

Integrated Water Resources Management in the Lower Jordan Rift Valley

Sustainable Management of Available Water Resources with Innovative Technologies



Work package 5, Deliverable D 506

Economic Implications of Water Protection Zones

Ingo Heinz⁽¹⁾
Mahmoud Hammad⁽²⁾
Ali Hayajneh⁽³⁾

⁽¹⁾ University of Dortmund (formerly)

⁽²⁾ Consultant of the SMART II research project, Bethlehem, Palestine

⁽³⁾ c/o Ministry of Water and Irrigation (MWI) of Jordan

May 23th, 2013

Corresponding author:

Dr. Ingo Heinz
University of Dortmund (formerly)
Bierstraße 9, 58239 Schwerte, Germany
Ingo.Heinz@uni-dortmund.de
++49-2304-74831

Sponsored by



Federal Ministry
of Education
and Research

Sponsored by the German Federal Ministry of Education and Research (BMBF):

FKZ 02WM1079-1086 and FKZ02WM1211-1212

Project Coordination:

Main Coordinator:	Assistant Coordinators	
Prof. Dr. Nico Goldscheider Institute of Applied Geosciences, Karlsruhe Institute of Technol- ogy Adenauerring 20b 76131 Karlsruhe Germany Phone: +49 (0) 721 60845465 Fax: +49 (0) 721 606 279	Prof. Dr. Martin Sauter Department of Applied Ge- ology 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 Environ- mental Research (UFZ) Permoserstr. 15 04318 Leipzig Germany Phone: +49 (0)341 235 30 00 Fax: +49 (0)341 235 2885

<http://www.iwrm-smart2.org/>

CONTENTS

1 INTRODUCTION	5
2 METHODOLOGY	5
3 CASE STUDIES	8
3.1 Jericho area	8
3.1.1 Potential of water protection zones in Jericho Area	8
3.1.2 Hydrogeology and vulnerability of groundwater	9
3.1.3 Guidelines of Protection Zones for springs in Jericho Area	10
3.1.4 Cost benefit analysis of Ein Sultan Spring Protection Zones	12
3.1.5 Cost benefit analysis of Duyuk, Nueimah and Shosa springs protection zone	20
3.2 Jordan river valley	25
3.2.1 Cost benefit analysis of Al-Buqouryah spring protection zone	25
3.2.2 Cost benefit analysis of Tabaqat Fahl spring protection zone	27
4 SUMMARY AND CONCLUSIONS	28
REFERENCES	30

Acknowledgements

Sincere appreciations are extended to all institutions in Palestine and Jordan, which provided information and advisory services. These include the Jordan Ministry of Water and Irrigation (MWI), the Palestinian Ministry of Agriculture and the Municipality of Jericho. This study would not have been possible without the results from previous reports performed by the Palestinian Hydrological Group (PHG) in Ramallah.

1 INTRODUCTION

The following analysis deals with the economic implications of water protection zones (WPZ). Such an analysis may be seen as unnecessary, as only geological, hydrological and health issues matter. Indeed, the main purpose of WPZ is to prevent contamination of drinking water. But why is an economic analysis useful?

First, there are several options to protect water, such as ban of pesticides, limited application of fertilizers, fences to prevent the access of people and animals, the prohibition of roads, petrol stations, power plants and other perilous activities (Nick, A. 2011). By using the *cost effectiveness analysis* the total cost of reaching water quality objectives can be minimised (Edwards, C. 2011a). The economic resources saved can be invested in other beneficial water projects.

Second, WPZ can be assessed by using *cost benefit analysis* (CBA). For instance, the cost of connecting houses to sewage networks may be lower than the economic value of increased crop yields due to more water for irrigation purposes. Moreover, high-quality drinking water has an economic value for domestic, commercial and industrial users (Heinz, I., 2009). CBA studies investigate to which extent precautionary measures in the water sector can produce surplus of economic benefits over costs (Edwards, C. 2011b).

The aim of the case studies carried out at Jericho area and Jordan river valley is to show that *WPZ can ensure not only the provision of safe drinking water but can lead also to economic values added for the society as a whole.*

2 METHODOLOGY

The economic benefits of WPZ

Some cost benefit studies focus on the costs of diseases (e.g. diarrhoea) due to contaminated drinking water. Examples are expenses for medical treatment and losses in incomes due to inability to work (Cameron, J. and Jagals P. 2011). If water-protecting activities would take place, these costs can be reduced. More information on the DALY method (Disability-Adjusted Life

Year), in particular, can be found in Edwards, C. (2011). Another approach explores the willingness to pay for less water-borne health risks (van Kooten, G. 1996).

The idea of both approaches is that contaminated drinking water is causing health problems and that economic benefits can be achieved (e.g. cost savings in the health sector) by reducing water pollution. *Both approaches are questionable, if water-protective measures should be made dependent on whether economic benefits exceed the costs.* In contrast, water authorities have to ensure that any diseases are prevented as far as possible.

A similar methodology is to assess the health costs, which can be prevented if drinking water standards are met. However, it is extremely difficult to determine the health cost that will emerge, if precautionary measures would not have been undertaken.

An alternative approach is to estimate the economic benefit of WPZ by considering the amounts users are ready to pay for safe drinking water. It is assumed that water prices reflect the economic value of one cubic meter. This approach will be used in the case studies below. The idea is that without precautionary measures the water will be sooner or later cease to be suitable for drinking purposes or complex treatment techniques are required to eliminate, for instance, nitrates and pesticides (Heinz, I. 1996).

However, the economic benefit of WPZ will be understated, if water tariffs do not reflect the full cost of water (including abstraction, purification, distribution, and sanitation). In such cases, the estimated benefits may represent lower bounds.

If houses will be connected to sewage networks to prevent water pollution, cesspits and the expenses for operating them are not more needed. The cost savings are added to the economic benefits of WPZ. Further benefits can emerge, if the collected wastewater is used for irrigation purposes and generates extra incomes in agriculture.

The costs of WPZ

To provide uncontaminated drinking water, first of all restrictions in land use (e.g. ban of pesticides) are needed. Thus, farmers' income losses due to such restrictions represent cost of WPZ.

Furthermore, the costs of construction or rehabilitation of sewage networks and of connecting houses are considered. The annual capital costs are calculated by using the capital recovery factor, depending the useful lifetime and the discount rate. The fees to be paid for connecting to sewage networks are not added as they are financial transfers only.

Further costs of WPZ include the expenses for sign posts, fences and monitoring of water quality and risks.

Cost benefit analysis of WPZ

In the following case studies, the key question is whether the total economic benefit exceeds the cost, i.e. under which conditions WPZ result in values added. If there is a surplus of benefit over the cost, the precautionary measures undertaken are economically worthwhile. This is true regardless, who has to contribute to the cost. Farmers located in WPZ may be financially supported by the municipality, if they face income losses due to restrictions in land use. The citizens pay usually the cost of WPZ by higher water tariffs, as they benefit mostly from the precautionary measures.

3 CASE STUDIES

3.1 Jericho area

I. Heinz and M. Hammad

3.1.1 Potential of water protection zones in Jericho Area

In Jericho area, springs are main natural suppliers for the water used, especially water used for domestic use. Ein Sultan spring, with an annual discharge of about 5.5 MCM, is the main supplier of water for domestic, commercial and public use in Jericho City central area (Table 1). Meanwhile, Jericho city is considered as an important city for tourism activities. Deterioration of water quality would require costly treatment and may affect adversely various economic activities in Jericho area.

In the lower area of this watershed, the Ein Sultan, Nueimah, Duyuk and Shosa springs are the main resources. Water from Ein Sultan spring is used in Jericho City for domestic and agricultural demand, while the Ein Duyuk, Nueimah and Shosa springs are used for irrigation purposes in the Nueimah and Duyuk areas, which are dominated by agricultural activities.

Spring Name	Elevation	Average Discharge (MCM/yr)
Duyuk	-115	4.97
Nuweima	-110	2.63
Shosah	-110	0.64
Ein Sultan	-215	5.6
Al Qilt& Al Fawwar	10	7.1
Al Fawwar	75	5.81
Fara	290	0.89
Jummaizah	285	0.38
Ru'Yan	250	0.41

Table 1: Average Spring Discharge in Duyuk & Nueimah watershed (PWA 2010).

According to Marie et al (2004), "The source of fresh water in the area is derived from ground water, which is tapped from the aquifer systems of the shallow Plio-Pleistocene and the deep Cenomanian (East Mountain) aquifers. Unfortunately, the ground water quality of the shallow

aquifer system has been deteriorating in this area for some time. In the Jericho region, for example, dissolved chloride concentrations have increased to more than 2000 mg/L during the last 30 years". Therefore, there is a need for protecting the water resources as continued groundwater pollution threatens the water supply for all water users.

