



**SWIM-H2020 SM, Expert Facility**  
**Activity No. EFS-JO-1-WP1**  
**Training Report: Assessment of Drought Using**  
**WEAP-ArcSWAT Hydrological Modeling in Amman-**  
**Zarqa Basin (AZB)**

Version	Document Title	Author	Review and Clearance
1.0	WEAP Training and Capacity building for Expert Staff at Ministry of Water and Irrigation - Jordan	Saleh Al Qur'an	Maggie Kossida, NKE



## THE SWIM AND H2020 SUPPORT MECHANISM PROJECT (2016-2019)

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The SWIM-H2020 SM is a Regional Technical Support Program that includes the following Partner Countries (PCs): Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, [Syria] and Tunisia. However, in order to ensure the coherence and effectiveness of Union financing or to foster regional co-operation, eligibility of specific actions will be extended to the Western Balkan countries (Albania, Bosnia Herzegovina and Montenegro), Turkey and Mauritania. The Program is funded by the European Neighborhood Instrument (ENI) South/Environment. It ensures the continuation of EU's regional support to ENP South countries in the fields of water management, marine pollution prevention and adds value to other important EU-funded regional programs in related fields, in particular the SWITCH-Med program, and the Clima South program, as well as to projects under the EU bilateral programming, where environment and water are identified as priority sectors for the EU co-operation. It complements and provides operational partnerships and links with the projects labelled by the Union for the Mediterranean, project preparation facilities in particular MESHIP phase II and with the next phase of the ENPI-SEIS project on environmental information systems, whereas its work plan will be coherent with, and supportive of, the Barcelona Convention and its Mediterranean Action Plan.

The overall objective of the Program is to contribute to reduced marine pollution and a more sustainable use of scarce water resources. The Technical Assistance services are grouped in 6 work packages: WP1. Expert facility, WP2. Peer-to-peer experience sharing and dialogue, WP3. Training activities, WP4. Communication and visibility, WP5. Capitalizing the lessons learnt, good practices and success stories and WP6. Support activities.



## Disclaimer:

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## ABBREVIATIONS

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AZ	Amman-Zarqa
AZB	Amman-Zarqa Basin
JVA	Jordan Valley Authority
MWI	Ministry of Water and Irrigation
WAJ	Water Authority of Jordan



# 1 GENERAL INTRODUCTION

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Within the scope of work of the EU funded SWIM-H2020 SM, the project is implementing in Jordan an activity titled "EFS-JO-1: Mainstreaming Drought Risk Management, with a focus on proactive measures". This activity aims to support Jordan in enhancing preparedness and response to drought-related natural disasters and boost the resilience in the water sector through a series of interrelated activities that include training of the Ministry of Water and Irrigation (MWI) staff on the application of the "Water Evaluation and Planning" (WEAP) system for drought risk management. In order to achieve that, two training events will be conducted:

- Training no. 1, focusing on building the capacity of the MWI towards the efficient use of the WEAP water resources management model;
- Training no. 2, focusing on the application of the "Water Evaluation and Planning" (WEAP) system and integration with ArcSWAT hydrological modelling for drought risk management

**This training report pertains to training no. 2 which took place at the Ministry of Water and Irrigation between 02 and 07 September, 2018**

## 1.1 RATIONALE OF ACTIVITY

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WEAP was selected as an appropriate tool to enable and enhance strategic water resource planning within the Water Policy Directorate of the Jordanian Ministry of Water and Irrigation (MWI). As part of task 5 of the above mentioned activity EFS-JO-1, SWIM-H2020 SM undertook a review and assessment of the current capacity of the WEAP model available at the MWI for Amman Zarqa Basin (AZB), with a view to identify gaps in the current simulation and existing conceptual model, required model enhancements, and data needs for adequate simulation (focusing on the pilot area of Amman-Zarqa Basin). To this effect, a demo model was built for the AZB, aiming to improve the previous WEAP results and better represent/ reflect the complete hydrological processes. The demo model has been built for AZB and was populated with relevant data. The model included the calculation of irrigation water demand, water balance and groundwater over-abstraction, and a full hydrological analysis for AZB. The model can also integrate (at a later stage) hydrological input data and crop yield requirements together with environmental and other restrictions allowing for the analysis and assessment of different sustainability aspects (e.g. water use efficiency, water productivity of irrigated crops, etc.).

