

# Using socio economic indicators for integrated water resources management ( Demand Management - case study)

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# *Water resources in the west Bank*

- The West Bank is the eastern part of historic Palestine. Water in the West Bank comes originally from **rain water (150 to 700 mm/year** (PHG, 2004)). The total quantity of rainfall on the West Bank is **2248 million cubic meter** (MCM), 68, 3.2 and 28.8% of these quantities are distributed as evapotranspiration, surface runoff and natural recharge, respectively (Abu Zahra, 2001). The main fresh water resource in the West Bank is ground water, this quantity is abstracted from three main aquifers, **eastern aquifer (Safe yield = 172 MCM/year)**, **north-eastern aquifer (safe yield = 145 MCM/year)** and western aquifer (safe yield = 362 MCM/year), whereas, 69 MCM per year are utilized by Palestinians in the West Bank, (Article 40 of Oslo B agreement). 297 springs and seeps are distributed over the West Bank, of which, 291 (53% of total discharge) are discharging water of excellent quality (Abu Zahra, 2001) and 6 springs or groups of springs are of a brackish nature. The total reported discharge of these springs is 24-119.9 MCM/year (Nseibeh and Nasser Eddin, 1995), mainly used for irrigation.

# *Water resources in the west Bank*

Seasonal wadis are also considered as a considerable water resource; its annual quantity is approximately 74 MCM/year (52 and 22 MCM/year in the eastern and western wadis, respectively). Low percentage of this quantity can be utilized as a result of lack of infrastructure essential for collection, storage and distribution at a large scale, and the same goes for urban (14 MCM/year) and natural (70 MCM/year) runoff (Abu Zahra, 2001). Additionally, rain water harvesting in cisterns is a considerable water resource in the West Bank, its annual quantity is estimated as 6.6 MCM/ year. Finally, the Palestine share in Jordan River (257 MCM/year) is inaccessible since 1967 due to Israeli military measures (World Bank, 1997).

