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Feasibility of Protection Zones for Water Resources in arid areas: Case Study; EIN Sultan spring - Jericho, Palestine

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Abstract:

Increasing demand on current available water resources, urbanization and different economic activities put increasing pressure on existing water quality derived from these resources. An emerging need exists for protecting water resources in Palestine. In addition to the need for a strategy for solving such a problem, there is a need to show economic feasibility of implementing protection zones. In this paper, a methodology is introduced with real case study of how economic feasibility of water protection zones can be assessed concentrating on arid areas in Palestine. Ein Sultan spring is assessed using the introduced methodology; it has multiple users from different sectors (i.e., domestic, agriculture, commercial and public use) and multi-year cost benefit analysis technique used to show feasibility of water protection zones on long run. The study shows that even in arid areas in Palestine - where small quantities are derived from springs- implementation of water protection zones is still feasible, the results of this study emphasize on importance and feasibility of water resources protection zones

Key words | Water Protection Zones, cost benefit analysis, Ein Sultan spring.

1. Introduction

1.1 Overview and Problem Statement

For Palestinians, available water resources are opposed to different challenges in terms of quantity and quality, with limited access to water resources and increase in demand due to high population growth and needs for other growing sectors. “The interaction of an increasing demand for water due to population growth and the decrease of groundwater resources will be intensified in the near future.

Thus, the water supply situation could worsen significantly unless sustainable water resource management is conducted" (Grabe et al. 2012). Quality challenges are because of the fact that the majority of water resources originate from karst aquifers that are generally considered to be particularly vulnerable to pollution and anthropogenic impacts from various sources, such as agricultural land use, waste disposal sites, leakage of storage tanks or pipelines, release of untreated domestic wastewater and industrial activities (Goldscheider, 2010). Therefore protecting current available water resources is of high importance. However, implementing water protection zones do not provide additional quantity of water than protecting the current available water resources and this causes that the additional value of implementing such options to be not known or clear for many people. This research aims to provide explanation about the current situation and importance of water protection zones for water resources in arid areas. On the other hand, it aims to provide a methodology for different water specialist for economic assessment of water protection zones.

1.2 Study Area

1.2.1 Location and Available Water Resources: Jericho area is located in the lower part of the Al Qilt and Al Nueimah watersheds that are located in the south-eastern part of the West Bank (Figure 1). They extend from the central mountains of the West Bank in the west to the Jordan River in the east.

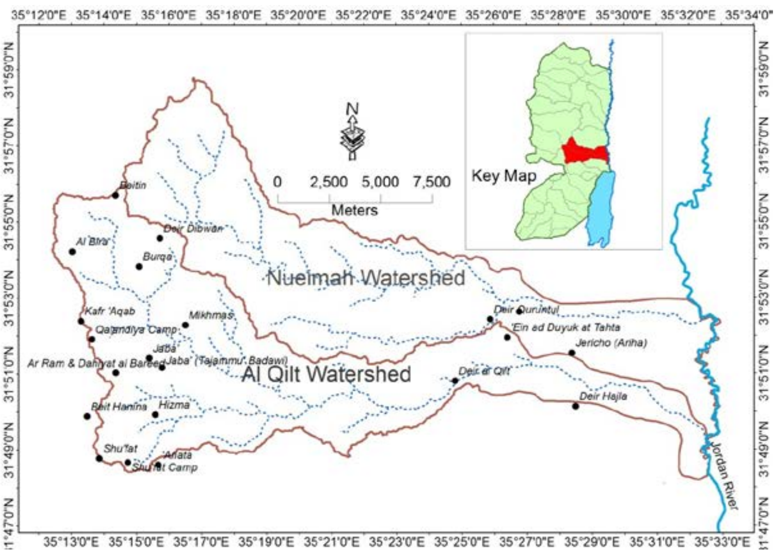

Figure 1: Location map of Al Qilt and Nueimah watershed,

ISSN 2348 – 7968

Source: After PHG database (2011).

