



**Quantification and spatial delineation of
currently untapped water resources**

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Editors

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0. Executive Summary

A methodology for water budget assessments has been developed in the context of the SMART II project and applied to the Palestinian case study areas Wadi Auja and Wadi Nueimah, as well as for the Jordan study area Wadi Kafrein. The assessments focus on the estimation of the so-called currently and future untapped water resources. The currently untapped water resources (CUWR) represent a quantitative value of the still non-activated and unused surplus of water, taking the activation of the remaining water potential and the minimization of water losses by adequate hydro-infrastructure into account. Based on water demand projections by [Sadah & Tamimi \(2011\)](#), the future untapped water resources (FUWR) are estimated for the year 2030 for each study area. Since water demand projections for the agricultural sector are not being considered, due to the related uncertainties, it can be concluded that the estimated future untapped water resources refer to that non-activated, unused surplus of local water resources which would be available for agricultural development within the next two decades.

The results show that each of the rural Wadis under study present a high water potential which is partially not activated and partially lost due to inadequate or damaged hydro-infrastructure, such as the old Auja canal where 60% of the water potential of Auja spring is being lost. Due to Israeli groundwater abstractions in the West-Bank, the groundwater availability of the freshwater carbonate aquifer system is being reduced.

Further hydrogeological assessments are required to tackle the uncertainties with regards to the sustainable yield of the rather complex regional groundwater systems in the valley and mountain areas.

Hydro-infrastructure interventions are required in order to protect and activate the considerable water potential in the areas under study. This surplus could be used for the sustainable development of irrigated agriculture in the LJV. For future negotiations with Israeli water authorities, it is recommended to consolidate the present investigations in quantitative, qualitative, economic and legal terms.

1. Introduction

The case study focuses on the rural basins of Wadi Auja and Wadi Nueimah in the Palestinian territories in the Lower Jordan Valley and Wadi Kafrein on the Jordanian side. The current water resources situation with regards to water availabilities and demands is analysed for each study area. The budget assessment considers both, the used and not yet activated water sources, as well as the current and minimized loss rates for water transfer.

Based on the analyses, quantitative values of currently untapped water resources (CUWR) and future untapped water resources (FUWR) are calculated, considering increases of the water demands until the year 2030.

These values offer a first basis for agricultural development plans and the planning of further IWRM measures in the study areas.

2. Objectives

The guiding research and development objective of the deliverable is to quantify the present and future untapped water resources in selected case study areas in the Lower Jordan Valley, considering all types of water sources, including fresh and brackish groundwater, surface runoff and wastewater.

The present deliverable summarizes the research methodology, achieved results, main conclusions and recommendations with regards to further studies.

3. Applied Approach

Untapped water resources represent the potential quantity of water in a region that is not yet used or activated by local water users. Figure 1 illustrates the suggested approach applied in this study. Currently and future untapped water resources (CUWR, FUWR) are estimated by subtraction of water demands from the water availability for each of the different water sources. The water availability of a specific source of water is being calculated based on the water potential for actual and minimized water losses. The approach requires the analysis of current and future water demand values. Potential import of treated effluents from neighbouring basins is being taken into account.

The results represent net values of the water quantity per year that can be used for sustainable development of the agricultural sector in the LJV or further water development activities, e.g. in the tourism sector.

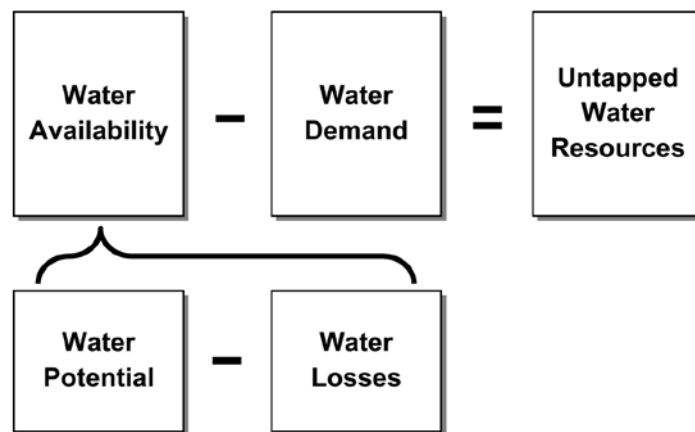


Fig. 1: Suggested approach for the quantification of untapped water resources

Water Potential

The water potential refers to the total amount of water of a specific source. Values can be derived by hydrological studies, including water balance assessments for the hydro(geo)logical system, monitoring of water quantity and quality and numerical modelling.