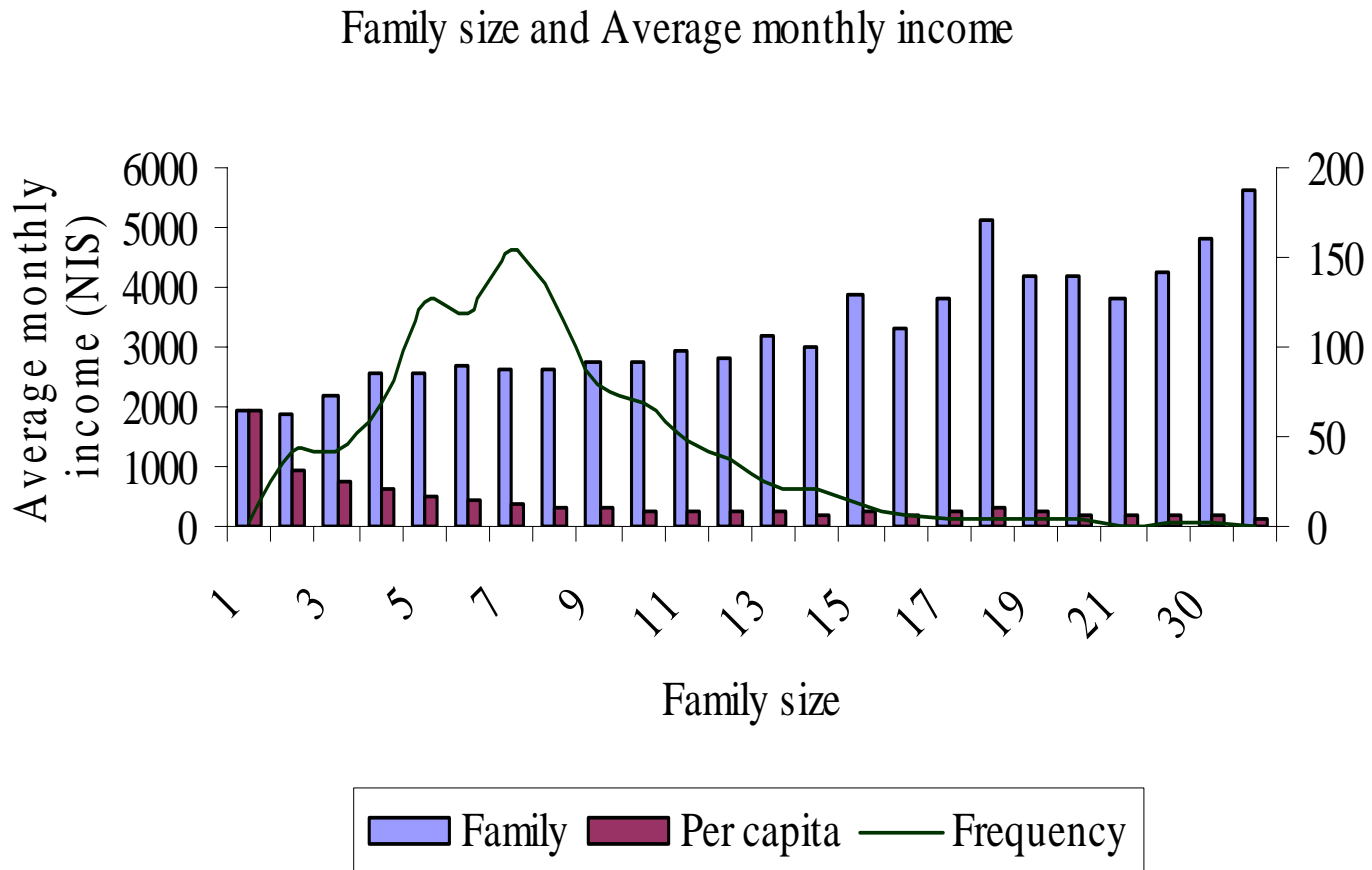
# *Water supply in the West Bank*

- The actual available water is significantly lower than 1020MCM/year due to the lack of accessibility to groundwater and infrastructure needed to fully utilize the surface water resources. **The available water per capita (water supply) differs considerably among West Bank governorates; it ranges from 29L/capita.day in Tubas governorate to 200L/capita.day in Jericho** (PWA, 2002). Most of water available per capita is lower than the average value stated by WHO guidelines **(150L/capita.day)**. This could be attributed to lack of accessibility to water resources and poor water supply management.

# *Water demand in the West Bank*

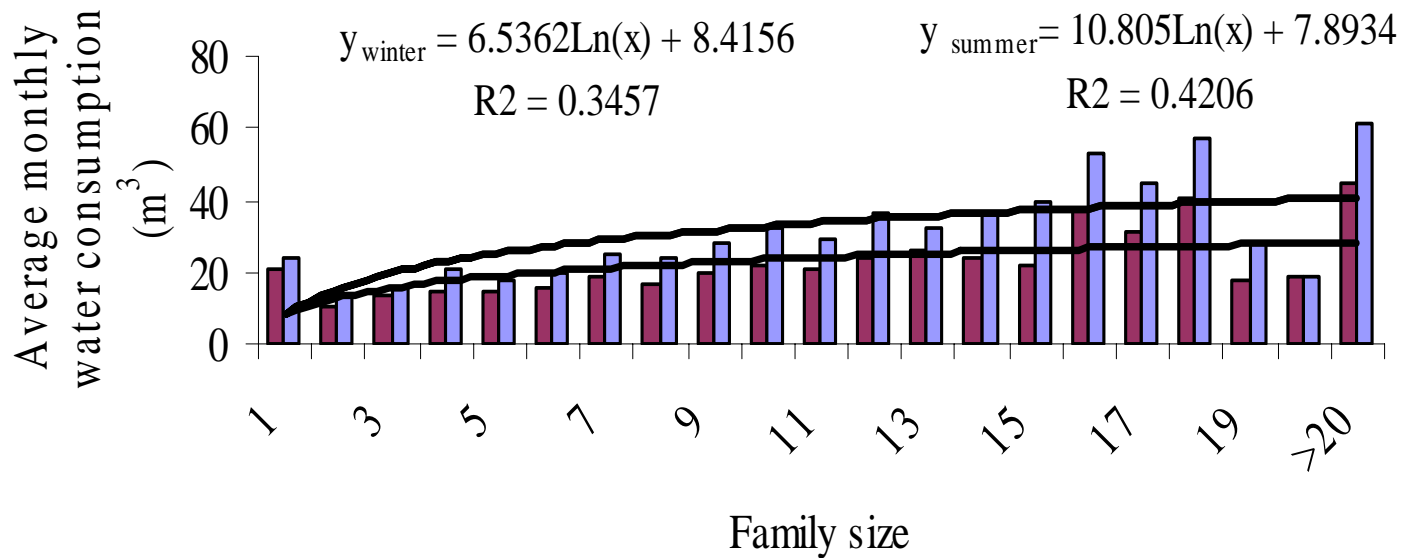
Domestic water demand can be calculated based on ■ WHO minimum domestic water consumption standards of 100l/c/d. as the total population of the West Bank is 2,372,216 then the annual domestic water demand is **86.64 MCM**. the agricultural demand is **266 MCM/year** (Jayousi, 2000). The industrial demand is **201.36** (Abu Zahra, 2001). Therefore the summation for water demand for the three sectors is **554 MCM/year**.