Jericho area has high agricultural, tourism and commercial activities. In Jericho area, springs are main natural suppliers for the water used, especially water used for domestic use. Ein Sultan spring, with annual discharge of about 5,500,000 m^3/yr represents the main supplier of water for domestic, commercial and public use in Jericho City. Deterioration of water quality would require costly treatment and may affect adversely various economic activities in Jericho area.

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 an urgent need for protecting the water resources as continued groundwater pollution threatens the water supply for all water users.

1.2.2 Hydrogeology and vulnerability of groundwater in Jericho area

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, 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. Most areas of the lower part of Al Qilt Nueimah watershed have moderate groundwater vulnerability. The concept of groundwater

ISSN 2348 – 7968

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 & Zaporozec, 1994).

1.2.3 Guidelines of Protection Zones for springs in Jericho Area

There are no current Palestinian guidelines for water protection zones (WPZ), and therefore it is an obstacle for assessment of WPZ locations, yet there are guidelines in Jordan. The Jordanian WPZ guidelines refer to cases where the residence time of water is 50 days. The Residence time in Al Qilt watershed is expected to be in the range of 50 - 54 days (Ghanem and Hammad, 2013). Therefore, the Jordanian guidelines can be applied as long as no Palestinian guidelines exist knowing that Palestine and Jordan share the Jordan valley basin. According to Jordanian guidelines, a water resource should be surrounded by three nested zones in which specific activities are prohibited. The three categories of Protection zones are as the following:

Zone I: It is the closest to water intake and has the strongest restrictions and is defined as 50 meters at least in the upstream direction, 10 meters in the downstream direction and 15 meters at each side (Figure 2). Activities in this zone are totally prohibited and the areas within the protection zone 1 should whenever possible be owned and fenced by the Water Authority.

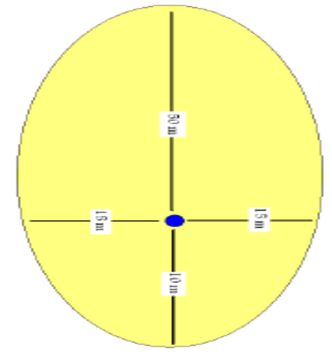

Fig. 2: Protection zone I for a spring

Zone II: According to Jordanian guidelines (Tarawneh et al, 2006); “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.”The activities allowed in Zone II are limited to residential activities and organic agriculture and priority is to be given for the establishment of an appropriate sewerage network.

Zone 3: Includes the protection of the entire surface catchment area. Zones 3 aims to protect against pollution over long distances, such as contamination by radioactive substances or chemicals which are non or hardly degradable (Margane, A et al 2007).

2. Methods

The methodology used has two aspects, the first aspect is related to hypothetical assumptions in making the feasibility assessment and the second is related to tools used.

Regarding the tools, WEAP hydrological balancing model was used to derive spring flow data and to simulate how the water resource is allocated to different sectorial users considering priorities, the model can also provide ability to project expected spring flow in coming years considering externalities (i.e. considering declination of flow due to negative climate change effects). GIS maps were used to calculate agricultural areas that are affected by restrictions on fertilizers in zones II. Finally cost benefit analysis (CBA) is used to assess the feasibility of water protection zones; the CBA is made on multi year basis. For each year costs and benefits are calculated. Calculations of costs include the costs of implementing protection zones that are defined according to local guidelines, implementing protection zones includes constructing monitoring facilities near the water resource, also may prohibit specific activities such as industrial factories that cause pollution or extensive use of fertilizers in near agricultural activities, the reduction in profit for these activities due to restrictions is considered in the side of costs. Figure 3 shows summary of the introduced methodology. For integration of CBA with hydrological model data, calculations of Costs and benefits are obtained by transforming all possible running costs and benefits into monetary unit per each cubic meter of water used, while investment costs are annualized (In the case of yearly calculation and if monthly calculation to be used so as annual values would be changed into monthly values).

