Integrated Water Resources Management in the Lower Jordan Rift Valley

Sustainable Management of Available Water Resources with Innovative Technologies

BMBF IWRM R&D Programme

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SMART – MOVE

D 4.1

Methodology, data and Information for the preparation of adaptive water plans both sides the Jordan river

Task 4.1.1:

Participative IWRM implementation concept for the development of water plans both sides the Jordan river

Task 4.1.2:

Scenarios for agricultural development in the Lower Jordan Valley, based on stakeholder consultations (Cluster East: task 4.2.3 – Annex 1)

Task 4.1.3:

Scenarios for urban development & related water sectors (task 4.2.3 - Annex 1)

Task 4.1.4:

Consolidation of water budgets on catchment cluster level

Task 4.1.5:

Water resources system analysis

Task 4.1.6:

Stakeholder consultations on management objectives, measures, weighting and selection of priority interventions

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1. Introduction

The key objective of SMART-MOVE work package no.4 on Water Resources Planning, which consists of 5 project deliverables, is to tackle the challenge in creating water development plans to address the increasing water scarcity, taking the highly fluctuating and extreme hydrological conditions (both spatial and temporal) of the region into consideration. Such water plans would contribute to the sustainable development by activating additional sources of water, improving the robustness of the water resources system through structural measures as "system upgrades", minimizing water deficits as well as social and environmental impacts during drought events, giving special attention to economic considerations.

This report presents the suggested participative water resources planning approach together with the basic works to identify priority structural interventions which may be considered for the required upgrade of the water resources system.

2. Objectives

The main objectives of the present deliverable D4.1 may be summarized as follows:

- Development of a participative water resources planning approach for IWRM implementation;
- Provide scenarios for agricultural development in the Lower Jordan Valley;
- Provide scenarios for urban development and related water sectors in Jordan;
- Consolidation of water budgets on catchment cluster level and impact analysis for extreme hydrological and different agricultural and socio-economic development scenarios;
- Analysis of the water resources system on catchment cluster level in order to develop structural measures for the required upgrade of the water resources system;
- Stakeholder consultations on management objectives, measures, weighting and selection of priority interventions.

All objectives refer to the SMART water resources planning approach as presented in the following chapter 3 (fig.3.1).

3. Participative Water Resources Planning Approach

For the sustainable development of the water resources in the lower Jordan Valley on both sides of the Jordan River and the expansion of existing water resource systems, SMART-MOVE has developed a universal methodological planning approach based on the concept of Integrated Water Resources Management (IWRM). The planning approach is shown schematically in Figure 3.1 below:

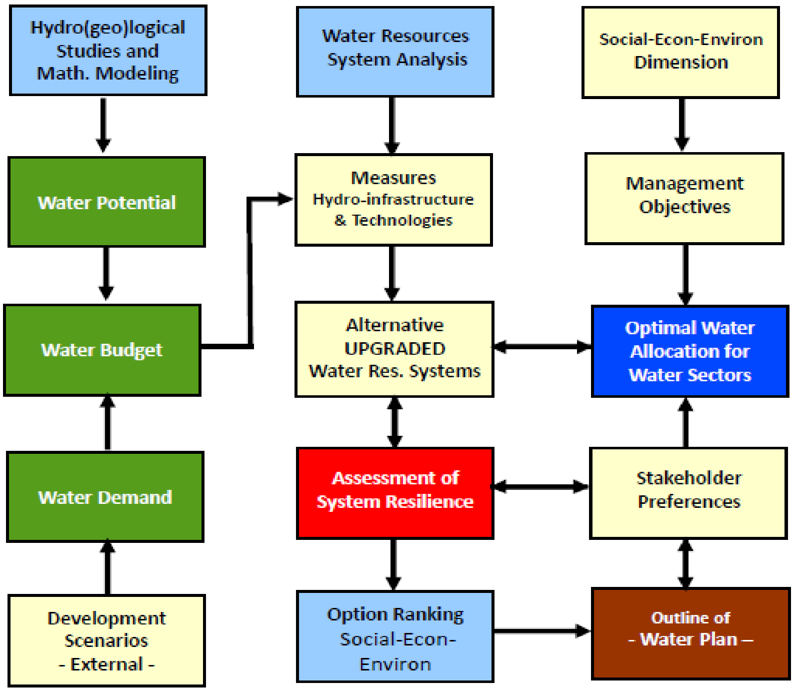

Figure 3.1: Smart-Move: Water Resources Planning Approach

The standardized and clearly structured procedure ensures the transparency of the decision-making process, e.g. with regard to the identification and evaluation of alternative measures. The planning concept is strictly participatory and requires close cooperation with regional stakeholders and decision-makers, which has been part of smart projects for many years and which has also been successfully continued within the framework of the SMART-MOVE project. In this way, the later acceptance by the decision makers of the results achieved can be ensured. The step-wise approach leads to recommendations towards the implemention of an IWRM strategy for system upgrade and sustainable system management or- with other words - to a water plan at the catchment cluster level with high robustness to hydrological variability and extreme events, taking into account social, environmental and economic factors. The engineering approach focuses on the identification and sizing of structural water management measures to improve the hydrological robustness of the water resource system and the implementation of development objectives in the catchment area. The standardized planning approach developed here created an excellent basis for the cross-border management of water resources in the region. The systemResilience (water demand coverage, water deficit, watersupplyreliability) is acessed by theWEAP model and numerical groundwater simulation.

4. Agricultural Development Scenarios

By far the largest user of water in the valley region of the study area is the irrigated agriculture. They account for a large part of the total water requirement. To cover food needs in the Palestinian territories, the irrigation area in the Jericho-Auja Valley needs to be significantly expanded in the coming years. As an agricultural development goal, the Palestinian Ministry of Agriculture (MoA) wants to expand the current irrigation area in the valley of a total of 32,980 dunum (3298 ha) to the total irrigable area of about 43,000 dunum (4300 ha) within the next 10 years. The irrigation area at Auja village has to be more than doubled to meet the needs. This goal has be expressed by an appropriate agricultural development scenario. Further development scenarios, considering a lower degree of agricultural expansion has been derived, too (Walter et al., 2018). As a rule, however, a full expansion was assumed, as shown graphically in Figure 4.1. Assuming a mean water demand of 1,000 m³ per dunam per year, this results in an increase in agricultural water demand from currently about 33 million m³ per year (MCM/a) to 43 MCM/ a in 2025. Thereafter it remains constant.

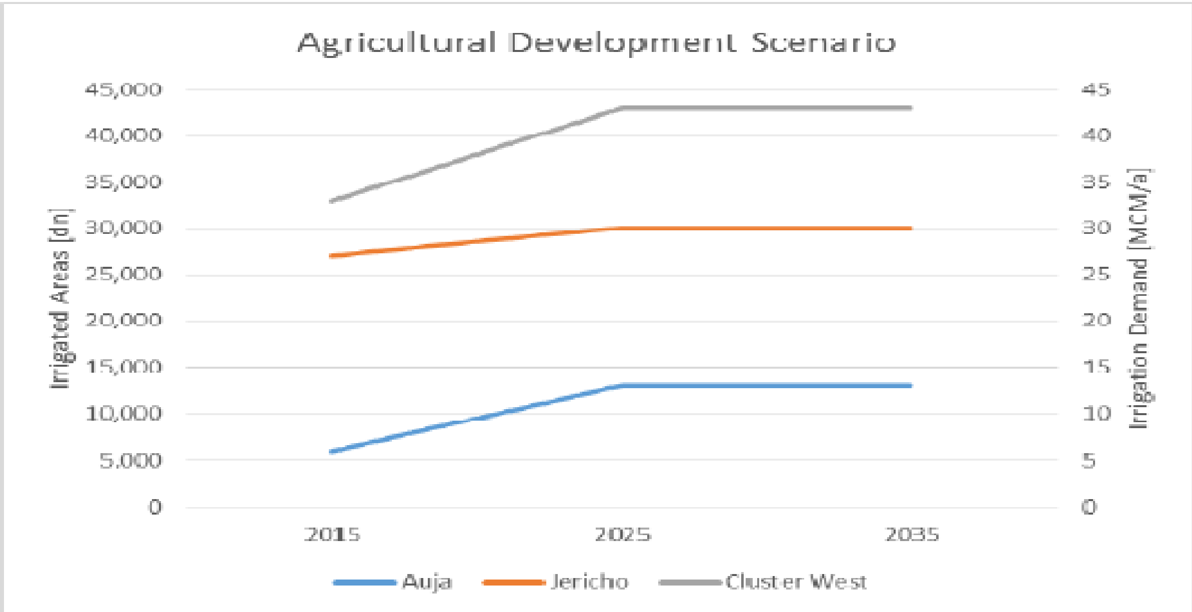

Figure 4.1: Agricultural scenario: "full extension" of the irrigation area to the total irrigable land