# Socio-economic indicators

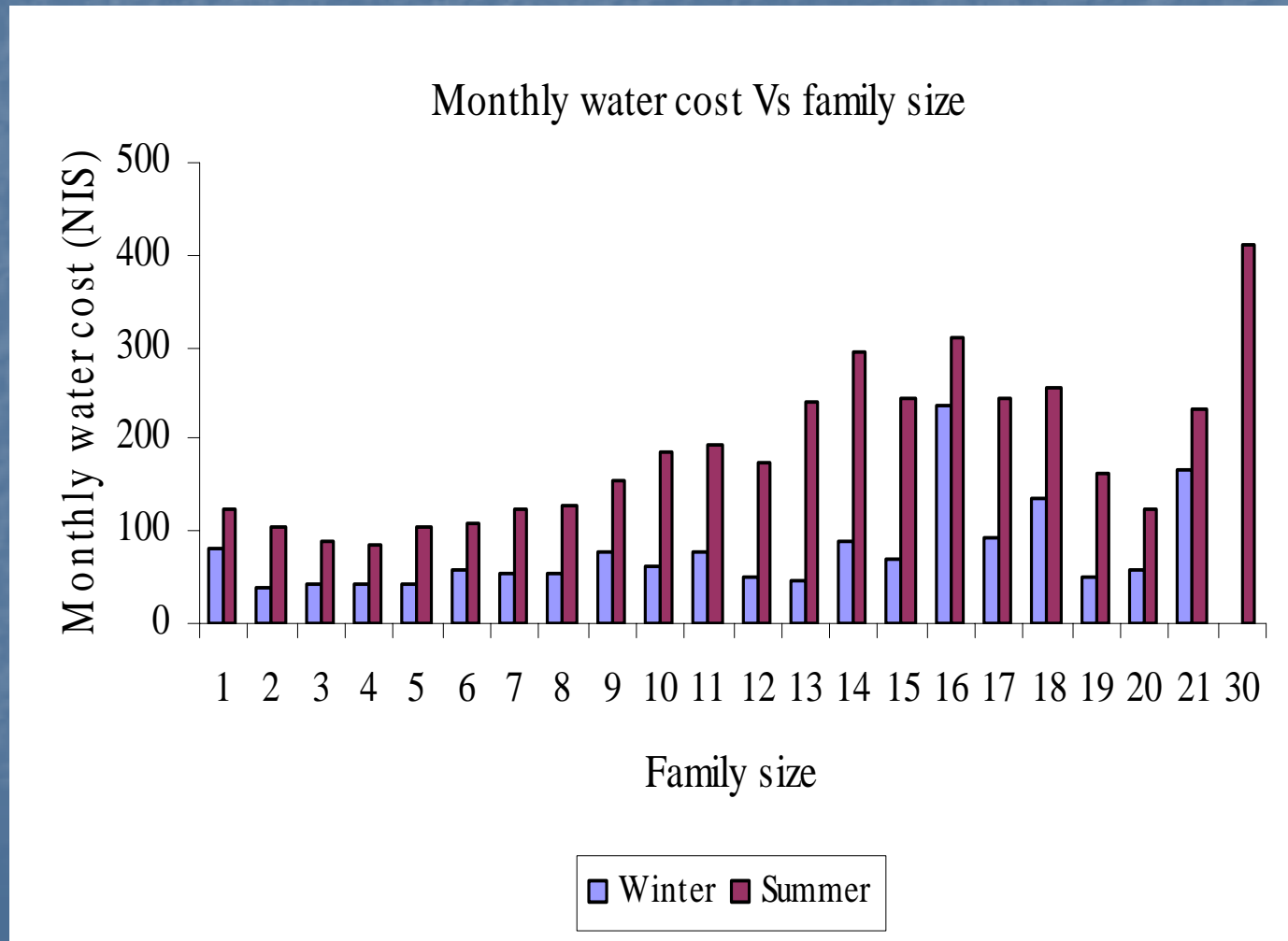


# Socio-economic indicators

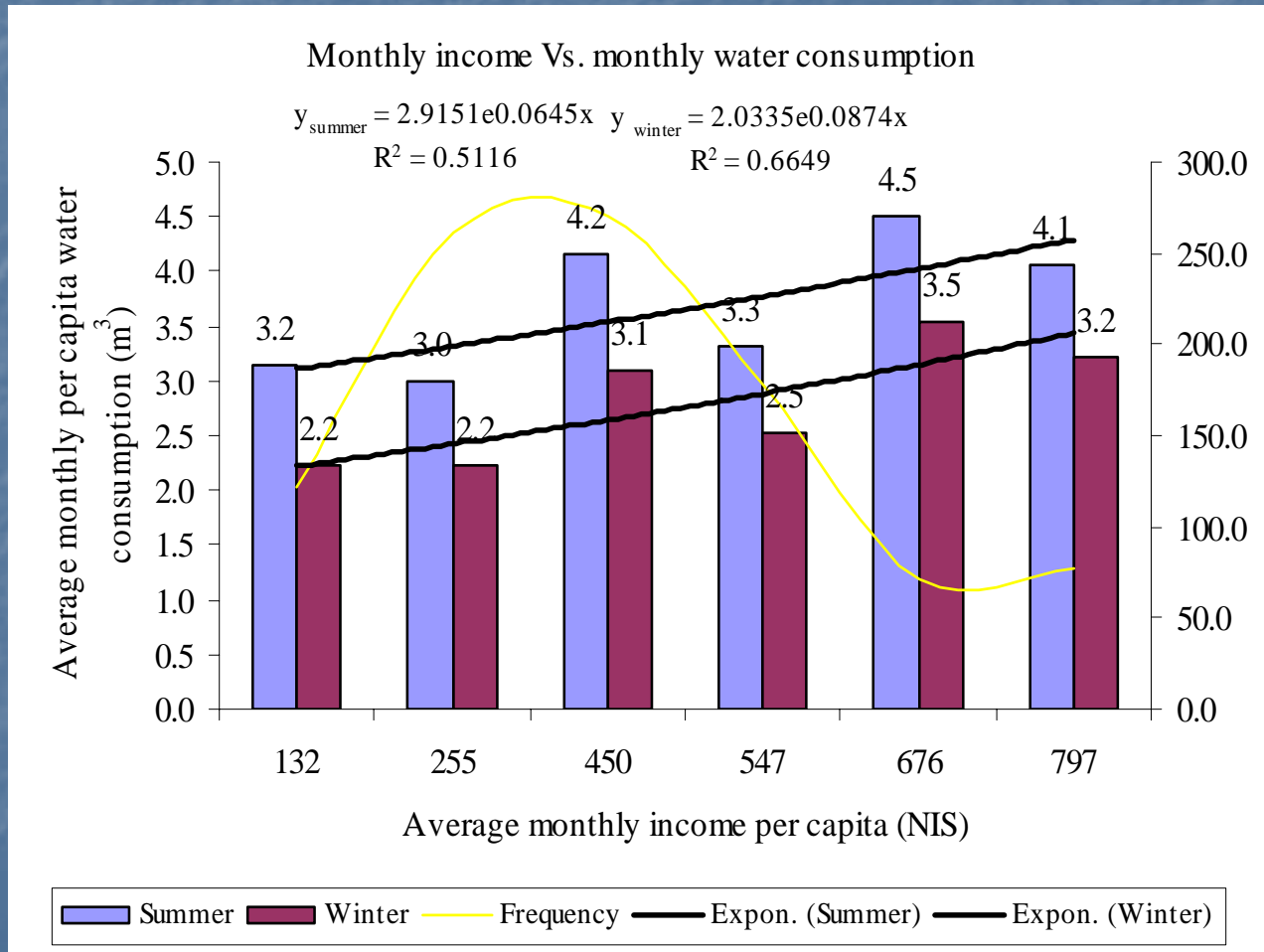
Family size and water consumption for connectors and non connectors



# Socio-economic indicators



# Socio-economic indicators



Seasonal attitude for water consumption in the connected and unconnected households to water networks in the West Bank.

