Sustainable Water Resources Development in the Thirsty Lands: Water Resource Development in the Lowest Place in the World; Jericho

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Abstract

Attempts at developing water resources in lands affected by water scarcity in the Middle East have been thousands and have a long history. This study focuses on the sustainable development of water resources in Jericho in the Occupied Palestinian Territories (oPt) where exploding urbanization and extensive use of water is yearly increasing. The degradation of both water quality and quantity in Jericho, which is used to be the green basket in the region, is increasing every year. Sustainable water resources' development, which is based on releasing the stresses on the ground as well as surface waters and on the protection of the environment, is viewed increasingly as mean to protect the existing resources for the incoming generations and to present tangible benefits for policy decision makers. Despite important gaps in information about spatial and temporal characteristics of water and wastewater in Jericho, we suggest that an integration between water and sanitation systems, based on the reservoir control approach, could achieve sustainability.

Keywords: demand, Jericho, reservoir control, reuse, sustainability, waster treatment.

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Introduction

Water resources development in the Jordan river valley (fig. 1) has a long history and has been studied and analyzed by many researchers and international donors such as; ARIJ (1995), JICA,(2008), KRI (2006), GLOWWA(2010), PWA(2000-2008), many alternatives for developing water resources such as; rainwater harvesting, reuse of wastewater, desalination of brackish water, Red-Dead Canal project recharge, etc. (http://www.deadseaproject.eu/Publications/FGM2Palestine.pdf) However, most of these studies were fund driven and spent lots of time and money for evaluating different scenarios for developing water resources without conducting any practical steps. Nevertheless, there are growing concerns in the region because some of these studies affected policy decision makers and international donors as they started “risky projects” such as rain water harvesting in the Jordan river valley. We think that there are many reasons that may cause the failure of these projects due to surface runoff quality and quantity (see Fig. 2), high evaporation, feasibility, and sustainability. Our approach is based on the integration between water supply and sanitation systems. The spatiotemporal characteristics of water supply and demand for domestic purposes and agriculture in a region like Jericho is characterized by high flow rates during dry seasons and low flow rates in wet seasons. Accordingly, among the proposals for water resources developing in the region, the sanitation system is the only system that can supply a water resource which responds to variations in terms of supply and demand. However, social and technical aspects that are related to the reuse of wastewater affect negatively policy decision makers and the donor community. On the other hand, the idea of surface runoff

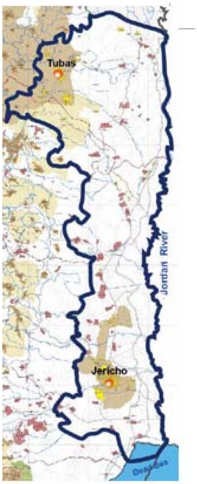

Fig. 1 The Jordan River Valley

harvesting is getting a greater acceptance and support. This is because people think that harvested rainwater from fields and streets are cleaner than treated wastewater which is not true. In our study we will try to concentrate on one single aspect which is to show how an integrated water/sanitation system, based on reservoir control approach, could be sustainable.

Fig. 2 Surface runoff in rainy day in Jericho (2008)

Water supply systems should be strongly linked to sanitation systems in urban areas in terms of technology development and management. However, in reality this tends not to happen in developing countries and fails in main two aspects; development and management. Jericho, which is the lowest and one of the oldest cities in the world, in the occupied Palestinian Territories (oPt), is situated at approximately 300-400 m below sea level and located 8 km northwest of the Dead Sea as shown in Fig. 2. It is considered as the food basket and the main international gateway for the Palestinian territories. The Mediterranean climate is prevalent in Jericho, having four months of hot dry summer and a short winter with rain from November to March. The Jordan Rift Valley is warmer and drier than other areas in the oPt. The average annual rainfall is 168 mm in Jericho. The coolest month is January with the mean temperature of 13.30C in Jericho, while the warmest month is July or August with the mean temperature of 30.00C in Jericho (PCBS, 2005), the warm climate even in the winter season provides some competitiveness in the agricultural industry, and advantages for recreation and tourism. The mean annual relative humidity (RH) in the Jericho district is 50% as shown in Fig. 3.