3.1.2 Hydrogeology and vulnerability of groundwater

According to Abdul Ghafoor (2005), groundwater in the lower part area exists in Quaternary Aquifer, which consists mainly of gravels, cobbles and boulders inter-fingering with impermeable layers of saline marl deposits and transported from the western slopes of the Jordan Valley forming alluvial fans. The groundwater in this aquifer is stored in gravels zones separated by marls deposits (Figure 1), which are not well defined, either vertically or horizontally. The infiltration of floodwater in wadies is the main source of aquifer recharge during the winter season. Meanwhile, the water quality of this aquifer varies with location, good groundwater quality occurs near the wadies, where fresh groundwater is available. It is believed that this aquifer is overlaying the Lisan Formation, which is acting as impermeable or a very low permeability layer. The general direction of groundwater flow in the Quaternary Aquifer is towards Jordan River and the Dead Sea.

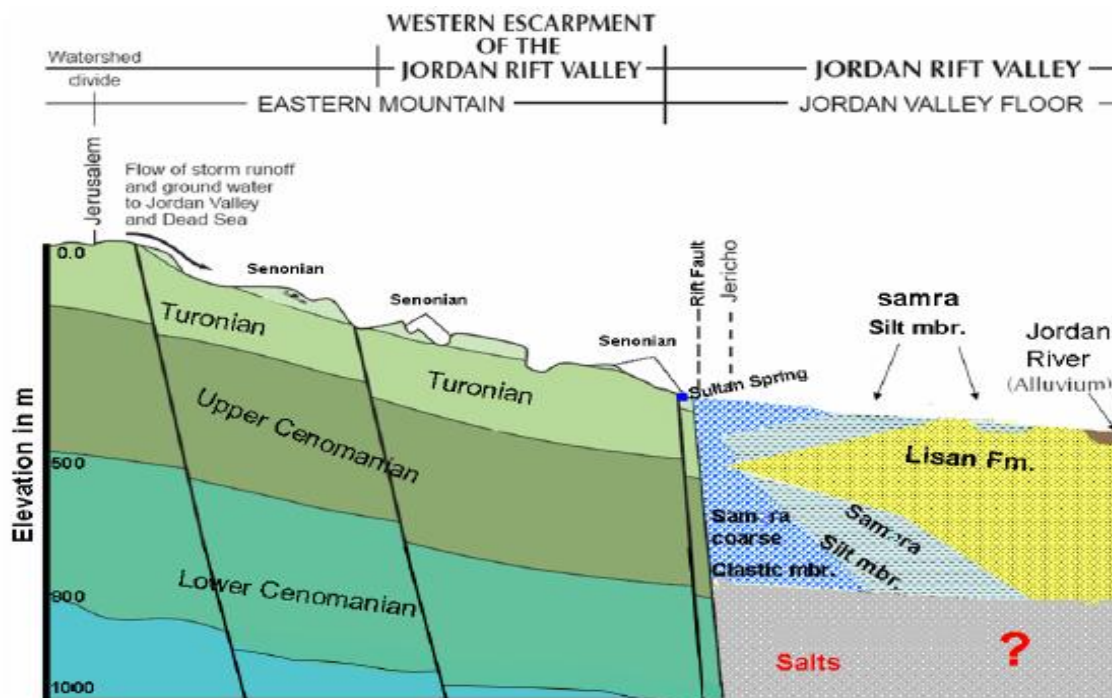


Figure 1: Geological Cross Section in Study Area (Khayat 2005)

Most areas of the lower part of Al Qilt Nueimah watershed have moderate groundwater vulnerability (Fig. 2). The concept of groundwater vulnerability is based on the assumption that the physical environment provides some natural protection to groundwater against human impacts, especially with regard to contaminants entering the subsurface environment (Vrba, J. and Zapotoc, A. 1994, Goldscheider, N. 2002).

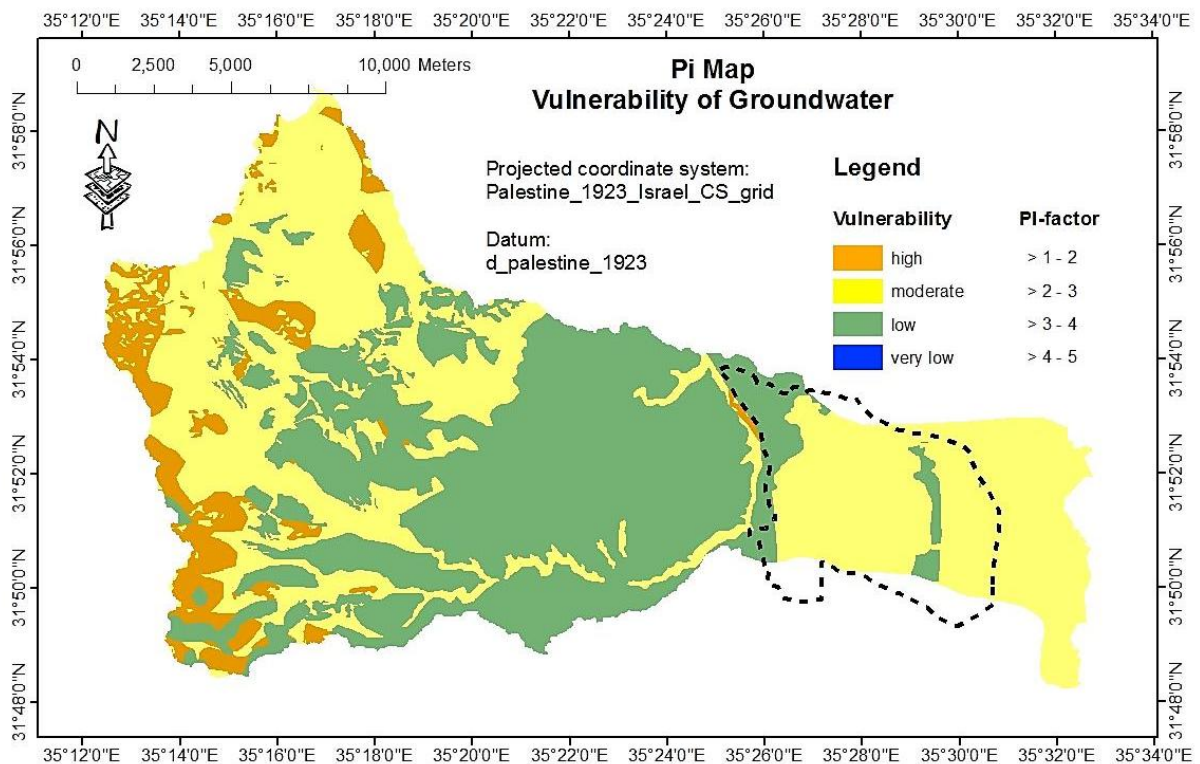


Figure 2: Vulnerability Of Groundwater map (Edited by M. Hammad from Bastian, D. 2012).

3.1.3 Guidelines of Protection Zones for springs in Jericho Area

There are no current Palestinian guidelines for water protection zones, yet there are guidelines in Jordan. These guidelines refer to cases where the residence time is 50 days. Residence time in Al Qilt watershed is expected to be in the range of 50 - 54 days (Ghanem 2013). Therefore, the Jordanian guidelines are applicable as long as no Palestinian guidelines exist.

According to these guidelines, a water resource should be surrounded by three nested zones in which specific activities are prohibited. Zone I is the closest to water intake and has the strongest restrictions. Protection zones for springs are categorized in three types as following:

Zone I

This zone is defined as 50 meters at least in the upstream direction, 10 meters in the downstream direction and 15 meters at each side (Figure 3). The areas within the protection zone 1 should whenever possible be owned by the Water Authority and fenced by taking into consideration the current situation in the area. The activities in this zone are exclusively limited to those related to water resource intake.

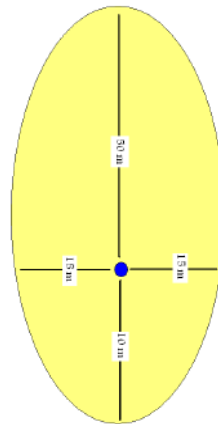


Fig. 3: Protection zone I for a spring

Zone II

According to Jordanian guidelines (Rihab Tarawneh 2006); “Protection zone II is defined in view of the hydraulic information, studies and technical reports that provide sufficient knowledge to the water sector experts to estimate groundwater flow velocities, residence time and pollutant transport time such that the time needed for the microbiological pollutants to reach the water source is 50 days minimum given that the maximum protection distance in the upstream is 2 km. The distance in the downstream direction should be between 50 and 150 m depending on the characteristics of the water source. In cases where the dominant geological feature is a Karst aquifer system, vulnerability to pollution mapping, if available, are to be used and technical consultation is sought in that regard.”

