jordan River Valley only

**) The higher numbers show the added value under the assumption that only 20% of the WWTP cost represent the cost of water reuse

Table 4: Cost, benefits and values added of water management options at Lower Jordan valley

As the values in Table 4 indicate, especially water reuse projects are most cost-beneficial and should be promoted in improving the water situation at the LJRV.

CONCLUSIONS

With regard to the feasibility of IWRM strategies, it is important to keep in mind that the implementation of cost-beneficial water projects can fail, if there are no sufficient financial resources. Usually, projects are to be financed by charging the water users, such as farmers, citizens and entrepreneurs. In special cases,

however, they cannot fully afford the costs. Other funds are required, such as governmental, private or international donors (e.g. World Bank, USAID and KfW). In Table 5, financial issues discussed in the study are highlighted:

To ensure the *financial feasibility* of projects it is essential to specify the allocation of gains and losses resulting from IWRM strategies. In the best case, all parties involved will gain and there will be a fair distribution of the values added. At the Jericho central sub-area, several different water users such as farmers, citizens and entrepreneurs are supplied from the new resources, which can be allocated separately to different users: The new resources from rehabilitated groundwater wells and storm water harvesting are mainly designed for agricultural irrigation; the water transported from the Duyuk spring and saved by rehabilitation of networks are dedicated for municipal users of Jericho City.

However, by water reallocation municipal users may benefit, whereas the agricultural users will not be faced with economic losses. At the Jericho central sub-area, for example, the extra supply devoted for agricultural irrigation amounts to around 3 MCM/yr, but the demand is supposed to grow from currently 0.01 MCM/yr to 1.4 MCM/yr in 2031 only. On the other hand, for municipal water users there will be a water shortage in the near future, if the new resources cannot become available in time. At such a case, the financing of new projects can be facilitated by an appropriate reallocation of water resources.

Financial issues	Description
Full cost principle	The true costs of water projects are to be taken into account
Water pricing	Water users have to pay the full cost of water projects by considering all the beneficiaries
Cost recovery	The financing of water projects should be ensured by adequate charging of users, trading schemes, grants and build operate transfers
Optimization	By maximizing the values added of water projects the financial requirements can be reduced
Reallocation of resources	Resources should be allocated to users as cost-beneficially as possible to ensure the financing of new water projects
Water trading	The financial feasibility of projects can be facilitated by buying water rights
Distribution of costs and benefits	Water exchange between agriculture and cities can be financed by adequate distribution of costs and benefits

Table 5: Overview of financial implications of IWRM strategies

Intersectoral water trades should be promoted with special regard to wastewater reuse projects as well. If farmers use the treated wastewater, freshwater could be released for improving the water supply of citizens resulting in considerable economic benefits. To ensure the financial feasibility of such a water reuse project, the water price for the citizens may be raised. In special cases, it is advisable to waive charging the farmers for delivering treated wastewater and even to grant them compensation payments.

Such an intersectional water exchange may be established at the Jericho east and central sub-areas: The effluents from the projected Jericho wastewater treatment plant can be used for irrigation in agriculture; less water from freshwater resources, such as the En Sultan Spring and rehabilitated wells, would be required for irrigation. The released freshwater water can be used for municipal users. Such agreements may be applied to storm water harvesting, provided the increases in farmers' incomes are relatively small and there will be considerable benefits for the municipal users.

As outlined in the Jordan Valley case study, the financing scheme can influence the annual costs. For instance, at the Built Operate Transfer (BOT) approach applied increasingly for public infrastructures, the concession right is granted to private contractors to invest and to operate the water project within a certain period. If BOT will be applied in case of the Kufranjeh dam, the annual capital cost will be significantly higher compared with the above estimated value. The payback period (amortization) is 20 years and shorter than the supposed usable lifetime (depreciation).

For the cost-benefit analysis, however, the annualized capital cost based on the useful lifetime should be taken into account. Otherwise, the benefits emerging in the years beyond 20 years will be compared with annual capital cost of zero in the following 30 years (as in these years no loans must be paid back). It should be mentioned, that the BOT approach is more attractive for the future generation rather than for the present as the latter has to pay the cost with higher charges. But the future generation should be charged as well in order to build up a fund, from which the replacement cost can be financed by using own resources instead of loans.

By applying time-referenced cost-benefit analyses water managers can decide when different water projects should be constructed and which capacity they should have to perform the most cost-efficient IWRM strategies. Important influencing factors are the future water demands, the changes in water availability, the costs of projects and the water values (municipal prices and profitability in agriculture). Such an approach helps to prevent economic losses, to maximize the benefits of water projects and to ensure the financial feasibility of IWRM strategies.

7 Costs of different IWRM technologies in the West Bank (study 708)

SUBJECT OF INVESTIGATION

The report provides first a broad overview of the current socioeconomic and hydrological conditions at the West Bank. The situation is characterised by high unemployment rates (average 19%), low family incomes, water shortage and poor water management. The availability of water per capita particularly at the West Bank ranges from 29 to 150 liter per day, but is mostly below 100 liter. Widespread are seasonal water cut-offs, mainly during in dry summers. 30% of the communities or 700,000 people are currently not served by any water network. There, purchasing water from trucks and hauling water from standpipes are typical. At the West Bank, the gap between supply and demand will increase dramatically in the coming years.

The second and main part of the report focuses on water management issues in the Jericho city and its surroundings.

RESULTS

In Jericho (around 20,000 inhabitants), ground & spring water is the main resources. Potential water resources are flood flows from the valleys of Wadi Qilt and Wadi Nuwei'meh. Currently, Jericho has no wastewater collection system and treatment, only cesspits exist. The irrigated agriculture plays a major role as this area is the 'food basket' of the West Bank. The total water deficit (unmet demand) will increase presumably from 0.44 MCM/yr in 2010 to 3.28 MCM/yr in 2040, if no measures would be undertaken. The study discusses several water management options with special regards to their costs, including inter alia:

- Rehabilitation of wells,
- Drilling of new groundwater well,
- Purchasing water use rights,
- Construction of grey water treatment plants,
- Demand management,
- Network maintenance,
- Construction of a wastewater treatment plant,
- Storm water harvesting,
- Construction of brackish water treatment plants.

Examples of investment costs are 25,000 € (around 33,000 US\$/m³) for gray water treatment plants, 3,75 million € (around 4.9 million US\$/m³) for storm water harvesting and 35 million € (around 46 million US\$/m³) for the Jericho WWTP.

According to an investigation of the Palestinian Hydrological Group (PHG) for the West Bank and Gaza (2005-2007), rehabilitation of wells for domestic and agricultural users is most cost-effective option (0.7 US\$/m³), followed by rehabilitation of springs (1.5 US\$/m³) and domestic water supply systems (6.0 US\$/m³), replacement of water meter (8.0 US\$/m³) and rehabilitation of spring and irrigation conveyance systems (30 US\$/m³). The construction of infrastructures to utilize surface water plays a minor role in the current water management at the West Bank, since there is no access to the Jordan River. Exemptions are projects for storm water harvesting. There are many wadis, where dams can be built, such as Wadi Qilt.