5. Water Budgets and Impact Assessment under extreme Conditions

Water budget calculations based on long-term historical time series

To assess the current situation in Cluster West, water availability was compared with sector water demand in 2016. Table 5.1 summarizes the results, distinguishing between available fresh water, brackish water and waste water resources. For the visual distinction, the water resources were colored in blue, red and grey, respectively. The calculations were made for the entire catchment area up to the aboveground watershed, so that also the one Samia well group in the mountain region of the Eastern Aquifer with an annual water withdrawal in the amount of 1.9 MCM/a was considered. From the Israeli side already 9 MCM/a are abstracted from the aquifer. Due to partially damaged and old water infrastructure in the study area, at present only about 40% of the spring discharge are used. Aside from the Auja dam, no structures are available for the retention of surface water. For the use of the retention at Auja, however, further infrastructure is needed (Walter et al., 2018). The Israeli water supply company MEKOROT is currently providing about 6.7 MCM/a from their water supply network, which are subject to water losses. The deeper carbonate aquifer in the valley is not used yet but contains brackish water. The water potential is estimated to be about 7 MCM/a. A reuse of the treated wastewater of the waste water treatment plant (WWTP) at Jericho is not yet available. The collection and treatment of the produced waste water and reuse in agriculture would create an additional water potential that can be activated. Table 5.1 shows a significant water deficit, indicating that, in the long-term, current water needs cannot be met by existing water infrastructure. The forced overuse of the alluvial system leads to a permanent lowering of groundwater levels.

Table 5.1: Present water availability versus water demand - Cluster West (2016)

Cluster West: Sources of Water	Water Availability 2016	Total WD 2016	Water Demand 2016		Water Budget 2016
			Irrigation	Dom./Comer.	
	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]	[MCM/a]
1.1 Springs	11,7	32,3	19,5	12,8	
1.2 Surface Runoff	0,0				
1.3 Alluvial Aquifer	4,8				
1.4 Carb. Aq. Eastern Basin	1,9				
1.5 Mekorot	4,7				
1. Fresh Water - SUM	**23,1**	**32,3**	**19,5**	**12,8**	**-9,2**
2.1 Alluvial Aquifer - Brack.	2,5	14,0	14,0	0,0	**-11,6**
2.2 Deep Carb. Aquifer -Brack.	0,0				
2. Brackish Water - SUM	**2,5**				
3.1 Treated Effluent	0,0	0,0	0,0	0,0	**0,0**
SUM	**25,6**	**46,3**	**33,5**	**12,8**	**-20,8**

Not least because of the constantly increasing demand for water in the study area (Table 5.2), it is necessary to upgrade the water resources system, which will be discussed in more detail below.

Water availability forecast

However, the analysis of the hydrological data showed an increased occurrence of dry years with pronounced periods of drought and significantly reduced spring discharges in the study area in recent years. Since this indicates an influence of climate change, the long-term historical time series, in particular concerning the spring discharges, were no longer considered sufficiently representative (Schmidt et al., 2018). In terms of water availability, we therefore used climatological-hydrological scenarios, also to account for the increase in drought periods and increasing water scarcity in the study area. The below figure 5.1 shows, for example, the forecast of the discharge of Auja spring in the period from 2016 to 2035 for the moderate MWDM scenario and the MDDM dry scenario. The results show that the assumed climatic conditions during the drought periods strongly affect the spring discharge time series and thus the water availability in the cluster. For more comprehensive information on the impact of the climatic-hydrological conditions in the study area on the water availability and demand coverage, reference is made to the Project Deliverable D44 (Rusteberg et al., 2018c).