## 2 OBJECTIVES OF ACTIVITY

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The purpose of the current training was to build the capacity of the MWI staff in using WEAP as a tool for drought management and train them on developing a node-based disaggregated water resources



management model of AZB in WEAP for assessing the water balance (i.e availability versus demand for the different economic sectors and demand nodes) using hydrological simulation processes.,

The AZB WEAP model allows for:

- Simulation of the hydrological balance in the basin (for a better representation, a link with the ArcSWAT model was implemented)
- Evaluation of the balance between groundwater recharge and abstraction for the period 2001-2015, the quantification of the groundwater over-abstraction, and the Investigation of the impact of the current practices (i.e. the actual groundwater abstraction) on the aquifer - Linking the over-abstraction to specific water using sectors (domestic, agricultural, industrial) and Governorates' water demands
- Feeding data (over-abstraction/unmet demand) to calculate relevant drought vulnerability indicators useful in decision and policy-making

Supporting holistic water planning and drought mitigation in the AZ Basin by providing a decision support tool to the MWI whose staff have been trained to use and expand its application in other areas.

To improve the WEAP results and obtain a better representation of the physical hydrological processes, linkages to ArcSWAT have been established, so that the ArcSWAT output can be used to feed data into WEAP. In this regard, the MWI staff had also been trained on calibrating the WEAP model and linking WEAP to ArcSWAT..

After successful completion of the workshop, the participants will have a general understanding of how water resources assessment tools can be used to determine water demand and availability at the basin and sub-basin levels, a good knowledge on how to use the WEAP-ArcSWAT tool for the Amman-Zarqa Basin, and the capacity to make changes and build additional scenarios on the AZB WEAP system. and how to extract policy-relevant results from WEAP regarding groundwater over-abstraction assessment and drought management..

### 3 EXPECTED RESULTS OF ACTIVITY

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After successful completion of the training, the participants will:

1. Have a general understanding of how water resources assessment tools can be used to determine water demand and availability at the basin and sub-basin levels, which constitute key components of drought risk management
2. Understand how link and use the WEAP-ArcSWAT models for the hydrological analysis of the AZ Basin.
3. Be able to calibrate and set up WEAP models for other basins for calculating water balance components and assessing groundwater over-abstraction and other key variables (e.g. unmet demand)
4. Be able to make changes and build additional drought modeling on the AZB WEAP system





## 4 PROFILE OF THE PARTICIPANTS

- MWI staff directly involved in drought management, water resources management and planning, hydrological and water balance modelling (e.g. staff from the Water Policy Directorate and/or the Drought Management Unit of the MWI ).
- Representatives from MWI Directorates and Units, the Water Authority of Jordan (WAJ), and the Jordan Valley Authority (JVA) are targeted in this training.

## 5 EVALUATION OF THE EVENT

### 5.1 RESULTS OF THE EVENT

#### A. Organizational, administrative and planning issues before and during the event

A set of 7 criteria (A1-A7, See table 1 below) was assessed by the participants, using a qualitative description ranging between “Excellent” to “Poor”.

Figure 1 summarises the results of the evaluation for the organisational and administrative issues. Figure 2 focuses on planning issues. The total no. of replies obtained were 11.

The overall rating of 3.45 out of 4 (3.45/4) indicates that the event was well appreciated.

Table 1: Criteria for the evaluation of the organization, administrative and planning issues

A. ORGANISATIONAL, ADMINISTRATIVE AND PLANNING ISSUES BEFORE AND DURING THE EVENT	
A1	Efficient logistics: accommodation, transportation, location of venue and interpretation
A2	Handling of Emerging needs and attentiveness to participants concerns
A3	Adequacy of the presentations (Presentations correspond and contribute to the planned objectives and are conducive to enhanced shared understanding and participation on addressed topics)
A4	Clarity, coverage and sufficiency of concepts, objectives, anticipated outputs
A5	The materials distributed were helpful
A6	Efficiency and effectiveness of the facilitation
A7	Overall rating of the event