A further important option is the reuse of treated wastewater. The report describes use cases, including their costs, in several countries (e.g. Cyprus, Israel, Lebanon, and Morocco). At Palestine, a prominent example is the Al-Beirah water reuse system, developed in 2000. The effluents are being discharged through the Wadi Al-Ein and conveyed by a 5 km pipeline to the Dir-Dabwan agricultural area. The investment cost are 7 million € (around 9 million US\$) and the unit cost of treatment 0.32 €/m³ (around 0.5 US\$/m³).

CONCLUSIONS

Within the next 10 years, it is intended to improve the water sanitation at Palestine by constructing huge municipal wastewater treatment facilities, financially supported by international donors, such as USAID and KfW. In 2000, about 73% of the households at the West Bank have cesspit sanitation. Several small-scaled treatment plants have been constructed recently in the rural areas. Most of the rural sanitation facilities entail trickling filters and natural treatment systems preceded by septic tanks. At Palestine (West Bank and Gaza strip) within the residential areas, approximately 50 – 70% of urban wastewater is collected and only a few WWTPs exist, however their performance is poor.

From the regional perspective, several future large-scaled water projects are under consideration, such as the desalination of seawater and brackish water (Israeli plants; Mediterranean and Red Sea projects), the Red-Dead Sea Canal, more water from the lake Tiberius and the West-Ghor canal. The report provides an overall comparison of the investment costs per cubic meter between different water management options.

With special regards to the Jericho area, the recommendations are oriented on better governance of water management, improvements in spring water conveyance systems, implementation of storm water harvesting and artificial recharge, promotion of wastewater treatment and reuse, and more focus on cash crops in irrigated agriculture.

8 Social acceptability of different IWRM technologies in the West Bank (study 709)

SUBJECT OF INVESTIGATION

The report starts with a broad literature overview of the definitions of IWRM. It points out also the socioeconomic and political prerequisites for the implementation of this approach. The following chapter 1 deals with the main drivers for the social acceptance, such as water and poverty, water pricing and tariff structure, willingness to pay and affordability. The next chapter addresses the reuse of treated wastewater as an IWRM component. Subject of chapter 3 is the Jericho case study, which elaborates the hydrological and socioeconomic implications of IWRM strategies at a specific water basin in Palestine. The report closes with conclusions and recommendations.

RESULTS

There are many recent international programmes (for instance, initiated by the UNDP and World Bank) that aim to improving the access to better water supply and sanitation to the poor, particularly in developing countries. Water pricing as an important constituent of IWRM is subject of many studies world-wide. In one of them, water pricing is understood as a tool to achieve several goals, such as cost recovery, redistribution of income, improvement of water allocation and water conservation. The willingness to pay analysis is a wide-spread applied approach to assess the value of water services and IWRM strategies. It is related to water prices, profits, incomes and the affordability to contribute to the costs of water. Arguments can be found against to relying on this approach. One of them concerns the accuracy and reliability of the outcomes from questioning water consumers. Furthermore, often in poor countries the willingness to pay can be high, however the affordability to pay the cost of adequate water services is low.

In chapter 2 of the report, the recent international literature on wastewater reuse is reviewed in great detail. With special regards to the social acceptability the main requirements are pointed out. They include minimal health risks, reduced water pollution, conservation of water resources, reasonable costs and positive perception of water reclamation. A major role plays the charges on using treated wastewater, particularly in irrigated agriculture. Farmers will refuse to join water reuse projects, if there are no economic incentives. A similar behaviour can be expected if the difference between these charges and the cost or prices of freshwater as an alternative resource is negligible. Particularly in countries like Palestine or Jordan, religious doctrines and Islamic traditions may here and there hamper the readiness of applying treated wastewater. Thus, in those countries very restrictive rules for water reclamation exist.

Some results from the Jericho case study are referring to the report 708, dealing with the costs of water management options at this area (reviewed above). These results concern the hydrological and socioeconomic conditions and the list of IWRM strategies. In the report 709, the outcomes of surveys of households and farmers on their socioeconomic situation and water use are presented.

Furthermore, the current water tariff systems and the household opinion on the affordability to pay water prices were surveyed. According to the findings, 78% of the registered customers are falling in the tariff block no. 1 (0-100m³) with a water price of 1 NIS/m³, and the majority of residents in Jericho expressed an affordability of 1 NIS/m³.

The water prices for *agricultural users* depend of institutional conditions, such as the ownerships and agricultural shares in the resources. The Jericho municipality calculated the water price of 0.36 NIS/m³ and was eventually determined alternatively at 0.36 NIS/m³ or 0.20 NIS/m³. Regarding the affordability and willingness to accept the prices for the current water services, the findings show that the incomes of most of the farmers is low (85% of the interviewed farmers have a monthly average of underneath the 3000 NIS level; full-time farmers have even less incomes) and that they would not be ready to pay higher prices, even if the performance of water supply would be improved.

Since the tariff systems for the domestic, commercial and agricultural users appear to be somewhat unbalanced, the report contains some recommendations how to improve them. With respect to the water tariffs for *municipal users*, the block rate settings should be revised in order to align it with the actual water consumptions, to encourage water saving and to ensure social equity and cost recovery. In the report, proposals for modified domestic, commercial and agricultural tariff structures can be found.

Finally, an overview of the social acceptance of different water management options is provided: Many people prefer water harvesting, because it is a cheap option and does not need permissions from Israel. Only a low percentage of people is willing to purchase water from Israelis or from other farmers, because of the water price and the missing trust in the reliability of water supply. Many of the farmers prefer drilling of own wells to keep the water costs low and to be independent on other sources. The readiness to use treated wastewater is low.

CONCLUSIONS

The social acceptance of IWRM technologies is dependent on many influencing factors, including cultural and religious values, level of knowledge, affordability and price of water, governmental water policy, crop pattern and requirements of the markets. To raise the acceptance actions are required, such as better governance, promotion of water reuse, education programmes and more participation of the people concerned.

9 Institutional feasibility of alternative IWRM technologies in the West Bank (study 710)

SUBJECT OF INVESTIGATION

The performance of the IWRM approach needs adequate institutional structures to achieve an effective and equitable governance of water problems. The report provides firstly a brief *overview of the historical development of water regulations* in Palestine. In particular, it shows what happened before and after the Oslo Agreement II of 1995. In the next chapter, the *state institutions and non-governmental organisations at the West Bank* are described. Chapter 3 highlights the goals and challenges in the Palestinian water policy. It shows also the progresses and the constraints in *improving the governance*. The following chapter deals with the results of a *case study at the Jericho municipality*. Finally, recommendations for *institutional reforms* in the water sector are made.

RESULTS

The Joint Water Committee (JWC), an Israel – Palestinian body, was set up 1995 under Oslo accords (Bryant, C. 2012). This body has four sub-committees: water, wastewater, hydrology and water pricing. Its purpose is to implement the regulations of article 40 the 1995 Oslo interim agreement.

The main elements of the Palestinian Water Policy have been incorporated in the *Water Law No 3 (2002)*. Based on this Water Law, the National Water Council (NWC) was established as a high level cross ministerial and stakeholder forum with decision making powers, addressing the governmental water policies and tariffs, the funds for water investments, the regional and international co-operation, and the activities and budget of the Palestine Water Authority (PWA). The NWC met once in March 2006, and has not met since.

