German-Lebanese Technical Cooperation Project

Protection of Jeita Spring

WEAP Balance of the Jeita Groundwater Contribution Zone, Lebanon

- A DSS to improve Water Resources Management -

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ECHN Early Career Hydrogeologists' Network

(1): Federal Institute for Geosciences and Natural Resources (BGR)

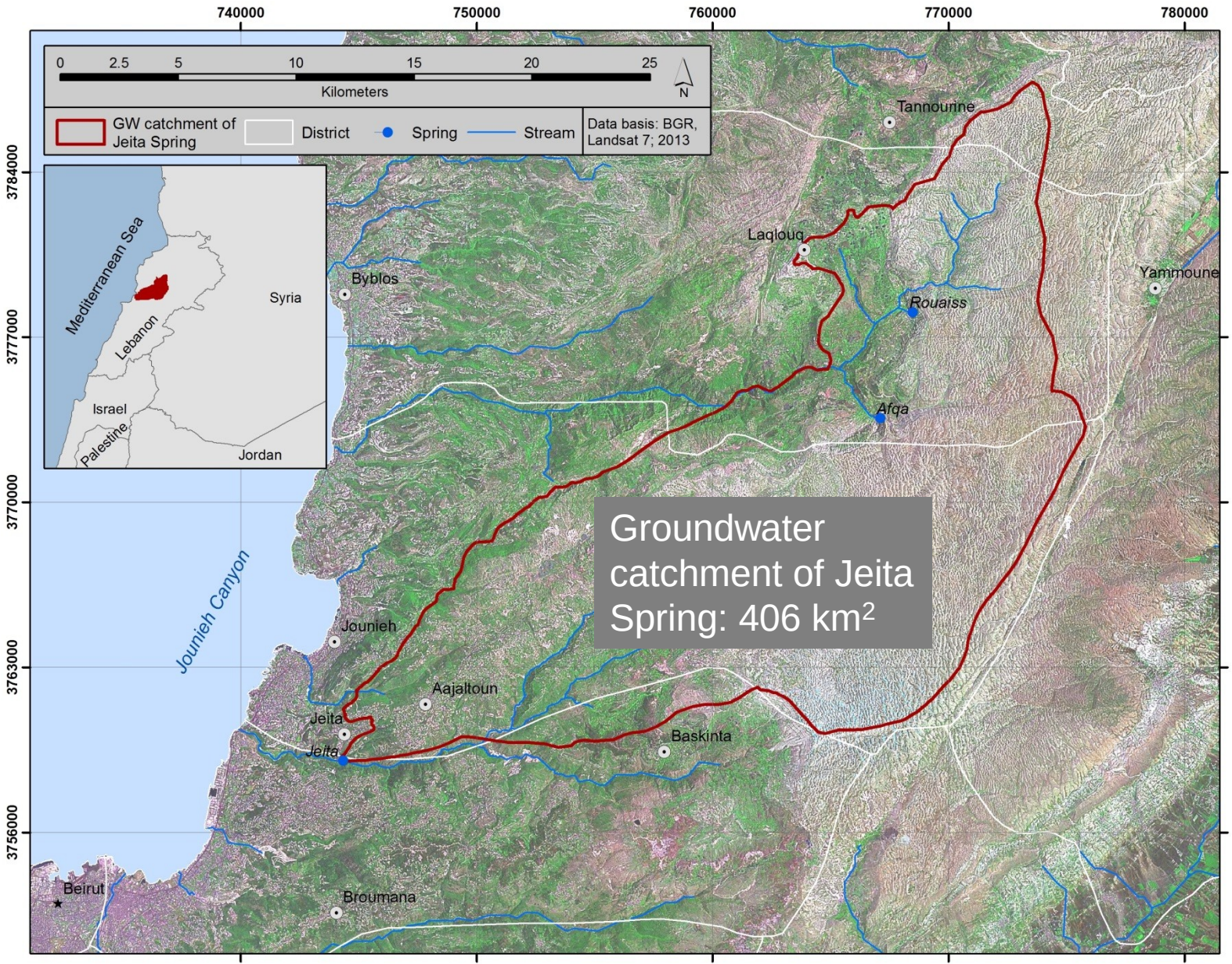
Outline

- Study Area
- Problem Statement
- Model Objectives
- Methodology: WEAP Model
- Results
  - Water Balance
  - Climate Change Scenario
  - MAR Option
- Conclusion

I. Introduction

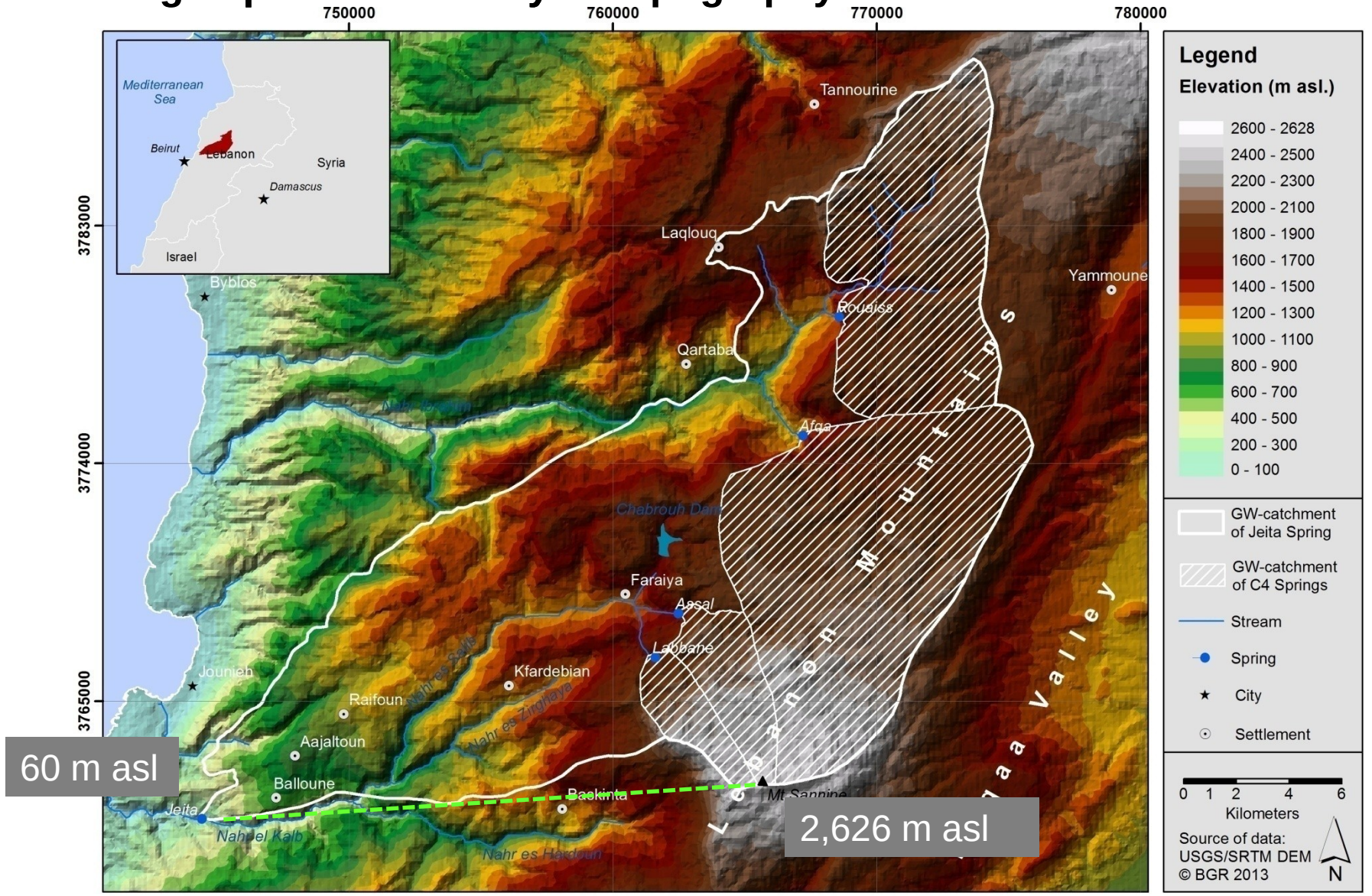
- Jeita Spring provides approx. 75% of Beirut's drinking water
- Karst spring draining the Jurassic (J4) aquifer
- Seasonal variation of discharge:
  - Rainy season OCT – APR
  - Dry season JUN – SEP
- **Short term challenges:**
  - At present (water year 2014) **extreme water shortage**:
    - - 40% of average rainfall (2013)
    - - 75% of average (2011-2013) discharge of Jeita Spring
  - Rapid increase of water demand: influx of Syrian refugees (> 1.1 Mio)
- **Long term challenges**
  - Climate Change

