International Conference
Hydrogeology of Arid Environments

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Water Balance for the Aleppo Basin, Syria – Implications of Land Use on Simulated Groundwater Abstraction and Recharge

A. Schlote, V. Hennings & U. Schäffer

Referee: Alexander Schlote

Bundesanstalt für Geowissenschaften und Rohstoffe

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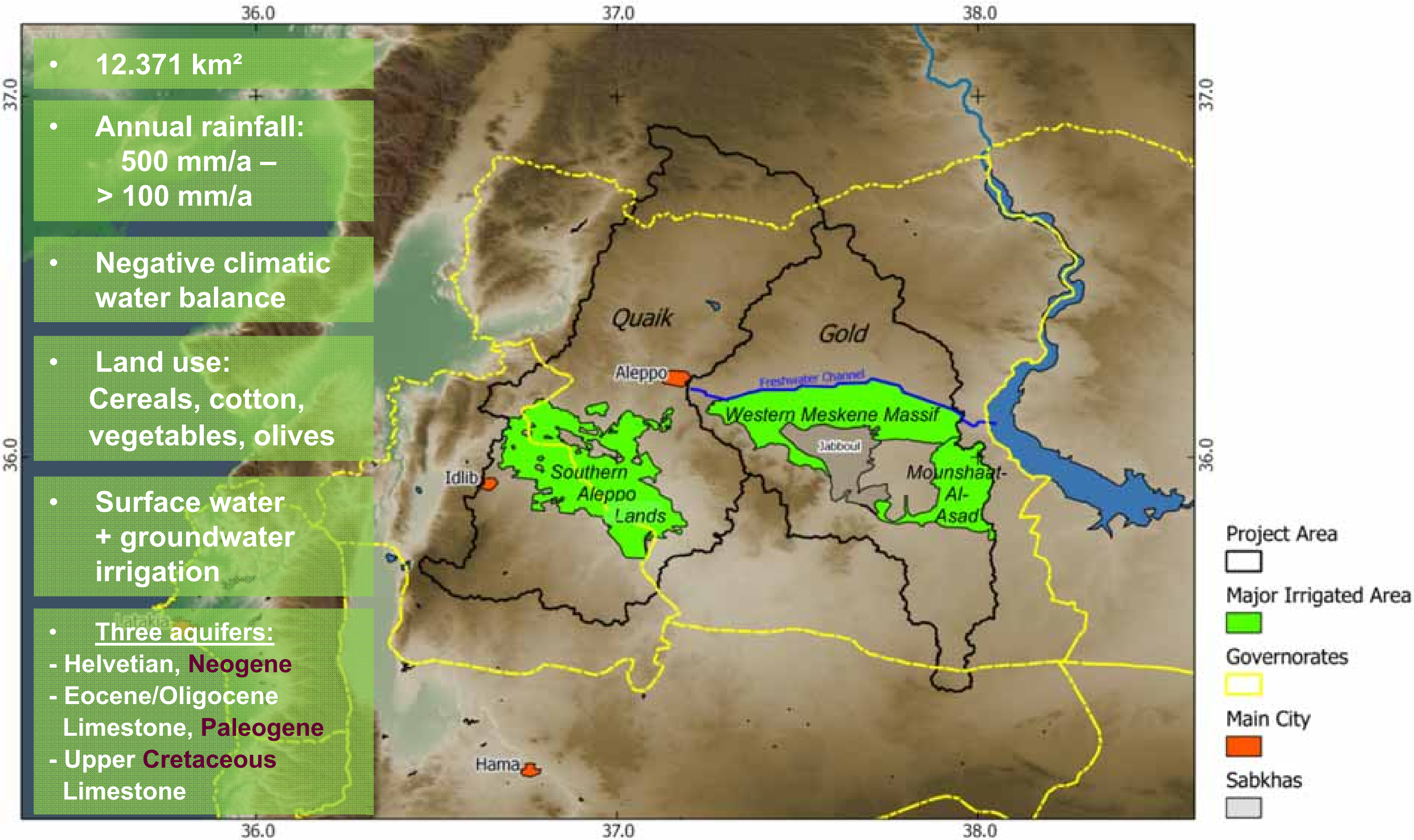
Project Area

- 12.371 km²
- Annual rainfall:
  500 mm/a –
  > 100 mm/a
- Negative climatic water balance
- Land use:
  Cereals, cotton, vegetables, olives
- Surface water + groundwater irrigation
- Three aquifers:
  - Helvetian, Neogene
  - Eocene/Oligocene Limestone, Paleogene
  - Upper Cretaceous Limestone