Even though a Palestinian Water Law and several ministries exist, there are problems in enforcing the current legislation. The lack of investments in improving the water infrastructure, the scattered nature of the water sector and management bodies are hampering the responsible decision makers, particularly at the PWA, to set-up adequate rules, regulations and water tariff systems. A further problem is that the Palestinians have not the full control over their resources. They are in part dependent on the water supplies from Israel and need often the approval of Israeli Water Authorities. These and other factors have led to *inefficient and uncoordinated water management*.

The report highlights the main challenges for the Palestinian water policy as follows:

1. Asymmetric power and capacity in water governance hampering rational planning of Palestinian water resources and infrastructure.

2. Increasing gap between supply and demand in the coming years.
3. Need to regulate, monitor, and control the managerial, technical and financial performance of the water utilities.
4. Dependence on the approval of Israeli authorities for water projects within the West Bank.
5. Low level of investments in the water sector.
6. Uncertainty about the future socioeconomic, institutional and political conditions.

The fundamental principles for *reforming the current governance* in the water sectors include inter alia: a) Aligning clear responsibilities to central governmental institutions and local water management bodies; b) Public participation in water management at all levels and c) Integrated water resource management (IWRM) to ensure efficient and sustainable water utilization.

The PWA developed a *reform plan* that was adopted by the Council of Ministers by means of Legislation No. 13/13/04 in December 2009. A Reform Steering Committee (RSC) was established to monitor its implementation. The RSC includes Ministries that are related to the water sector, such as the Ministry of Finance, Ministry of Local Government, Ministry of Health, Ministry of Planning and Administrative Development and the Ministry of Agriculture. It incorporates also the Palestinian Environment Quality Authority (PEQA) and representatives of the PWA, water utilities and the civil society. The Council of Ministers decided to implement this strategic reform plan between 2011 and 2013.

The objectives of the program aims are:

- Rectifying utility services in a way that equitability in the provision of high quality services will be ensured.
- Improving capabilities, recovering operating costs of water facilities and organizing them more effectively.
- Achieving more sustainable management of water resources by means of enhancing institutional knowledge, policies, monitoring capabilities and enforcing of the water law.
- Increasing awareness of managing water demand.
- Establishing strong institutions that will clearly define the roles, responsibilities and interrelationship between the actors in the water and wastewater sector.
- Meeting the infrastructure requirements by improving the investment policies for sustainable water supply and sanitation.

The report points out the constraints for an effective Palestinian water policy, amongst others: The PWA operates both as regulator and implementer, and water supply service remains in the hands of several hundred separate municipal water departments and local councils. Furthermore, there is the weak ability of PWA to negotiate effectively in the JWC.

In the following, the institutional challenges in the water sector are pointed by using the example of *Jericho municipality*.

Case study

The current water governance structure in Jericho city is rather complicated. In the past, the water of Ein Sultan Spring – the main resource - was flowing through open channels and supplying water for all purposes, including the agricultural and household water use. After the construction of drinking water supply network, part of the spring's water was pumped under the direct control and management of the Jericho Municipality. With the urban expansion and population growth, part of the water used to irrigate agricultural land was designed for domestic water use.

In 1994, a decision was made to convert the open canals conveying the spring's water to agricultural land into pressurized pipe system in order to improve irrigation efficiency and reduce the losses (evaporation and canal leakage) of nearly 40%. The Decree No. 38 was issued in 1998 to establish a new entity, called *Ein El-Sultan Water Institution – Jericho*. This decree has authorized the Palestinian Water Authority (PWA) to supervise the financial and administrative issues of the new institution.

In order to organize better especially the irrigation water users of Ein EL Sultan spring, in 1999 the *Ein Sultan Irrigation Water Users Association (ESIWUA)* was founded. In 2002, a meeting took place to define stakeholders' roles in managing the allocation of water among the domestic and agricultural users. The participants agreed to allocate 58% of the spring's water for agriculture and 42% for domestic use. They also agreed that this arrangement is valid for two years from the actual start of operation of the project, after the two years, both the Municipality of Jericho and ESIWUA should re-evaluate the needs of each sector. However, all these initiatives were not successful as expected.

CONCLUSIONS

The stakeholders are challenged to establish a new form for involving the ESIWUA in water management. In the report, recommendations have been made how to ensure that farmers get actually their designated quotas in time and how to determine better the responsibilities of ESIWUA, Jericho Municipality and other stakeholders. In addition, suggestions can be found, how to establish new institutional frameworks and how to apply more effective water management instruments.

10 Assessment of multiple water qualities in Israeli municipalities (study 711).

SUBJECT OF INVESTIGATION

The study addresses the issue of multi-objective decisions in water management. Such decisions are typically characterized by a large set of options and multiple, conflicting and incommensurate objectives. Multi Criteria Decision Making (MCDM) is a discipline aimed at supporting decision makers who are faced with numerous and conflicting objectives, such as sustainable utilization of aquifers, reliability of water supply for different demands and insurance of satisfactory income levels. This methodology aims at highlighting those conflicts and deriving a way how to come to a compromise in a transparent decision process.

The analysis focuses mainly on alternative water management strategies dealing with various options of using resources with different qualities, such as freshwater, treated wastewater, saline water and flooding water. In trying to determine the best management strategy to tackle water shortage, priorities for the allocation of different resources are needed. The impacts of each action on different objectives are to be investigated. In the report, the usefulness of the Multi-Criteria Analysis (MCA) is demonstrated by means of a case study at Israeli localities in the Lower Jordan River Valley.

Before that, the water situation in Israel with special regard to socioeconomic characteristics (e.g. water pricing) are described.

RESULTS

Water in Israel is considered as a national resource of utmost importance, and the concentration of all water resources management is in the hands of the governmental *Water Authority*. The water supplied to agriculture is mainly provided by the National Water Company “Mekorot”, and Agricultural Association. According to the *Water Law* (1959), water use requires a license. This includes well drilling, abstraction, supplying, consumption, sub-surface recharging, and water treatment. The license consists of rules regulating the use of water resources.

The Water Law established an administrative annual *quota allocation* mechanism. The quota allocation, for instance, to *domestic* water use is regulated through a differential pricing system. Allocations for *agriculture*, the main water user, are based on the needs as defined in the agricultural plan for the locality. Over the years the composition of water used by agriculture has changed. While the share of agriculture in overall water use tends to decline, it is still 57% in recent years. Since 2000 environmental issues have become more important and sustainable principles guide the nationwide multi-

year agricultural development plan. The main objectives in the context of water are: efficient use of runoff water and collection of rainwater; utilization of recycled effluent and marginal water resources.

Israel has already reached the stage when natural groundwater and surface water resources are fully utilized. Therefore, treated wastewater is viewed as an agricultural resource, and its utilization is recognized as economically beneficial. Freshwater for irrigation is limited, and a choice between using freshwater or reclaimed wastewater does not exist. National policy calls for the gradual replacement of freshwater quota allocations to agriculture by reclaimed wastewater.

In 2000, treated wastewater constituted about 17% of consumption by the agricultural sector. By 2008, in the wake of several years of drought, effluents constituted about half of the water supplied to agriculture. Today, the reclaimed wastewater used in agriculture is approximately 75% of the treated wastewater country wide, compared to less than 5% in the USA.