Regarding hypothetical assumptions, all possible costs are considered while only direct benefits were considered postponing indirect benefits consideration to implementation period, the reason is that quantifying costs and benefits of water protection zones includes intersections between many different variable elements and factors, as an example indirect benefits can be in the form of reduced health costs due to improved drinking water quality and in order to understand the magnitude of such benefits; there is a need to know the possible reduction of pollution load in relation to establishment of each protection zone. Such calculation is really hard and difficult as reduction of pollution in an area would depend on characteristics of geology, groundwater recharge, climate, pollution source type and quantities (that depends on population number, population growth rate and water use rate per capita in the case of domestic wastewater) , type of aquifer...etc. Finally, linking all previously stated factors would not give a specific relation that can be truly generalized for all areas assuming abundancy of data that is unfortunately not the case in most of arid areas. Further questions may emerge like “what is tourism benefits due to increase of water quality?”, “what is ecological benefits due to increase of water quality?” and so on that would require a huge amount of data for calculation that is not available in most cases. As a solution, indirect benefits are ignored as this methodology is aimed for feasibility assessment prior to implementation of protection zones to help decision makers and water planner to have an idea about feasibility of water protection zones with minimum amount of data while considering important factors such as losses in agriculture due to restrictions and variation of discharge and allocation through projection period. The methodology also does not include any stakeholder participation, this is not ignorance as stakeholder participation would be important in implementation period rather than initial feasibility assessment where stakeholders’ willingness to pay would be crucial in assuring successful implementation of water protection zones. On the other hand, benefits from protection zones for domestic uses is obtained by multiplying quantities of water saved from pollution by economic value of water, as information about value of water may be not available it is suggested to use the magnitude of domestic tariff as water economic value as the tariff does not cover the full cost of water (production, treatment and distribution) and therefore represents the lower limit of water economic value, if water economic value is known then it is used in the calculations. In calculating costs of implementing protection zones, the losses to agriculture are assumed to take place due to restrictions if organic products market is still uncommon

ISSN 2348 – 7968

(as shown in following case study), but if agricultural organic products market is active the profitability analysis of water used in agriculture should be revised as there is chance that the organic products fetches higher prices in the market which may compensate a part of the losses even in presence of a reduction in quantity. There is also a chance that farmer shifts to different crops or utilize different techniques in response to the restriction but this is not considered in this methodology as this falls in the part of possible scenarios and requires further investigation from stakeholders that makes this closer to implementation phase rather than initial assessment one.