Water Availability

In order to activate the water potential of a specific source and to make that water available to different water users, hydro-infrastructural measures need to be implemented. These intervention may consist in the installation of shallow or deep pumping wells, surface water retention structures, pipelines for water transfer and distribution etc. Depending on the type of intervention, a certain amount of the water potential is lost on the way to the water user. In the present study, the water availability is estimated for both, the current situation and

minimized water losses, assuming that damaged or old hydro-infrastructure is being rehabilitated or substituted. The water availability is calculated by subtraction of water losses from the water potential of a specific source.

Water Losses

Water losses occur during the process of water abstraction, transport and application. Major losses take place during the water transfer, due to inefficient hydro-infrastructure, high infiltration or evaporation rates on the way between source and water user in the study areas. Current water losses are derived by analysis of the present hydro-infrastructure situation, monitoring measures and stakeholder consultations. A modernization of the local water infrastructure is a potential IWRM measure to increase the water availability in the area. Thus, this study includes budget calculations with so called minimized losses to better represent the effects of such measures and future water management perspectives.

Water Demand

The present water consume for the current situation (base year 2010) and future water demand (year 2030) is delineated for the relevant water sectors based on assessments and projections provided by the Palestinian Hydrology Group – PHG ([Sadah & Tamimi, 2011](#)). These include the actual water consume for agricultural purposes, domestic demand and water demand for industry, commerce, tourism and other minor sectors.

Among these, agricultural water demand for irrigation is the most abundant. For the future untapped water resources (FUWR) analysis, just the present agricultural consume is considered, since the development of the irrigation sector in the LJV is suffering from huge uncertainties due to a lack in sustainable water management strategies and viable water policies. It can be concluded that the estimated future untapped water resources refer to that non-activated, unused surplus of local water resources which would be available for agricultural development within the next two decades.

4. Application to Selected Case Study Areas

4.1 Palestine

Wadi Auja

The rural area of Wadi Auja (260km²), including Auja village with around 4,550 habitants, strongly relies on agriculture and local water resources (PCBS, 2010). Tables 1 and 2 sum up the results of currently untapped water resources (CUWR) and future untapped water resources (FUWR) analyzes for Wadi Auja. The water budget assessments are classifying the different sources according to the type of water, separating between fresh water (blue), brackish water (red) and waste water resources (grey).

Tab. 1: Currently untapped water resources for Wadi Auja

Water Source	WP	Israeli Abstr.	Water Loss				Water Availability		Total WD	Sector Water Demand 2010			Water Surplus	CUWR **
			actual *		min.		actual state	min. Loss **		Irrigation	Dom.	Ind. etc		
	[MCM/a]	[MCM/a]	%	[MCM/a]	%	[MCM/a]			[MCM/a]				[MCM/a]	[MCM/a]
1.1 Spring	9.70	0.00	60	5.82	20	1.94	3.88	7.76	3.38	3.38	0.00	0.00	0.50	4.38
1.2 Surface Runoff	1.20	0.00	90	1.08	20	0.24	0.12	0.96	0.12	0.12	0.00	0.00	0.00	0.84
1.3 Carb. Aq. west	8.00	6.00	100	2.00	10	0.20	0.00	1.80	0.50	0.00	0.50	0.00	-0.50	1.30
1. Fresh Water - SUM	18.90	6.00		8.90		2.38	4.00	10.52	4.00	3.50	0.50	0.00	0.00	6.52
2.1 Alluvial Aquifer	1.00	0.00	10	0.10	10	0.10	0.90	0.90	1.50	1.50	0.00	0.00	-0.60	-0.60
2.2 Carb. Aquifer east	3.00	2.00	100	1.00	10	0.10	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.90
2.3 BW Springs	0.00	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Brackish Water - SUM	4.00	2.00		1.10		0.20	0.90	1.80	1.50	1.50	0.00	0.00	-0.60	0.30
3.1 Treated Effluent	3.50	0.00	100	3.50	0	0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00	3.50
3.2 Raw Waste Water	0.00	0.00	100	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Waste Water - SUM	3.50	0.00		3.50		0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00	3.50
SUM	26.40	8.00		13.50		2.58	4.90	15.82	5.50	5.00	0.50	0.00	-0.60	10.32