II. Study Area



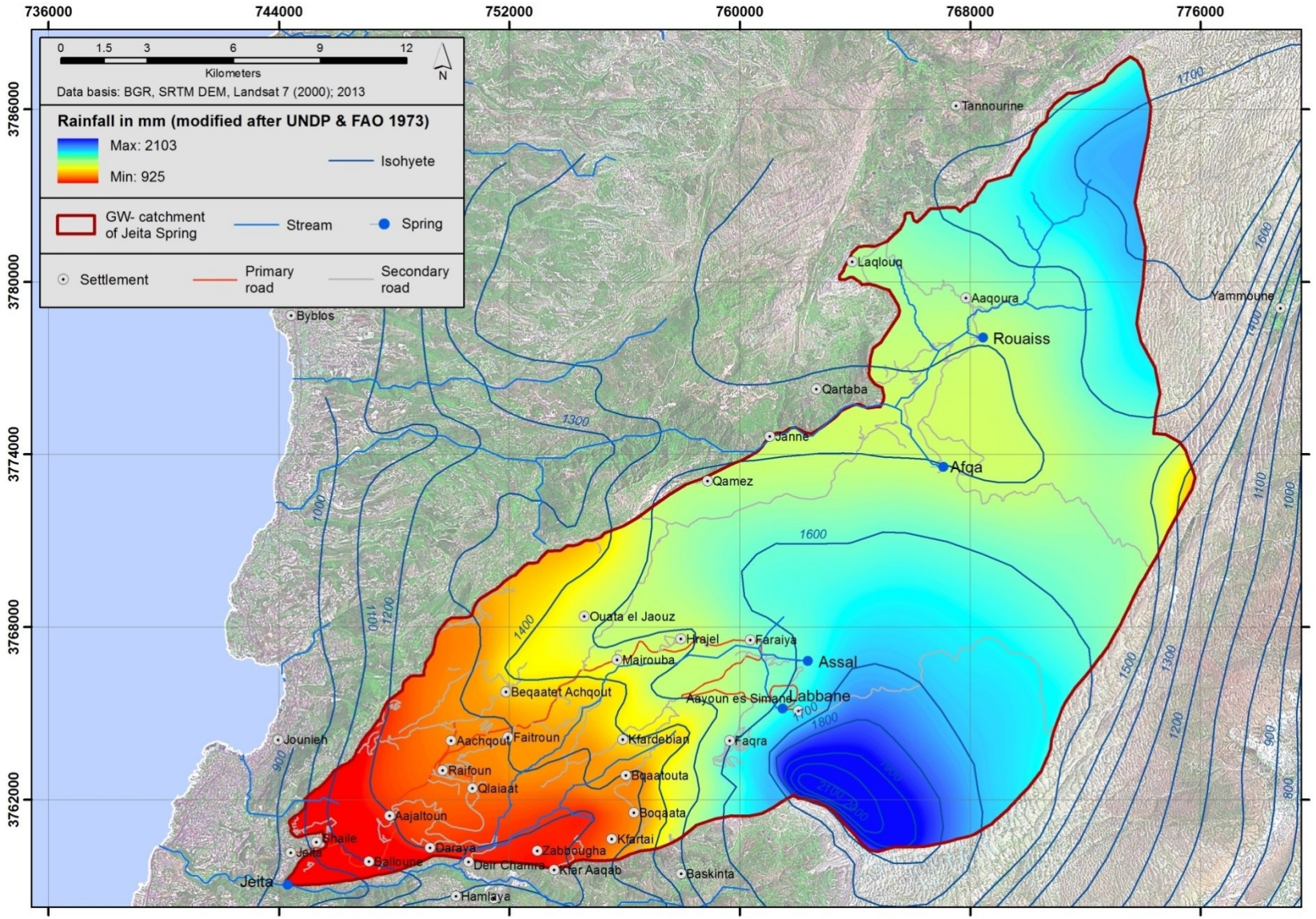
II. Study Area

- **High spatial variability of topography**



II. Study Area

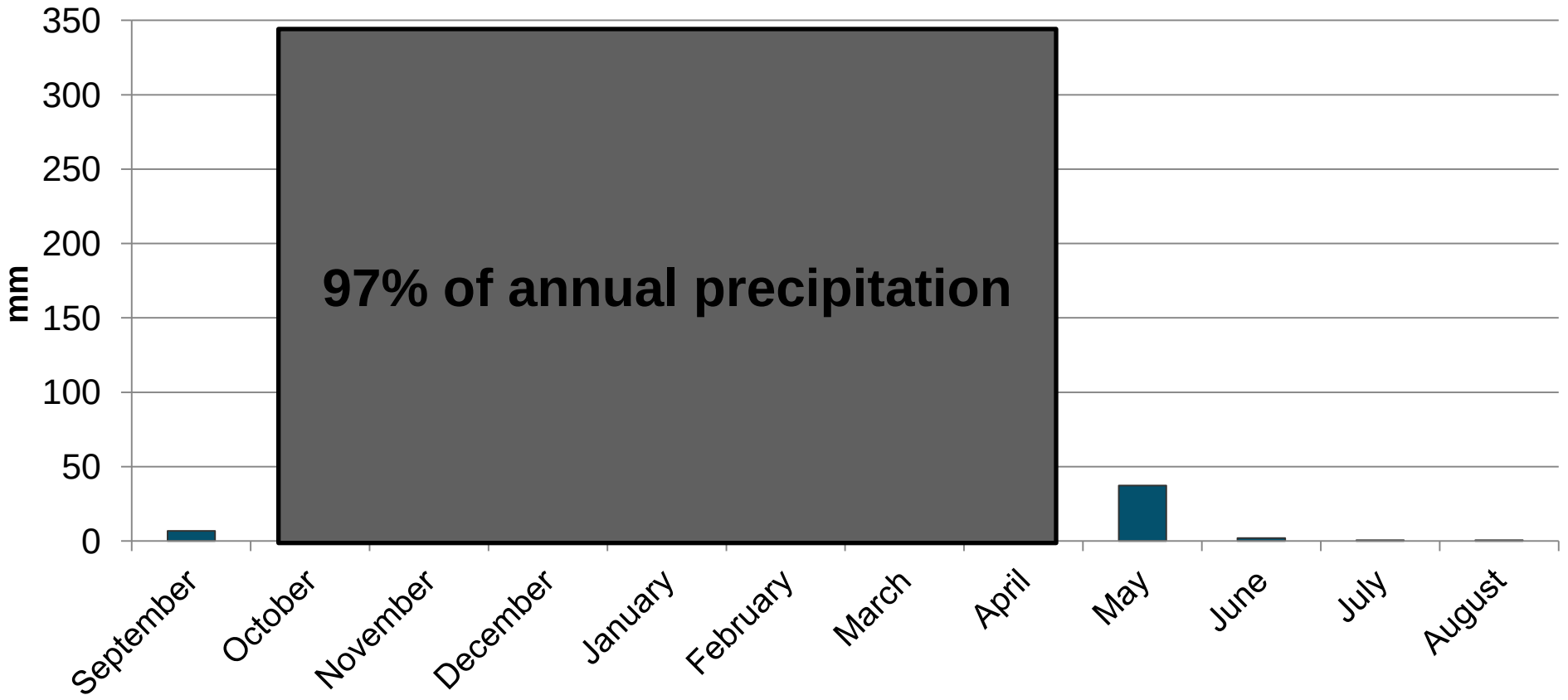
- **High spatial variability of precipitation**