Apart from constructing reservoirs in Israel, another storage method practised is the percolation of effluents through the soil and dilution into the aquifer. The Dan Region Wastewater Treatment Plant (Shafdan) is a complex inter-regional system that collect, treats and reclaims municipal and industrial wastewater by mechanical-biological wastewater treatment facility. The Shafdan produces high-quality irrigation water, which is very close to drinking water quality. Total of 130 MCM/yr are injected into the aquifer for final filtration, pumped from it after a period of about six months and are sent to the Negev Desert for irrigating farms. Approximately 70% of agricultural activity in the Negev is irrigated using these effluents, thereby saving millions of cubic meters of drinking water in Israel. The large scale desalinization plant together with the other plants provides capacity 10% of the country's total freshwater resources. The increasing desalination of seawater has raised concerns in agriculture, as the desalinization process removes ions that are essential to plant growth (e.g. calcium, magnesium) while concentration of boron is highly toxic to many crops.

The differences in water prices reflect not only the quality and cost of water supply, but also the government's goal to encourage use of different water types. The prices for reclaimed wastewater used by agriculture are lower than freshwater to encourage farmers to increase the substitution of freshwater for effluent (Tab. 1).

	Freshwater	Effluent	Brackish water
Agriculture	1.628-5.003	0.721-1.881	0.664-0.995
Domestic	2.811	--	--
Industry	2.031-4.762	1.523	1.320-1.523

*) 1 Euro ~ 5.5 NIS

Table 1: Water prices NIS*/m³ (2011)

Since 2008, the government agreed to allow holders of water allocations to sell up to 30% of their quota allocation to other farmers by transferring the actual transaction via the National Water Carrier. This action enables some water trading.

The Jordan Valley is the major producer of dates and 80% of the yield is exported. At the northern part of the JRV there are approximately 16,000 dunam, and 4,000 dunam at the southern part. The water demand for this brand at the northern part of the JRV at the first 6 years is 300-400 CM/Y per Dunam, while mature trees demand 1,600-1,800 CM/Y per dunam. At the southern part of the JRV, mature trees demand 2,200 CM/Y per dunam. Only palms are irrigated with *reclaimed wastewater* and they can tolerate high salinity and 60/90 mg/l BOD/TSS. The major water demand period for this cultivation is in March-April.

There are 4,600 dunam of table grapes in the Jordan Valley. In the past, this crop suffered from ongoing crises, but is now expanding from year to year. 70% of the yield is exported and is half of the grape export of the State of Israel. The SBS (Early Sweet) brand was developed in the local R&D. The crops are grown under unique nets that were developed by the LJRV R&D agriculture center.

Pepper is the main cultivation grown at winter and spring seasons, with variety of species. The long season of growth makes it possible for a long period of marketing (8 months a year), for exporting and for the local Israeli market.

The fresh spices grown in the LJRV are all designated for exportation, and they are half of Israel's exported spices. 3,000 dunam of basil, peppermint, tarragon, arugula and asphodel are yield during all seasons due to special crop system which was developed by the LJRV R&D agriculture center. Other agricultural crops include; cherry tomatoes, eggplants, flowers, citrus fruits, olives, pomegranates, chicken, turkey, dairy, goats and sheep barns.

Table 2 shows the water demand for the different crops growing in the LJRV.

Cultivation	Average Water consumption (CM per Dunam* per season)	Season duration (month)
palm	300-1,800	--
Pepper	1,600	10
cherry tomatoes	1,700	9
basil	1,500	9
arugula	400	4
asphodel	1,350	9

*1 Dunam = 1,000m²

Table 2: Cultivation water demand in the LJRV

The main water consumption region is Fazaal-Naaran, because it is the largest cultivation area, consuming approximately 37% of the water in the LJRV. Furthermore, it is important to mention that additional of 300-500 CM per Dunam of freshwater is needed for soil rinsing, each time before renewing plantation (solar soil disinfection is also implemented).

In the northern part of the LJR, **brackish** water for agriculture use is provided from the Jordan River, which has a high saline level (1,200-3,200mg Cl⁻ per liter) and is appropriate only to irrigate date palms. Along the Dead Sea shore there are two spring clusters (Feshkha springs). Their salinity varies between 600-6000mg/l Cl⁻ (Hötzl et al., 2008: chapter 3.3.2) and the total discharge is approximately 90-95 MCM per year. Most of the spring's water flows to the Dead Sea without utilization.

Two Water Associations exist in LJR, which supply water to agricultural use, and each operate a water reservoir: Tirza at the northern part of the LJR, and Og at the south.

- The Tirza reservoirs (5 different reservoirs containing total of 5-9 MCM) collect winter **floodwater** flowing downstream from the Nablus region to Tirza stream. It is designated to collect 1.5-4.5 MCM from a single floodwater event. The water source has inferior quality. This water source is mixed with different types such as brackish water from the Jordan River, and treated wastewater, but dilution is executed solely by the water supplier before supplied to the farmers. *Untreated wastewater* flowing from eastern Jerusalem neighbourhoods and Ma'ale Adumim locality direct to Og and Kidron streams is collected and transformed by pipelines to Tirza reservoirs. The treated wastewater (primary and secondary treatment processes) after dilution is being used for irrigating palm trees, containing 200-250 mg/l Cl⁻, and approximately 10/5 BOD/TSS. The water sale price is 1.07 NIS/m³, due to the Water Association's primary investments in infrastructure and pipe lines (more than 80 km of pipeline transferring wastewater from Og and Kidron streams to Tirza reservoir).
- Og reservoir (2 reservoirs with volume of 1.5 MCM each) also collects *wastewater* from the Og and Kidron streams. The water quality after secondary treatment processes has approximately 20/30 BOD/TSS. The water sale price (increasing-block tariffs) is determined according to its chemical quality.

Mekorot (a governmental authority) is the main *freshwater* supplier for the LJR consumers, and it supplies the water by a local distribution network, mainly from drilling water from the mountain aquifer. This system is isolated from the main Israeli national water systems, and therefore water cannot be transferred from other sources of freshwater available in the state. The LJR population is solely dependent on this local freshwater distribution network. The water is drilled from 23 wells and pumping units from the aquifer reservoir, approximately 400-700m depth with salinity of 50-400mg Cl⁻ per liter (the drinking water regulation is 600mg Cl⁻ per liter).

This underground reservoir is located underneath the Judea and Samarian Mountains. The annual water drilled from the mountain aquifer at the LJR wells is approximately 33 MCM/yr (valid for 2010). The drilling wells are located along the mountain bed (eastern slopes of the Samarian Hills) and the water is transferred gravitationally from the wells closer to population centers and to the agricultural consumers by pipe lines.

Freshwater from drilling wells are inadequate during the demanding season. In addition, the water level drops from year to year due to intense pumping and causes saline water and stops the pumping.

For instance, the salinity of the water damaged the greenhouse flower yield, which led the farmers to abandon this cultivation for other crops.

Case study

In the selected study area at Lower Jordan River Valley (LJRV) there are substantial sources of residual waters, such as brackish water of various degrees of salinity and treated effluents (Fig. 1). A proper mixing of these waters can be channelled for the irrigation of different crops, thus releasing freshwater for other uses (domestic, tourism, industry and water sensitive crops). While this approach is being deployed in the area, its socioeconomic implications remain to be quantified.