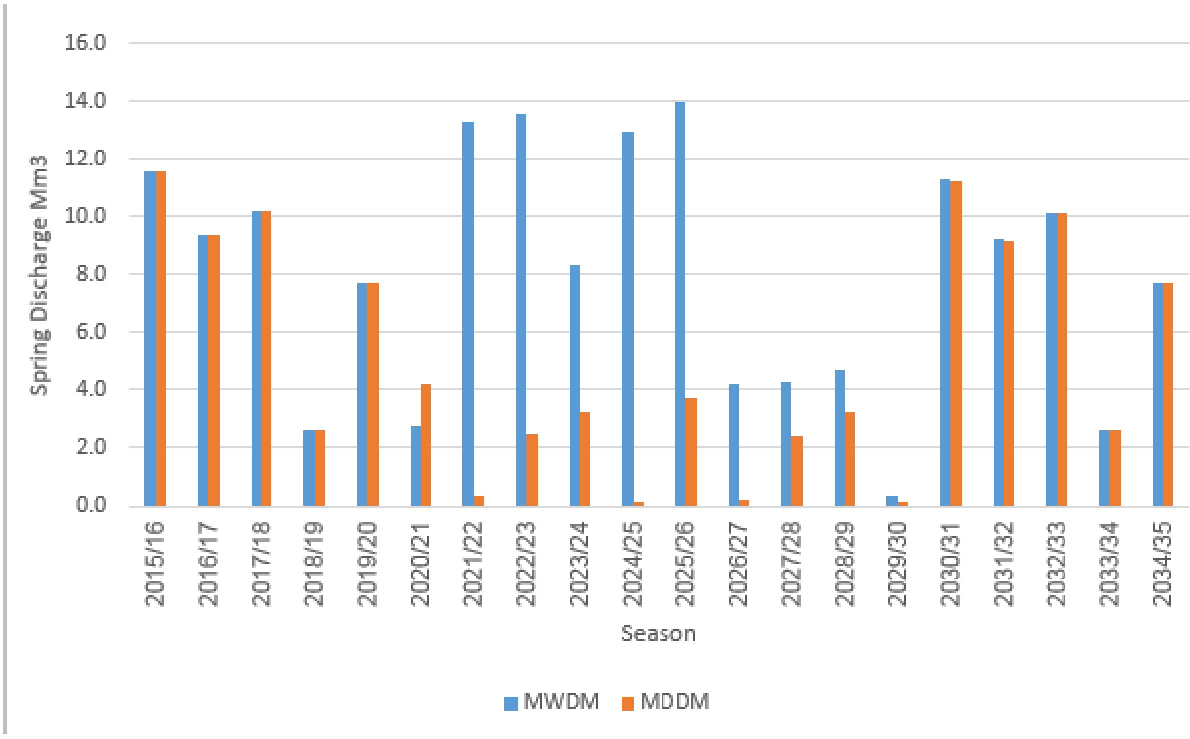

Figure 5.1: Forecast of Auja spring discharge / MWDM- and MDDM-Scenario (2015-2035)

<u>Water demand forecast</u>

For further investigations, the catchment area cluster, due to different socio-economic and physical characteristics, i.a. concerning water use, was divided into 3 areas. Figure 5.2 illustrates the division into the so-called Auja Area, the Jericho Area and Ramallah (East) Area:

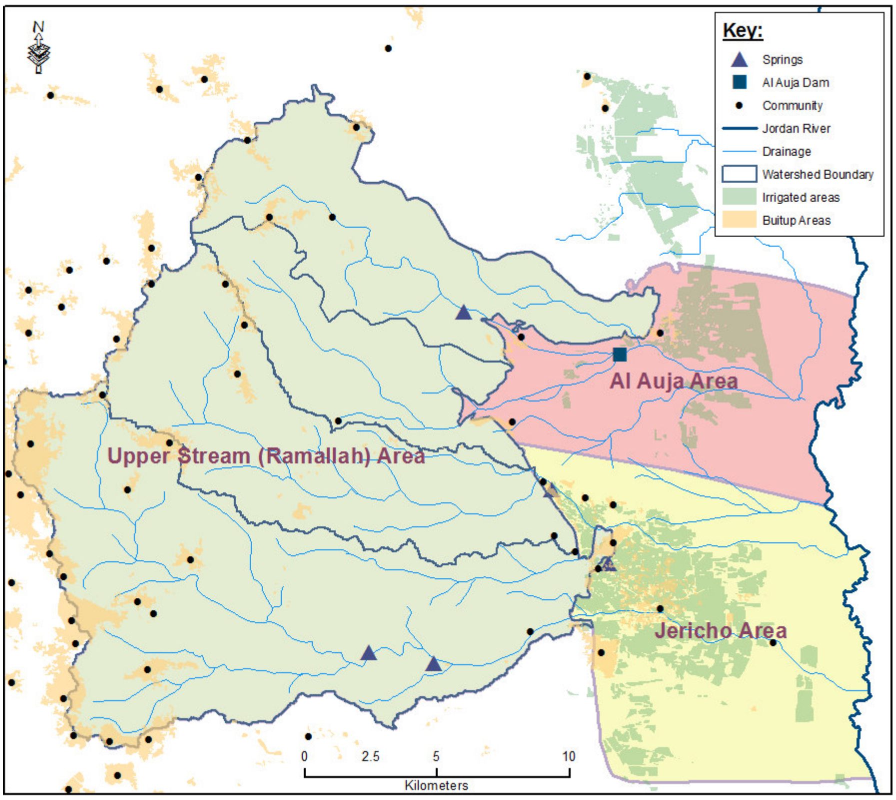

Figure 5.2: Division of the study area into three management zones

Table 5.2 shows the demand forecasts for the subsections presented above in millions of cubic meters per year (MCM / a) in the period from 2015 to 2035 at intervals of 5 years. With regards to underlying assumptions, reference should again be made to the project report D44 (Rusteberg et al., 2018b). It can be seen that the water demand in the catchment cluster will increase from 47.3 MCM / a to about 75.5 MCM/a. This represents a significant increase of 29.2 MCM or about 65% within 20 years.

Figure 5.3 graphically depicts the water demand forecast for the planning period, distinguishing between the three sub-areas as well as domestic and agricultural water needs. The agricultural development scenarios have already been briefly described in the before section.

Table 5.2: Development of the water demand in the management zones (2016 – 2035)

Year	2016	2020	2025	2030	2035
	Water Demand (MCM/a)				
Al Auja Area	6.61	8.49	10.84	12.38	13.94
Jericho Area	31.78	33.36	35.20	37.22	39.35
Ramallah Area	7.90	9.35	14.84	18.65	22.24
Total	46.29	51.10	60.88	68.26	75.53