II. Study Area

- **High temporal variability of precipitation**

Mean monthly precipitation in the Jeita catchment in mm



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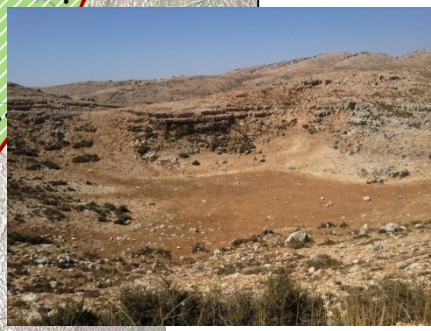
II. Study Area

- **High karstification of the Jurassic (J4) and Cretaceous (C4)**

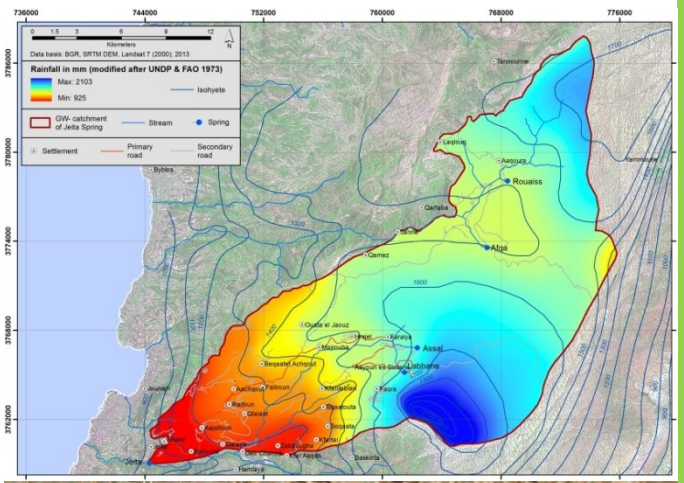
J4 (Ibrahim Valley)



C4 plateau

III. Problem Statement

- **Quantity of Jeita discharge influenced by:**



Hydrogeology & Ecosystem — **Climate: present & future**

Agriculture

Domestic

III. Problem Statement

- **Seasonal variation of discharge of Jeita Spring**

Available resources for supply management*

?

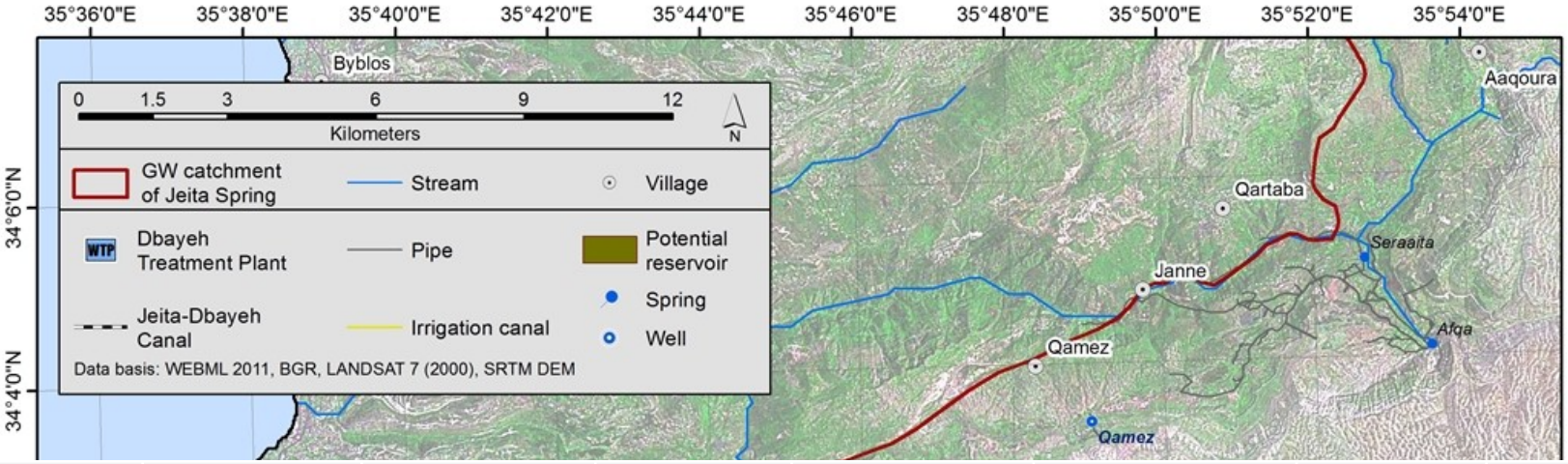
***Demand management poorly developed in Lebanon**

IV. Model Objectives

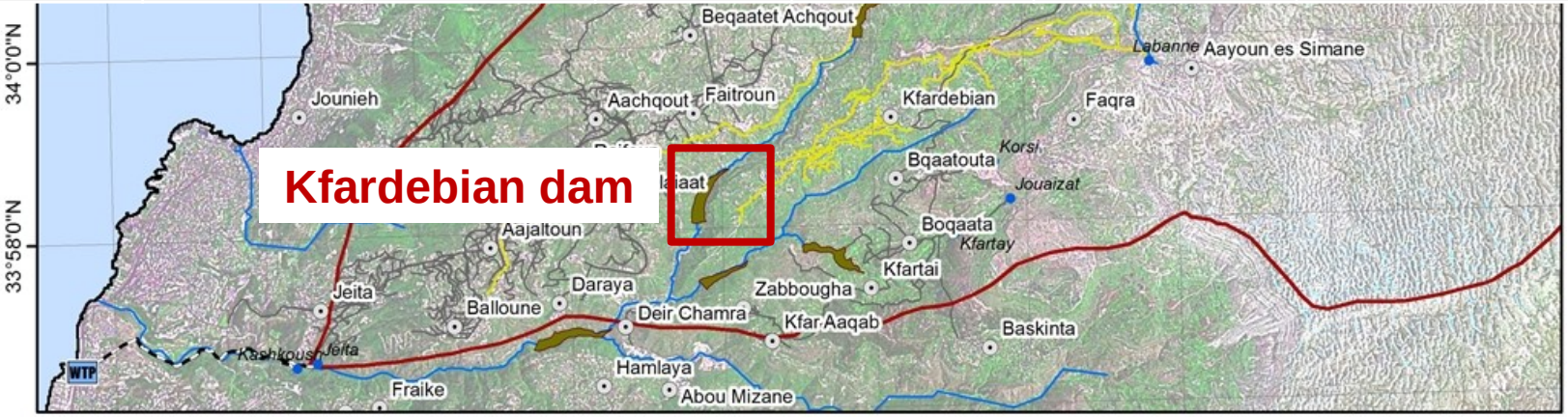
- Hydrological balance/budget on a monthly basis
  - Quantification of hydrological components:
    - Rainfall
    - Evapotranspiration
    - Surface runoff
    - GW recharge
  - Quantification of domestic & agricultural demand/supply
- Origin of Jeita's groundwater
- Future scenarios: Climate Change
- Water management options: MAR