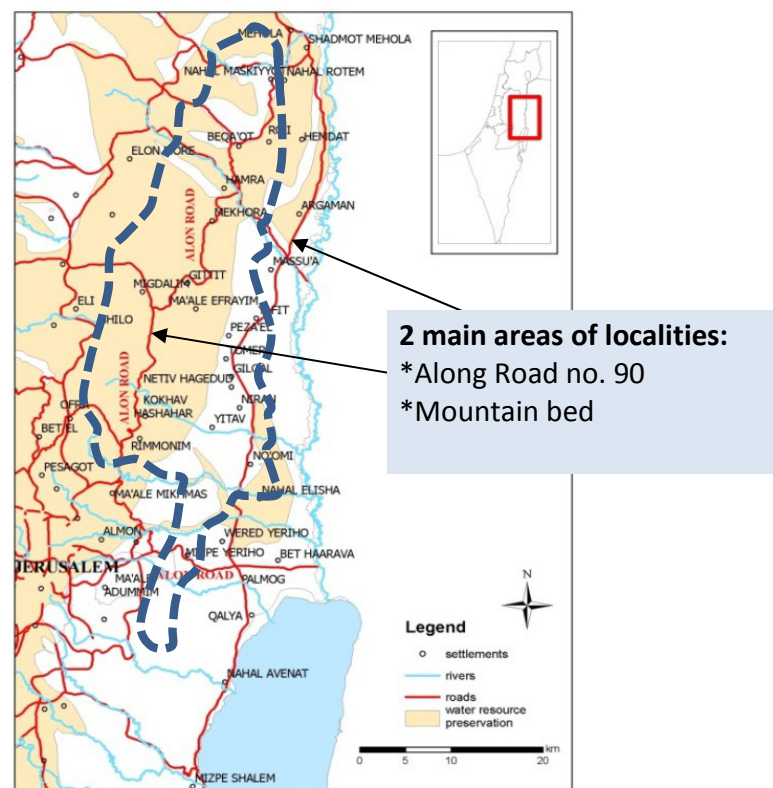


Figure. 1: Location of the case study

In order to construct an comprehensive IWRM concept for the LJRV, it is important to identify all the water resources, their potential and the locations for utilization, the customers and their needs (drinking, agriculture) and the agricultural planning (types of crops, irrigation periods etc.).

The main objectives as decision criteria for implementing IWRM displayed in Table 3.

<i>Decision criteria</i>	<i>Objectives</i>
C1	Aquifer sustainability - preserving water levels and its quality in order to minimize the impact on the fresh water resource
C2	Natural environment preservation
C3	Maximisation the economical profit
C4	Reliability of water supply, including minimizing the gap between water demand and supply especially on peak demands

Table 3: Decision criteria for IWRM

The farmers in the study area can use four sources of water: Freshwater, floodwater, saline water from the Jordan River and reclaimed wastewater.

Freshwater pumped out of the wells from the regional mountain aquifer (Judea Group aquifer) by "Mekorot" Company, are – a mentioned - inadequate during the demanding season. The water level drops from year to year due to intense pumping and causes saline water and stops the pumping.

Previous studies show that by *drilling new wells additional freshwater* of approximately 25 MCM/year can be produced. This additional amount adds to the current water abstraction from Israeli and Palestinian wells of approximately 25 MCM/year. The water from the wells in the western and central parts can be supplied to Ramallah, Jerusalem, Bet Lehem area and Male Edumim, while the water in the eastern part can be supplied to the Lower Jordan Valley.

The source, "marginal water" is a mixture of different types and has inferior water quality, and it is therefore appropriate only to irrigate date palms: Winter *floodwater* that flows from the Nablus region to the Tirza reservoir, *saline water* from the Jordan River, and *reclaimed wastewater* from Og and Kidron stream. "*Marginal water*" can be provided from Tirza and Og reservoirs.

Saline water can be supplied to the study area from Feshaha and Kane-Smar springs, which are the outlet of the mountain aquifer. The total discharge is approximately 95 MCM per year and they are brackish to saline (600-6000 mg/lit Cl⁻). Today, the water is not used and flow to the Dead Sea and lost there. *Usage of the spring water would require a desalination plant and pipeline system.*

The possible uses of water resources in the area for different purposes are defined as *alternatives* A1, A2, A3 and A4 (Table 4).

Alternative	Water Sources	Water Use
A1	Freshwater	Traditional and high precision agriculture
	Marginal water	Palm Trees Irrigation
A2	Freshwater	Traditional and high precision agriculture
	Marginal water	Palm Trees Irrigation
	Additional freshwater from new wells	Traditional and high precision agriculture
A3	Freshwater	Traditional and high precision agriculture
	Marginal water	Palm Trees Irrigation
	Additional marginal water	Palm Trees Irrigation
A4	Freshwater	Traditional and high precision agriculture
	Marginal water	Palm Trees Irrigation
	Spring saline water	Palm Trees Irrigation

Table 4: Alternatives of water use for different purposes

By applying the Multi-Criteria Analysis (MCA) and the Analytical Hierarchy Process (AHP) various alternatives can be ranked in order to determine the most favourable IWRM strategy. This approach consists of three steps:

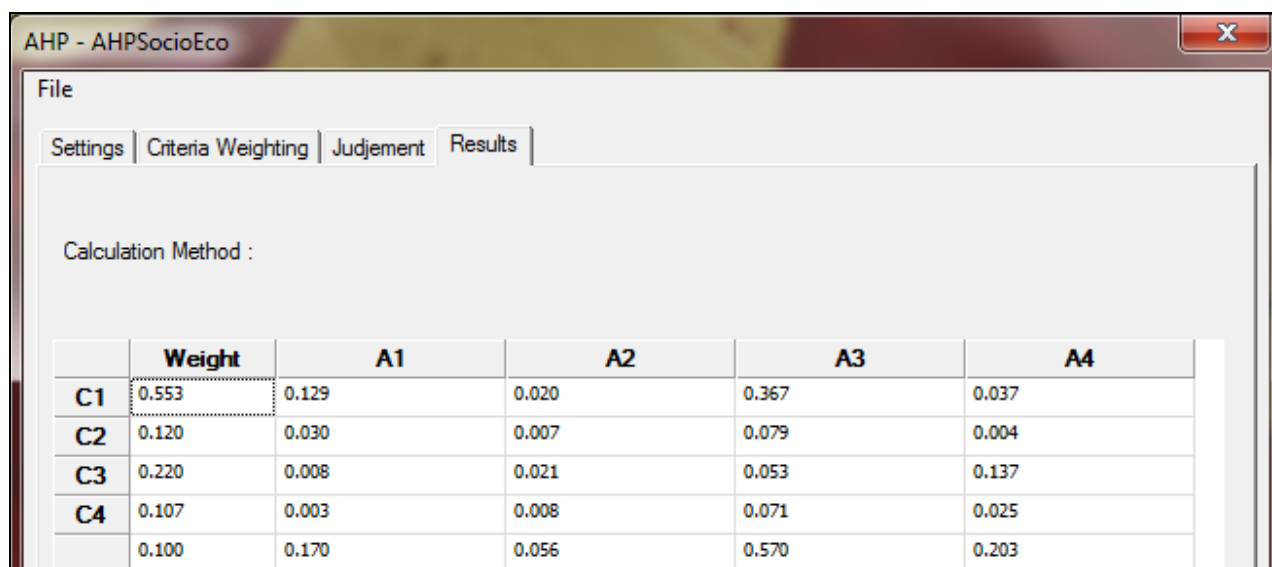
1. Each criterion is assigned a weight that represents the preference of the decision makers with regard to the objectives on the basis of a nine point scale (1 = equal important; 2 = experience and judgement slightly favour another; ...; 9 = the evidence favouring one element over another is of the highest possible order of affirmation). By that, the different decision criteria C1, C2, C3 and C4 can be prioritised (Table 3).
2. Accordingly, priorities for the alternatives A1, A2, A3 and A4 are gained by judging their performances with respect to each of the decision criteria (Table 4). This provides the relative weights for these alternatives related to each of the four criteria. (In the report, these weights are not shown; they can be calculated by dividing the weights of the alternatives A1, A2, A3 and A4 displayed in table 5 for each of the four decision criteria C1, C2, C3 and C4).
3. The weights of the alternatives are weighted with the relative weights of each the four criteria (step 1). This allows to prioritise and rank the four alternatives.