WP: Water Potential
WD: Water Demand

Dom.: Domestic Water Demand
CUWR: Currently Untapped Water Resources

Ind.: Industrial Water Demand

* with loss equal to 100% for non-activated water sources

** assuming the activation of water potentials by hydro-infrastructure taking a minimum loss rate into account

Water potential in Wadi Auja sums up to 26.4 MCM/a on an average basis. From this quantity 8 MCM/a are abstracted by the Israeli wells to cover parts of the local water demand for settlements.

Fresh water resources are the most abundant in Wadi Auja, taking the local major water source Auja spring with an annual mean discharge of 9.7 MCM into account (Schmidt, 2014). Additionally, an average of 1.2 MCM/a of surface runoff are considered (Abadi, 2006). However, due to strong variability in surface runoff, this value is difficult to quantify (Moe et al. 1998). The fresh water potential of the deep carbonate aquifer of the lower valley is estimated in 8 MCM/a of fresh water. Israeli abstraction amounts to 6 MCM/a, leaving a total of 2 MCM/a for Palestinian water users.

According to the Israeli water supply company MEKOROT, additional 3 MCM/a may be extractable from the deep carbonate aquifer in the mountain areas. Due to the related uncertainties, this value has yet not been considered in the water budget analysis. In general, the local groundwater potential has been roughly estimated for the time being and requires further studies, including an in-depth characterization of the aquifer system and further groundwater modelling studies in the area.

Brackish water resources are available in the shallow alluvial aquifer and the eastward part of the deep carbonate aquifer system. Sustainable abstraction from the alluvial aquifer is estimated as 1 MCM/a, while the carbonate aquifer could supply an average of 3 MCM/a. In the eastern part of the deep carbonate aquifer in the valley Israelis abstract 2 MCM/a of brackish water, thus reducing the amount of extractable water for the Palestinian to 1 MCM/a.

In addition to local fresh and brackish water sources, 3.5 MCM/a of treated effluent from the treatment plants of Jericho and El-Bireh could be imported to Wadi Auja and, therefore, are considered in the water budget as external resources.