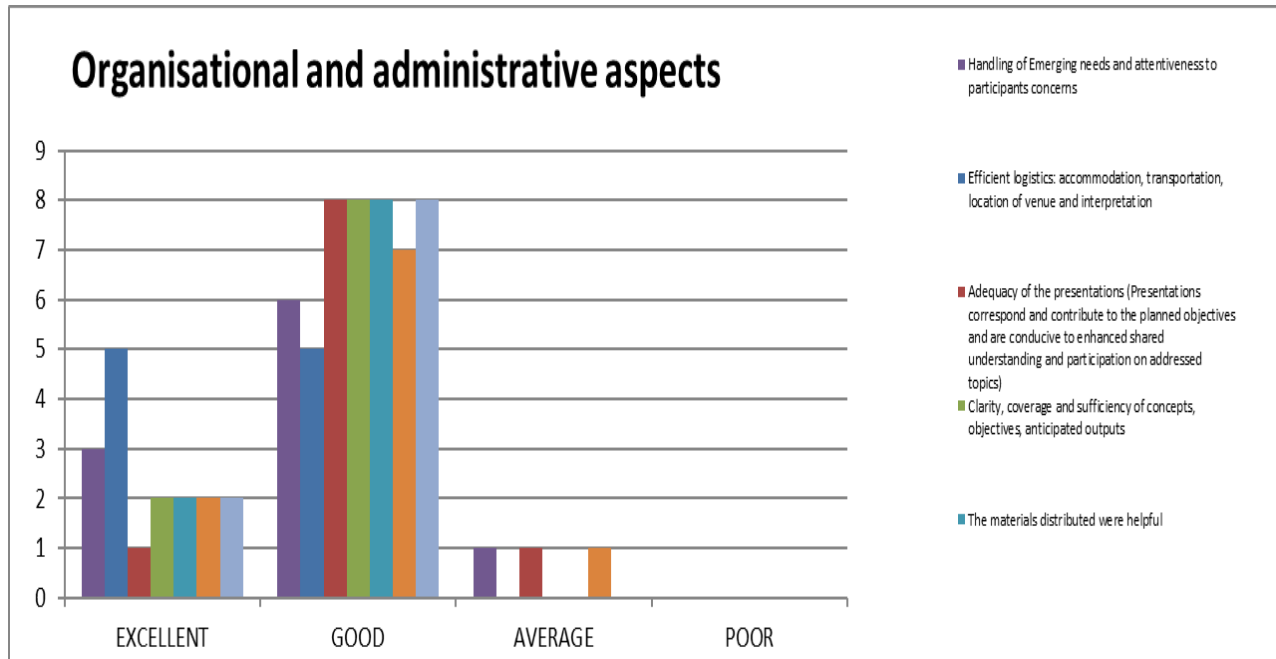


Figure 1. Organizational and Administrative Aspects

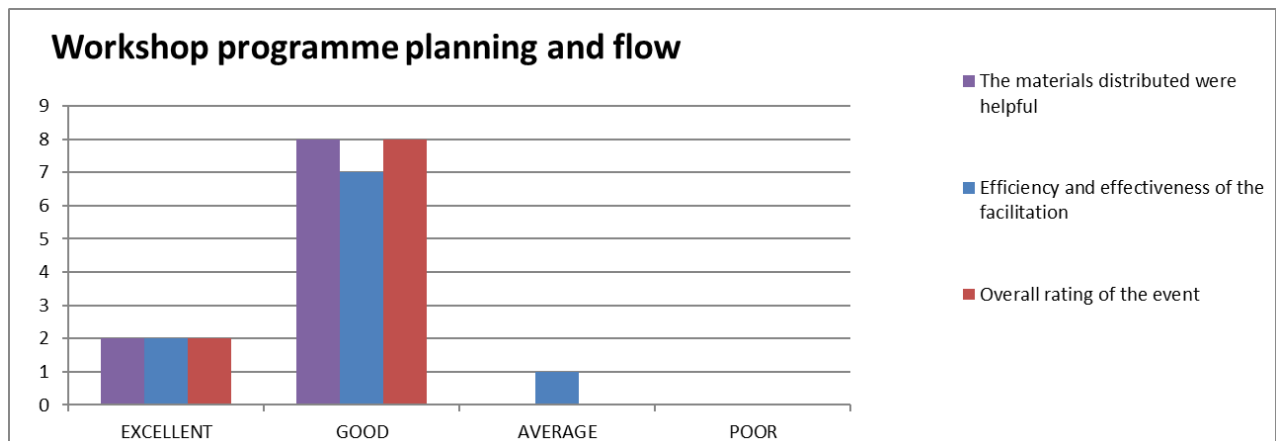


Figure 2. Workshop Program Planning and flow

**B. Feedback by participants on Technical Aspects:**

The figures 3-6 below present the feedback received from the participants on the technical aspects of the event (see table 2 for the criteria used for evaluation of the technical aspects of the training).