Activities allowed in Zone II:

- The activities are limited to residential activities and organic agriculture (no use of chemical fertilizers or pesticides).
- Priority is to be given for the establishment of an appropriate sewerage network or cess-pools.
- Relating to agricultural development activities or existing industries which produce wastewater and may have an impact on the environment and water resources, these are

to be obliged to implement environmental sound practices and comply with corrective measures decided by the responsible agencies.

Zone 3

This zone aims to protecting the entire catchment area and to preventing pollution over long distances, such as contamination by radioactive substances or chemicals which are non or hardly degradable (Margane, A et al 2007).

3.1.4 Cost benefit analysis of Ein Sultan Spring Protection Zones

Current activities around the Ein Sultan Spring that cause pollution are the domestic wastewater cesspits in Ein Sultan Camp that are located at the upper Ein Sultan Spring. To avoid pollution, the **cesspits should be prohibited and a wastewater collection network should be implemented**. Currently, there are around 750 water connections; each of them is representing one house or family, so that there are approximately 750 cesspits (Jericho Municipality 2013). Moreover, several farms exist upper of Ein Sultan spring and pesticides and fertilizers are used that threatens of causing more pollution (Fig. 4a and Fig. 4b).

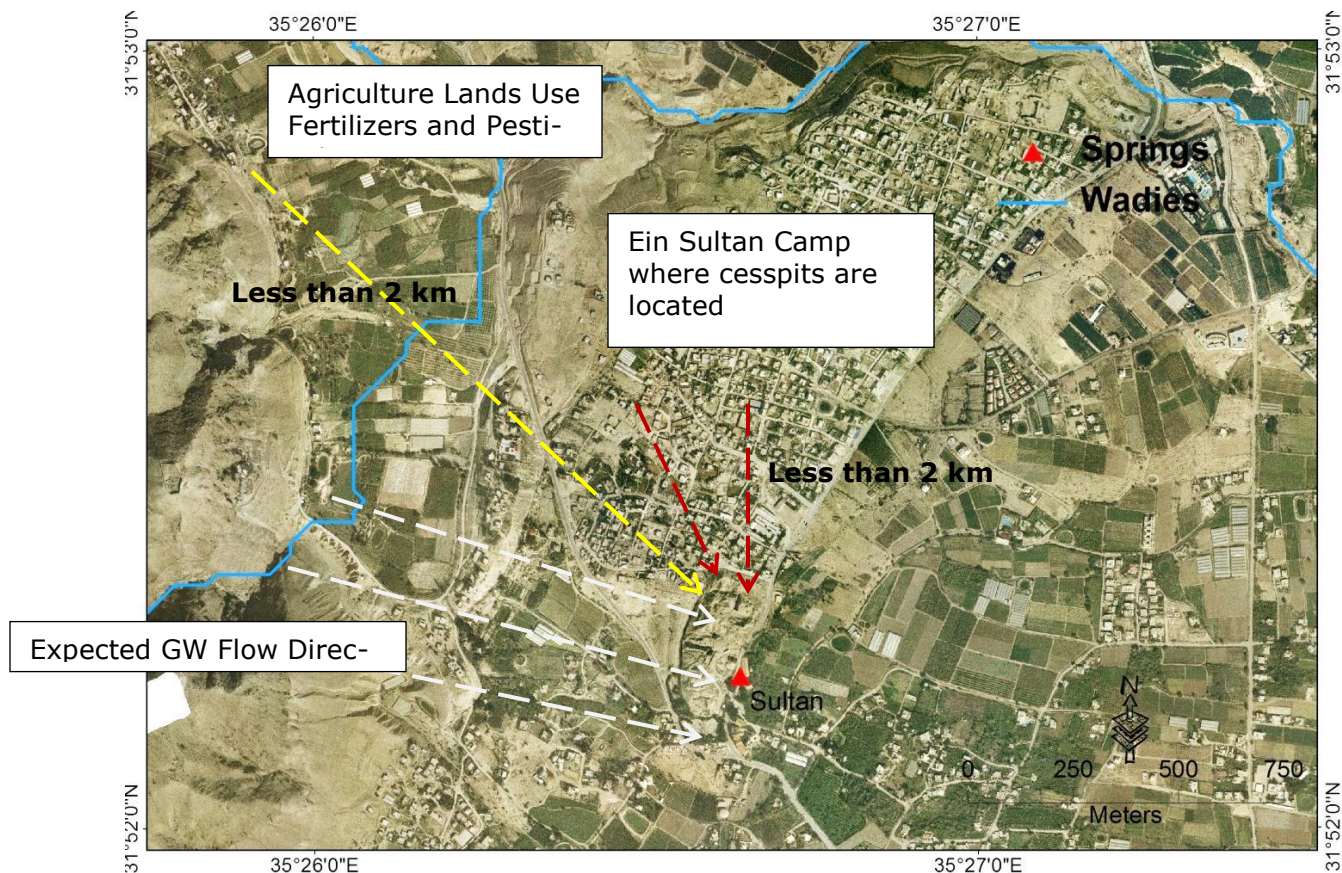


Figure 4a: Potential pollution sources for Ein Sultan Spring

These farms belong to Duyuk and Nueimah sub-areas. The pollutions sources are located within a distance of less than 1 km upper Ein Sultan Spring. This calls for restrictions for the use of fertilizers and pesticides.

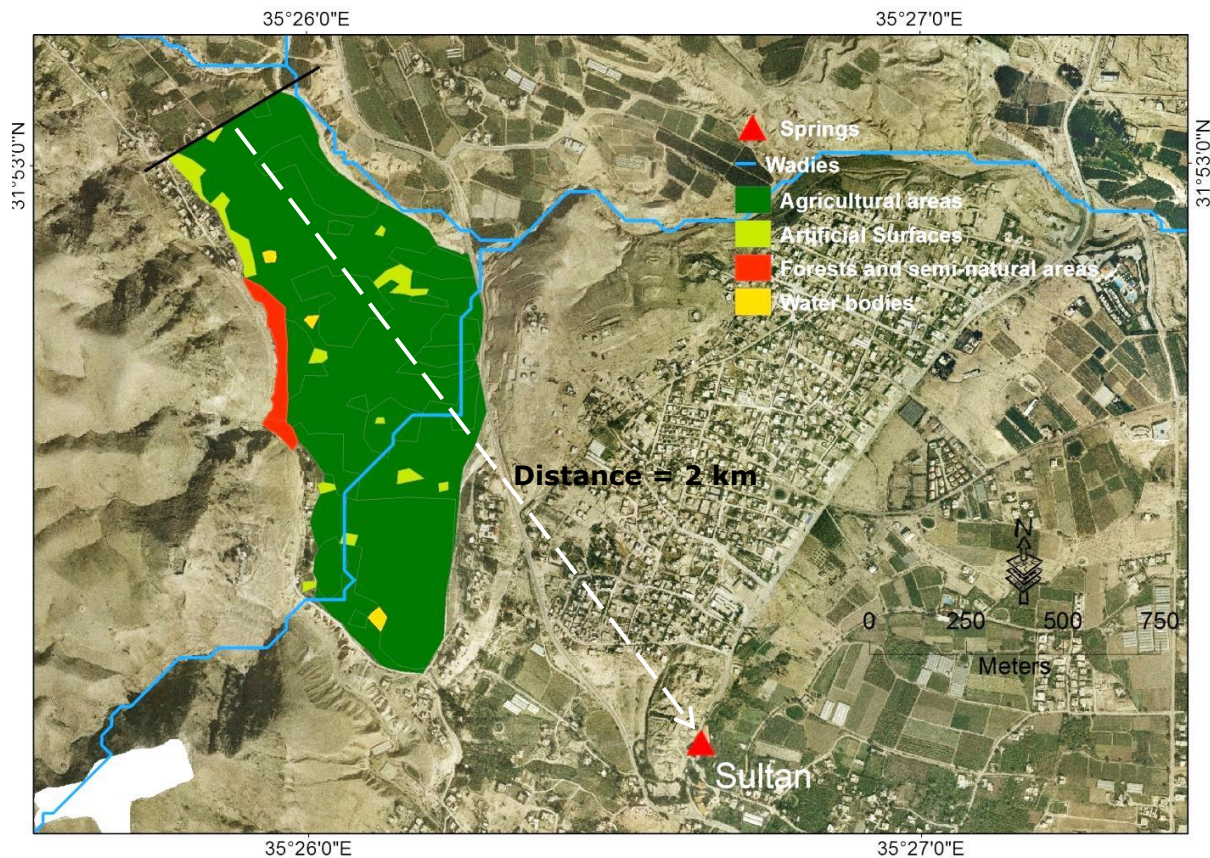


Figure 4b: Location and land use of fertilizers and pesticides restriction area upper of Ein Sultan spring

The cost of a sewage collection network for Ein Sultan Camp is about 1.345 million USD (Consulting Engineering Center, 2010). The corresponding annualised capital cost amounts to 113,910 USD/yr (useful life time of 30 years; discount rate of 7.5 %).

