Open section of the Israel National Water Carrier in the highlands between Lake Tiberias and the coastal plain (© Heinz Hötzl)

IWRM Concept and WEAP-Application, Cluster West

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KEY FINDINGS

Development of a participative standardized water resources planning approach to support sustainable water resources development both sides of the Lower Jordan river;

Identification of hydro-infrastructural measures to upgrade the existing water resources system at the so-called catchment Cluster West and to activate the remaining water potential by deep wells, surface runoff retention, controlled groundwater recharge and waste water reuse inside the basin and surrounding areas;

Even with the implementation of all measures, the water sector demand during the planning horizon of 20 years cannot be covered. Future water crises will particularly affect the mountain area near Ramallah;

In spite of all efforts, significant future water imports into the study area will be required to ensure sustainable development.

Introduction and Objectives

This section presents a summary of the work on water resources planning which were developed in a representative Palestinian sub-catchment of the Lower Jordan Valley (LJV) in order to demonstrate and improve the resilience of the water resources system against high hydrological variability and extreme drought events as well as the water resources planning process itself. Detailed information is provided by Rusteberg (2018a).

The so-called Cluster West Jericho-Auja in the Palestinian Territories of the Lower Jordan Valley is representative for many areas in the Lower Jordan Valley (LJV) with regards to its water resources system as well as the prevailing dry climate and socio-economic conditions. The lower parts of the 3 watersheds Auja, Nueimah and Qilt have considerable development potential with regards to trade and tourism. Furthermore, suitable climate and high land fertility result in a great agricultural potential. Therefore, the LJV is of major importance for Palestinian crop production. Jericho city with 25,000 habitants is the major urban center. The south-western urban parts near Ramallah present industrial and commercial potential (Figure 2). The difference in elevation between the lower and upper parts is ca. 1,000 m. All water sectors present significant and increasing water deficits. The water resources need to be further developed and the Integrated Water Resources Management (IWRM) concept to be implemented in order to guarantee sustainable development, especially of irrigated agriculture as most important economic sector, in spite of increasing drought conditions due to climate change.

IWRM implementation requires the activation and conjunctive use of all available water resources by structural measures in the first place. Therefore, the present research focuses on the outline of a water plan for the upgrade of the existing water resources system (WRS), consisting of a combination of hydro-infrastructural measures to improve the resilience and robustness of the WRS against high hydrological variability and extreme dry conditions.

Methodology

For the sustainable development of water resources in the Lower Jordan Valley both sides of the Jordan River and upgrade of the existing water resources systems, a generalized participative water resources planning approach has been developed within SMART-MOVE, based on the IWRM principles.

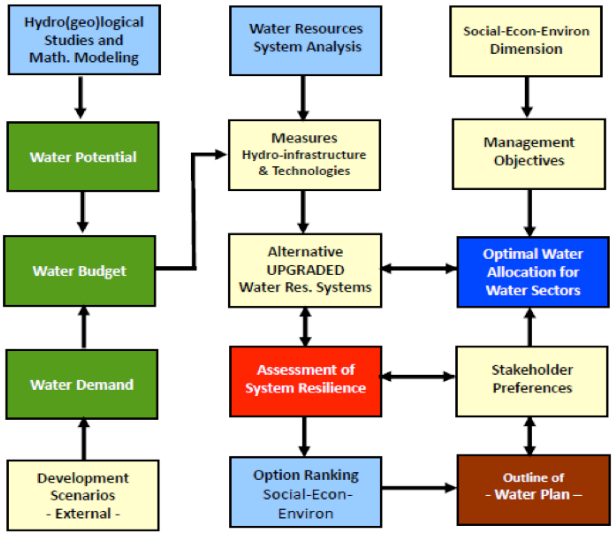

Figure 1: Water Resources Planning Approach (Rusteberg, 2018a)

The standardized and clearly structured procedure ensures transparency of the decision-making process and, therefore, acceptance of the suggested water development plans. The planning concept has been developed in close cooperation with the regional stakeholders and decision makers. The step-wise approach leads to the development of water plans on basin level with high robustness against hydrological variability and extreme events, taking the social, environmental and economic performance into consideration. Figure 1 presents a flow chart of the water resources planning approach. The approach has been built from an engineering point of view and as such it concentrates on the identification and dimensioning of so-called structural IWRM measures to improve the resilience, robustness and performance of the water resources system. Following the planning approach, an integrated water plan is developed which identifies the required hydro-infrastructural and technological interventions for sustainable system upgrade and operation. The transparency and standards of the suggested planning approach may serve as basis for any negotiation between the partner countries on the transboundary management of their water resources. The step-wise procedure requires water budgets forecast based on different scenarios for socio-economic development and climatic conditions during the planning horizon of 20 years. Further steps relate to the analysis of the water resources system to identify potential measures for the upgrade of the existing hydro-infrastructure as well as stakeholder consultations on the development goals, water management objectives and selection of representative technical (water supply), socio-economic and environmental indicators.