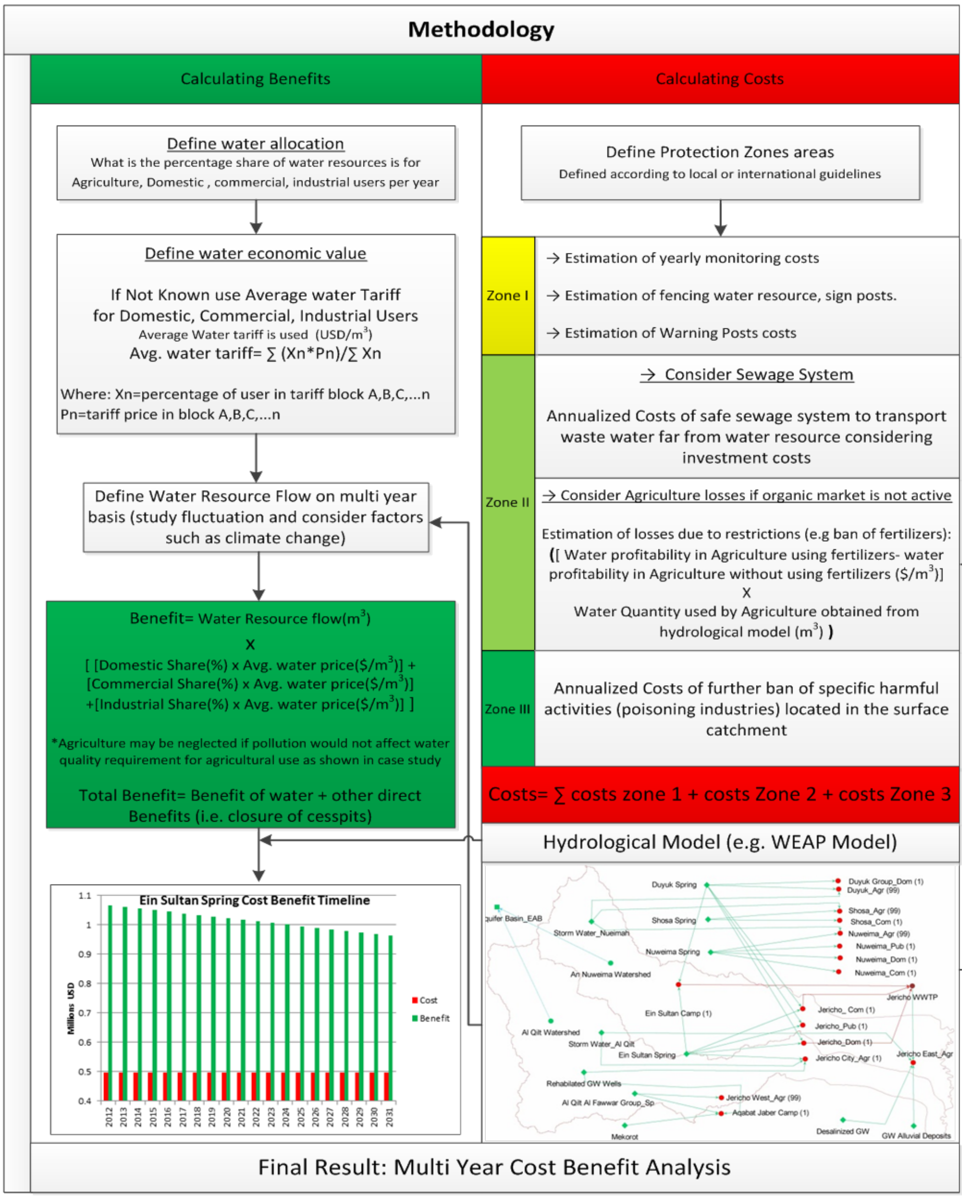

Figure 3: Methodology

3. Results and Discussion

3.1 Ein Sultan Spring Water Allocation

According to a local agreement; 48 % of Ein Sultan Spring discharge is currently allocated to domestic users in Jericho city, 2.7 % is allocated to the Ein Sultan refugee camp while the remaining 49.3% goes for Agricultural activities. From the domestic share; 6.4% is reallocated by users for further 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 inside Jericho city camps' users, respectively.

Considering water prices, camps and public sector get water for free as a social subsidy while commercial and domestic users have to pay a price that ranges from 1 - 5 NIS/m^3 according to tariff block (equivalent to 0.26-1.31 USD). The tariffs do not cover the full capital and operation and maintenance (O&M) costs of the water services; thus they understate the economic values of water. Table 1 shows the average water prices and indicates the lower bound of water values for different users.

Table 1: Average prices of water for users of water from Ein Sultan Spring

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
	Average		*0.32*	*0.384*
Ein Sultan Camp	----	2.7	0.00	0.38

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

**) Agricultural users buy the domestic water

The discharge of Ein Sultan is expected to decrease (Fig. 4) (PWA, 2012). The decrease is due to climate change causing declining rainfalls. A further reason is the overexploitation of aquifer. This development will have impacts on the economic value of water delivered to the users.