<b>Connected areas</b>	<b>Unconnected areas</b>
Average family size 7.49 persons	Average family size 8.36 persons
Average monthly water use in summertime 26.06 m <sup>3</sup>	Average monthly water use in summertime 18 m <sup>3</sup>
Average monthly water use in wintertime 20 m <sup>3</sup>	Average monthly water use in wintertime 13 m <sup>3</sup>

# *Water poverty and international measurements*

- Water poverty is a situation where a nation or region cannot afford the cost of sustainable clean water to all people at all times. **Assessment water poverty, it is often essential to be identified via meaningful indicators so as to galvanize decision makers and funding agencies into action (Fietelson and Chenoweth, 2002).** Indicators should enable the identification of trends over time and provide a basis for international comparisons (UK, Department of the environment, 1996). Moreover, useful indicators should be measurable and the necessary data should be obtainable (Gallopín, 1997). They also need to focus on the structural implements to the sustainable supply of water, so as to facilitate policy responses.

# Approach

- **The Falkenmark water stress indicator is one of the most commonly used indicators for describing water availability in a country.** According to Falkenmark, water availability of more than **1,700m<sup>3</sup>/capita/year** is defined as the threshold above which water shortage occurs only irregularly or locally. Below this level, water scarcity arises in different levels of severity. **Below 1,700 m<sup>3</sup>/capita.year, water stress appears regularly.** However, below 1,000m<sup>3</sup>/capita.year water scarcity is a limitation to economic development and human health and well-being. Finally, below 500m<sup>3</sup>/capita/year, water availability is a main constraint to life (Falkenmark, 1989). Raskin *et al.* (1997) criticize this indicator, as it does not reflect the significant differences in water use patterns between countries. Moreover, Falkenmark (1989) who developed this indicator, initially focused on sub-Saharan Africa, where she assumed countries need to be self-sufficient in terms of food, due to their low purchasing power. Hence she defined water scarcity and stress as a function of the ability to maintain food self-sufficiency.

# Approach

**Water availability index (WAI)** is another approach used to measure water poverty. WAI includes surface water as well as groundwater resources, and compares the total amount to the demands of all sectors, i.e. domestic, industrial and agricultural demands (equation 1). The month with the maximum deficit or minimum surplus respectively is decisive. **The index is normalized to the range  $-1$  to  $+1$ . When the index is zero, availability and demands are equal.**

# Approach

**Sullivan (2002) advanced an alternative notion**, suggesting that water poverty should be an aggregate index based upon the percentage of water being used in a region combined with percentage of the population with access to safe water and sanitation, and the percentage of the population with easy access to water for domestic use. This index was called conventional composite water poverty index (WPI). The formula that gathers these elements is:

$$WPI = wa A + ws S + wt (100-T) \quad (2)$$

Where;

A: Adjusted water availability assessment (%)

S: Population with access to safe water and sanitation.

T: The index represents time and effort taken to collect water for household.

A, S and T are between 0 and 100.

*wa*, *ws* and *wt*: Are the weights given to each component of the index ( $wa + ws + wt = 1$ ).

The resultant from equation (2) is divided by 3 to have a number between 0 and 100.

# Approach

As recognized internationally the Palestinian territories in ■ among the most deprived countries in the world when it comes to the water resources, this is due to the fluctuating **political**, **social** and **economic** conditions which resulted in very weak institution performance indicators. This paper used international social, economic and **Water Poverty Index (WPI)** indicators as a common ground for various indicators as an attempt to build future demand scenarios. An increasing gap was found between water supply and demand.

# Water poverty index/ Conventional approach

- Conventional WPI (equation 2) can be calculated as follows:
- *Resources (R)*
- As mentioned before, domestic, agricultural and industrial water demands are 554 MCM/year. Consequently,
- *Access (S)*
- The percentage of population with access to safe water and sanitation respectively, are 86 and 24.5% Therefore,
- $(100-T)$
- The median monthly income is 1,600 NIS (PCBS, 2005). In the connected areas, average monthly water bill in summer and winter are 121.55 and 69.5 NIS<sup>[1]</sup>, respectively. However, for the unconnected areas, average monthly water bill in summer and winter are 194.64 and 35NIS, respectively (PHG, 2002). Accordingly, if the wintertime is considered as 4 months then the weighted average of monthly water bill is 104.03 and 141.42 NIS for the connected and unconnected areas, respectively. Therefore, this amount is equivalent to 6.5 and 8.8% of time. Therefore,
- $T = 6.5 \times 86\% + 8.8 \times 14\% = 6.82\%$ .
- And  $(100-T) = 100 - 6.98 = 93.17\%$
- According to water situation in the West Bank, availability of water is considered as the main problem, accessibility is considered less important and time is considered the least important. Therefore, the suggested two weighing methods that were considered in calculating WPI according to the conventional method are:
- $Wa1 = 0.4$ ,  $ws1 = 0.25$  and  $wt1 = 0.15$ ; and  $wa2 = 0.5$   $ws2 = 0.35$   $wt2 = 0.25$
- Accordingly, WPI according to the first and second weights are 55.42 and 44.56.
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- <sup>[1]</sup> One US\$ is equivalent to 4.5 NIS according to the current exchange rate.