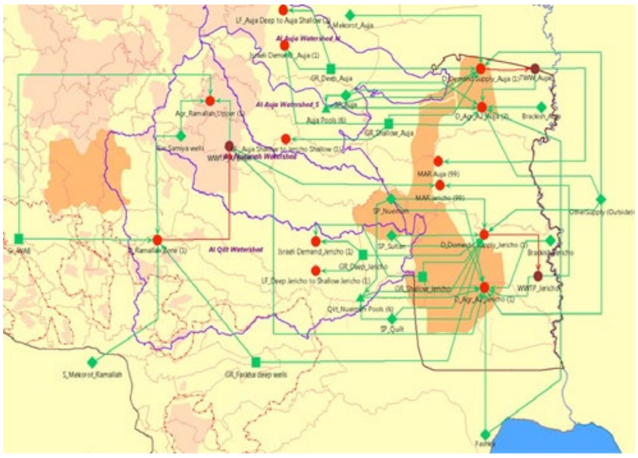

Figure 2: Division of Cluster West in Budget Zones.

Alternative IWRM-strategies are being defined as a combination of potential hydro-infrastructural interventions. The impact of those strategies on system resilience (water demand coverage, water deficit, water supply reliability) has been accessed by the Water Evaluation and Planning System WEAP (weap21.org) and Groundwater modeling. For these investigations, the catchment cluster, due to different socio-economic and physical characteristics was divided into 3 areas. Figure 2 illustrates the division into the so-called Auja Area, the Jericho Area and Ramallah (East) Area.

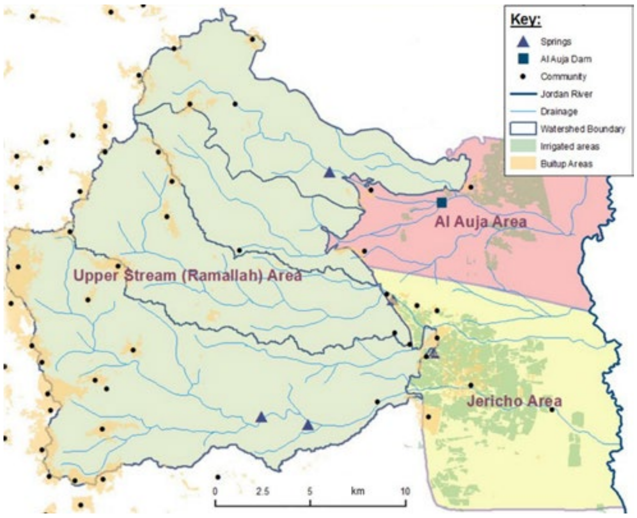

Figure 3: Representation of the Water Resources System at Cluster West with the WEAP model.

The schematic representation of the water resources system with the water sources and water supply nodes as basis for the application of the WEAP model is depicted in Figure 3. It already includes the different potential measures for system upgrade according to Table 1.

The identification and dimensioning of the IWRM measures was accomplished in close collaboration with the project partners, as well as with Palestinian and Israeli stakeholders and decision makers. Table 1 defines a set of alternative IWRM strategies as combined structural measures, with the individual measures

Table 1: IWRM Strategies for the upgrade of the Water Resources System at Cluster West.

IWRM STRATEGY	SURFACE RUNOFF RETENTION (SPRING SURPLUS FOR CONTROLLED MAR)	SHALLOW AND DEEP WELL INSTALL-ATIONS (MOUNTAIN AREA AND VALLEY)	FULL TREATMENT AND REUSE OF LOCAL WASTEWATER FROM THE VALLEY	TREATED EFFLUENT IMPORT FROM AL-BIREH	DEEP WELLS IN MOUNTAIN AREAS ABOVE FESHCHA SPRINGS AND TRANSFER TO RAMALLAH	BRACKISH WATER TRANSFER FROM FESHCHA SPRINGS	ADDITIONAL WATER IMPORT
A	X						
B	X	X					
C	X	X	X				
D	X	X	X	X			
E	X	X	X	X	X		
F	X	X	X	X	X	X	
G	X	X	X	X	X	X	X

being gradually aggregated. All strategies consider the rehabilitation of the water distribution network together with the installation of pipelines to minimize water transfer losses. The most efficient usage of spring discharge for water supply and Managed Aquifer Recharge (MAR) is considered an obligatory measure and basis for all strategies. Not explicitly listed is the so-called do-nothing (business as usual) approach, which assumes that no system upgrades will be implemented and that the existing water resources system will continue to be managed in its unchanged form. All strategies aim at further extension of the irrigated land in the valley around Jericho-Auja to the maximum irrigable area with the next 10 years (RUSTEBERG, 2018a).

The IWRM strategies were compared in technical (water supply), socio-economic and environmental terms. Due to the major research objective, special attention has been given to the improvement of system resilience, taking a moderate and a dry climate scenario into account. The following water supply indicators were considered: Total water supply delivered, unmet demand, demand coverage and water supply reliability. For more detailed information please refer to Rusteberg (2018a), Rusteberg et al. (2018d) and corresponding project deliverables (www.iwrm-smart-move.de).