The wastewater collected by the planned sewage network would be treated at the projected WWTP at Jericho east sub-basin and the effluents would be used for agricultural irrigation purposes (cf. SMART II report 706 & 707).

Restrictions for using fertilizers and pesticides would reduce crop yields. The losses in farmers' income represent cost of the precautionary measures, regardless to which extent financial compensations will be paid.

By implementing all the precautionary measures the currently good quality of Ein Sultan Spring could be protected.

48 % of Ein Sultan Spring discharge is currently allocated to domestic users in Jericho city according to an agreement on local level, and 2.7 % is allocated to the Ein Sultan refugee camp. 6.4% of the water designed for domestic use is used for agriculture activities. 69.1 %, 17 %, 5.3 % and 2.2% of the water for the domestic use of Jericho city is allocated to domestic, public, commercial, and camps users, respectively (Fig. 5).

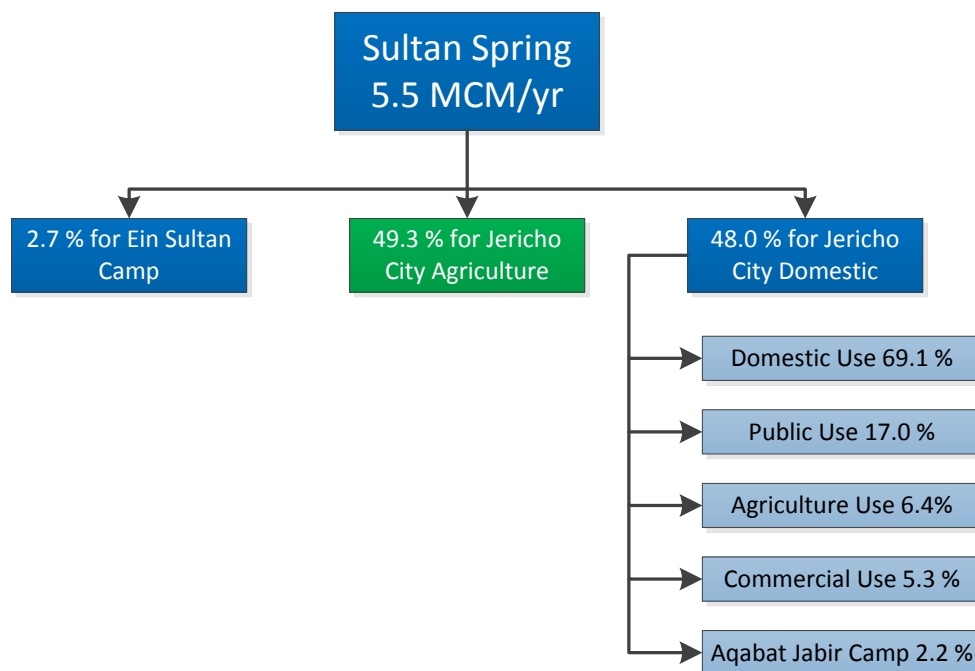


Figure 5: Allocation of Water for Ein Sultan Spring (PHG (2010)).

The domestic and commercial users pay different prices. While the camps and public sector get water for free, commercial and domestic users have to pay a price that ranges from 1 - 5 NIS/m³

according to tariff block. The tariffs do not cover the full capital and O&M costs of the water services; thus they understate the economic values of water.

User	Use of domestic share (%)	Use of Spring (%)	Average Price (USD)	Water Value (USD) *)
Jericho City domestic	69.1	33.17	0.38	0.38
Jericho City Public	17.0	8.16	0.00	0.38
Jericho City Agriculture	6.4	3.07	0.38 **)	0.38
Jericho City Commercial	5.3	2.54	0.46	0.46
Aqabat Jabir Camp	2.2	1.06	0.00	0.38
	<i>Average</i>		<i>0.32</i>	<i>0.384</i>
Ein Sultan Camp	----	2.7	0.00	0.38

*) Lower bound of water value (no full cost recovery)

**) Agricultural users buy the domestic water

Table 2: Average prices of water for users of water from Ein Sultan Spring

Table 2 shows the average water prices and indicates the lower bound of water values for different users.

The discharge of Ein Sultan is expected to decrease (Fig. 6). The decrease is due to climate change causing declining rainfalls. A further reason may be the extensive use of groundwater resources from the Israeli side. This development will have impacts on the economic value of water delivered to the users.

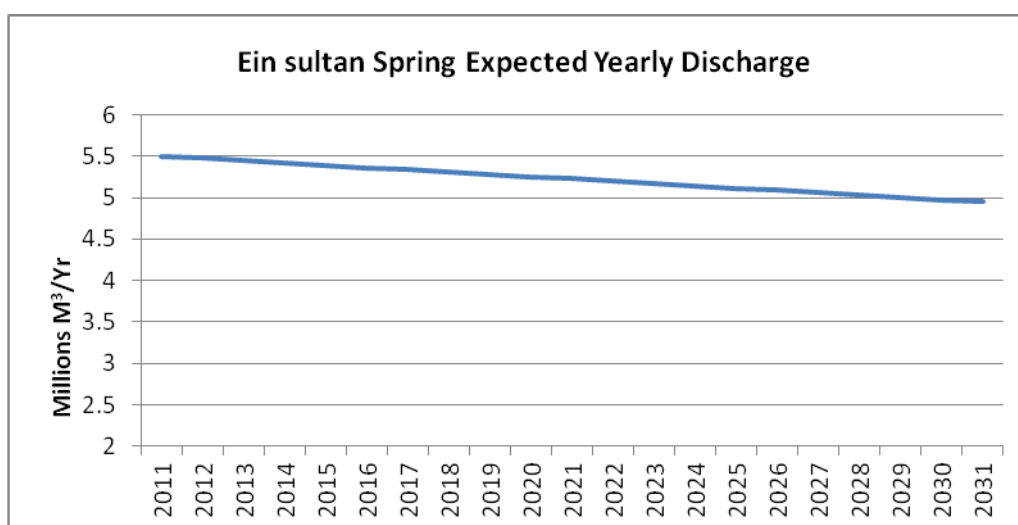


Figure 6: Ein sultan Spring Expected Yearly Discharge in 2011-2031

As mentioned, restrictions on using fertilizers and pesticides in the agricultural lands, which are in distance of less than 2 km upper of Ein Sultan spring, will lead to losses in farmers' income. Losses in incomes represent cost of WPZ, even if farmers will be compensated. However, no data are available. Therefore, it is assumed that agricultural production would decrease in the range of 20% (minimum value) and 50% (maximum value).

Water profitability (USD/m³)				
		Without use restrictions	With 50 % production Losses	With 20 % production losses
Crop pattern	(%)			
Banana	44.58	1.18	0.47	0.93
Vegetables	37.60	1.01	0.29	0.92
palms new	0.00	0.00	0.00	0.00
palms before 2011	7.22	2.96	1.34	2.34
Citrus	8.64	0.73	0.24	0.62
plastic houses	1.95	0.73	0.29	0.92
Average		1.19	0.44	1.00

Table 3: Water profitability in the Duyuk and Nueimah area without and with restrictions in agricultural land use

The restrictions in agricultural land use would decrease the average water profitability from 1.19 USD/m³ to 0.44 USD/m³ (50 % losses) and from 1.19 USD/m³ to 1.00 USD/m³ (20% losses), respectively (Table 3). The income losses per year can be calculated as follows:

- a) Multiplying the number of agriculturally used dunums with the average yearly water requirement (= water volume used) and
- b) Multiplying the water volume used with the decreases in water profitability.

As Table 4 shows, 854.3 dunums of the total area is agriculturally used.