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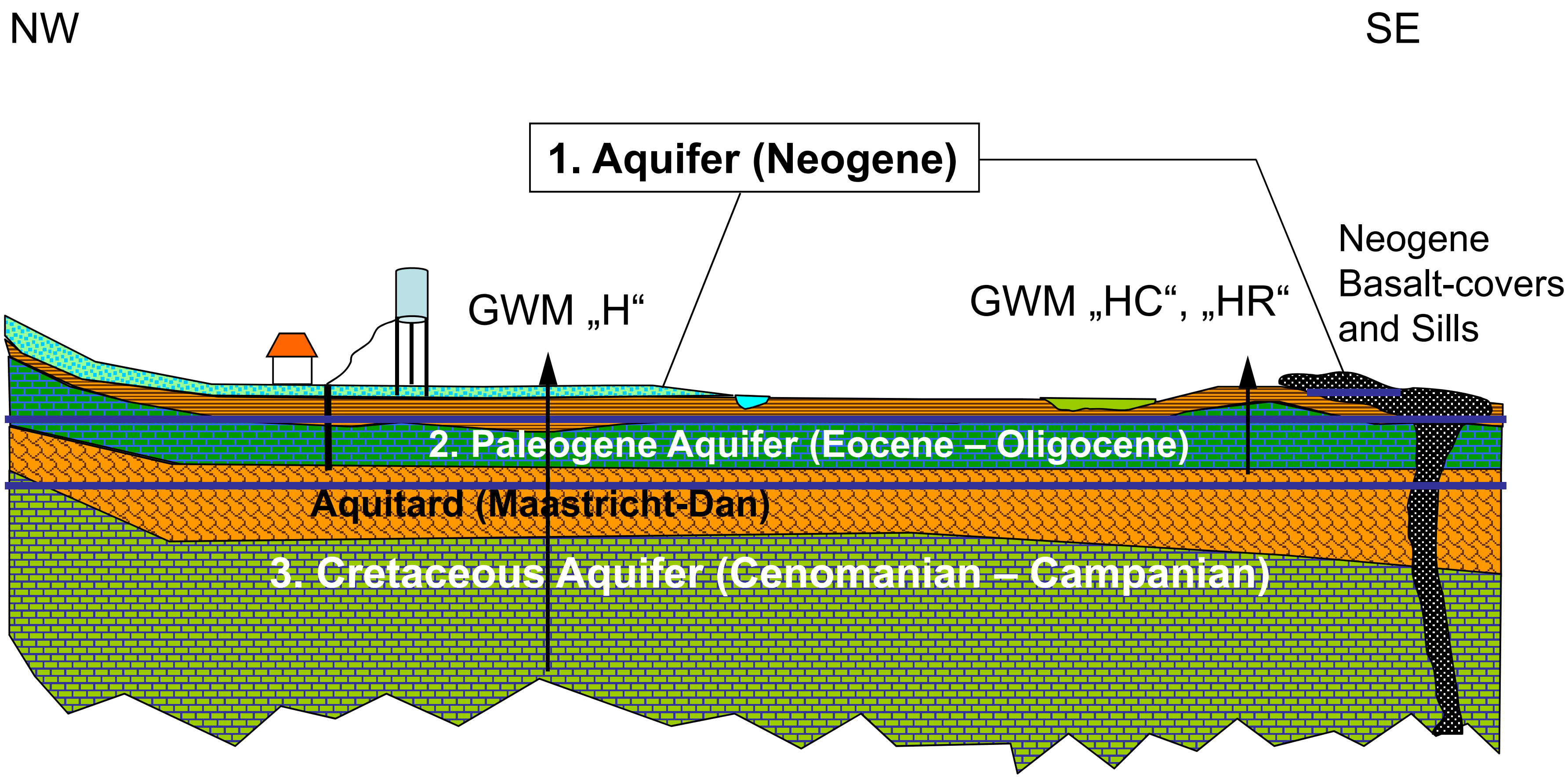
Hydrogeology in the Aleppo-Basin
(schematic)