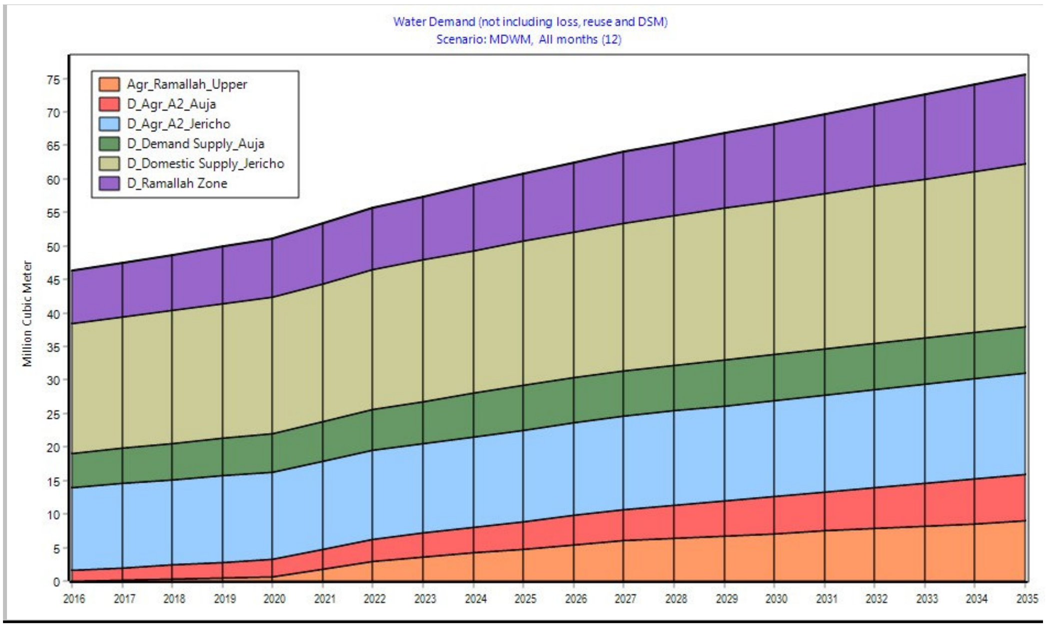

Figure 5.3: Water demand forecast for the three management zones

<u>Impact Asssessment</u>

The project also looked at how extended dry periods with significantly reduced rainfall and water availability would affect irrigated agriculture. To this end, the indicators calculated for the moderate climatic scenario (MWDM) were to be compared with the results obtained for the dry scenario. With regard to agricultural development, it is assumed that the existing irrigation area in the Jericho-Auja area will be expanded to the maximum usable area within 10 years (see section 4). As the following figures show, pronounced droughts have a significant impact on the coverage of agricultural water needs. All calculations assume that water withdrawals from the alluvial shallow groundwater system must be limited to the annual natural groundwater recharge plus controlled aquifer recharge less system outflows to ensure sustainable management of the aquifer. Any further use of the aquifer should not be permitted and is interpreted as a water deficit. Figure 5.4 illustrates the un-met demand for the region around Jericho-Auja in an exemplary manner for the so-called "do-nothing approach". It can be seen that, in the case of the dry scenario, significantly larger water deficits exist in the region Agriculture are recorded. Compared to the temperate scenario, there is a 97 million cubic meter (MCM) larger water deficit over the entire planning period. In the case of the dry scenario, it is clearly evident from the results of the beginning of the drought period after 5 years (2021). The results show that the duration of the low-precipitation period has a significant influence on the water demand coverage and thus the water deficits. Further details are provided in D44 (Rusteberg et al., 2018c).

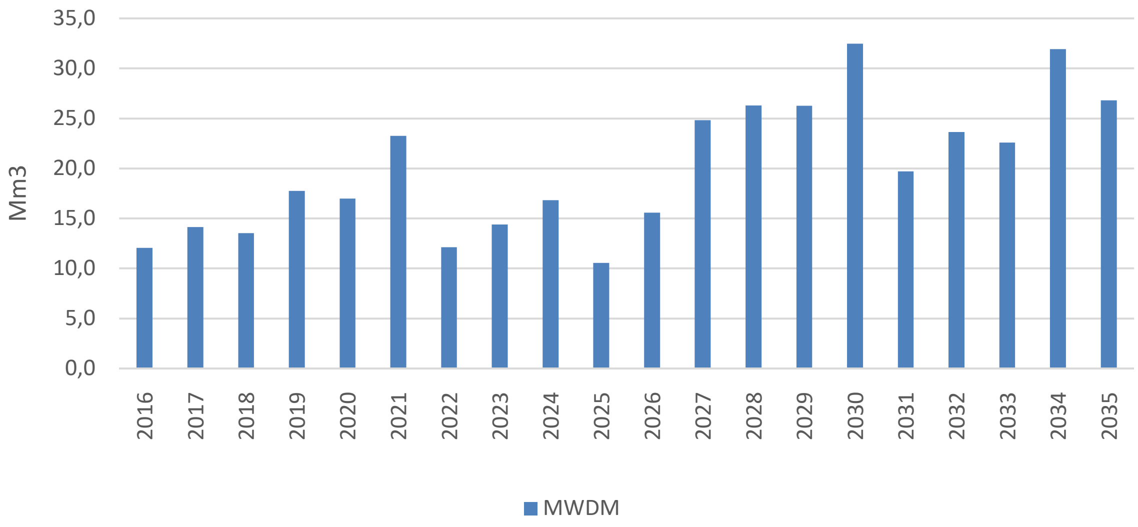

Figure 5.4: Un-met agricultural water demand at the study area Jericho-Aujaand the two climatic scenarios MWDM and MDDM

Figure 5.5 summarizes the average monthly values of demand coverage for the Auja irrigation area. Only in the months of January, February and March, in the case of the dry season, around 60% of agricultural water needs be covered on a long-term average. In the months of June and July, demand coverage averages only 40%.

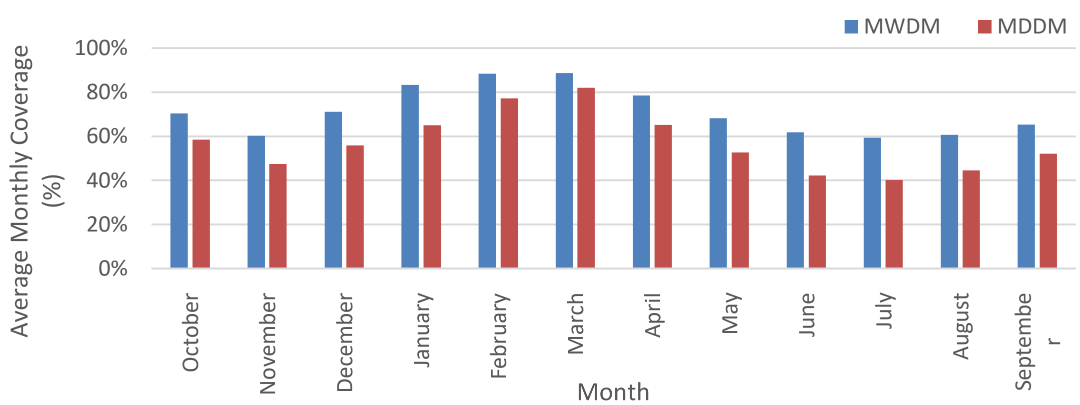

Figure 5.5: Mean monthly covered agricultural water demand(Jericho-Auja), taking both climatic scenarios MWDM and MDDM into account