Land Use	Area (dunum)	Average water re- quirement (m3/dunum)
Agricultural areas	854.3	2,100
Artificial Surfaces	28.5	0
Forests and semi-natural areas	17.8	0
Water bodies	3.4	0
Total	904.1	

Table 4: Land use and water requirement

The cost benefit analysis of the WPZ for Ein Sultan Spring below will consider the following costs (Tab. 5):

	Cost (USD/yr) *)	Cost (USD/yr) **)
Sign Post	100	100
Operation, monitoring quality & hazards	18,750	18,750
Wastewater network for Ein Sultan Camp	113,910	113,910
Economic losses due to agricultural restrictions	1,360,491	363,409
Total Cost	1,493,251	496,169

*) 50 % losses in agricultural production

**) 20 % losses in agricultural production

Table 5: Cost of Ein Sultan spring water protection zone

As economic benefits of the WPZ are taken into account:

- The economic value of water protected, calculated by multiplying the volume delivered yearly to domestic, commercial and public users with the average water tariffs (Table 2).
- The cost savings due to replacement of cesspits by the sewage network.

There are around 750 cesspits located in the Ein Sultan camp. According to the SMART II report 709 (PHG 2012), a cesspit with an average volume of 25 m³ is usually emptied once every 5 - 6 months where each tank load costs 50 NIS. Most of the cesspits are leaking and therefore have pollution risk to groundwater and environment. Nevertheless, the costs of emptying the cesspits reflect the lower bound for the value of environmental damages, which could be pre-

vented once the sewage system is operating. The cost saving from closing the cesspits is estimated to 19,634 USD/yr.

Note, that there are additional benefits for farmers from treated wastewater reuse, as the wastewater generated from Ein Sultan camp is transferred to the projected WWTP at Jericho East sub-basin.

Table 6 summarises the CBA outcomes for the WPZ of Ein Sultan spring, assuming 20% losses in agricultural production due to land use restrictions (rounded numbers). Supposing that the precautionary measures would be implemented soon, value added of about 590,000 USD/yr can be expected.

		(USD/yr)
Cost		500,000
Benefit		1,090,000
-	Economic value of water supplied to municipal users	1,070,000 *)
-	Cost savings due to shutting down cesspits	20,000
Added value of WPZ		590,000
*) 2.788 Mm ³ represents the water volume currently supplied to municipal users (Fig. 5). The average water value is 0.384 USD/m ³ (Tab. 2).		

Table 6: Costs, benefits and added value of protection zone for the Ein Sultan spring

The figures 7a and 7b display the estimated costs and benefits within the period from 2011 to 2031 each for the lower (20%) and the upper (50%) bound of economic losses in agriculture.

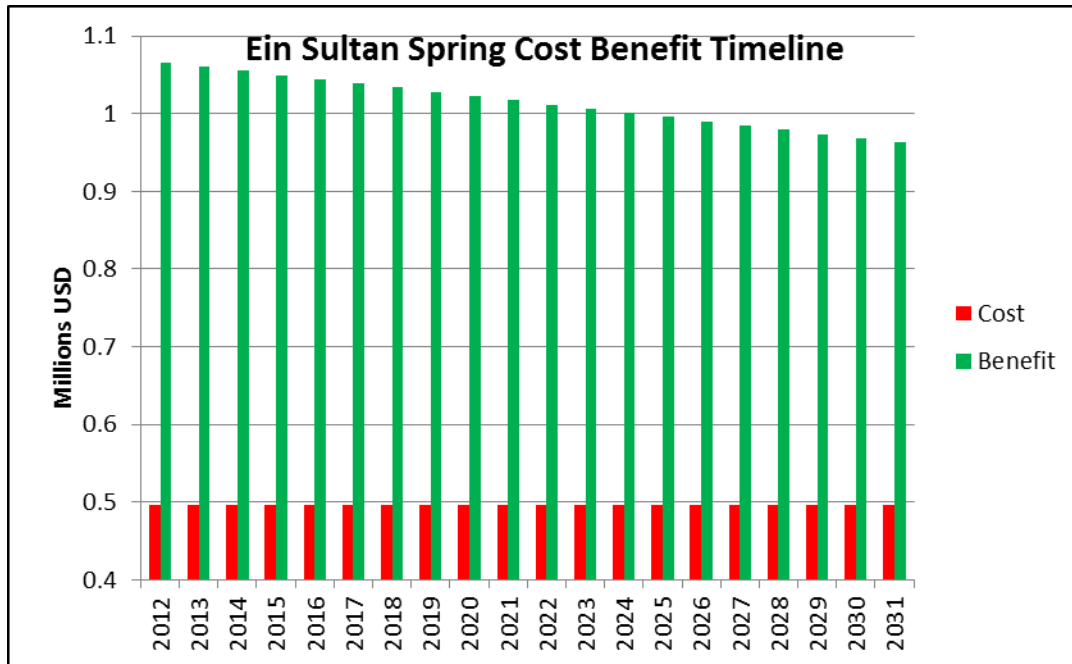


Figure 7a: CBA of Ein Sultan spring water protection zones assuming reduction in agriculture production by 20% in 2011-2031

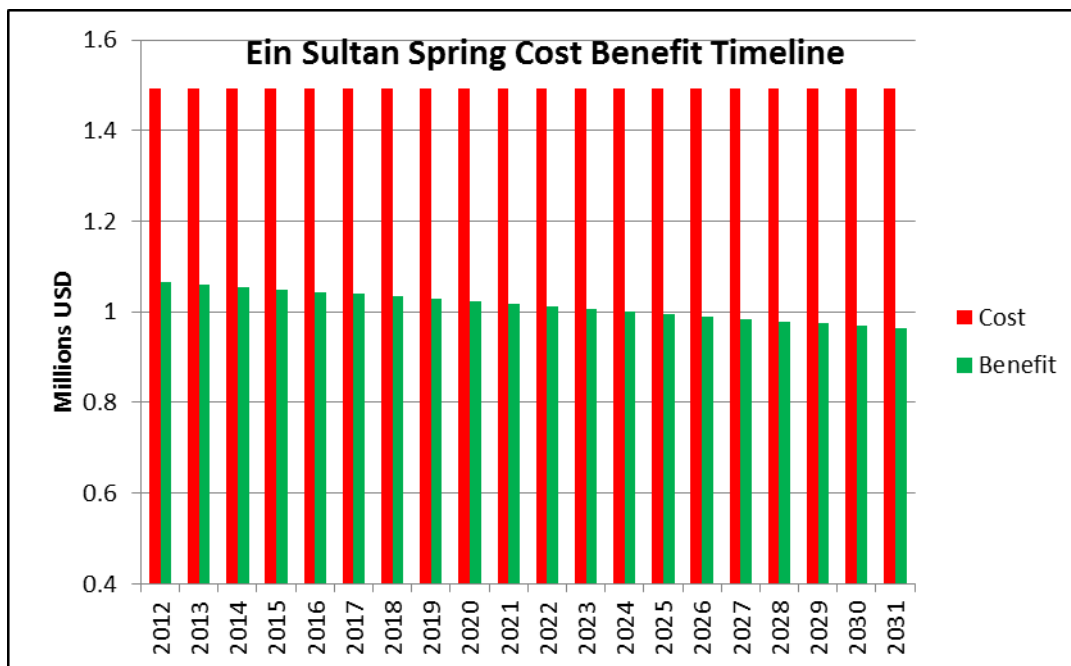


Figure 7b: CBA of Ein Sultan spring water protection zones assuming reduction in agriculture production by 50% in 2011-2031

As the results of the CBA show, surplus of the economic benefits over the costs of the proposed WPZ for the En Sultan spring and consequently considerable values added can be expected (Fig. 7a). However, it depends on the economic losses due to the land use restrictions in agriculture whether this will be really happen or not (Fig. 7b). More investigations in this regard are needed.

Note, that the cost and benefit numbers are rough approximations. In particular, the economic benefit of high-quality water may be higher, if the water tariffs would represent cost-recovery water prices.

3.1.5 Cost benefit analysis of Duyuk, Nueimah and Shosa springs protection zone

Even though most of the water quantity produced is allocated to agriculture; domestic users are still dependent on water from Duyuk, Nueimah and Shosa springs. Regarding pollutants, there is no major pollution sources are located upper the springs, and only mountains exist, yet some Bedouins are watched very near to springs that may cause pollution effects on water from animal rising (Fig. 8). People in Duyuk and Nueimah have also cesspits, yet such cesspits are located lower stream and therefore have no effects on springs' water quality. On the other hand, there are no Israel or Palestinian urban areas located in the near mountains (Fig. 9a, 9b and 10).