Table 2: Criteria for the evaluation of the technical aspects of the training

B. FEEDBACK ON TECHNICAL ASPECTS	
<b>B1</b>	<p><b>Coverage of the event</b>  <b>In your opinion did the event cover (tick one of the following):</b></p> <hr/> <p>All the topics necessary for a good comprehension of the subject nothing more</p> <hr/> <p>Some topics covered are not necessary</p> <hr/> <p>Some additional topics should be included</p>



B. FEEDBACK ON TECHNICAL ASPECTS	
	No reply
	<b>Total Replies</b>
<b>B2</b>	<b>Level of difficulty</b>
	Difficult
	Adequate
	Elementary
	No reply
	<b>Total Replies</b>
<b>B3</b>	<b>Length of the training</b> In your view the workshop duration (tick one of the following):
	Longer than needed
	Sufficient
	Shorter than required
	No reply
	<b>Total Replies</b>

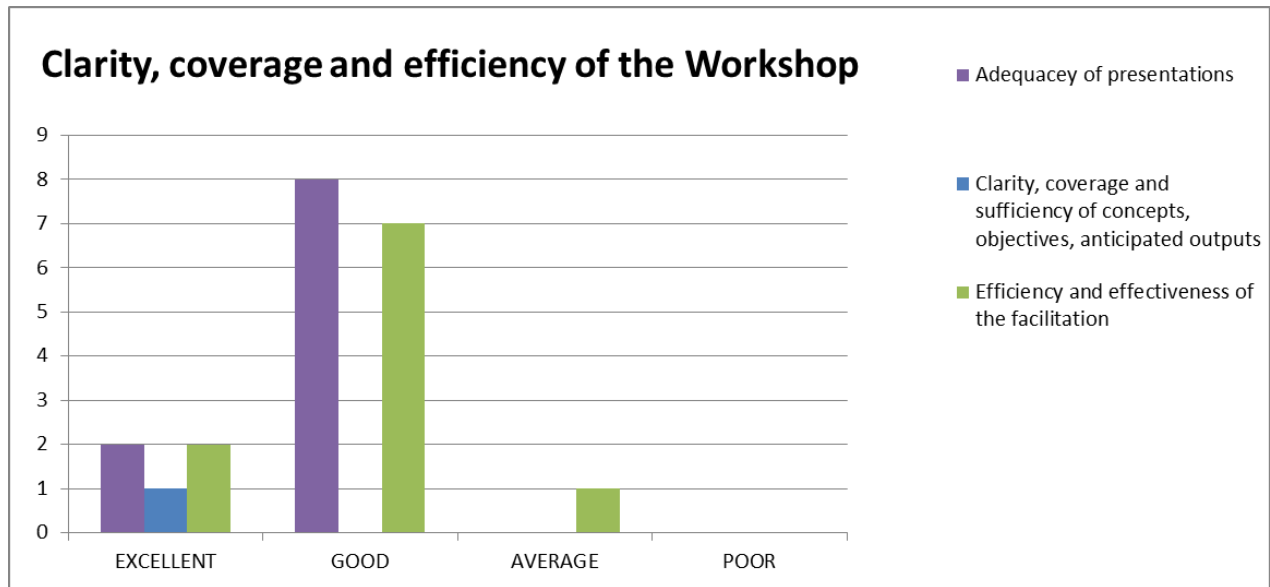


Figure 3. Clarity, Coverage and Efficiency of Workshop

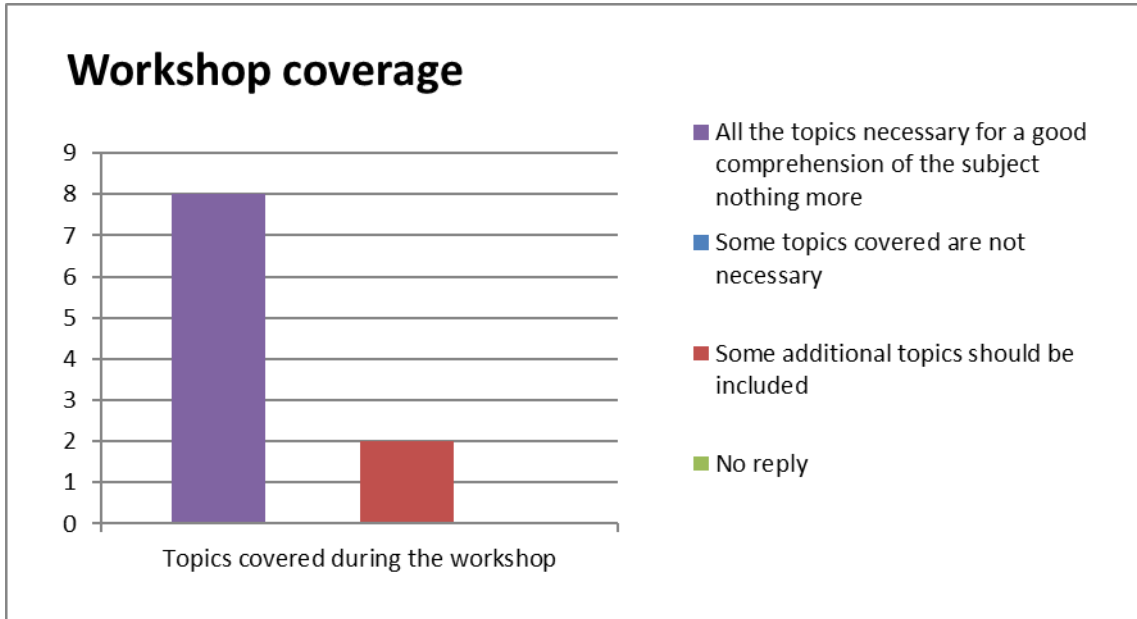


Figure 4. Workshop Coverage

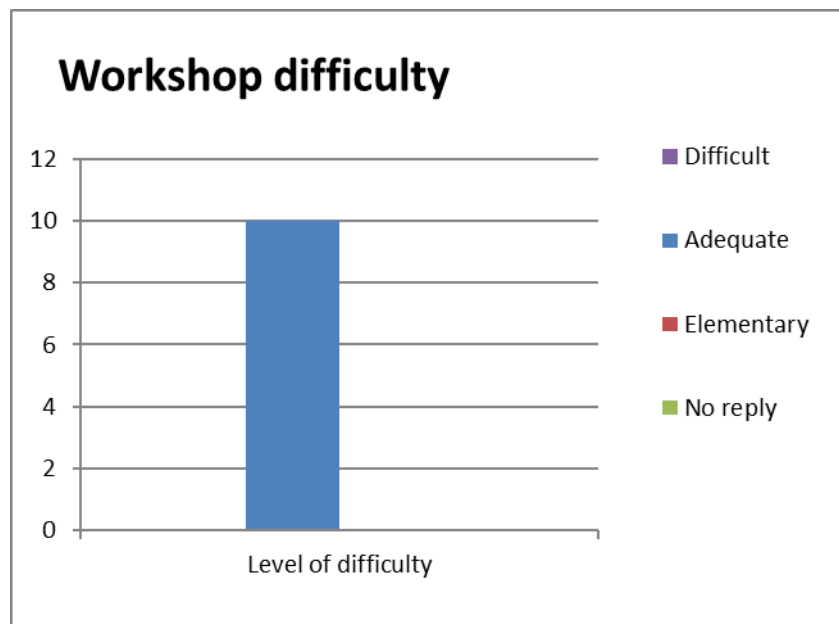


Figure 5. Workshop Difficulty

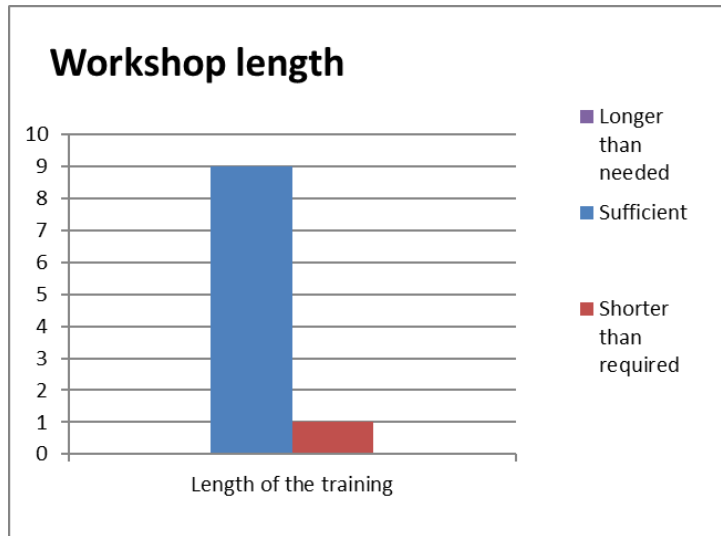


Figure 6. Workshop Length

**A. Proposals for improvements**

The participants were requested to respond to questions on the relevance of the training, and linkage with their future work, and suggest proposals for improvements. The following answers have been obtained:

<b>B4</b>	<b>What is the most valuable thing you learned during the workshop (knowledge or skills)?</b>	
	<i>How to build a groundwater balance and abstraction Model in WEAP How to import data from ArcSWAT into WEAP model Using ArcSWAT Hydrological Modeling</i>	
	<b>Total Replies</b>	<b>11</b>
<b>B5</b>	<b>How do you think that the current event will assist you in your future work on the subject?</b>	
	<i>ArcSWAT: it depends if they use the model regularly or not, it is so helpful model because it calculates the water budget so that Ministry of Water and Irrigation can rely in such models for calculating the annual water balance. WEAP_ groundwater balance Model will assist us in analyzing the drought events during the last 15 years (2001-2015)</i>	
	<b>Total Replies</b>	<b>11</b>
<b>B6</b>	<b>Please indicate whether (and how) you could transfer part of the experience gained from the event to your colleagues in your country?</b>	
	<i>The participants will work in groups and will exchange the data and information to reach the good use of WEAP. Transfer the knowledge in the examples given and presentations</i>	
	<b>Total Replies</b>	<b>7</b>
<b>B7</b>	<b>What did you like most about this event?</b>	
	<i>The event (it was good) The attitude of the instructor and ability to clarify the ideas.</i>	
	<b>Total Replies</b>	<b>11</b>
<b>B8</b>	<b>What needs to be improved?</b>	



	<i>More time for such valuable course. More future scenarios for climate change should be introduced. Also more practices are very important specially through integrating ArcSWAT and WEAP.</i>	
	<b>Total Replies</b>	<b>11</b>

**B. Remarks by the trainer**

A set of 9 criteria (B1-B9, see table below) are used hereby by the trainer to provide an overall assessment of the event..

B1	<b>Efficient and effective performance and interaction by participants</b> A new knowledge has been raised for participants in this training, adding to their skills the knowledge on how to obtain hydrological input data for WEAP by using ArcSWAT Modelling.
B2	<b>Efficient and effective cooperation and team spirit</b> The participants were distributed into working groups and each group was assigned specific tasks based on their backgrounds and skills. The training showed high and effective cooperation accordingly.
B3	<b>Level of achievement of planned objectives</b> All planned activities were achieved.
B4	<b>Did the event contribute to helping participants practice skills or gain knowledge related to course concepts</b> Yes. All participants worked together in one team to maximize the benefit from using ArcSWAT and WEAP hydrological modelling. Every group of the participants worked on different concepts which were combined under one methodology.
B5	<b>What worked well during the event</b> Open Discussions, Building real-case model in AZ Basin for groundwater balance and abstraction
B6	<b>What didn't work well and why</b>
B7	<b>What components/concepts did participants seem to understand well</b> Integration of Rainfall and Runoff Modelling and Calculation of Water Mass-Balance.
B8	<b>Were there any components/concepts that participants appeared to not understand</b> Some concepts for customizing the data for ArcSWAT modelling because it requires an ArcGIS modelling approach and not all participants are very proficient in practicing the ArcGIS tools.
B9	<b>What aspects of the event could be improved and what to be kept</b> Participants need more time to be trained in more case studies and real data and examples.



## 6 ANALYSIS OF THE RESULTS OF THE TRAINING COURSE

The training succeeded in mobilising a good number of trainees that are implicated in water resources management and planning at the MWI, as indicated in Table 4 below.

Table 3: Workshop participation/ demographics

		Comments
Total No. of participants actually attending one or more training days	12	
Total No. of participants Planned to attend	20	The original plan (before the Terms of Reference (TORs) were changed) was to open the training for other relevant organisations such as the Ministry of Agriculture and NCARE and NGOs. This has changed in the revised TORs to target only MWI designated staff, being responsible for planning and water resources management in Jordan
Planned/Actual	60%	
Number of organisations/agencies/authorities that were represented	1	The training was intended for the MWI staff
Gender balance (% of women participants)	85.3%	
NGO representation: No. of participants from NGOs	-	The training was intended for the MWI staff

After the training workshop, an assessment questionnaire was distributed to test the level of knowledge of the participants in the various subjects of the training. Ten (10) participants of the twelve 12 (10/12) filled the assessment questionnaire.