6. Water Resources System Analysis

Figure 6.1 shows a schematic representation of the water resource system with the water outlets and water supply nodes as the basis for applying the WEAP model, with the possible expansion measures already included:

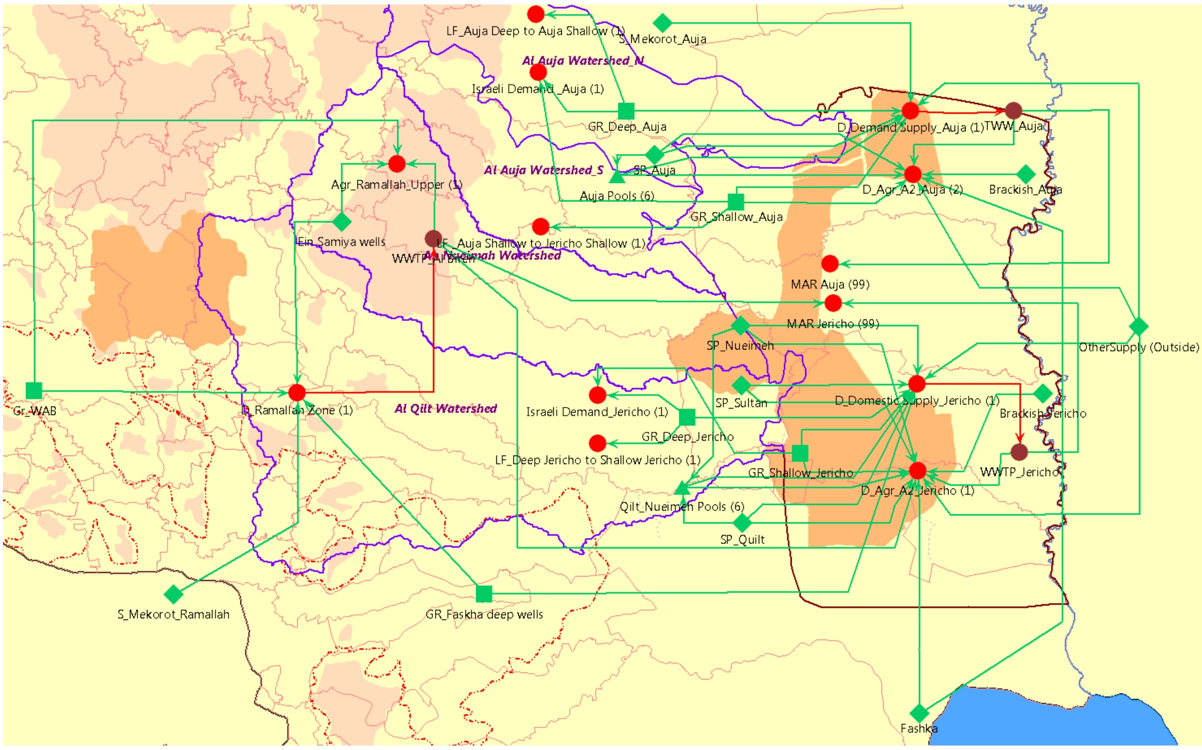

Figure 6.1: Schematic of the existing water resources system at Cluster West together with the potential "Upgrades" as basis for the application of the WEAP model

The potential supply from the water resources in Al-Auja-Jericho area was evaluated using the WEAP model (Deliverable D44) under the two climatic conditions (i.e. MWDM and MDDM) for Do-Nothing scenario. The results show that the average annual supply from all water sources to the demand centers in Auja-Jericho area is ranging between 21 - 26 Mm3 for normal (NWDM) and dry (MDDM) climate scenarios respectively. These rates are subject to increase up to around 40 Mm3/yr by implementing the suggested strategies as defined in Deliverable D44.