Figure 8: Duyuk and Neuimah Springs Field Photo (Source: Mahmoud Hammad 2011)

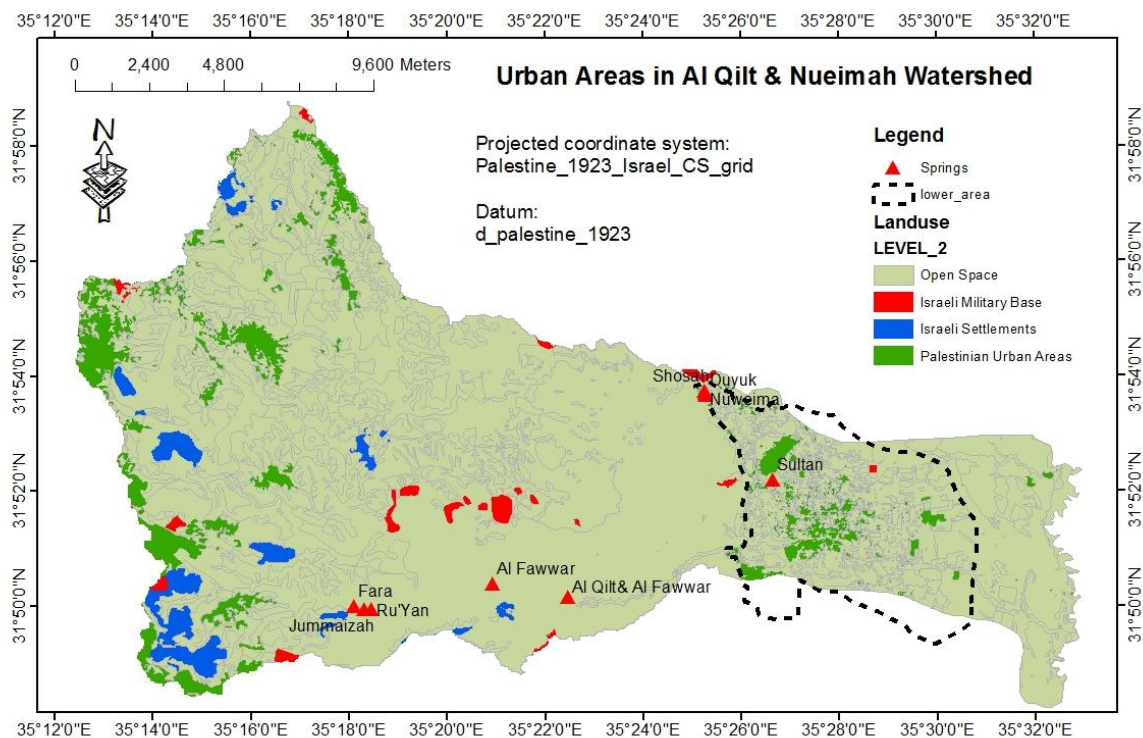


Fig 9a: Urban Areas in Al Qilt and Nueimah Watershed

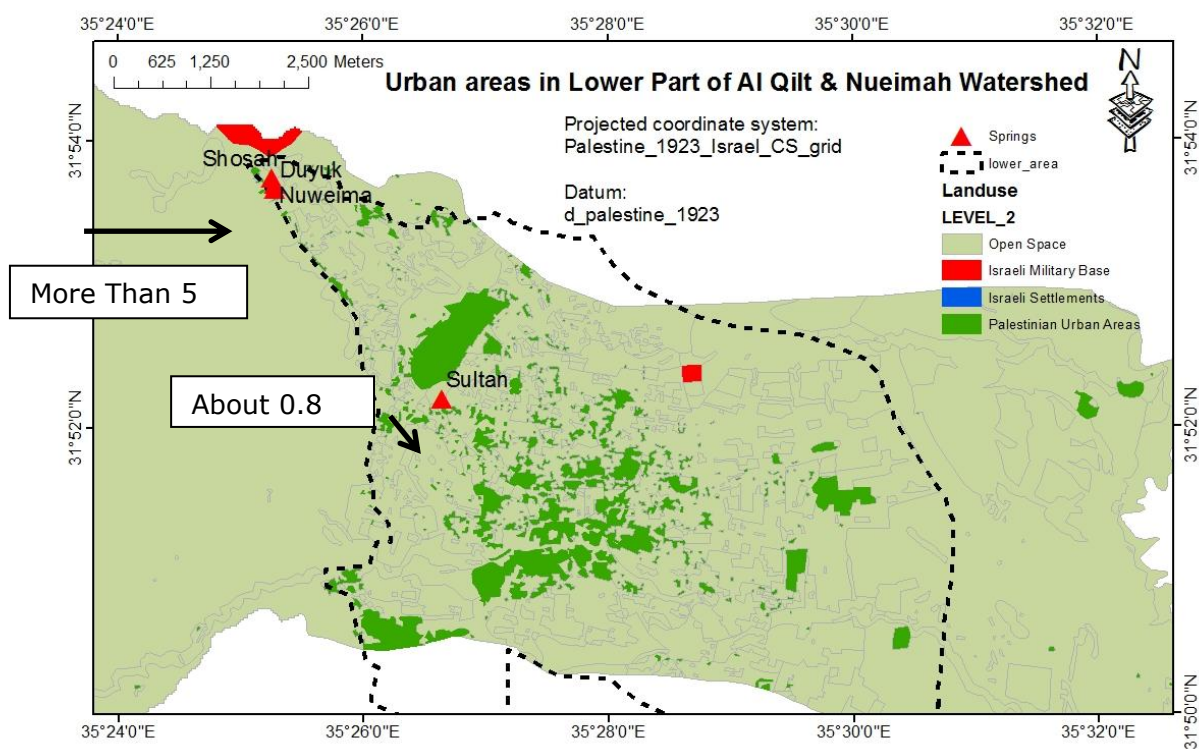


Fig 9b: Urban areas in lower part of Al Qilt and Nueimah Watershed

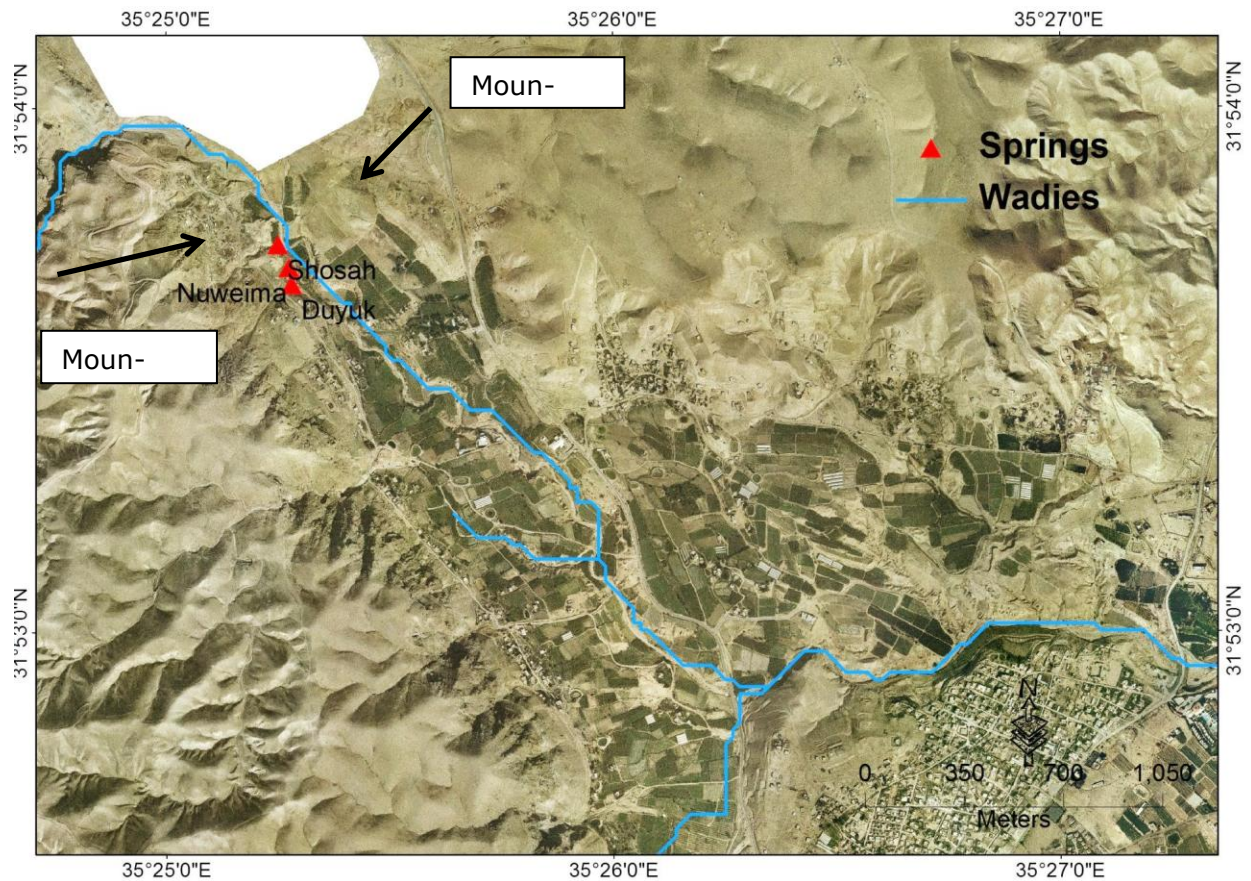


Fig. 10: Aerial image for the area of Duyuk, Nueimah and Shosa springs group

Domestic users currently demand about 0.5 MCM/yr and this amount of water is provided to domestic, commercial and public users in the Shosa, Nueimah and Duyuk areas. In comparison with the Ein Sultan spring area, where domestic users get a fixed share, at these areas domestic users have the highest priority. At present, the domestic water demand is small. Nevertheless, the demand for high-quality water is expected to increase to about 0.9 MCM/yr in 2031 (Fig.11).

Domestic and commercial users pay for water according to different water tariffs (Table 6). Like in the Jericho city, public users do not pay for the water. Nevertheless, the water volumes delivered to these users have an economic value, which is to be considered in estimating the economic value of high-quality water.

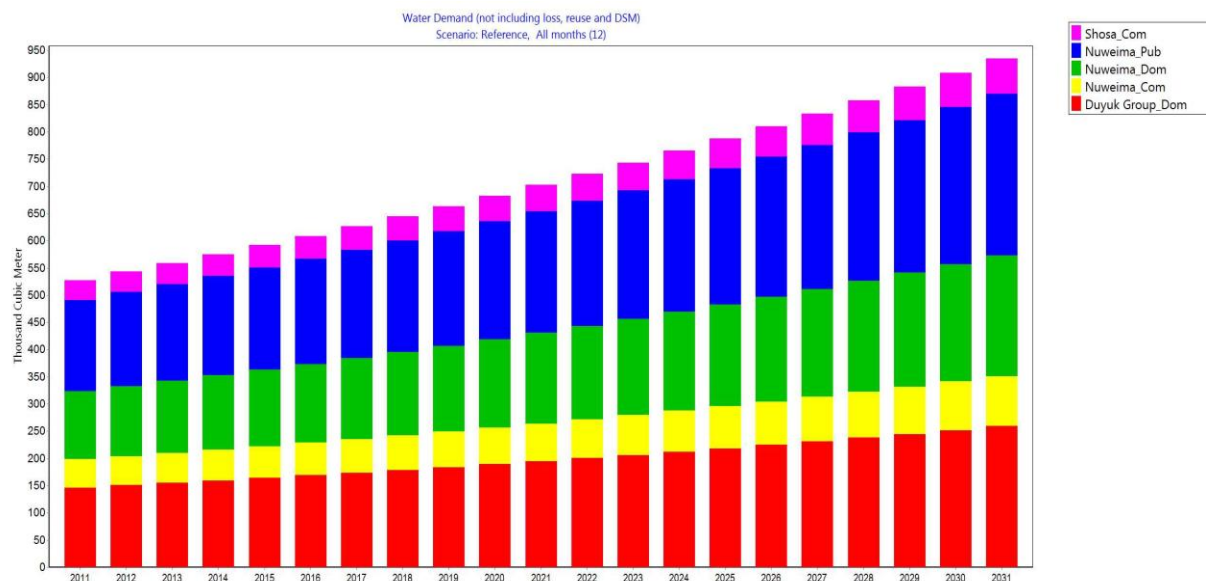


Fig. 11: Duyuk, Nueimah and Shosa area water demand for domestic, commercial & public use in 2011-2031

Duyuk Nueimah Domestic Tariff

Block no.	Consumption Category	Price (NIS/M ³)
1	0 -100,000 m ³	2 NIS/m ³

Duyuk Nueimah Commercial Tariff

Block no.	Consumption Category	Price (NIS/M ³)
1	0 -1,000,000 m ³	4 NIS/m ³

Table 6: Domestic and commercial water tariff in Duyuk Nueimah villages

The cost benefit analysis of the proposed water protection zone for Duyuk Nueimah Shosa spring group considers the following cost items (Tab. 7):

Item	Cost (USD/yr)
Sign Post	100