IV. Model Objectives

- **MAR Dams**



Dam	Elevation [m asl]	Dam crest [m]	Storage [MCM]	Surface area [m²]	Catchment [km²]	Rainfall [mm/a]	Rain volume [MCM/a]
Kfardebian	720	100	7.3	225	91	1,565	142

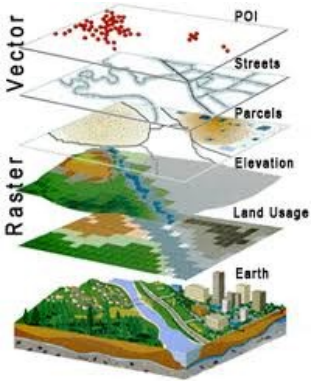


V. WEAP Model

- **W**ater **E**valuation **A**nd **P**lanning 
- Non-commercial software
- Developed by the Stockholm Environment Institute
- Used within the MENA region:
  - Jordan, Morocco, Tunisia, Palestine, Syria
- Conceptual in- & output model
- Modelling of hydrological budget:
  - Time step: daily to annual
- Natural and anthropogenic supply and demand
- Scenario development
- **Groundwater balance**

V. WEAP Model

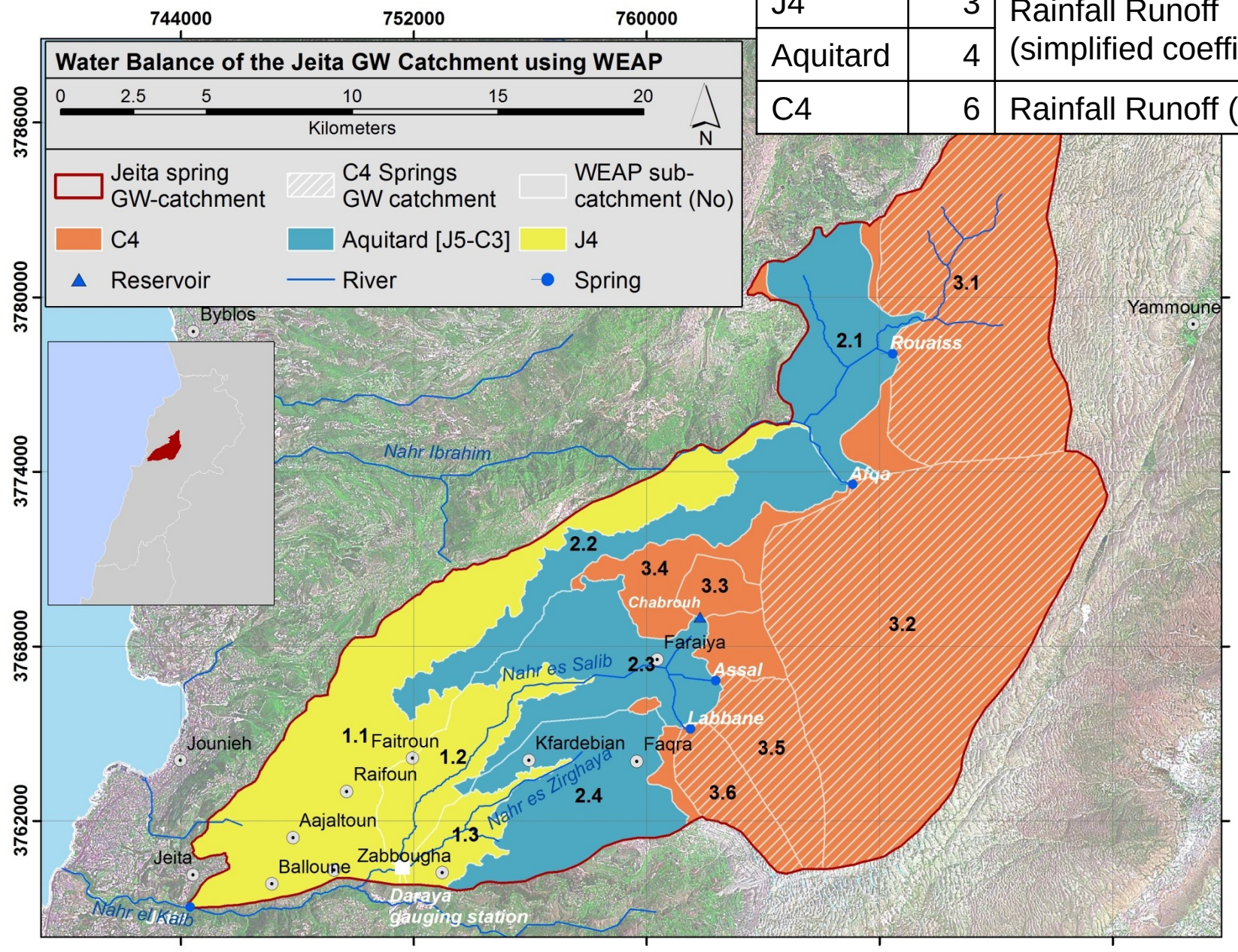
- Discretisation: sub-division into 13 sub-catchments:
  I. Hydrogeology
  II. Surface runoff
  III. Spring- & reservoir catchments



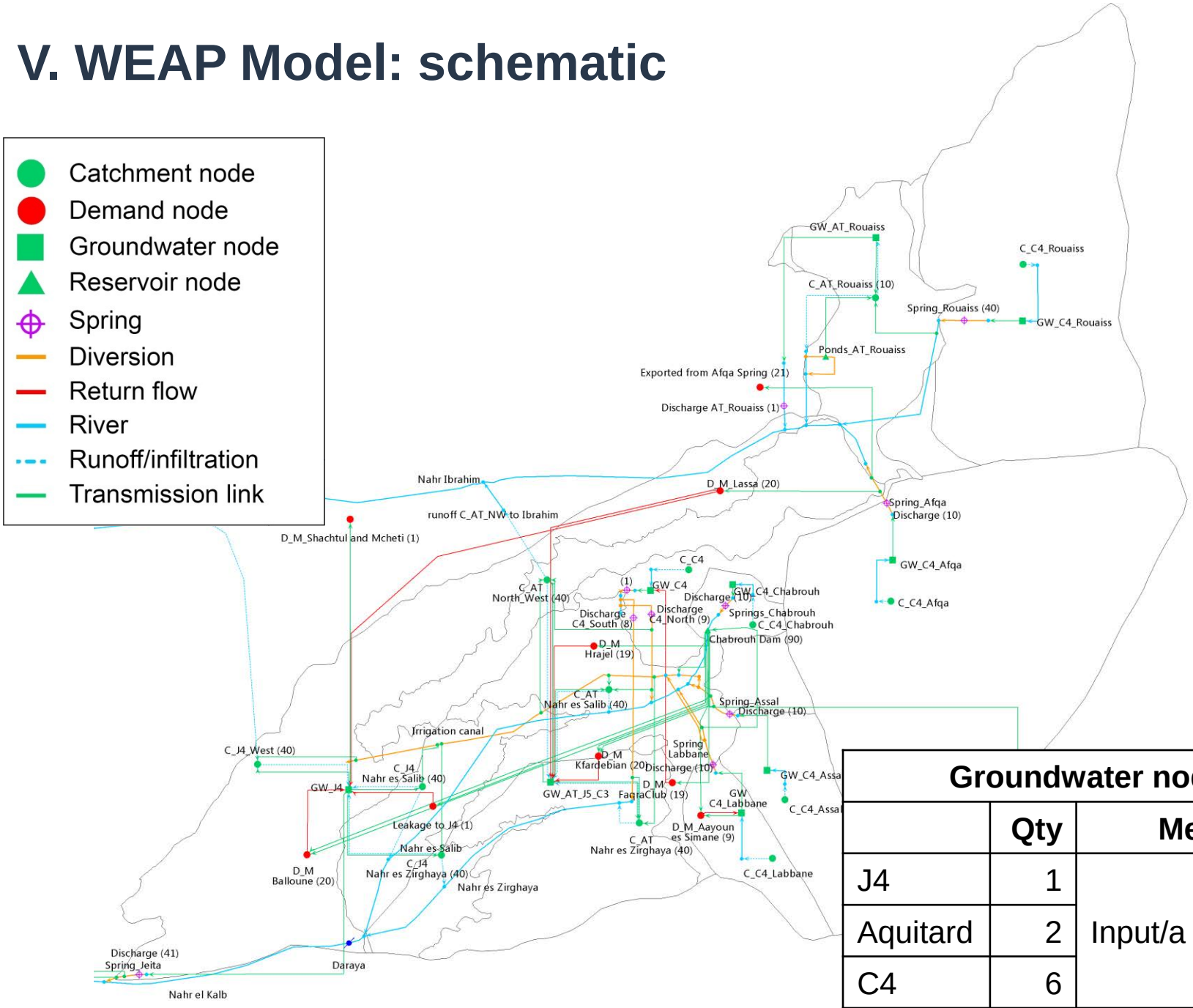
- Reflect spatial variability:
  - Topography
  - Hydrogeology: Aquifer /Aquitard
  - GW recharge
  - Climate
- Calibration: groundwater discharge, stream flow