# Water poverty index/ Holistic approach

- *Resources (R)*
- As discussed before, the actual water resource is 124.6 MCM/year. The current water demand is 554 MCM/year. Therefore,
- $R = 124.6/554 = 22.5\%$

# Water poverty index/ Holistic approach

- *Access (A)*
- As mentioned before, % of population with access to safe water and sanitation are 86.0 and 24.5%, respectively.
- % of water demand by agriculture is  $266/554 = 48.0\%$
- Therefore,
- **A = 52.83%**

# Water poverty index/ Holistic approach

## *Capacity (C)* ■

GDP per capita = 1,051 (UNDP, 2004) → C1 = 1.051%. ■

Under-five mortality (per 1000) = 25 (UNDP, 2004) → C2 = 25%. ■

Education enrolment rate = 86% (UNDP, 2004) → C3 = 86%. ■

Gini coefficient = 0.32 → C4 = 32%. ■

Accordingly, ■

**C = 36%** ■

# Water poverty index/ Holistic approach

## *Use (U)* ■

Domestic water consumption with total water quantity = ■  
 $71.41/1020 = U2 = 7.0\%$ .

Proportion of GDP derived from agriculture = 9.6% (MAS, 2004). ■  
The actual amount of water consumed by the agricultural sector is 90 MCM/year, so the agricultural consumption =  $90/1020 = 8.8\%$ .  
→  $U2 = 9.6/8.8 = 109\% = 100\%$

Proportion of GDP derived from industry = 14.7 % ( MAS, 2004). ■  
The Domestic and Industrial water consumption per capita in the ■  
West Bank 76 m<sup>3</sup>/year (Abu Zahra, 2001), therefore, the annual  
industrial and domestic water consumption is 180, 29 MCM/year,  
hence quantity of water consumed by industry =  $108.88/1020 = 10.7\%$ .  
→  $U3 = 14.7/10.7 = 131.21\%$ . →  $U3 = 100\%$ .