Operation, monitoring quality & hazards	18,750
Total cost	18,880

Table 7: Summary of Cost items for Duyuk Nueimah Shosa springs group water protection zone

The results of the cost benefit analysis within the period from 2011 to 2031 are shown in figure 12 indicating the importance and increasing economic value of precautionary measures for the Duyuk, Nueimah and Shosa springs.

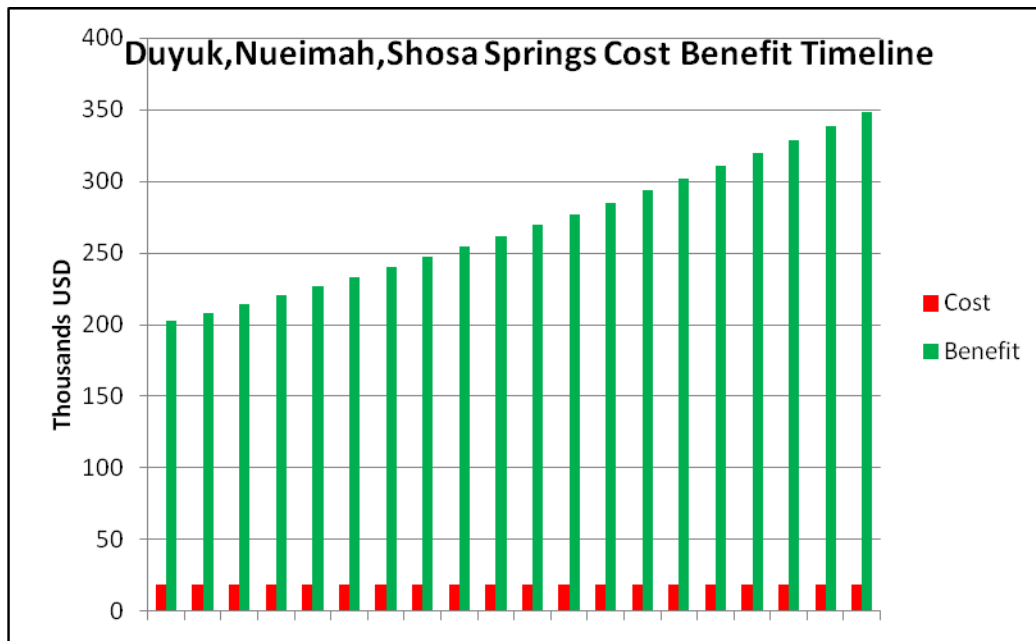


Figure 12: CBA of Duyuk Nueimah Shosa springs group water protection zones in 2011-2031

3.2 Jordan river valley

I. Heinz and A. Hayajneh

3.2.1 Cost benefit analysis of the Al-Buqouryah spring protection zone

The Al –Buqouryah spring is located in wadi Shueib catchment three km from As-Salt city at an altitude of 700 m above sea level. Al –Buqouryah spring is one of the main drinking water resources for As-Salt city with an average discharge of 4.8 MCM per year. The following figure shows the situation of the water protection zone.



Figure 13: The location of the Al-Buqouryah spring

The number of houses in Al- Buqouryah zone is around 2,500, while 20% of the houses are unconnected to the sewer system (around 500). The connection fee to be paid once by the house owner to connect to the sewer system is estimated at an average of 300 US\$.

In order to analyze the cost and the benefit of protecting Al- Buqouryah spring, all related costs and benefits for implementing the water protection zone are to be evaluated. Table 8 shows the estimated initial capital and operation cost for each action in implementing the protection zone. The capital cost must be annualized since the objects are to be replaced after their useful life-time. A discount rate of 6% is used. The connection fees are not included as the cost of connecting the 500 houses is already taken into account.