V. WEAP Model

Catchment nodes		
	Qty	Method
J4	3	Rainfall Runoff (simplified coefficient
Aquitard	4	
C4	6	Rainfall Runoff (soil moisture)



V. WEAP Model: schematic



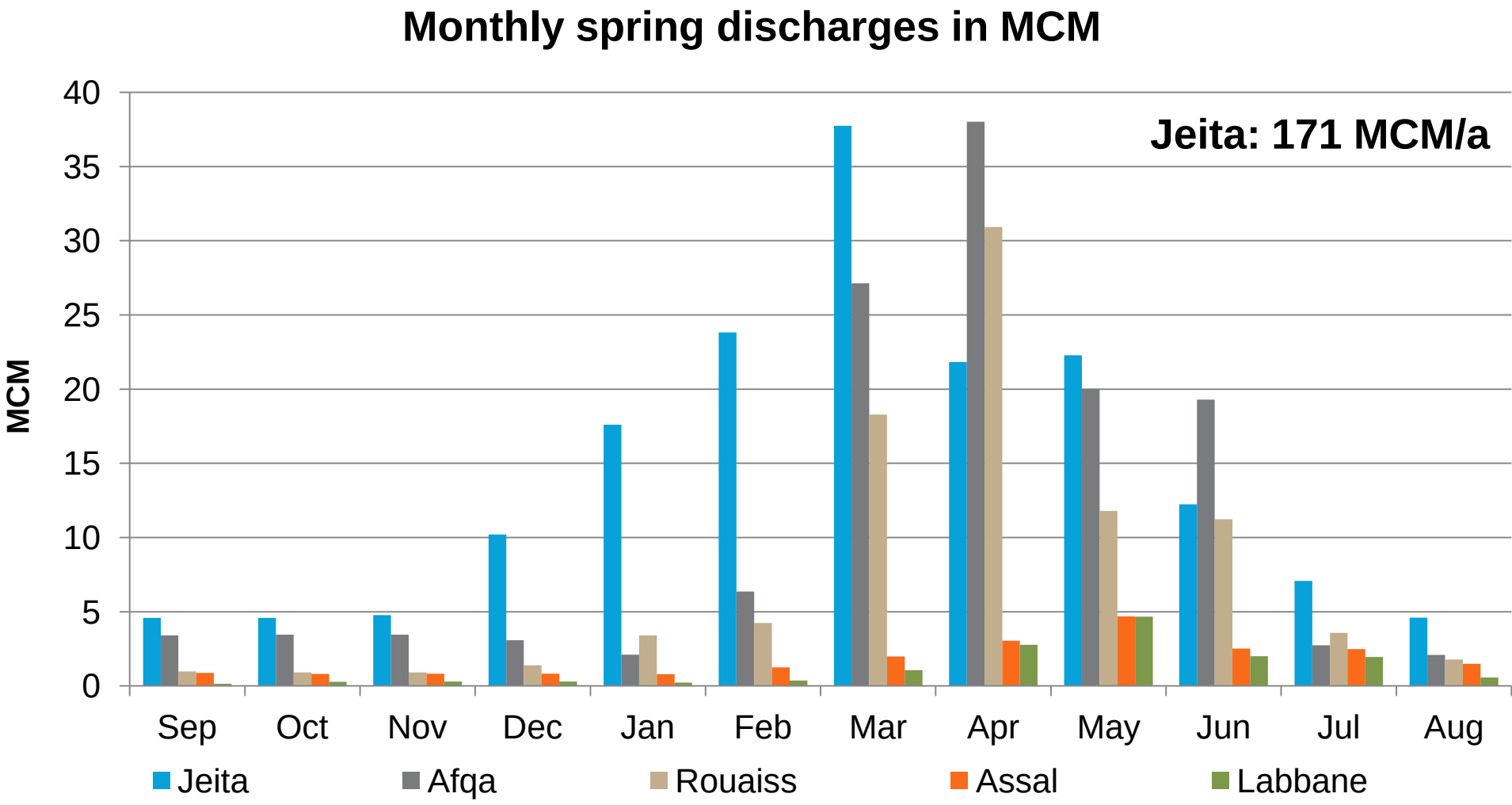
Groundwater nodes		
	Qty	**Method**
J4	1	Input/a = output/a
Aquitard	2	
C4	6	

Multiparameter probes
parameters:
Water level
Temperature
EC
pH
ORP
DO
(ammonium)
(ISE)

Telemetric data transfer

- multiparameter probes
- gauging stations (weir, ADCPs)
- direct discharge measurement (> 300 dilution tests)