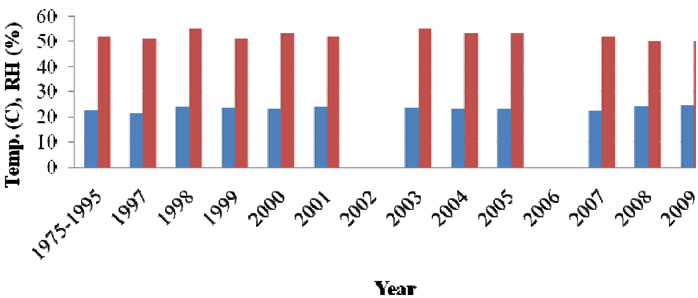

Fig. 3 Annual averages of ambient temperature and relative humidity in Jericho (PCBS, 2010)

The existing land for Jericho city covers the total area of approximately 35 km2 with two refugee camps. The city mainly consists of flat agricultural lands (40% of total land) and unused lands in the southern part of the city (35% of total land). The built-up area is 7.0 km2 accounting for about 20% of the total land and spreads from the city centre (JICA, 2008). According to the Palestinian Central Bureau of Statistics (PCBS), the population of Jericho city was approximately 20,416 in 2006. The city has the lowest population density compared to the major cities in the oPt at 69 persons per km2. The estimated population for Jericho is assumed to be around 40,000 in 2030, based on an annual average population growth rate of 2.7%.

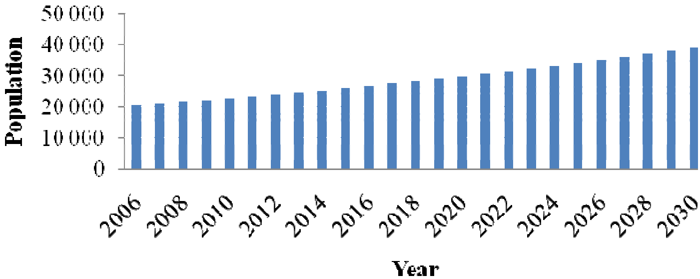

Fig. 4 Predicted population increase in Jericho

Jericho district is known for its agricultural activity, the total agricultural planted area in the district is about 2,420 hectares and the total estimated production is 54,071 tons (JICA, 2008). The main cultivated crops in the district are vegetables, fruit trees, and field crops. Recently, the demands on water supply in Jericho city for irrigation are yearly increasing and causing stresses on the only available groundwater resources and additional water supplies have to be developed. According to the Palestinian water Authority (PWA) in 2003, ground water and purchased water from "Mekorot", an Israeli water supply company, are the main water source there, the average water supply is estimated to be around 175 lpcd. The main water resource is Ein–El Sultan spring, with a capacity of 650 m3/hour. About 40% of this water is used for domestic purposes and the remaining is used for irrigation. Wastewater is discharged to cesspits in each residential building. According to the Engineering department at Jericho Municipality, wastewater treatment plant (5000 m3/day-10,000 m3/day) and about 45 km of sewers could manage wastewater during the next 20 years (PECDAR, 1998). Without wastewater treatment., the surface and the groundwater could be contaminated from cesspits because the groundwater level, based on data provided from the PWA, is around 355-375 m below the sea level. Treated wastewater can be recharged to the aquifer (Harpaz, 1971; Maliva, 2004) and reused for irrigation. The necessary issues to be considered in wastewater treatment in Jericho are: the selection of treatment process which can be sustainable and the cost recovery. Recently, the financial situation in Jericho municipality is improving as shown in Fig. 5.

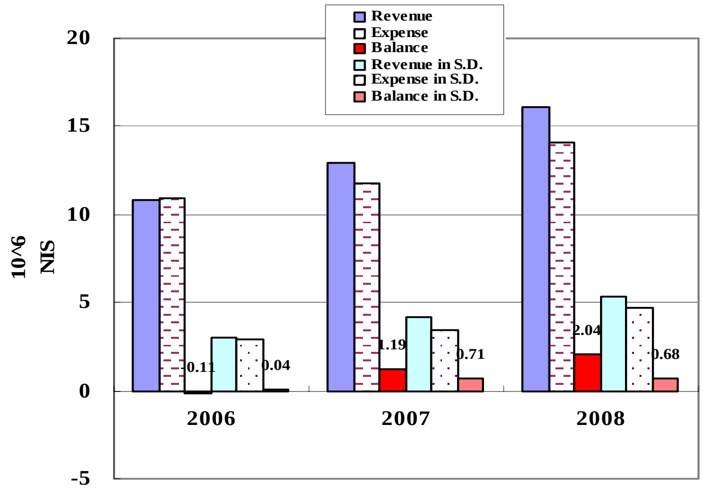

Fig. 5 Balance of Jericho Municipality in 2006-2008 (1US$~ 3.7 NIS). (SD: Service Department)

The following treatment technologies were proposed by Japan International Cooperation Agency (JICA) in 2009 for having a capacity of 5000 m3/day: AFP: Aerated Facultative Pond, EAAS: Extended Aeration Activated Sludge

SBR: Sequencing Batch Reactor, SP: Stabilization Pond, the estimated operation and maintenance and investment costs are shown in Fig. 6, according to this figure, the Sewerage facilities would be feasible from the financial, institutional point of view.