	Investment cost	Annual cost
	US\$	US\$/yr
Fence and signpost	500	100*)
Operation & monitoring		12,500
Rehabilitation & operation of the sewer system **)		21,000
Connecting 500 unconnected houses to sewer system	500,000 ***)	36,300 ****)
Income losses of farmers due to land use restrictions		n.a *****).
Total cost		> 69,900

*) Lifetime 5 years

**) Assumed as the costs of depreciation of the total sewage system; treatment cost included

***) 1,000 US\$ per house

****) Lifetime 30 years

*****) Data not available.

Table 8: Costs of the water protection zones Al- Buqouryah spring

Table 9 shows the economic benefits of protecting the spring.

In the case of Al-Buqouryah spring, the economic benefit of water protection zone exceeds significantly the cost. This is true, even though the cost of sewage disposal may be underestimated.

ed, the farmers' income losses are not considered, and the extra incomes in irrigated agriculture due to the additional water availability are rough approximations (incomplete data).

	Benefit US\$/yr	Notes
Water value of protected water (4.8 Mm ³ /yr)	3,360,000 *)	0.7 US\$/m ³ **)
Cost savings due to shutting down of cesspits	900,000 ***)	360 US\$/house/yr
Farmers benefit from additional amount of treated wastewater	2,400,000 ****)	0.5 US\$/m ³ *****)
Total Benefit	6,660,000	

*) 4.8 MCM x 0.7 US\$/m³

**) Water tariff

***) 2,500 houses x 360 US\$

****) 4.8 MCM x 0.5 US\$/m³

*****) Profitability of treated wastewater (lower than the freshwater value)

Table 9: Benefits of the water protection zone Al- Buqouryah spring

3.2.2 Cost benefit analysis of the Tabaqat Fahl spring protection zone

The Tabaqat Fahl spring is located in the Tabaqat Fahl village in north Shouneh district. It is a very important water resource used mainly for drinking purposes. The annual average discharge for Tabaqat Fahl spring is around 5.3 MCM per year. The number of houses in Tabaqat Fahl spring zone is around 1,000 houses, while around 50% of the houses are unconnected to the sewer system. The cost benefit analysis for protecting the Tabaqat Fahl spring is performed like in the case of the Al- Buqouryah spring.

The estimated costs and benefits of the protection measures are in the same order as in the case of the Al- Buqouryah spring (Tables 8 and 9). The economic benefits are shown in Table 10.

	Benefit US\$/yr	Notes
Water value of protected water (4.8 Mm ³ /yr)	3,710,000 *)	0.7 US\$/m ³ **)
Cost savings due to shutting down of cesspits	360,000 ***)	360 US\$/house/yr
Farmers benefit from additional amount of treated wastewater	2,650,000 ****)	0.5 US\$/m ³ *****)
Total Benefit	6.720.000	

*) 5.3 MCM x 0.7 US\$/m³

**) Water tariff

***) 1,000 houses x 360 US\$

****) 5.3 MCM x 0.5 US\$/m³

*****) Profitability of treated wastewater (lower than the freshwater value)

Table 10: Benefits of the water protection zone Tabaqat Fahl spring

As in the Al- Buqouryah spring case, at the Tabaqat Fahl spring, the economic benefit exceeds significantly the cost of the water protection zone.

4 SUMMARY AND CONCLUSIONS

As the economic evaluation of water protection zones showed by using examples in Palestine and Jordan, precautionary measures can lead to considerable benefits for domestic, commercial and public users. To some extent, farmers can benefit as well.

The economic benefits include cost savings due to connection of houses to sewage networks, maintenance of safe drinking water supply and provision of treated wastewater to agricultural users for irrigation purposes. On the other hand, expenses are required, such as for safeguarding and operating protection zones and installation and rehabilitation of sewage networks. Furthermore, production losses due to restrictions in land use, particularly in agriculture, can incur.

As the studies at the Jericho area and Jordan River valley proved, surplus of benefits over the costs can be expected in most cases. The implementation of water protection zones contributes not only to safe drinking water supply but also to reducing water pollution resulting from poor sanitation (e.g. leak cesspits and sewage systems). Under special conditions, restrictions particularly in agricultural land use (e.g. ban of agro-chemicals), can cause considerable income

losses, so that the costs of designing water protection zones may exceed the economic benefits.

The provision of high-quality water represents the major economic benefit of precautionary measures. The reason is the great importance users attach to this type of water, even if tariffs do not reflect its true value. In cases, where the cost are lower than the benefit, water protection zones are economically worthwhile, i.e. values added and additional gains in societal welfare will emerge.

Investigations are needed with regard to the impacts of safe drinking water supply on the future economic development of communities. More information on the financial implications of water protection zones would be useful as well: Who pays the costs of restrictions in land use, to which extent farmers should get compensation payments and what are the affects of precautionary measures on the prices of high-quality water?

REFERENCES

Abdel-Ghafour, D. (2005): Small-Scale Storm Water Harvesting in Wadi El-Qilt Ramallah: Palestinian Water Authority.

Bastian, D. (2012): RE: PI map data. Type to HAMMAD, M.

Cameron, J. and Jagals P. (2011): The practice of economic assessment of small-scale drinking-water interventions. In: Cameron, J., Hunter, P., Jagals, P. and Pond, K.: Valuing Water, Valuing Livelihoods (eds.), IWA Publishing, London.

http://whqlibdoc.who.int/publications/2011/9781843393108_eng.pdf

Consulting Engineering Center (CEC). (2010): Preparatory Survey on Sewer System, Procurement, Materials and Goods Price and Cost Estimation for Jericho Wastewater Collection, Treatment System and Reuse Project. Palestine.

Edwards, C. (2011a): Cost-effectiveness analysis in practice. In: Cameron, J., Hunter, P., Jagals, P. and Pond, K.: Valuing Water, Valuing Livelihoods (eds.), IWA Publishing, London. http://whqlibdoc.who.int/publications/2011/9781843393108_eng.pdf

Edwards, C. (2011b): Social cost-benefit analysis – summarizing the global evidence on drinking water interventions. In: Cameron, J., Hunter, P., Jagals, P. and Pond, K.: Valuing Water, Valuing Livelihoods (eds.), IWA Publishing, London.

http://whqlibdoc.who.int/publications/2011/9781843393108_eng.pdf

Ghanem, M. (2013): Discussion about residence time in Jericho area. Personal Communications.

Goldscheider, N. (2002): Hydrogeology and Vulnerability of Karst Systems – Examples from the Northern Alps and the Swabian Alb. PhD, University of Karlsruhe.

- Heinz I. (1996): Costs and benefits of pesticide reduction in agriculture: the best solutions. Symposium of the International Association of Agricultural Economists, Wageningen, The Netherlands, 25 – 27 April.
- Heinz, I. (2009): Water scarcity, wastewater reuse and the economic value of water. Proceedings of the 7th International European Water Resources Association Conference (EWRA), 27-28 June, Limassol, Cyprus.
- Khayat, S.K. (2005): Hydrochemistry and Isotope Hydrogeology in the Jericho Area/ Palestine. PhD, University of Karlsruhe, Germany.
- Jericho Municipality (2013): Interview about sewage collection system in Ein Sultan camp.
- Margane, A., Schmidt, G., Schelkes, K., Khalifa, N. and Subah, A. (2007): Contributions to the protection of water resources in Jordan.
http://www.bgr.bund.de/EN/Themen/Wasser/Veranstaltungen/iah_2006/presentation_schelkes_pdf.pdf?__blob=publicationFile&v=2
- Marie, A., Vengosh, A. (2001): Sources of Salinity in Ground Water from Jericho Area, Jordan Valley. Ground Water, 39, 240-248.
- Nick, A., Foppen, J.W., Kulabako, R., Xavier, D.L., Samwel, M., Wagner, F. and Wolf, L. (2011): Sustainable Sanitation and Groundwater Protection. Sustainable sanitation Alliance, SuSanA factsheet, GIZ, Bonn.
- PHG (2010): Water Master Plan For Jericho City. Jericho: Palestinian Hydrological Group.
- PHG (2012): Social acceptability of different IWRM technologies in the West Bank. Palestinian Hydrological Group. SMART II Report 709.
- Tarawneh, R. & Margane, A. (2006): Drinking Water Resources Protection Guidelines. Amman, Jordan: Ministry of Water and Irrigation.
- Van Kooten, G. (1996): Benefits of Improving Water Quality in Southwestern British Columbia: An Application of Economic Evaluation Methods. Economics of Agrochemicals, Sym-

posium of the International Association of Agricultural Economists, Wageningen, The Netherlands, 25 – 27 April.

Vrba, J. and Zoporozec, A. (eds.) (1994): Guidebook on Mapping Groundwater Vulnerability. International Contributions to Hydrogeology (IAH), 16: 131, Hannover.