Tab. 2: Future untapped water resources for Wadi Auja

Water Source	WP	Israeli Abstr.	Water Loss						Water Availability		Total WD	Expected Sector Water Demand 2030 (Irrigation Values of 2010)				Water Surplus	FUWR **
			actual *			min.			actual state	min. Loss **		Irrigation	Dom.	Ind. etc			
			[MCM/a]	%	[MCM/a]	%	[MCM/a]	%									
	[MCM/a]	[MCM/a]	%	[MCM/a]	%	[MCM/a]	%	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	
1.1 Spring	9.70	0.00	60	5.82	20	1.94	3.88	7.76	3.38	3.38	0.00	0.00	0.50	4.38			
1.2 Surface Runoff	1.20	0.00	90	1.08	20	0.24	0.12	0.96	0.12	0.12	0.00	0.00	0.00	0.84			
1.3 Carb. Aq. west	8.00	6.00	100	2.00	10	0.20	0.00	1.80	0.87	0.00	0.87	0.00	-0.87	0.93			
1. Fresh Water - SUM	18.90	6.00		8.90		2.38	4.00	10.52	4.37	3.50	0.87	0.00	-0.37	6.15			
2.1 Alluvial Aquifer	1.00	0.00	10	0.10	10	0.10	0.90	0.90	1.50	1.50	0.00	0.00	-0.60	-0.60			
2.2 Carb. Aquifer east	3.00	2.00	100	1.00	10	0.10	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.90			
2.3 BW Springs	0.00	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
2. Brackish Water - SUM	4.00	2.00		1.10		0.20	0.90	1.80	1.50	1.50	0.00	0.00	-0.60	0.30			
3.1 Treated Effluent	3.50	0.00	100	3.50	0	0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00	3.50			
3.2 Raw Waste Water	0.00	0.00	100	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
3. Waste Water - SUM	3.50	0.00		3.50		0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00	3.50			
SUM	26.40	8.00		13.50		2.58	4.90	15.82	5.87	5.00	0.87	0.00	-0.97	9.95			
WP: Water Potential			Dom.: Domestic Water Demand						Ind.: Industrial Water Demand								
WD: Water Demand			FUWR: Future Untapped Water Resources														

* with loss equal to 100% for non-activated water sources

** assuming the activation of water potentials by hydro-infrastructure taking a minimum loss rate into account

Several water sources of water in Wadi Auja are not yet activated (loss rate=100%), such as the freshwater in the deep carbonate aquifer west, the brackish water in the deep carbonate aquifer east and surface runoff. The latter is not sufficiently harvested, since parts of the

highly variable storm floods are retained by the Auja dam, but mainly lost to the underground due to low efficiency of water storage. This water should be stored in the alluvial aquifer system by Managed Aquifer Recharge, which would require the installation of a pipeline between the dam and the recharge facilities. In this way losses might be reduced to 20%.

Approximately, an average of 6 MCM/a of Auja spring water is lost, due to damages in the old canal between the spring and the irrigated lands (Sadah & Tamimi, 2011, Aliewi et al, 2007). Rehabilitation of the canal or installation of a pipeline could reduce these losses to a maximum value of 20%. For the activation of groundwater resources, a loss rate of 10 being considered, since the distances of water transfer are rather short.

According to table 1, the current water availability is about 4.9 MCM/a for Wadi Auja. Activation of new sources, modernization of hydro-infrastructure and treated effluent imports could triple this value to 15.8 MCM/a.

The current water demand is covered by Auja spring and pumping from the alluvial aquifer. Around 5 MCM/a of irrigation water are required for local agriculture (Sadah & Tamimi, 2011). The lower valley is of major importance for Palestinian crop production (JICA, 2007). While the major part can be covered by the spring, an overpumping of the alluvial aquifer is necessary to cover this demand. The current water balance is negative, due to the over-exploitation of the aquifer system. As a consequence, the groundwater level of the shallow alluvial aquifer system is constantly decreasing (Abdel-Ghafour, 2005). The small domestic water consume of 0.5 MCM/a is currently covered by Mekorot wells in the deep carbonate freshwater aquifer. It is expected that the domestic demand, due to population growth, will rise to 0.87 MCM/a in 2030 (Sadah & Tamimi, 2011).

Based on the available data, **CUWR** can be quantified with 10.32 MCM/a for Wadi Auja. Due to the increased domestic water demand in the region, the **FUWR** are slightly lower with 9.95 MCM/a, which would be available for the sustainable development of irrigated agriculture. Without treated effluent import, this value would be reduced to 6.45 MCM/a.

Wadi Nueimah

Wadi Nueimah (128km²) comprises the major urban center of the area, Jericho City with 25,000 inhabitants. Tables 3 and 4 summarize the results of CUWR and FUWR analyses for Wadi Nueimah.