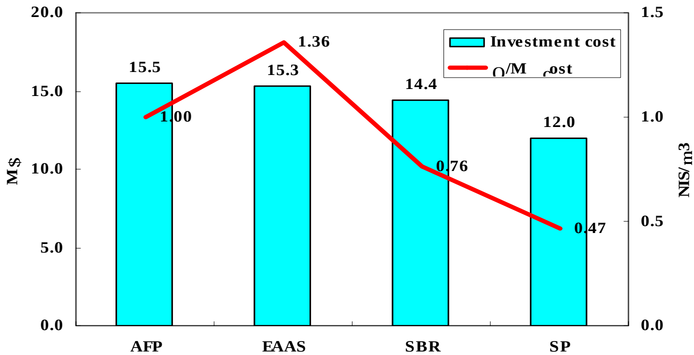

Fig. 6 estimated investment and operation costs in Jericho

Wastewater treatment and reuse are viewed as increasing in many areas as means to improve water supply for fresh water growing demands. (Jansen et al., 2007; Wei et al., 2007; Zabalaga et al., 2007). However, farmers are not ready to use treated wastewater due to social aspects (Farooq et al., 1983, and technical aspects mainly due to high salinity Toze (2006), Chiou (2007), and requirements of new irrigation practices. Also, these technical concerns were considered in the proposed Red-Dead canal project.

Reservoir control approach

We think that sustainability of both water and sanitation systems could be achieved by integrating the two systems as demonstrated in Fig. 7; the water system is represented as a reservoir (WS) that has inputs (I) from springs, wells, rainfalls, etc, outflows are mainly losses and influent to another reservoir (WWS) that represents the sanitation system within a region, the outflows of this reservoir are an input to first reservoir (O') and losses (O). The changes in the storage (ΔS) in each reservoir for a period of time (t), season, can be expressed as follows;

$$\Delta S / \Delta t = (It + It+1)/2 - (Ot + O\ t+1)/2 \quad (1)$$

The characteristics of the water and sanitation system in Jericho are as follows: almost steady state inputs to WS except the water purchase, losses are mainly caused by infiltration and/or evaporation, the outflow (I') is recently discharge to the Dead Sea. In the future I' will be the influent to WWS, the effluent of WWS will be again subjected to losses due to infiltration and evaporation and O' as an input to WS. The following conditions are necessary for achieving sustainability in the study areas; - minimize (L,O): this could be achieved by reducing the leakage in the existing old water network, inaccurate water meters, evaporation. O can be minimized by selecting tertiary wastewater treatment technology. These options can maximize (I',O'). However, in realty this tends not to happen and a co-benefit or co-control should be introduced, the importance of this integrated system is that it can be used to be applied to many scenarios for water supply/wastewater treatment tariff system. The increasing demand from WS can be effectively controlled by a water tariff system aiming, at one hand, at saving water and on the other hand, at enforcing irrigation with a reclaimed wastewater from WWS that also could save the water from the increasing demands for fresh water from WS. The integrated system requires that the leak should be minimized and new applications, such as prepaid water meters, should be introduces.

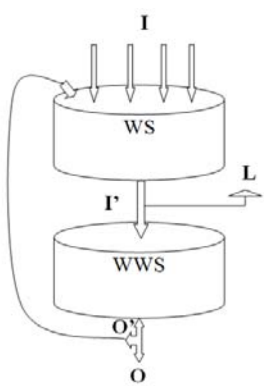

Fig. 7 demonstration of reservoir control for integrated water-sanitation system

Implementing the integrated water-sanitation systems is not easy to establish because in many countries the two systems are managed separately. We recommend that such an approach should be demonstrated on a pilot scale in order to quantify the benefits. This will make it easier for policy decision makers to think more seriously about large scale regional projects. On the other hand, the capacity building and a computerized system could optimize the operation and maintenance of the system which represent the main aspects in achieving sustainability.

Conclusions

This study focuses on sustainable development of water resources in Jericho in the Occupied Palestinian Territories (oPt) where exploding urbanization and extensive use of water is increasing every year. The degradation of both water quality and quantity in Jericho, which is used to be the green basket in the region, is increasing year after year. Sustainable water resources' development, which is based on releasing the stresses on the ground as well as surface waters and on the protection of the environment, is viewed, increasingly, as a mean to protect the existing resources for the incoming generations and to present tangible benefits for policy decision makers. Despite important gaps in information about spatial and temporal characteristics of water and wastewater in Jericho, we suggest that an integration between water and sanitation systems, based on the reservoir control approach, could achieve sustainability. Further, research is needed in practical application of the water-sanitation integrated system based on pilot and regional scales, respectively.

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