Regarding the prioritization process in step 1, a *pair-wise comparison* between the criteria is needed, which provides the relative weights for the four criteria. In the case study, the criteria hierarchy became: C1 > C3 > C2 > C4 (Tab. 5, 1st column). This result indicates that aquifer sustainability has the highest

priority in order to preserve the only fresh water source in the study area. Criteria 1 is viewed as more important than the other criteria due to the highly significance of the mountain aquifer.

With regard to step 2, a *pair-wise comparison* between the alternatives provides *for each of the four criteria* weights of the alternatives according to their performance of the respective objectives. For instance, regarding to criteria C1 the weight of alternative A3 is 0.6636 and of alternative 2 is 0.036. This means, that alternative A3 is superior to alternative 2 with respect to the objective 'Aquifer sustainability'

In step 3, these weights will be multiplied with the respective weights of the four criteria. The outcomes for each of the criteria will be added to overall weights for each of the four alternatives. The sums indicate their priorities, as Table 5 shows:



	Weight	A1	A2	A3	A4
C1	0.553	0.129	0.020	0.367	0.037
C2	0.120	0.030	0.007	0.079	0.004
C3	0.220	0.008	0.021	0.053	0.137
C4	0.107	0.003	0.008	0.071	0.025
	0.100	0.170	0.056	0.570	0.203

Table 5: The outcomes of comparison of water resources alternatives for all policy criteria

In Table 5, the relative weights of the four criteria are displayed in the 1st column. As mentioned, C1 is the most important criteria with the weight of 0.553. The further columns show the weights provided by step 3. For instance, the value of 0.367 in the 4th column represents the outcome of multiplying the weight of criteria C1 (0.553) with the weight of alternative A3 (0.6636) indicating its performance of the respective objective, as aforementioned.

The last line of table 5 contains the *overall weights of each of the four alternatives*, which renders the following hierarchy: A3 > A4 > A1 > A2 (Tab. 4).

CONCLUSIONS

The MCA is a tool that helps water manager to consider multiple, conflicting and incommensurate objectives and their relative importance in selecting IWRM strategies.

According to the results of the case study, utilizing the Tirza and Og reservoirs capacity and adding marginal water to the LJRv water budget (A3) has a significantly higher preference rather than *adding new wells* (A2) or desalinating the brackish water from the springs (A4). In other words, the application of reclaimed effluents is much more favorable than the exploitation of more fresh or spring water.

DISCUSSION

The study applies the MCA, particularly as AHP approach, which was developed by the Mathematician Thomas Saaty in the 1980s. As mentioned, it provides a tool to rank alternatives and can facilitate complex decisions in situations with several conflicting objectives. Such situations can be found often in water management. However, particularly with respect to the case study presented above, water manager may wish more information:

1. What are the real *performance values* with respect to the various objectives? Step 2 provides only the relative weights of alternative water management options. For instance, what are the impacts of digging new wells on the status of aquifers, if the exploitation of more freshwater resources would be preferred? What are the yearly income losses of farmers in NIS or US\$, if measures to maintain aquifer sustainability would be taken?
2. How may affect *interdependencies* between the objectives the ranking of alternatives (Tab. 4)? For instance, to strive for more reliability of water supply and minimising the unmet water demand (decision criteria C4) will probably require more cost and may lead to reductions in incomes, such as of farmers or citizens (decision criteria 3).
3. What are the *trade-offs* between two different objectives if the performance of two alternatives are to be assessed? For instance, as Table 5 shows, alternative A4 has with 0.137 the highest weight concerning the objective 'maximisation the economical profits', which corresponds to the relative high *performance weight* of 0.6227 (step 2). This means, that *A4 is viewed as most important for increasing profits*. The latter may be interpreted as maximisation of *economic values added*. On the other hand, with respect to the hierarchy of decision criteria $C1 > C3 > C2 > C4$, the objective 'maximisation the economical profit' (Tab. 3) has a relative moderate weight of 0.220 compared with 0.553, attached to aquifer sustainability (Table 5, 1st column). Thus, pursuing the latter objective by implementing alternative A3 is better rather than striving for more profits through alternative A4. Obviously, there is a

trade-off between these two alternatives: What are the losses in profits, if measures to ensure aquifer sustainability will be taken and vice versa?

Especially from the *socioeconomic point of view*, trade-offs between alternatives are important to know, because they indicate the value of, for instance, aquifer sustainability in terms of *costs the community is ready to accept under consideration all other objectives* (such as reliability of water supply and natural environment preservation – Table 3). However, the performance with each of the objectives must be presented in physical and economic units, as mentioned above. Then, the stakeholders would have the opportunity to change their preferences and to revise the previous ranking of alternatives in an iterative way.

11 Participating framework for the decentralised wastewater treatment and water reuse for Jordan (study 712)

SUBJECT OF INVESTIGATION

Participatory planning is an important prerequisite for successful implementation of water management measures, especially those involving the *reuse of treated wastewater*. At present, households in Jordan are yet not closely involved in water management planning processes. However, while close cooperation with the people concerned throughout the entire planning process is important in order to attain acceptance, an enabling environment, i.e. framework conditions should be in place beforehand, which sets requirements for implementation, performance, and management of decentralized wastewater solutions on a systemic level (e.g. legal provisions, technical standards, health and environmental standard, assessment of macro-economic impacts, feasibility, etc.). Based on the institutional analysis and on experiences from implementing the pilot sites for decentralized wastewater management (SMART II work packages 3.1 and 10), a concept for a participatory planning process was developed and discussed with respective stakeholders.

RESULTS

1. IWRM and participatory planning

Participatory planning can be understood as a “*systematic process of preparing for the future by setting goals, selecting strategies, choosing activities, making schedules or budgeting resources for a period of time*” on community level. It is a process that aims at giving people the rights to participate in decisions

that can affect their quality of life. For this, it is organized in ways that promote achieving consent among the different stakeholders in the solution design for a particular issue, e.g. wastewater disposal.