Tab. 3: Current untapped water resources for Wadi Nueimah

Water Source	WP	Israeli Abstr.	Water Loss				Water Availability		Total WD	Sector Water Demand 2010			Water Surplus	CUWR **
			actual *		min.		actual state	min. Loss **		Irrigation	Dom.	Ind. etc		
	[MCM/a]	[MCM/a]	%	[MCM/a]	%	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	
1.1 Spring	8.20	0.00	30	2.46	20	1.64	5.74	6.56	3.12	2.86	0.21	0.05	2.62	3.44
1.2 Surface Runoff	2.00	0.00	90	1.80	20	0.40	0.20	1.60	0.00	0.00	0.00	0.00	0.20	1.60
1.3 Carb. Aq. west	3.00	2.00	100	1.00	10	0.10	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.90
1. Fresh Water - SUM	13.20	2.00		5.26		2.14	5.94	9.06	3.12	2.86	0.21	0.05	2.82	5.94
2.1 Alluvial Aquifer	2.00	0.00	10	0.20	10	0.20	1.80	1.80	0.00	0.00	0.00	0.00	1.80	1.80
2.2 Carb. Aquifer east	2.00	0.00	100	2.00	10	0.20	0.00	1.80	0.00	0.00	0.00	0.00	0.00	1.80
2.3 BW Springs	0.00	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Brackish Water - SUM	4.00	0.00		2.20		0.40	1.80	3.60	0.00	0.00	0.00	0.00	1.80	3.60
3.1 Treated Effluent	3.50	0.00	100	3.50	0	0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00	3.50
3.2 Raw Waste Water	0.00	0.00	100	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Waste Water - SUM	3.50	0.00		3.50		0.00	0.00	3.50	0.00	0.00	0.00	0.00	0.00	3.50
SUM	20.70	2.00		10.96		2.54	7.74	16.16	3.12	2.86	0.21	0.05	4.62	13.04
WP: Water Potential		Dom.: Domestic Water Demand						Ind.: Industrial Water Demand						
WD: Water Demand		CUWR: Currently Untapped Water Resources												

* with loss equal to 100% for non-activated water sources

** assuming the activation of water potentials by hydro-infrastructure taking a minimum loss rate into account

The Water potential in Wadi Nueimah sums up to 20.7 MCM/a on an average basis. From this quantity, 2 MCM/a are abstracted by the Israeli to cover parts of the local water demand for settlements.

As in Wadi Auja, fresh water resources are the most abundant in Wadi Nueimah, taking the local major water source, the spring group of Al Nueimah, Al Dyuk and Al Susa with an accumulated annual mean discharge of 8.2 MCM into account (Ali et al., 2009). Additionally, surface runoff amounts to an average of 2 MCM/a. The water potential of the the deep carbonate freshwater aquifer in the valley is 3 MCM/a. The Israeli abstraction is 2 MCM/a, leaving a total of 1 MCM/a for Palestinian water users. As in Wadi Auja, additional groundwater may be extractable from the deep carbonate aquifer in the mountain areas. According to MEKOROT, the value for Wadi Nueimah is estimated 2 MCM/a. Due to the related uncertainties, this value has yet not been considered in the water budget analysis.

Brackish water resources are available in the shallow alluvial aquifer and the eastward part of the deep carbonate aquifer system. Sustainable abstraction from the alluvial aquifer is estimated as 2 MCM/a, while the carbonate aquifer could supply an average of 2 MCM/a. In this area no Israeli wells are installed.

In addition to local fresh and brackish water sources, 3.5 MCM/a of treated effluent from the treatment plants of Jericho and El-Bireh could be imported to Wadi Nueimah and, therefore, are considered in the water budget as external resources.

Several water sources of water in Wadi Neimah are not yet activated (loss rate=100%), such as the freshwater in the deep carbonate aquifer west, the brackish water in the deep carbonate aquifer east and surface runoff. Up to now, there are no dams or retention structures which could harvest the surface runoff in the Wadi. As in Wadi Auja, this water should be retained and stored in the alluvial aquifer system by Managed Aquifer Recharge.