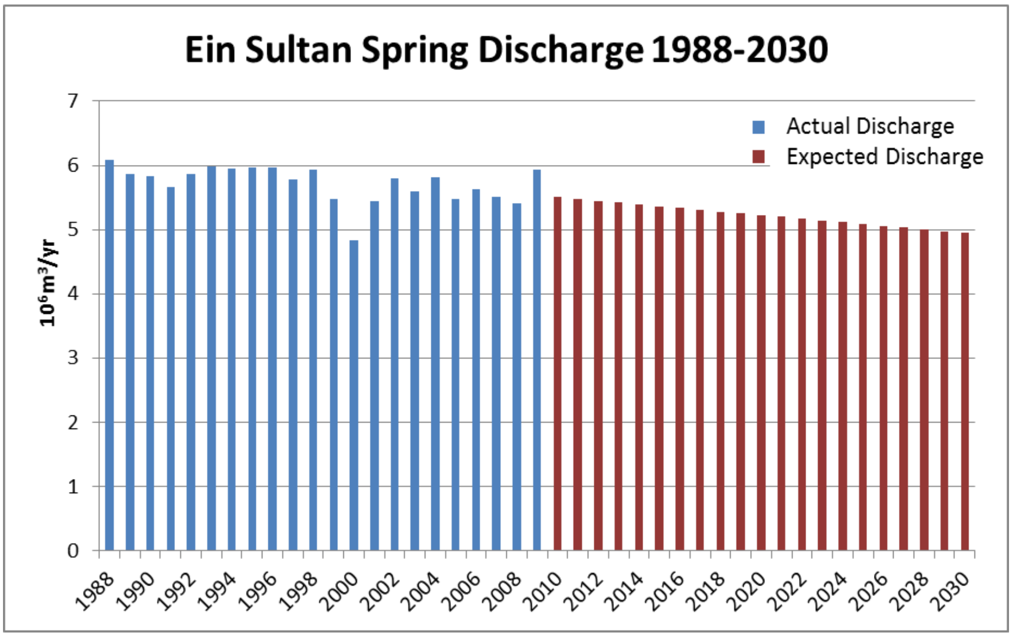

Figure 4: Ein sultan Spring Yearly Discharge in 1988-2009 (PWA, 2012) and expected discharge in 2010-2030

3.2 Potential Pollutants

Ein Sultan is located to the south east of the residential area of Ein Sultan refugee camp and Duyuk Nueimah agricultural areas. There is a potential pollution threat resulting from domestic wastewater cesspits of Ein Sultan refugee camp, currently, there are around 750 water connections, each is representing a house or family, so that there are approximately 750 cesspits (Jericho Municipality 2013). Another potential pollution source is pesticides and fertilizers used in farms of Nueimah Duyuk agricultural areas (Fig. 4). According to Tanji et al (2002) “Most nitrogen fertilizers are highly soluble and mobile in the soil, and nitrates readily enter drainage water through leaching processes”.

Avoiding pollution can be achieved by prohibiting cesspits and a suitable wastewater collection network should be constructed, on the other hand; restricting use of fertilizers and pesticides.By implementing all the precautionary measures the currently good quality of Ein Sultan Spring could be protected.