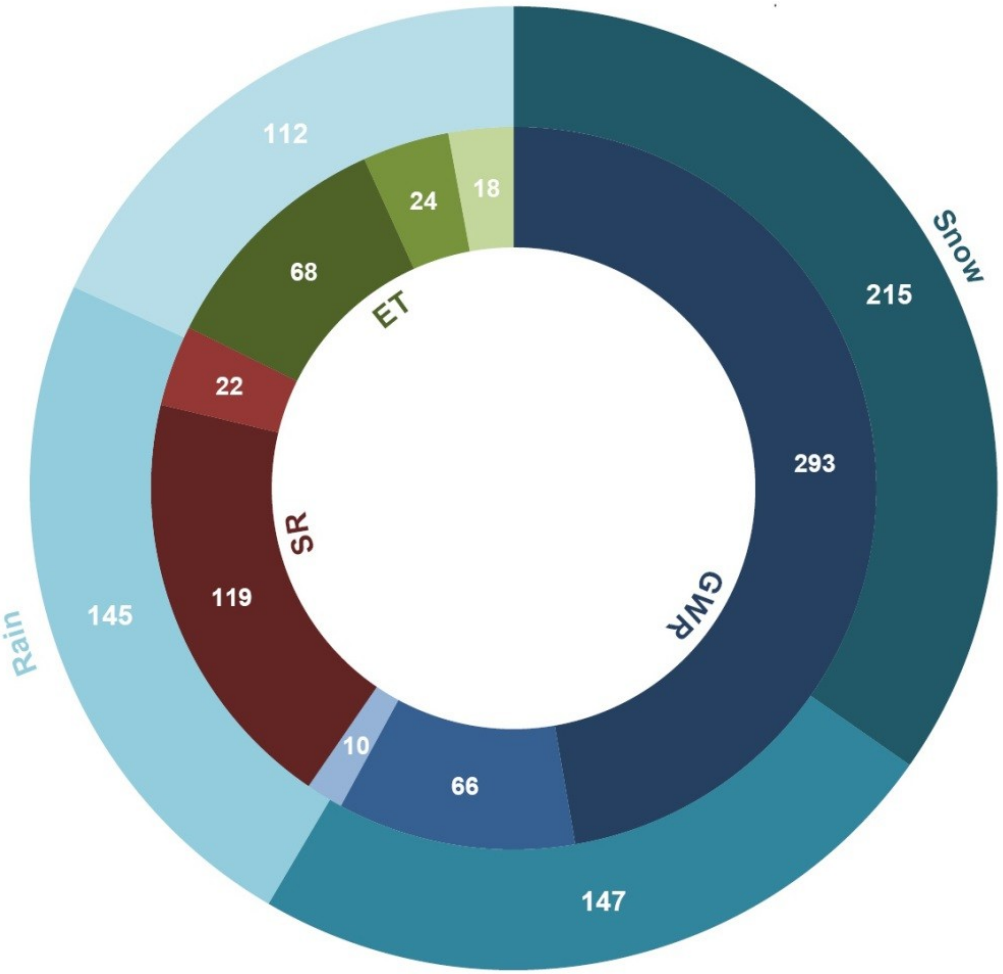
VI. Results: Water Balance



VI. Results: Water Balance

Annual natural in- & output from the Jeita GW catchment in MCM

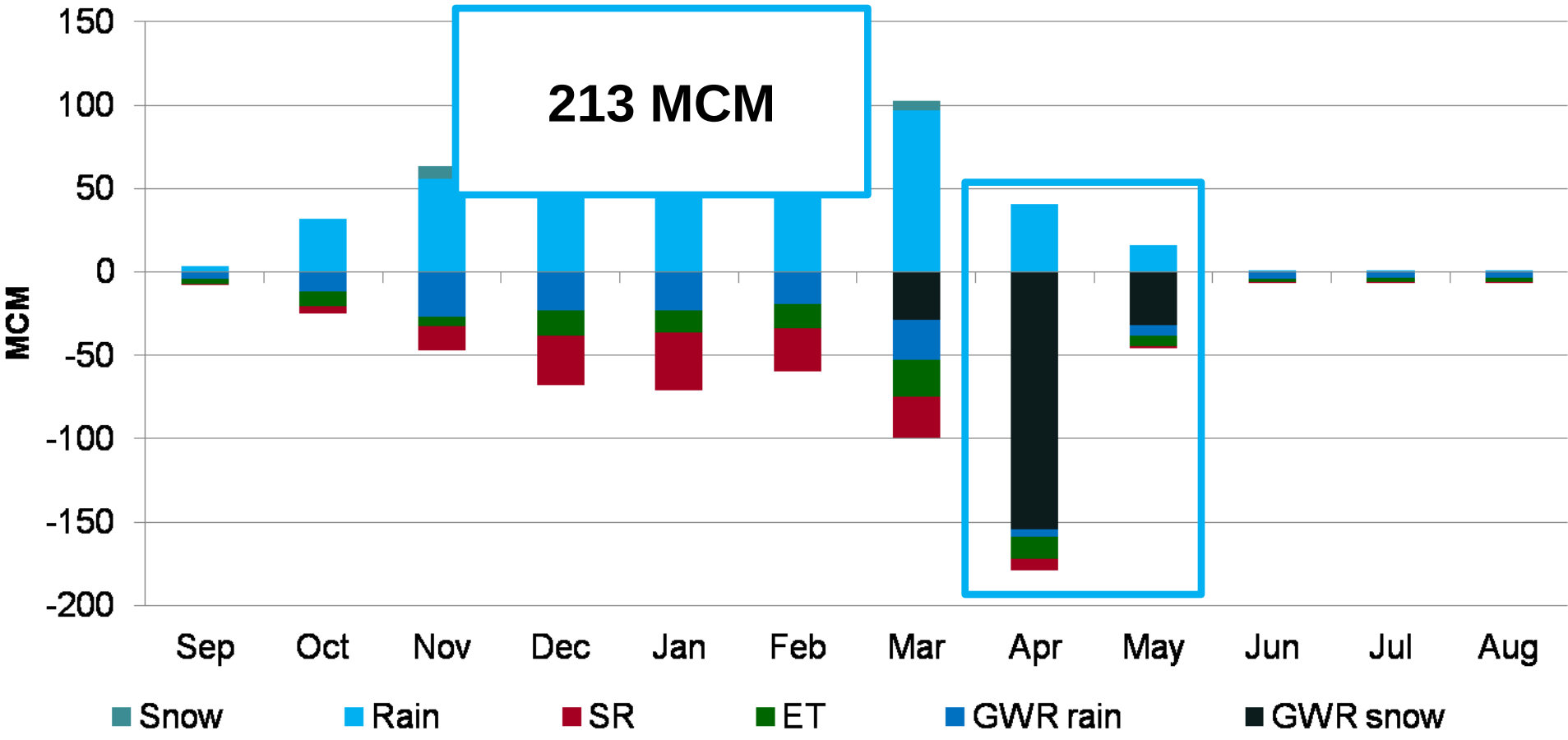
Hydrogeol. unit	GWR in %	SR in %	ET in %
Upper Aquifer (C4)	81.3	0.0	18.7
Aquitard Complex	7.0	80.8	12.2
Lower Aquifer (J4)	58.7	20.0	21.3



http://www.bgr.bund.de/jeita

VI. Results: Water Balance

Monthly in- & output from the Jeita GW catchment in MCM



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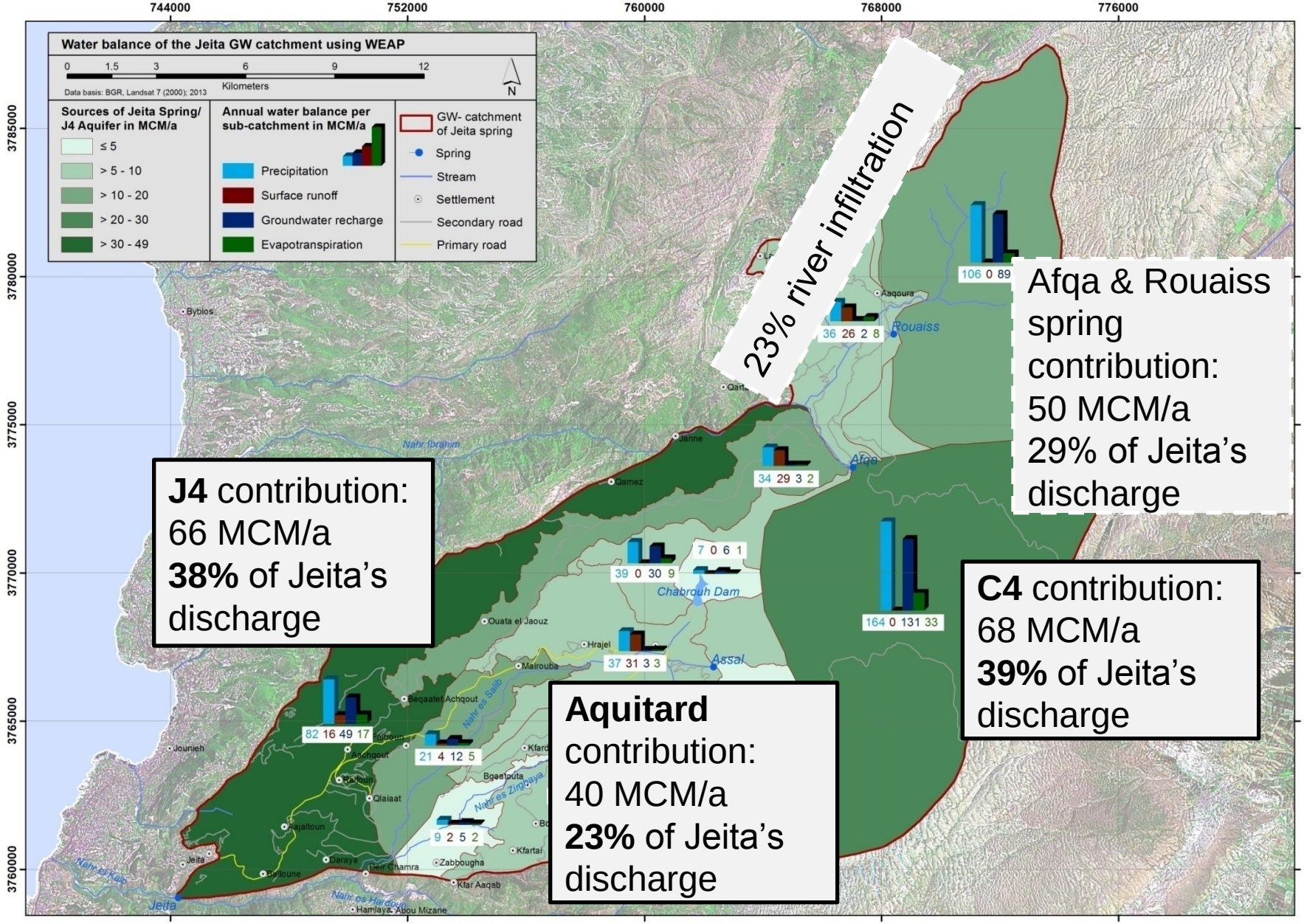
VI. Results: Water Balance – origin of Jeita's GW