The challenge for such a participatory planning process is to generate empowerment on community level while involving political leaders and public administration on national level. Participatory processes typically produce the following outcomes: (a) Community understanding of the problem and potential solutions and, therefore, the risks and benefits, (b) Community understanding of the problem and the chosen solutions so that citizens can contribute to its implementation and sustainability, (c) Exchange of ideas with the public for better general acceptance, (d) Financial, moral, and intellectual contribution of the community for the benefit of all, (e) Involvement of the private sector, i.e. investments on behalf of the community, (f) Clarification of roles and relationships among the different parties involved in implementing and maintaining the solution and (g) Day-to-day involvement of the community (including NGOs and community-based organizations) in various aspects of the implementation of the solution.

IWRM requires acquiring extensive knowledge, including scientific expertise, and having access to the practical know-how of the relevant actors. Measures must be developed on the basis of this knowledge that are suitable for achieving water management goals. According to Butterworth et al. (2010) several authors have critiqued the way *IWRM* has been interpreted and implemented as a relatively standard 'package' of reforms regardless of the context. A major criticism of *IWRM* approaches in 'developing' and 'transitional' countries, is that it often gives the impression of being externally imposed or adopted to please donors. Furthermore, they emphasize that the "gap between policymaking and implementation, underestimated in the best of situations, increases if policies are made at abstract scales."

Two prerequisites are necessary in order to implement water resources measures effectively. On the one hand, state power has to ensure compliance. In water policy, compliance is a crucial point, since it involves not only law-abiding but also voluntary cooperation and both are urgently needed for successful implementation. On the other hand, government has to render possible the coordination of various governmental institutions. Water interventions are prone to fail if, for example, water policy is systematically thwarted by agricultural policy. However, state can promote and facilitate stakeholder cooperation and cross-sector coordination, but cannot enforce them.

This leads to a *paradox conclusion*: Governance processes may substantially facilitate achieving complex and ambitious water development objectives such as Integrated Water Resources Management. However, they typically also produce contingent and arbitrary elements since they involve different actors with particular interests, knowledge, and capacities. Thus, government has to create and facilitate participation and cooperation of non-governmental actors in political decision-making while it continuously monitors and evaluates these processes so to assess whether and how they contribute to achieving water policy objectives. If governance processes fail, authorities must make use of their capacity to intervene. Since such interventions are costly, statecraft is geared towards preventing 'governance

failures'. Capacities required to effectively monitor and evaluate such processes usually are traditionally found in business management and consulting rather than in water engineering and public administration.

Discussions on governance sometimes suggest that governmental activity could be reduced to a 'lean state' or a 'minimal state' by distributing responsibilities and mobilizing resources. Petersen et al. find that the opposite is the case. The implementation of governance processes is more likely to produce *extension and augmentation of governmental activity* than its reduction.

2. Experiences from implementing pilot sites in Jordan

Historical conditions

Historically, the image of wastewater treatment in Jordan is not favourable. In the 1990 due to the high increase in wastewater flows most of the waste stabilization ponds plants (WSP) in Jordan became overloaded which reduced their efficiencies causing strong odours and fly accumulation. Public acceptance of these plants has been negative. Starting in the early 2000s many WSP were being replaced by mechanical treatment systems. Concern about odours and other environmental effects such as flies among local stakeholders in Jordan, however, persisted and were also voiced by residents during the site selection process.

Jordan has worked to manage irrigation with reclaimed water for several decades. Since the early 1980s the general approach has been to treat the wastewater and discharge it to the environment where it mixes with freshwater flows and is indirectly reused downstream in the Jordan Valley. Cultural and religious factors, however, influence how people view the reuse of wastewater in agriculture. It is important to know, for instance, that the Council of Leading Islamic Scholars in Saudi Arabia (13th session, decision no. 64, dated 25/10/139) issued a Fatwa in 1978 concerning the use of treated wastewater. It concludes that treated wastewater can be used even for ritual washings and drinking, provided that it presents no health risks. In 2002 another Fatwa encouraged the reuse of treated wastewater as a method of cleaning and preservation.

Structural conditions

One major problem of stakeholder involvement in Jordan is the case of absentee landowners, who typically own large properties in the rural and suburban areas, but live in Amman or elsewhere. Their participation and support for participatory planning processes can be decisive when their consent is needed, e.g. for use of the land or for implementing a treatment facility close to their property. During a progressed SMART II site selection process for a pilot treatment plant in a suburban community of Al-Salt, which is heavily impacted by dysfunctional wastewater disposal (wastewater overflow, insects, diseases, smell, etc.), a single absentee landowner employing his powerful connections in Jordan's government, forced cancellation of the pilot implementation, in order to prevent potential loss of market value of his land.

Circumstantial conditions

The pilot site selection coincided with the Arab spring and the associated turmoil peaks in Jordan in the years 2011 and 2012. The atmosphere between the central government and its authorities on the one hand and communities on the other was strained which complicated the site selection.

Since decentralized wastewater treatment is yet not an established approach in Jordan's water sector, the required standards and regulations for such systems along with arrangement for ownership, responsibilities for operation and maintenance are yet not in place. During the site selection process this circumstance resulted in protracted and extremely time-consuming negotiation between national and local representatives. The SMART II project team members of work packages 3.1, 7 and 10 facilitated the negotiation. At that the local team members, namely Bassim Abbassi and Nabil Wakileh, were primarily involved and held meetings with the concerned representatives on average once every week over a period of two and a half years. Persistence and dedication to the project goal over a time much longer than was planned was essential to the success of the site selection.

Eventually negotiation resulted, in an agreement on centralized management of the community pilot plant by the Water Authority of Jordan. In order to render this possible, the ownership of public land that is used for the treatment pilot site in this community had to be transferred to the Water Authority of Jordan.

3. Lessons learnt and recommendations

There are a number of lessons learnt from the site selection process, which constitute valuable information for preparing a future participatory planning process.

- *Involvement of local stakeholders*

In Jordan Municipalities, i.e. the locally elected community representatives, play a central role in engaging citizens in participatory planning processes. This means that the relationship between the central and regional offices of the water authorities on the one hand, and the respective community representatives on the other will need to be given careful attention. This concerns in particular the potential for transfer of competences and resources to the local authorities will need to be given careful attention and consideration in order to establish close cooperation.

- *Dealing with historical conditions*

In Jordan there exist a general association of the public between wastewater treatment and continuous odor and flies possibly impacting communities nearby the treatment plant. This concern originates from the period when wastewater stabilization ponds were the primary treatment technology in Jordan. In order to tackle the citizens' concern, numerous visits of concerned parties at the Research, Demonstration and Training Site for DWWT&R at Fuheis (Al-Salt) were organized to prove to stakeholders, that with the technologies employed there neither odor no flies occur. In future, those visits should be extended to the SMART II pilot treatment plants.

- *Dealing with structural conditions*

A major circumstance of the site selection was the influence of absentee landowners. For future implementation projects it is important to involve this stakeholder group early in the process. Gaining the attention and involvement of non-resident landowners, who may only be present for short periods if at all, may be a major challenge. Different potential solutions and ways to involve them in local wastewater solutions should be devised. Those may involve lease arrangements and other compensatory agreements, engaging them in the production of fodder and alfalfa or forestry and in particular communicating and marketing water protection and conservation needs to them.