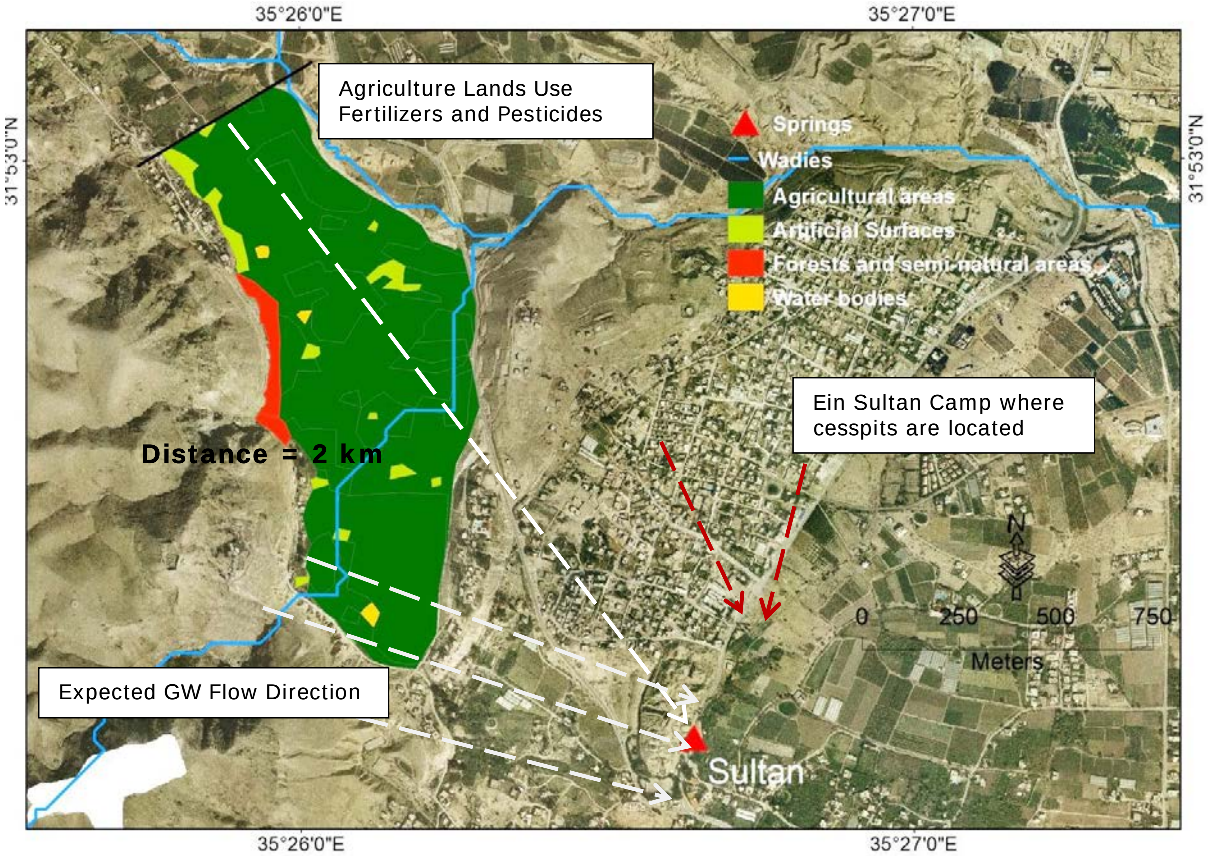

Figure 4: Potential pollution sources for Ein Sultan Spring and location and land use of fertilizers and pesticides restriction area upper of Ein Sultan spring

3.3 Cost benefit analysis of Ein Sultan Spring Protection Zones

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 %. (MAS, 2008). 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 (PHG, 2010).

On the other side, restrictions on using fertilizers and pesticides in the agricultural lands, which are in distance of less than 2 km upper of Ein Sultan spring (Fig.4); will lead to losses in farmers' income, losses in incomes represent part of 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). The restrictions in agricultural land use would decrease the average water profitability from 1.19 USD/m^3 to 0.44 USD/m^3 (50 % losses) and from 1.19 USD/m^3 to 1.00 USD/m^3 (20% losses), respectively. The cost benefit analysis of the WPZ for Ein Sultan Spring below will consider the following costs (Table. 2):

Table 2: Cost of Ein Sultan spring water protection zone

	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

On benefits side, there are around 750 cesspits located in the Ein Sultan camp. A cesspit with an average volume of 25 m³ is usually emptied once every 5 - 6 months where each tank load costs 50 NIS (around 13 USD). 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 prevented once the sewage system is operating. The cost saving from closing the cesspits is estimated to 19,634 USD/yr. On the other hand, it is important to 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. 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. The figures 5a and 5b 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.