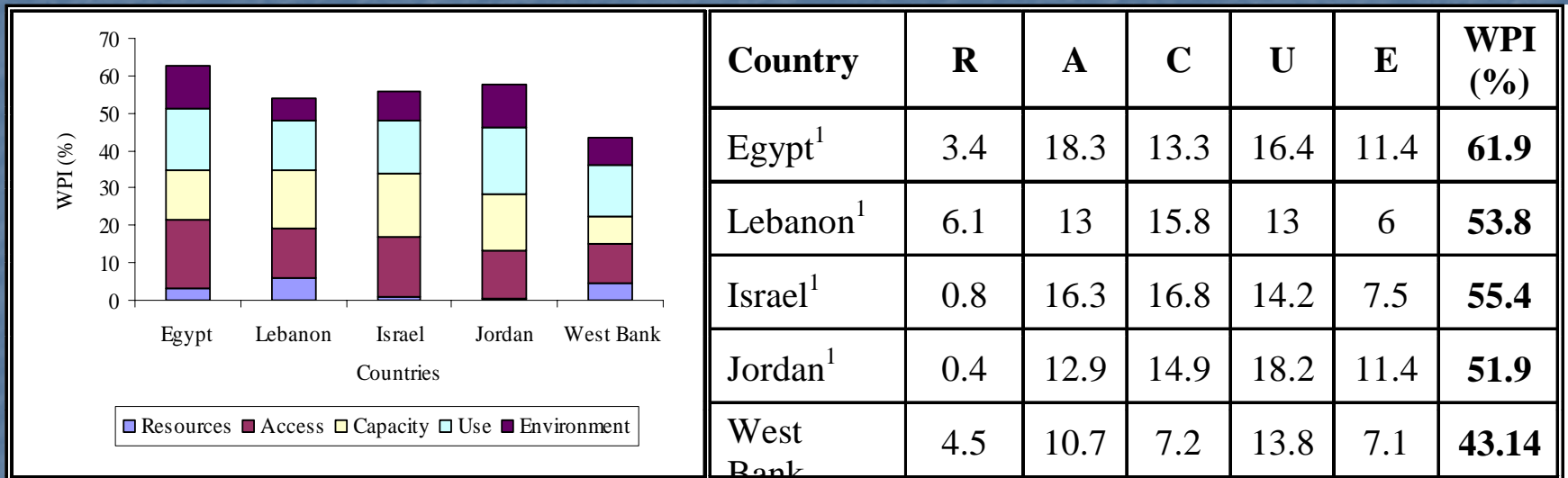
Therefore, ■

**U = = 69.0%. ■**

# Water poverty index/ Holistic approach

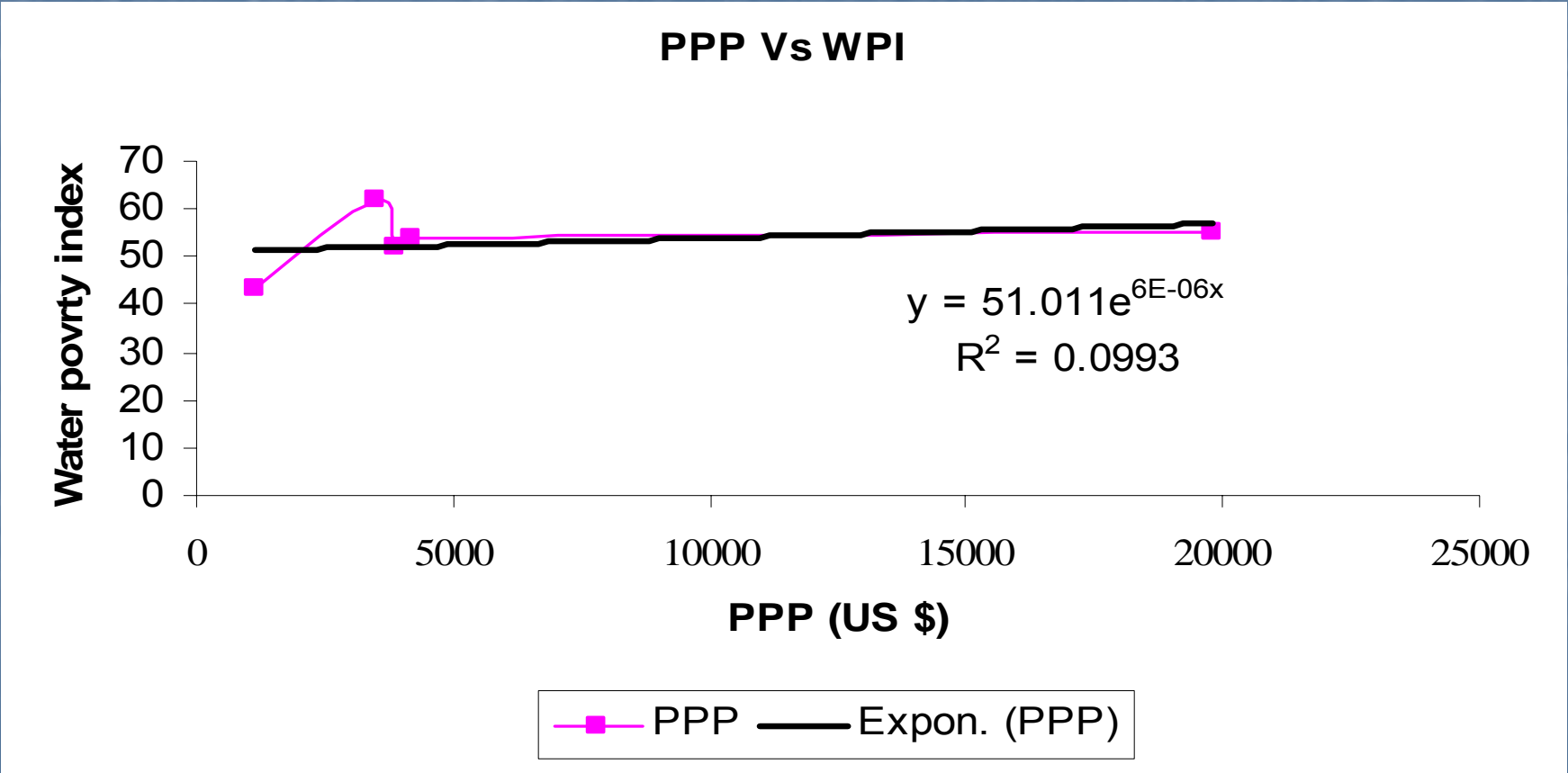
- *Environment (E)*
- Dissolved oxygen (**DO**), turbidity and total dissolved solids (**TDS**) were in compliance with WHO guidelines for drinking water. Average DO in the West Bank is 5.84 mg/L, therefore, DO index is calculated as follows:
- The maximum allowable TDS concentration according to WHO guidelines for drinking water is 1000 mg/L.
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# WPI components in the neighboring countries compared to the West Bank