## 7 CONCLUSIONS & OVERALL ASSESSMENT

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This training focused on linking the WEAP and ArcSWAT models in order to use ArcSWAT model output as input to the WEAP hydrological parameters, and improve thus the hydrological modeling within WEAP. The MWI staff has been trained on multiple aspects: how to develop a groundwater balance model in WEAP in order to quantify over-abstraction and unmet demand, how to estimate water demands and supply requirements of the various sectors (domestic, agricultural, industrial), how to simulate the water cycle components in WEAP and further import ArcSWAT outputs in WEAP to strengthen these simulations, how to set-up basic ArcSWAT models, how to build future scenarios in WEAP and estimate water demand projections based on proxy data, how to link the WEAP-ArcSWAT models.

The training was well received, and the participants further developed their skills. They now have the ability to deal with different parameters and variables that define the conceptual design and structure of river basin water resources management model in WEAP and ArcSWAT. They are now able to develop small scale simulations of water balance and simulate future scenarios of water demand and availability.





## 8 ANNEXES

### 8.1 AGENDA

Day 1: Opening and Overview		
9:00	Registration	All Participants
9:30	Opening Session Welcome Speech from MWI coordinator Opening Remarks Formulation of the Working Groups	
10:00	Demonstration of WEAP Model for AZ-Basin (Case Study for measuring groundwater over-abstraction) <ul style="list-style-type: none"><li>• Catchment principle in WEAP</li><li>• Data integration of Evapotranspiration (ET), Precipitation (PPT) and Effective rainfall.</li></ul>	
11:30	<b>Break</b>	
12:00	<ul style="list-style-type: none"><li>• Actual Abstraction VS Simulation</li><li>• Calculating the GW Over-abstraction using Unmet Demand (New model thinking)</li><li>• Estimation of all Water cycle elements (ET, PPT, Runoff, GW-recharge)</li></ul>	
12:30	<b>Break</b>	
13:30	Exercise for Calculating Water Budget by WEAP <ul style="list-style-type: none"><li>• Simplified Rainfall-Runoff Model</li><li>• Setting up (data and methods)</li><li>• Showing Results and Discussion</li></ul>	
15:00	<b>Wrap up of Day 1</b>	



DAY 2: Hydrological Modeling Using ArcSWAT		
9:30	Day 2 Sessions	Working Group 1
10:00	Working Group 1: ArcSWAT Hydrological Modeling <ul style="list-style-type: none"> <li>• SWAT model overview and applications               <ul style="list-style-type: none"> <li><input type="checkbox"/> Data Requirements, Format and Data Sources</li> <li><input type="checkbox"/> Conceptual Design of Hydrology in ArcSWAT</li> </ul> </li> </ul>	
<b>11:00</b>	<b>Break</b>	
11:30	ArcSWAT Modeling Procedures (Part 1) <ul style="list-style-type: none"> <li><input type="checkbox"/> Watershed delineation</li> <li><input type="checkbox"/> Land use and soil overlay</li> <li><input type="checkbox"/> HRU delineation</li> <li><input type="checkbox"/> Weather Data</li> <li><input type="checkbox"/> Model Run</li> </ul>	
<b>12:30</b>	<b>Break</b>	
13:30	ArcSWAT Modeling Procedures (Part 2) <ul style="list-style-type: none"> <li><input type="checkbox"/> Watershed delineation</li> <li><input type="checkbox"/> Land use and soil overlay</li> <li><input type="checkbox"/> HRU delineation</li> <li><input type="checkbox"/> Weather Data</li> </ul>	
<b>15:00</b>		
Day 3: Scenario Building Using WEAP		
9:30	Day 3 Sessions	Working Group 2
10:00	Working Group 2: WEAP Scenario Building and Strategy till 2025 <u>Building list of strategies</u> <ul style="list-style-type: none"> <li>• Drafting Water Security Plan Scenarios</li> <li>• Drafting Optimistic Scenarios</li> <li>• Drafting Future Water Projects Scenarios</li> <li>• Drafting the Business as usual Scenarios</li> </ul>	
<b>11:15</b>	<b>Break</b>	
11:45	Continued...	
<b>12:30</b>	<b>Break</b>	
13:30	Continued... <ul style="list-style-type: none"> <li>• Population Growth Scenarios</li> <li>• Fluctuations in Per-capita Water Use Scenarios</li> </ul>	
<b>15:00</b>		