Approximately, an average of 2.5 MCM/a of local spring water is lost, due to low efficiency of the canals which transfer the water to the irrigated land. According to the Palestinian Ministry of Agriculture, the actual loss rate is estimated in 30%, but may be reduced to at least 20% by adequate rehabilitation measures or pipeline installation. For the activation of groundwater resources, again a loss rate of 10 being considered.

According to table 3, the current water availability is about 7.7 MCM/a for Wadi Nueimah. Activation of new sources, modernization of hydro-infrastructure and treated effluent imports could more than double this value to 16.2 MCM/a.

Tab. 4: Future untapped water resources for Wadi Nueimah

Water Source	WP	Israeli Abstr.	Water Loss				Water Availability		Total WD	Expected Sector Water Demand 2030 (Irrigation Values of 2010)			Water Surplus	FUWR **
			actual *		min.		actual state	min. Loss **		Irrigation	Dom.	Ind. etc		
			[MCM/a]	%	[MCM/a]	%								
1.1 Spring	8.20	0.00	30	2.46	20	1.64	5.74	6.56	3.14	2.86	0.25	0.03	2.60	3.42
1.2 Surface Runoff	2.00	0.00	90	1.80	20	0.40	0.20	1.60	0.00	0.00	0.00	0.00	0.20	1.60
1.3 Carb. Aq. west	3.00	2.00	10	0.10	10	0.10	0.90	0.90	0.00	0.00	0.00	0.00	0.90	0.90
1. Fresh Water - SUM	13.20	2.00		4.36		2.14	6.84	9.06	3.14	2.86	0.25	0.03	3.70	5.92
2.1 Alluvial Aquifer	2.00	0.00	10	0.20	10	0.20	1.80	1.80	0.00	0.00	0.00	0.00	1.80	1.80
2.2 Carb. Aquifer east	2.00	0.00	10	0.20	10	0.20	1.80	1.80	0.00	0.00	0.00	0.00	1.80	1.80
2.3 BW Springs	0.00	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Brackish Water - SUM	4.00	0.00		0.40		0.40	3.60	3.60	0.00	0.00	0.00	0.00	3.60	3.60
3.1 Treated Effluent	3.50	0.00	0	0.00	0	0.00	3.50	3.50	0.00	0.00	0.00	0.00	3.50	3.50
3.2 Raw Waste Water	0.00	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Waste Water - SUM	3.50	0.00		0.00		0.00	3.50	3.50	0.00	0.00	0.00	0.00	3.50	3.50
SUM	20.70	2.00		4.76		2.54	13.94	16.16	3.14	2.86	0.25	0.03	10.80	13.02
WP: Water Potential			Dom.: Domestic Water Demand						Ind.: Industrial Water Demand					
WD: Water Demand			FUWR: Future Untapped Water Resources											

* with loss equal to 100% for non-activated water sources

** assuming the activation of water potentials by hydro-infrastructure taking a minimum loss rate into account

The current water demand at Wadi Nueimah is covered by the local spring group. Around 2.9 MCM/a of irrigation water are required for local agriculture. The domestic and industrial water consume are rather small and amount to 0.21 and 0.1 MCM/a, respectively. According [Sadah & Tamimi, 2011](#) these values should not increase significantly until 2030.

Based on the available data, CUWR can be quantified with 13 MCM/a for Wadi Nueimah and should not change significantly until 2030. Without treated effluent import, this value would be reduced to 9.5 MCM/a. This amount would be available for the sustainable development of irrigated agriculture.

4.2 Jordan

Wadi Kafrein

Tables 5 and 6 sum up the results of CUWR and FUWR analyses for Wadi Kafrein.