4. The HCES approach and participatory planning

The *Household-Centered Environmental Sanitation* (HCES) approach was chosen as the blueprint for the participatory planning concept. The special characteristics of the HCES approach is that it attempts to avoid the problems arising from ‘top-down’ or ‘bottom-up’ approaches, by employing elements of both in an integrated framework. It belongs to the group of communicative planning frameworks that focuses on participatory, bottom-up methodologies where planners solicit the participation of a variety of stakeholders in a democratic planning process. It aims at providing stakeholders at every level, but particularly at the household and neighbourhood level, with the opportunity to participate in the planning, implementation and operation of their local water resources management (Fig. 1).

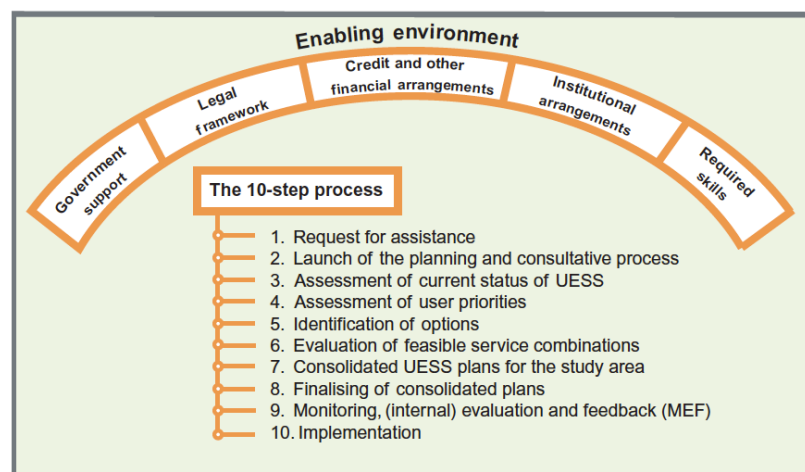


Figure 1: Defining Elements of the HCES Approach (Lüthi et al. 2010)

The HCES approach belongs to the group of communicative planning frameworks that focus on participatory, bottom-up methodologies where planners solicit the participation of a variety of stakeholders in a democratic planning process. It aims at providing stakeholders at every level, but particularly at the

household and neighborhood level, with the opportunity to participate in the planning, implementation and operation of their local water resources management. The HCES approach is chosen here because its basic principles are in accordance with the approach to decentralized wastewater management in the SMART II project. These are (Eawag 2005):

- People and their quality of life should be at the center of any environmental sanitation system.
- All environmental sanitation systems must be designed in such a way as to balance economic and environmental goods.
- Solutions of environmental sanitation problems should take place as close as possible to the place where they occur.
- 'Wastes', whether solid or liquid, should be regarded as resources.
- Environmental sanitation systems should be 'circular' – designed in such a way as to minimize inputs and reduce outputs.
- Problems relating to environmental sanitation should be handled within an integrated framework and this framework should itself be part of a wider system of integrated water resources, waste management and food production.

5. Applying the HCES approach in Jordan

In order to provide a concept tailored to the Jordan context, firstly the requirements for the enabling environment are outlined and secondly, the 10-step process is developed. In the case of local, decentralized wastewater management in Jordan, such an enabling environment may include the following items:

1. A national wastewater policy that supports participatory planning processes and – in the case of wastewater management – embraces the necessary scales of solutions, e.g. on-site, decentralized, semi-centralized, and centralized treatment systems
2. A national wastewater master plan that defines wastewater projects including also the allocation of funds
3. Definition of 'on-site', 'decentralized', 'semi-centralized', and 'centralized' wastewater treatment for Jordan
4. Standards for effluent quality that allow for cost-efficient decentralized solutions for different reuse purposes as well as an adequate number of parameters for monitoring compliance to these standards that are in accordance with all concerned sector competences (Ministry of Health, Ministry of Environment, Ministry of Water and Irrigation, Jordanian Institution for Standards and Metrology, etc.)
5. Arrangements for transferring competences and where required respective funds to local and/or regional authorities and communities
6. Provision of funds (e.g. development bank loan or grant) that will enable communities to realize wastewater projects
7. Provision of facilitators and trainers to develop the skills on the part of municipal and regional representatives required for implementing the HCES approach.

However, for initial application of the approach, i.e. a field test, it will not be practical or desirable to implement general changes in sector procedures, such as changes in legislations or standards. What is necessary is the approval of concerned authorities to make a temporary adjustment to appropriate standards and procedures to the extent needed so as to allow an initial implementation to HCES. This

may be a simple matter of providing a policy statement that the HCES approach should be tried out and to obtaining temporary waivers which allow it to proceed.

As for the enabling environment for decentralized wastewater solutions, Jordan is currently on a promising path. The Jordanian Water Strategy 2008-2022 states a decisive policy shift to decentralized wastewater treatment in rural and suburban areas where it is often more appropriate and economically feasible than centralized treatment. The Jordan Water Strategy also puts emphasis on the enforcement of wastewater related regulation, an issue that had practically been absent in the 1998 Wastewater Management Policy.

Standards for wastewater and sludge treatment and reuse for different users shall be updated and standards for the use of septic tanks in rural areas shall be issued. Effluent quality from WWTPs shall be regularly monitored. Monitoring is also foreseen for crops irrigated with treated wastewater and the groundwater quality near plants shall be observed. The institutional capacity for enforcing wastewater regulations shall be established. For industries, incentives shall be provided to meet the standards set for wastewater reuse. Water quality laboratories shall be upgraded and the staffs be trained. A key element of the 1997 strategy and 1998 set of policies was the promotion of private sector participation (PSP).

With regards to standard and regulations for decentralized wastewater management, the Ministry of Water and Irrigation (MWI) in cooperation with the Helmholtz Center for Environmental Research and have set out to develop an implementation strategy for decentralized wastewater management for rural and suburban areas in Jordan, over the next two years. For this purpose, the MWI has established a cross-sectorial Committee, the so-called *“National Implementation Committee for Effective Decentralized Wastewater Management Solutions in Jordan”* (NICE). The committee will be working on important issues such as technical and reuse standards, the definition of ‘decentralized’ systems for Jordan and on defining option for managing decentralized wastewater and reuse systems in rural and suburban communities.

In the following, the 10-steps of conducting a HCES participatory planning process (Fig. 1) tailored to Jordan will be developed (cf. full version of study 712).

CONCLUSIONS

A participatory planning process is complex, time intensive, requires financial and human resources and well developed soft skills (facilitation, moderation, negotiation, and communication with indirect stakeholders on the part of the process manager or project management team). Where implemented successfully it generates local ownership of the solution and hence sustainability. The latter is indispensable for cost-efficient and environmentally sound systems. In Jordan, where centralized treatment is not always the most cost-efficient option, decentralized solutions should be explored and where feasible and socially integrated they should be implemented. Their sustainability and effectiveness, however, will be out of the hands of the central government and will depend on the local and regional

actors. At that a participatory planning will be one of the keys to successful implementation. It is recommended to discuss and, if deemed appropriate, to further develop this participatory planning proposal in the context of the framework setting process of the *National Implementation Committee for Decentralized Wastewater Management in Jordan* (NICE).