DAY 4: Building WEAP Model (Linking Results from ArcSWAT with WEAP)		
9:30	Day 4 Sessions	Working Group 3
10:00	Working Group 3: WEAP-ArcSWAT Integration Visualization and interpretation of SWAT outputs <ul style="list-style-type: none"> <li>• Reading Results and integration of WEAP-ArcSWAT</li> <li><input type="checkbox"/> Input Data and Integration in WEAP</li> <li><input type="checkbox"/> Scale of Analysis</li> </ul>	
<b>11:00</b>	<b>Break</b>	
11:30	Final WEAP Model Building (Part 1) <u>Catchment Modeling (Water Supply):</u> <ul style="list-style-type: none"> <li><input type="checkbox"/> ETP Data integration with WEAP and ArcSWAT</li> <li><input type="checkbox"/> Calculating GW-Recharge Rates</li> <li><input type="checkbox"/> Calculating Surface Runoff</li> <li><input type="checkbox"/> Model Run</li> </ul>	
<b>12:30</b>	<b>Break</b>	
13:30	Final WEAP Model Building (Part 2) <u>Demand Modeling (Water Demands):</u> <ul style="list-style-type: none"> <li><input type="checkbox"/> Identifying Demands (Domestic, Agriculture and Industrial); Defining Activity Level and the water use rate</li> <li><input type="checkbox"/> Linking Demand-Supply Model</li> <li><input type="checkbox"/> Model Run</li> </ul>	
<b>15:00</b>		
Day 5: Scenario Building of WEAP		
9:30	Day 5 Sessions	Working Group 3
10:00	Final WEAP Model Building (Part 3) <u>Scenarios Integration (Different Options for Future):</u>	
<b>11:15</b>	<b>Break</b>	
11:45	Continued...	
<b>12:30</b>	<b>Break</b>	
13:30	Continued... <ul style="list-style-type: none"> <li>• Model Rrun</li> <li>• Discussion of the Results</li> <li>• Revision</li> </ul>	
<b>15:00</b>		



## 8.2 LIST OF PARTICIPANTS

COUNTRY	TYPE OF INSTITUTION (please use the options provided*)	TITLE (Mr/Ms )	FIRST NAME	LAST NAME	POSITION/ FUNCTION	ORGANISATION/ INSTITUTION	EMAIL
Jordan	GOVERNMENT AGENCIES	Ms	Razan	Alroud	GIS and Modeling	GIS and Modeling	<a href="mailto:razan_alroud@mwi.gov.jo">razan_alroud@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Mr	Ali	Ghanim	Policies and Strategic planning Directorate	Policies and Strategic planning Directorate	<a href="mailto:ali_ghanim@mwi.gov.jo">ali_ghanim@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Enaam	Batayneh	Water Demand Management	Water Demand Management	<a href="mailto:enaam_batayneh@mwi.gov.jo">enaam_batayneh@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Fatin	Shaban	Water Demand Management	Water Demand Management	<a href="mailto:fatin_shaban@mwi.gov.jo">fatin_shaban@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Wafa'	Shehadeh	Environment and Climate Change	Environment and Climate Change	<a href="mailto:fy7671@yahoo.com">fy7671@yahoo.com</a>
Jordan	GOVERNMENT AGENCIES	Ms	Ghadeer	Arafat	GIS and Modeling	GIS and Modeling	<a href="mailto:ghadeer_arafat@mwi.gov.jo">ghadeer_arafat@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Hadeel	Smadi	Policies and Strategic planning Directorate	Policies and Strategic planning Directorate	<a href="mailto:hadeel_smadi@mwi.gov.jo">hadeel_smadi@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Mr	Mohammad	Almasri	Water Resources Study Department	Water Resources Study Department	<a href="mailto:mohammad_almasri@mwi.gov.jo">mohammad_almasri@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Najah	Seelawi	Water Resources Study Department	Water Resources Study Department	<a href="mailto:najah_seelawi@mwi.gov.jo">najah_seelawi@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Maysa	Subah	GIS and Modeling	GIS and Modeling	<a href="mailto:maysaali@yahoo.com">maysaali@yahoo.com</a>
Jordan	GOVERNMENT AGENCIES	Ms	Safa'	Alshraideh	Policies and Strategic planning Directorate	Policies and Strategic planning Directorate	<a href="mailto:safa-alshraideh@mwi.gov.jo">safa-alshraideh@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Mona	Dahabiyeh	Modeling Department	Modeling Department	<a href="mailto:mona-dahabiyeh@mwi.gov.jo">mona-dahabiyeh@mwi.gov.jo</a>
Jordan	GOVERNMENT AGENCIES	Ms	Helda	Al-Shakatreh	Policies and Strategic planning Directorate	Policies and Strategic planning Directorate	<a href="mailto:hilda_alshakatreh@mwi.gov.jo">hilda_alshakatreh@mwi.gov.jo</a>