Results

Table 2 presents the water cost of the different measures as Average Incremental Cost (AIC), taking all construction, operation and maintenance cost into consideration. The calculations are based on a planning horizon of 20 years. The results show that controlled groundwater recharge by efficient usage of spring water surpluses and surface runoff is a most cost-effective measure.

The import of brackish water from the Feshcha springs is also an economic measure which would contribute significantly to the expansion of irrigated agriculture and the improvement of the system resilience against drought events. The water cost for the construction of deep wells in the valley exceeds already USD 0.40/m^3. The reuse of wastewater is still quite expensive, as the wastewater collection network needs to be significantly expanded. Furthermore, treated effluent import requires the construction of a pipeline from El-Bireh to the irrigated areas in the valley. The implementation of deep wells in the mountains of Feshcha is to be questioned due to the high water costs, but could be used to strengthen drinking water supply in the subarea of Ramallah East.

The assessment of water supply indicators for the different IWRM strategies and climatic scenarios show that in the case of the Do-Nothing approach, independent of the prevailing climatic conditions, large water deficits will occur in the future, which partially may be covered at the cost of a further overexploitation and emptying of the shallow alluvial Aquifer in the valley.

By implementing the suggested structural measures to activate the remaining local water potential as well as of adjacent areas, the water supply security and resilience of the water resources system can be significantly improved over periods of drought so that the implementation of all measures is strongly recommended from that point of view. The studies also prove the positive social impact of all interventions due to the above

Table 2: Average Incremental Cost of structural measures as part of integrated strategies.

	IWRM-MEASURES AS PART OF INTEGRATED STRATEGIES						
AVERAGE INCREM. COST	GW recharge with spring water surpluses	Flood Water Retention to enhance GW recharge	Deep wells in the area	Treated effluent reuse from Jericho WWTP for direct irrigation	Treated effluent import from El-Bireh	Deep Wells at Feshcha and transfer to Ramallah East	Brackish water imports from Feshcha springs (extra cost for desalination in brackets)
USD/M^3	**0.07**	**0.27**	**0.41**	**0.49**	**0.45**	**0.87**	**0.35** (0.39)

reason. Preliminary studies on water cost and cost-benefit relations indicate the economic viability of the suggested measures (Rusteberg et al., 2018b).

But it also became evident that even after implementation of all measures, the steadily increasing water demand cannot be fully

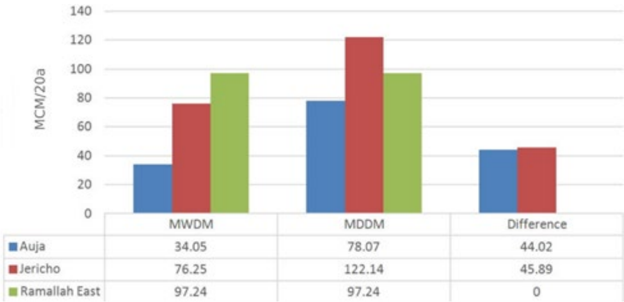

Figure 4: Total additional required water to be imported over the planning horizon of 20 years (2015-2035), taking the moderate climate scenario (MWDM) and the dry scenario (MDDM) into account.

covered, so that additional water imports into the study area will be necessary to enable sustainable development. According to Figure 4, depending on the climatic conditions, an average of 10 to 15 million m^3 (MCM) of additional water is required per year, with water deficit values being significantly above the mean during the dry periods. Future water crises will particularly affect the sub-area „Ramallah East" (Figure 3), provided that no further measures are being implemented. The already existing and further expected water shortages in the catchment cluster are representative for the situation of many areas in Palestine.

The development of wastewater reuse in irrigated agriculture in exchange (tradeoff) with fresh water from deep wells is certainly a key component of sustainable and integrated water management in the study area. Therefore, also wastewater imports from more remote areas, such as e.g. from Jerusalem, into the irrigated areas around Jericho-Auja should be taken into consideration. With regard to the options for significant freshwater imports, reference is made to the SALAM subproject (Rusteberg et al., 2018c).

Further Research Needs

Further research needs on the SMART-MOVE line of integrated water resources planning and management are:

> Validation of the innovative planning approach to support IWRM implementation in a participatory process together with stakeholders and decision-makers at regional and transboundary level;
> Need for innovative concepts to strengthen institutional development to anchor the IWRM principle in Palestine and Jordan;
> Studies on the import of treated wastewater from more remote areas into the Jericho-Auja irrigation area, i.e. from the Jerusalem area, to strengthen agricultural development;
> Strategies for the conjunctive management of brackish water, sewage and groundwater resources in the Jordan Valley for the purpose of sustainable agricultural development with special attention to resource conservation, in particular to avoid soil salinization;
> Spatial discretization of water sector demand and expected deficits during the next two decades for the entire West Bank, in particular urban areas, as a basis for integrated water resources management and „water trade" between neighboring sub-basins;
> Studies on how to realize additional fresh water imports, especially from seawater desalination at the Mediterranean coast, in the context of a transboundary management of water resources.

Capacity Development

Capacity development measures were realized at the Palestinian Water Authority (PWA) in Ramallah, Westbank, focusing on water resources planning, WEAP and MODFLOW applications in the study area.

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