VI. Results: Climate Change Scenario

- Modelling period: 2010 to 2040
- Based on the A1B scenario ([2])
  - *Most commonly used*
  - *Based on: Beirut, Cedars, Dahr el Baidar and Zahleh*

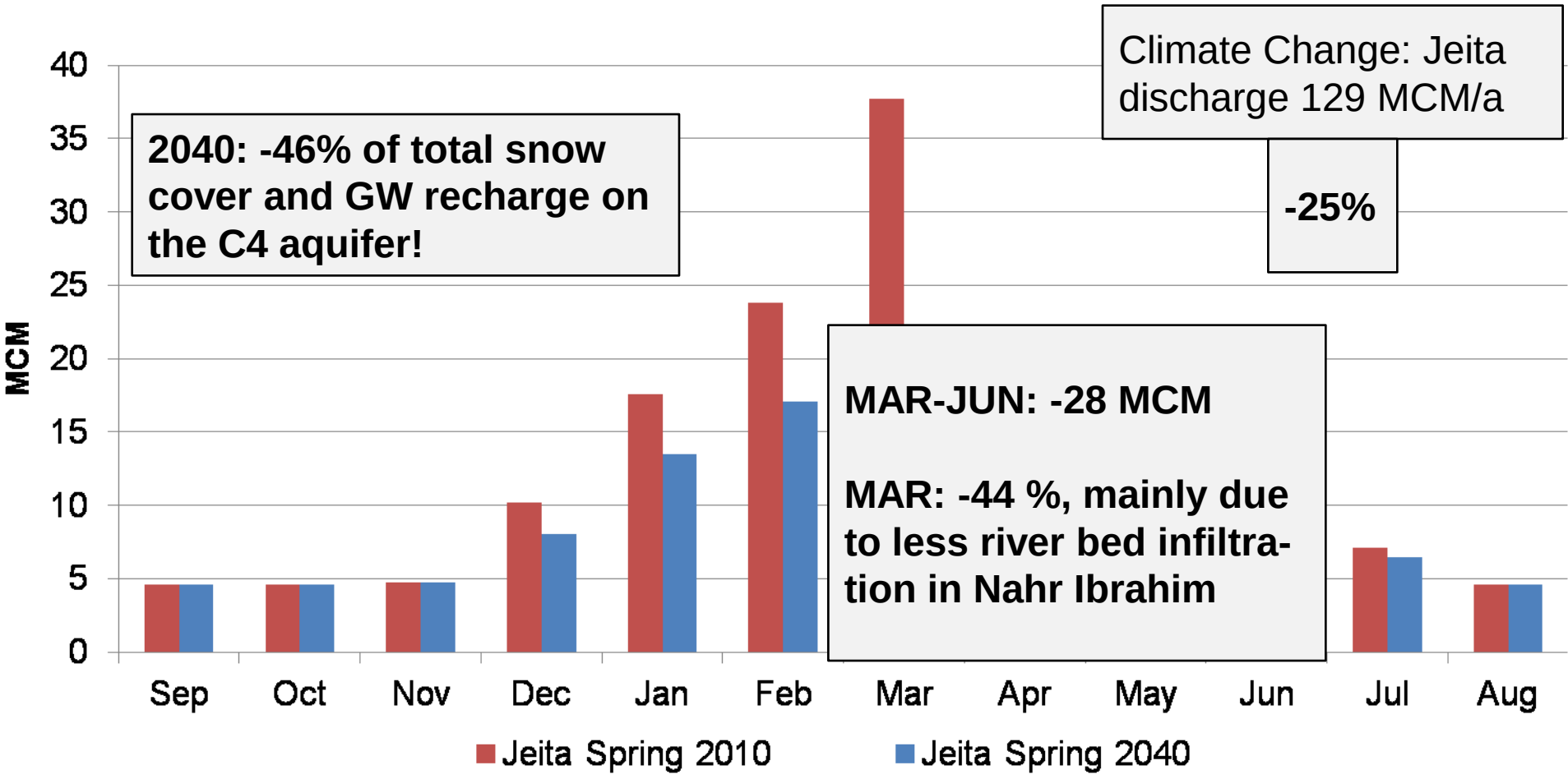
- Selected forecasts until 2040:

Precipitation (%)		Temperature (°C)	
Summer	Winter	Summer	Winter
-15	-20	+2	+1.75

([2]) MINISTRY OF ENVIRONMENT (MoE) (2011): Lebanon's Second National Communication to the UNFCCC. Republic of Lebanon, Ministry of Environment, 191 p.; Beirut/Lebanon.