Tab. 5: Current untapped water resources for Wadi Kafrein

Water Source	WP	Water Loss				Water Availability		Total WD	Sector Water Demand 2010			Water Surplus	CUWR **
		actual *		min.		actual state	min. Loss **		Irrigation	Dom.	Ind. etc		
		[MCM/a]	%	[MCM/a]	%								
1.1 Spring	12.30	25	3.08	20	2.46	9.23	9.84	7.50	2.50	3.50	1.50	1.73	2.34
1.2 Surface Runoff	7.50	14	1.05	5	0.38	6.45	7.13	0.70	0.70	0.00	0.00	5.75	6.43
1.3 Carb. Aq. west	8.90	25	2.23	10	0.89	6.68	8.01	1.00	1.00	0.00	0.00	5.68	7.01
1. Fresh Water - SUM	28.70		6.35		3.73	22.35	24.98	9.20	4.20	3.50	1.50	13.15	15.78
2.1 Alluvial Aquifer	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.2 Carb. Aquifer east	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3 BW Springs	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Brackish Water - SUM	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1 Treated Effluent	1.00	0	0.00	0	0.00	1.00	1.00	0.20	0.20	0.00	0.00	0.80	0.80
3.2 Raw Waste Water	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Waste Water - SUM	1.00		0.00		0.00	1.00	1.00	0.20	0.20	0.00	0.00	0.80	0.80
SUM	29.70		6.35		3.73	23.35	25.98	9.40	4.40	3.50	1.50	13.95	16.58
WP: Water Potential		Dom.: Domestic Water Demand						Ind.: Industrial Water Demand					
WD: Water Demand		CUWR: Currently Untapped Water Resources											

* with loss equal to 100% for non-activated water sources

** assuming the activation of water potentials by hydro-infrastructure taking a minimum loss rate into account

The water potential in Wadi Kafrein sums up to 29.7 MCM/a on an average basis (Alkhoury, 2011). As in the Palestinian study areas, fresh water resources are the most abundant in Wadi Kafrein. Local spring discharge of 12.3 MCM/a, high surface runoff of 7.5 MCM/a and a sustainable yield of 8.9 MCM/a from the local carbonate aquifer represent a high water potential for the area. Contrary to the prior studies, no data are available about the availability of brackish water sources. 1 MCM/a of treated effluent are available in Wadi Kafrein and are partially used for irrigation purposes (Alkhoury, 2011).

The actual loss rates in Wadi Kafrein reach values of 25%. The total loss of freshwater resources amounts to 6.4 MCM/a. With the implementation of more efficient modernized hydro-infrastructure, this value might be reduced to 3.7 MCM/a. 25% of the local spring discharge is currently lost. Modernization of the transport system could reduce these losses to at least 20%. Surface water harvesting is quite efficient in Wadi Kafrein, resulting in low water losses of about 14%. Abstraction from the local carbonate aquifer suffers from 25% losses. 1.3 MCM/a could be gained if the the loss rate could be reduced to about 10%.

The actual water availability at Wadi Kafrein amounts to 23.4 MCM/a. Modernization of hydro-infrastructure could slightly increase this quantity to 26 MCM/a.

Tab. 6: Future untapped water resources for Wadi Kafrein

Water Source	WP	Water Loss				Water Availability		Total WD	Expected Sector Water Demand 2030 (Irrigation Values of 2010)			Water Surplus	FUWR **
		actual *		min.		actual state	min. Loss **		Irrigation	Dom.	Ind. etc		
		[MCM/a]	%	[MCM/a]	%								
1.1 Spring	12.30	25	3.08	20	2.46	9.23	9.84	8.20	2.50	3.90	1.80	1.03	1.64
1.2 Surface Runoff	7.50	14	1.05	5	0.38	6.45	7.13	0.70	0.70	0.00	0.00	5.75	6.43
1.3 Carb. Aq. west	8.90	25	2.23	10	0.89	6.68	8.01	1.00	1.00	0.00	0.00	5.68	7.01
1. Fresh Water - SUM	28.70		6.35		3.73	22.35	24.98	9.90	4.20	3.90	1.80	12.45	15.08
2.1 Alluvial Aquifer	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.2 Carb. Aquifer east	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.3 BW Springs	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Brackish Water - SUM	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1 Treated Effluent	1.00	0	0.00	0	0.00	1.00	1.00	0.20	0.20	0.00	0.00	0.80	0.80
3.2 Raw Waste Water	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Waste Water - SUM	1.00		0.00		0.00	1.00	1.00	0.20	0.20	0.00	0.00	0.80	0.80
SUM	29.70		6.35		3.73	23.35	25.98	10.10	4.40	3.90	1.80	13.25	15.88
WP: Water Potential		Dom.: Domestic Water Demand						Ind.: Industrial Water Demand					
WD: Water Demand		FUWR: Future Untapped Water Resources											