1:Source: Sullivan, J.R Meigh and T.S Fediw (2002)

# Effect of increase of GDP on WPI



# Ranking of West Bank with the neighboring countries in terms of WPI components

<b>WPI component</b>	<b>Highest</b>	<b>Lowest</b>
Resources	Lebanon	Israel
Access	Egypt	<b>West Bank</b>
Capacity	Israel	<b>West Bank</b>
Use	Jordan	Lebanon
Environment	Jordan and Egypt	<b>West Bank</b>

# What is the future water situation in the West Bank??

## ■ Scenario 1: No change in the water resources

Effect of increase in population size on WPI value for the years (2005 to 2025). Agricultural and industrial demands were assumed to be constant throughout the tested period

Year	Population	Growth rate	Dom. W. demand MCM/year	Dom. water consumption MCM/year	WPI %
2005	2,372,216	3.0	86.64	71.41	43.27
2010	2,736,899	2.7	99.94	81.58	43.21
2015	3,110,489	2.4	113.61	91.85	43.16
2020	3,451,099 <sup>1</sup>	2.1	126.05	101.91	43.12
2025	3,773,082 <sup>1</sup>	1.8	137.81	111.42	43.09

- 1: These figures were projected according to the population growth rate; the corresponding values for growth rate were calculated based on linear interpolation.
- 2: Demand is calculated depending on WHO guidelines minimum domestic water requirements.
- 3: WPI value according to weights given as follow: R,A,C,U and E equal to 0.2,0.3,0.3,0.15 and 0.05 respectively

# What is the future water situation in the West Bank

- *Scenario 2: Increase in water resources/enhancement of existing supplies*

Values of WPI for the years 2005, 2010, 2015, 2020 and 2025 after an increase in water resources by 100 MCM/year.

<b>Year</b>	<b>WPI (%)</b>
2005	46.85
2010	46.70
2015	46.56
2020	46.45
2025	46.34

# What is the future water situation in the West Bank

- *Scenario 3: Improvement in the economical situation*

Effect of increase in GDP/capita on WPI value. Values of GDP/capita were taken according to the worst and best cases witnessed in the West Bank in the years 1999 to 2005.

<b>GDP/capita (\$)</b>	<b>WPI (%)</b>
1000	43.27
1051	43.27
1500	43.30
2000	43.34
2500	43.38

# Values of WPI for the year 2005 under the assumed condition of increase in water resources.

Condition	WPI %
Full control over Jordan river	52.55
Full control over ground water	63.52
Full control over 50% of ground water ( due to the lost share to the Israeli usage of part of the existing water)	51.27

# Conclusions and recommendations

The most important problem which the Palestinian water sector suffers from is the constant change in **the political and socioeconomic factors** and **lack of access and capacity to their water resources**. An increasing gap was found between water supply and water demand. Falkenmark approach (**286.20 m<sup>3</sup>/C/yr**) and Water Availability Index (**WAI = -0.39**) showed that available and accessible water resources are not sufficient. Additionally, Basic human needs index shows that basic needs of water are not achieved for many communities.

The conventional WPI approach showed that the values of Availability, access and time were **22.49%, 55.25%, and 6.98%** respectively. The corresponding WPI value is 51.63%. However, WPI-holistic showed that the following values for R, A, C, U and E were found to be 22.50%, 52.83%, 36.00%, 69.00% and 35.36% respectively. The corresponding WPI was found to be 43.14% when equal weights were used (0.2). Finally, it was found that an increase of 100MCM/year and/or GDP slightly shifts upward the WPI this is attributed to lack of capacity and accessibility to water resources.

**New water resources and local alternatives have to be introduced to bridge the gap between demand and supply. Additionally, the proposed Mega-projects are found to be unsustainable, politically unacceptable, and costly; and it has a minimal effect on the improvement of WPI.** Moreover, enhancement in **environmental policies and awareness** is recommended to shift the **WPI**. Finally, calculating of WPI at community level is essential to draw policies based on accurate information.