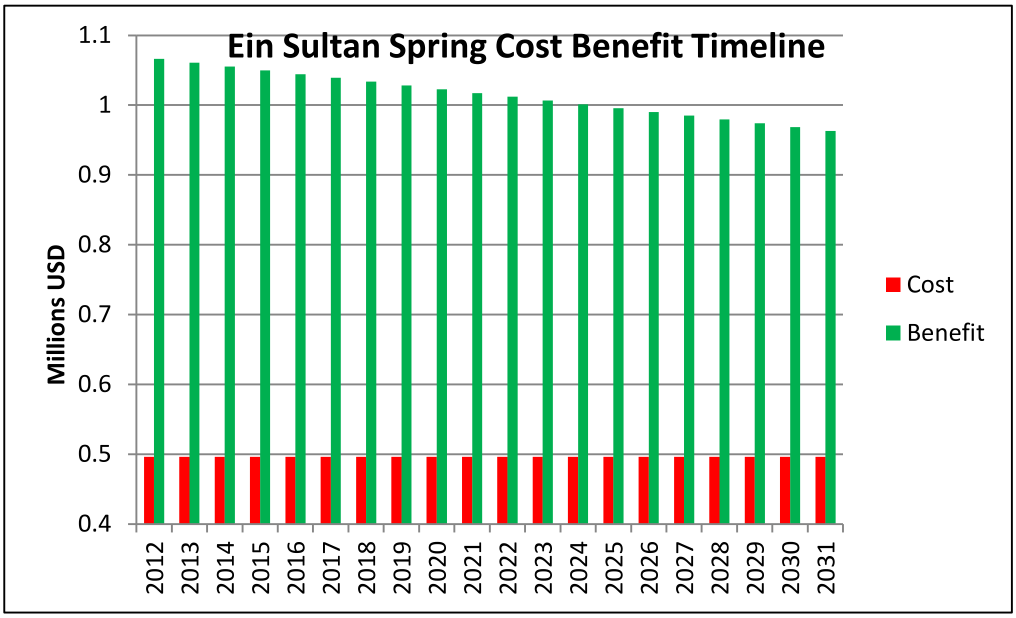

Figure 5a: CBA of Ein Sultan spring water protection zones assuming reduction in agriculture production by 20% in 2011-2031

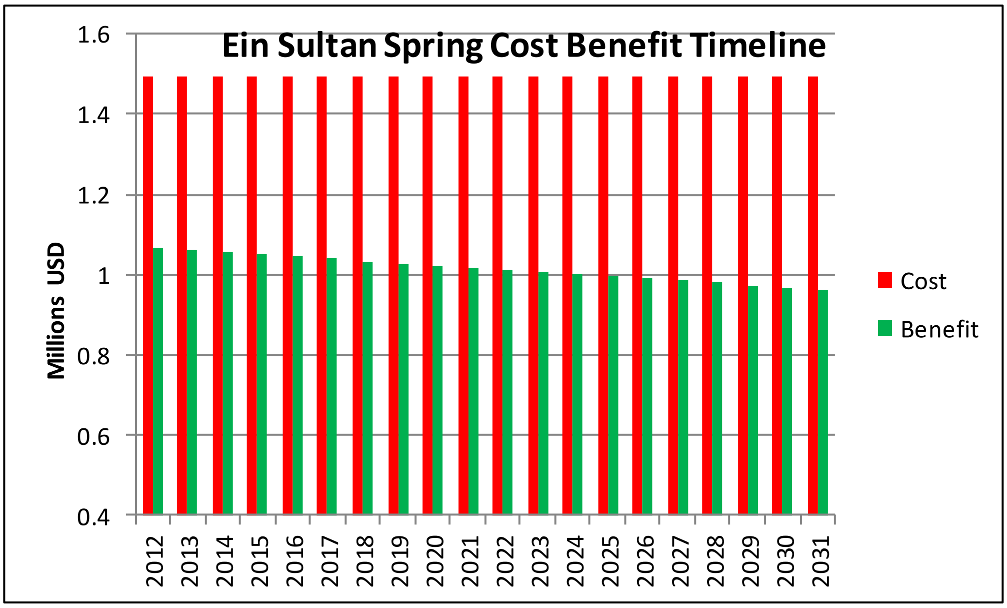

Figure 5b: CBA of Ein Sultan spring water protection zones assuming reduction in agriculture production by 50% in 2011-2031

4. Conclusions and Outlook

The present paper carries out an economic evaluation of water protection zones using cost-benefit analysis for the Ein sultan spring in Jericho area in lower Jordan valley. The results of the analysis show that precautionary measures of pollution to water resources represented by water protection zones 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 of pumping wastewater in cesspits due to connection of houses to sewage networks, maintenance of safe drinking water supply and provision of clean water for domestic 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, indicate the provision of high-quality water, which represents the major economic benefit of water protection zones. 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. Yet, further 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. Also investigation about how and who is going to manage water protection zones. The economic analysis of WPZ at Jericho area in lower Jordan River valley proved that surplus of benefits over the costs can be expected in most cases. Yet, under special conditions, restrictions particularly on 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. More investigations in this regard are needed and it important to 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.

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