* with loss equal to 100% for non-activated water sources

** assuming the activation of water potentials by hydro-infrastructure taking a minimum loss rate into account

The current water demand is covered by all water resources. 4.4 MCM/a of irrigation water are required for local agriculture. These are covered by spring discharge, surface water, groundwater and treated effluent. The domestic water demand of 3.5 MCM/a is fully covered by the local spring discharge. The projected value of 3.9 MCM/a in 2030 can still be covered by this source. Other demands in the region sum up to 1.5 MCM/a and may increase to 1.8 MCM/a in 2030. These demands are also fully covered by spring discharge.

Based on these data, CUWR can be quantified with 16.58 MCM/a for Wadi Kafrein. The FUWR are slightly lower with 15.88 MCM/a.

5. Main Results, Conclusions and Recommendations

The analysis showed that for all case study areas, considerable volumes of currently untapped water resources (CUWR) are available. These amounts even exceed the current water demands in that Wadis, which means that the today irrigated land could be at least doubled in each of the case study areas when activating the untapped water resources. The future untapped water resources (FUWR) for 2030 are just slightly lower than current values, due to the rural character of the basins and the applied methodology. Since water demand projections for the agricultural sector are not being considered, due to the related uncertainties, it can be concluded that the estimated future untapped water resources refer to that non-activated, unused surplus of local water resources which would be available for agricultural development within the next two decades.

The analysis provides valuable results for the sustainable development of the agricultural sector and extension of irrigated land in the valley. It also shows that additional measures are required to activate the remaining water potential. Without modernization of hydro-infrastructure, hence the reduction of loss rates, vast quantities of water are lost, especially in the Palestinian territories.

For Wadi Auja, a current water deficit of approximately 0.6 MCM/a is being quantified. This deficit is currently compensated by overpumping of the shallow alluvial aquifer in the valley. By activation of the local carbonate aquifer, improvements in surface water harvesting and reduction of transport losses, untapped water resources of around 6.5 MCM/a could be made available for local development. Additionally, treated effluents of up to 3.5 MCM/a may be imported from the WWTPs in Jericho and El-Bireh for irrigation purposes.

The water budget assessment for Wadi Nueimah shows a mean annual water surplus of 4.6 MCM. Untapped water resources have been identified with 9.5 MCM/a, allowing the future extensions of the local agricultural areas or even water export to Jericho or Wadi Auja. However, this implies the same investments in hydro-infrastructure and activation of water sources as for Wadi Auja. Again, treated effluents of up to 3.5 MCM/a may be imported from the WWTPs in Jericho and El-Bireh for irrigation purposes.

The case study of Wadi Kafrein presents a huge surplus of 14 MCM/a., which currently is not being explored. Additionally, 2.6 MCM/a could be gained by modernization of hydro-infrastructure, resulting in a CUWR of 16.6 MCM/a. Taking an increase of the water demand

of about 0.7 MCM/a in the year 2030 into consideration, an average of 15.9 MCM/a will be available for further agricultural development and other projects in the area.

In total, the studied areas reveal high potential for the activation of additional water resources as well as the necessity to increase the water management efficiency, especially by means of a modernization of the existing hydro-infrastructure.

Further hydrogeological assessments are required to tackle the uncertainties with regards to the sustainable yield of the rather complex regional groundwater systems in the valley and mountain areas.

Hydro-infrastructural interventions are required in order to protect and activate the considerable water potential in the areas under study. The activated water resources could be used for the sustainable development of irrigated agriculture in the LJV. For future negotiations with Israeli water authorities, it is recommended to consolidate the present investigations in quantitative, qualitative, economic and legal terms.

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