VI. Results: Climate Change Scenario

Discharge of Jeita Spring: Reference vs. Climate Change Scenario in MCM



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VI. Results: MAR Option

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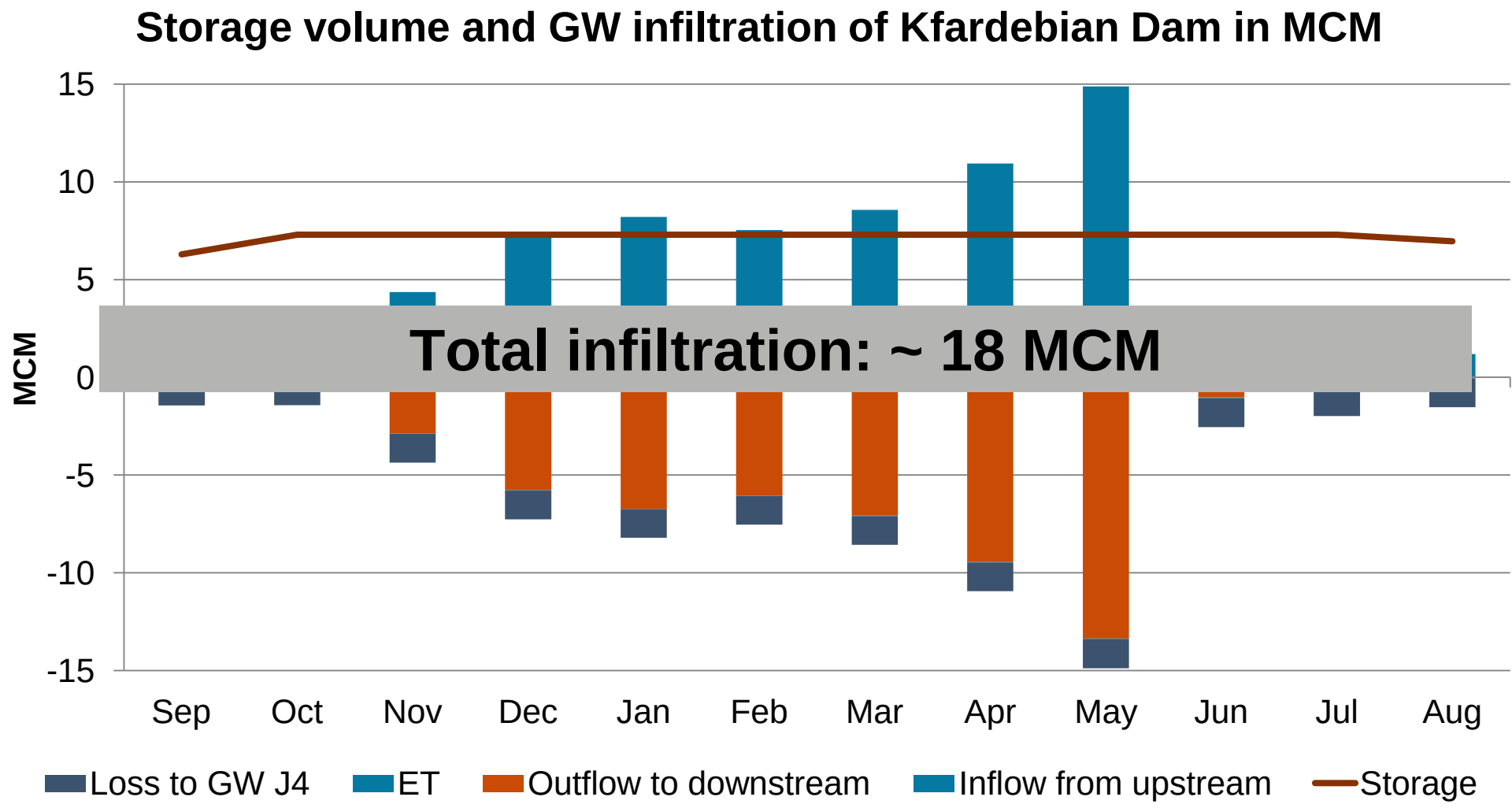

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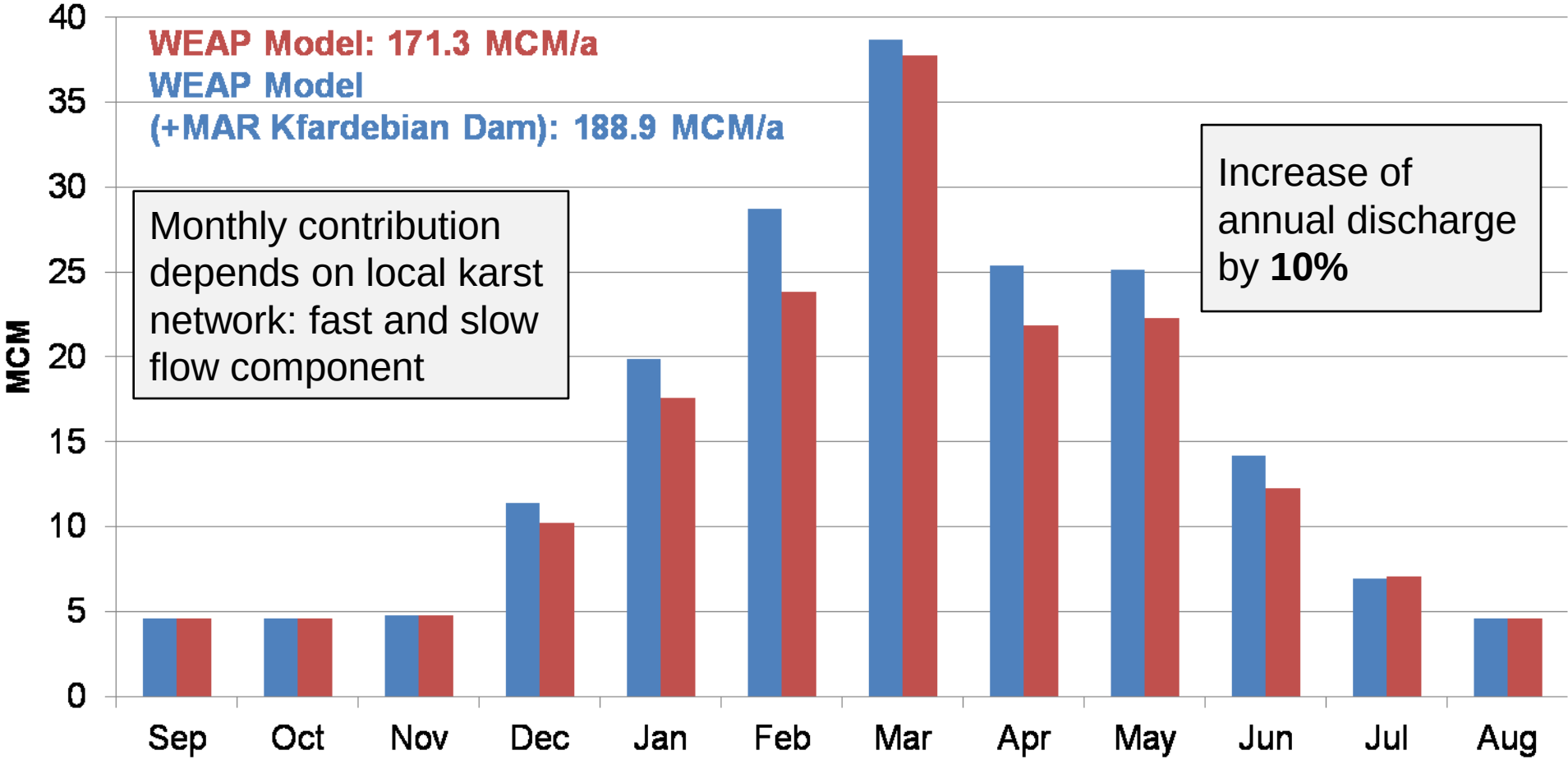
VI. Results: MAR Option

Discharge of Jeita Spring in MCM (+ Kfardebian Dam)



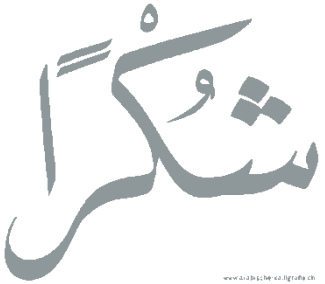
VII. Conclusion

- **Technical cooperation** offers a solid base for hydrological modelling: improved access to data & knowledge

  → Field studies important!
- Approx. 40% of Jeita's annual discharge comes from the entire **C4**
  - Approx. 28% of Jeita's annual discharge comes from Afqa and Rouaiss Spring → importance of **snow**
- Large quantities of water resources are unused: **141 MCM direct runoff** per year
- **Climate Change** (A1B Scenario):
  - *Snow cover will be reduced by 46%*
  - *Discharge of Jeita will decrease by 25% in 2040*
- Potential for **MAR**: Increasing discharge at Jeita Spring

  → for mediation of long term and short term challenges
- **WEAP** for assessment of **groundwater balance!**

Report available: http://www.bgr.bund.de/jeita



& Thank You!

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