Figure 6.2 shows the annual water supply to the demand centers, the figure clearly shows the un-stability of supply under the Do-Nothing scenario as a result of the projected annual rainfall. However, the annual supply amounts will start to increase with time in a very stable manner in case the suggested measures under different planning strategies were implemented. Accordingly, the total supply will increase to around 53 Mm3 in the year 2035 which will meet the demand requirements in Auja-Jericho area.

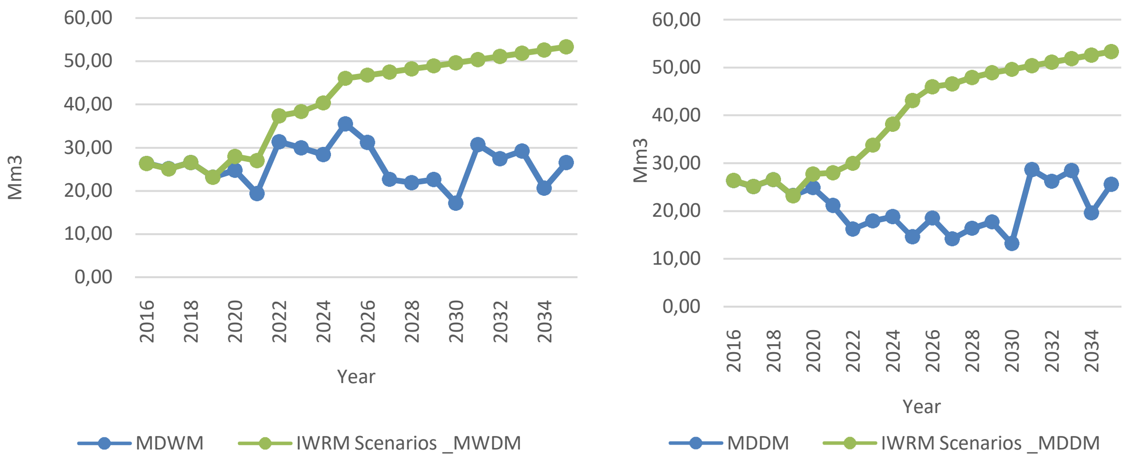

Figure 6.2: Annual water supply to Auja-Jericho Area under climate scenarios

The preparation of water plans for the area, whether if it includes a substantial part of the water supply to the city of Ramallah, must take into consideration the local conditions (high evapo-transpiration) and the high climate variability, which results in highly fluctuating patterns of water availability. One must separate the water system into two separate sectors:

1. Water supply for domestic/industrial purposes;
2. Water for agriculture

Water for domestic and industrial purposes has no flexibility and or adaptivity. Drinking water depends of the population and on the water consumption / capita, which is known and can't be reduced in a dramatic way. Water for industry has no flexibility either because it can usually pay high prices for it. This is not the case for agriculture. It can not pay any price for the water unless subsidies are applied and there is water left to supply. Therefore, a pragmatic approach has to be adopted in developing the agriculture in the LJV by:

- Using to the maximum extent possible brackish water;
- Using to the maximum extent possible treated effluent, also via a dramatic improvement of the treatment technologies and goals;
- Applying a smart management of the available water resources (using seasonal and or annual fresh water storage as a balancing instrument;
- Adopting a flexible approach to the agricultural development by allocating fresh water to the seasonal crop (with no-memory and therefore limited losses in case of drought) and by allocated the residual and brackish water to permanent crops.

These conclusions were drawn using the MOOC (Multi-Objective Optimal Control) approach to the Nueima-Auja_Kelt cluster and clearly indicated the above suggestions. To conclude, a proper water plan for the area should separate between demands that cant not have any flexibility (Domestic/Industrial) and demand that should show a high degree of flexibility and adaptivity.

7. Stakeholder Consultations and Selection of priority Interventions

The consultation with stakeholders (Farmers , experts , ex water minister and ex- agriculture minister has been undertaken to identify their priorities to be considered in the selection of priority measure for the upgrade of the existing water resources system at Cluster West. The main results of those consultation were:

- Treated wastewater, retention dams and development of springs are of high priority and urgent with regards to their implementation.
- No objection of importing water to cover the water demand but this option should be at commercial base and after exploitation of all local water resources.
- For long term strategy amulti-strategy based on combined water resources measures should be developed.
- Private sector can play a big role in secure fund for investment
- Regional cooperation to implement IWRM concept need mutual trust and confidence building measures to be studied and implemented.

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