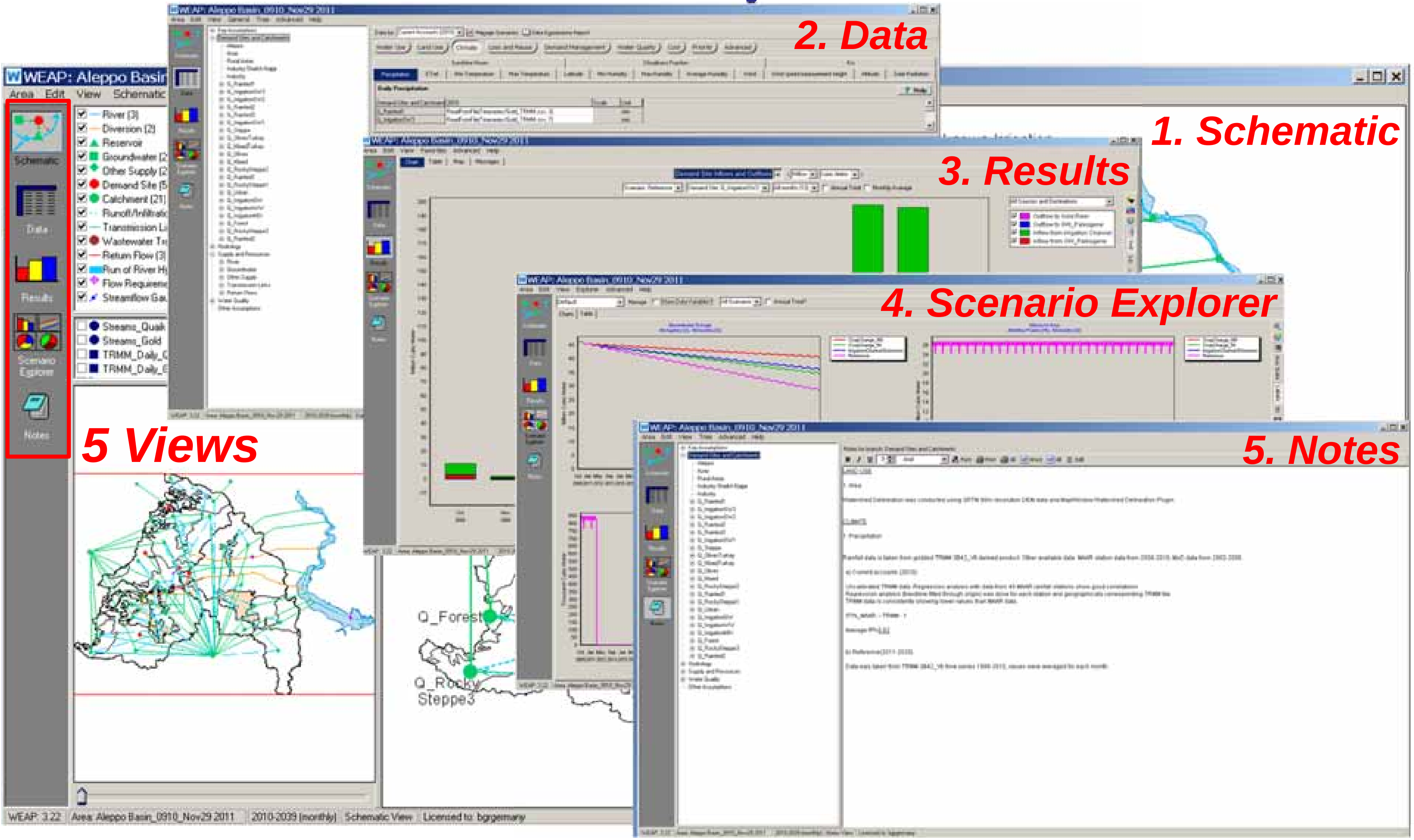
Source: F. Helms

Input data

Datasets for Aleppo Basin WEAP-Component

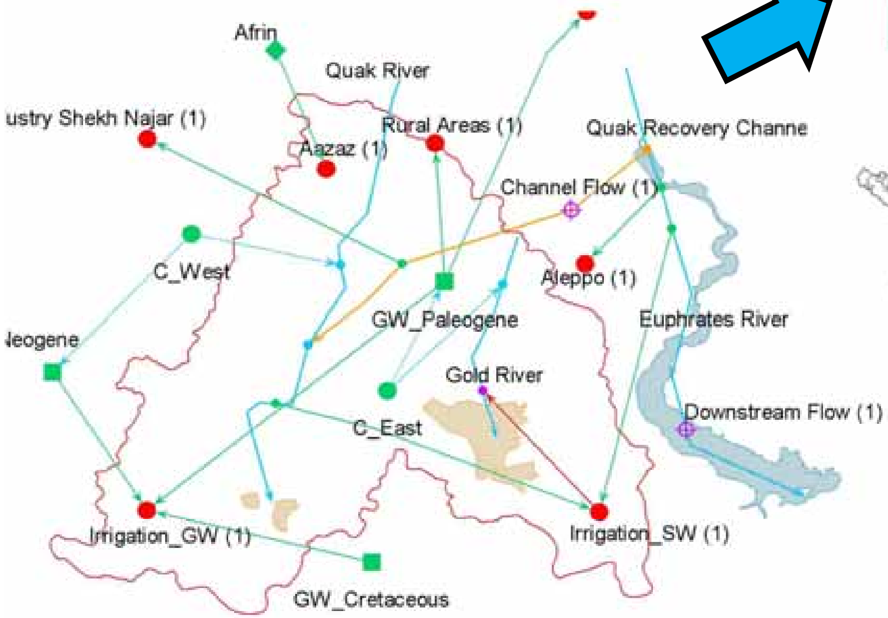
Data category	Source	Preparation Method	Result
Rainfall	- TRMM 3B42 remote sensing product	Verification with available ground measurements	Daily data, 0.25° resolution grid
Potential Evapotranspiration	- Climate station (ICARDA) - CLIMWAT (FAO)	Construction of annual isolines, regionalization of daily station data	Daily regionalized station data
Soil	- Soil maps - ICARDA report on soil resources	Digitalization of soil maps, derivation of AWC values	AWC values for each soil unit
Land Use	- LANDSAT satellite images - Land use data (MAAR)	Interpretation of satellite images, generalization	Generalized land use classification (raster)
Irrigation	- Land use map (MAAR 2003) - Irrigation area map (MoI 2002)	Delineation of irrigated areas	Shapefiles

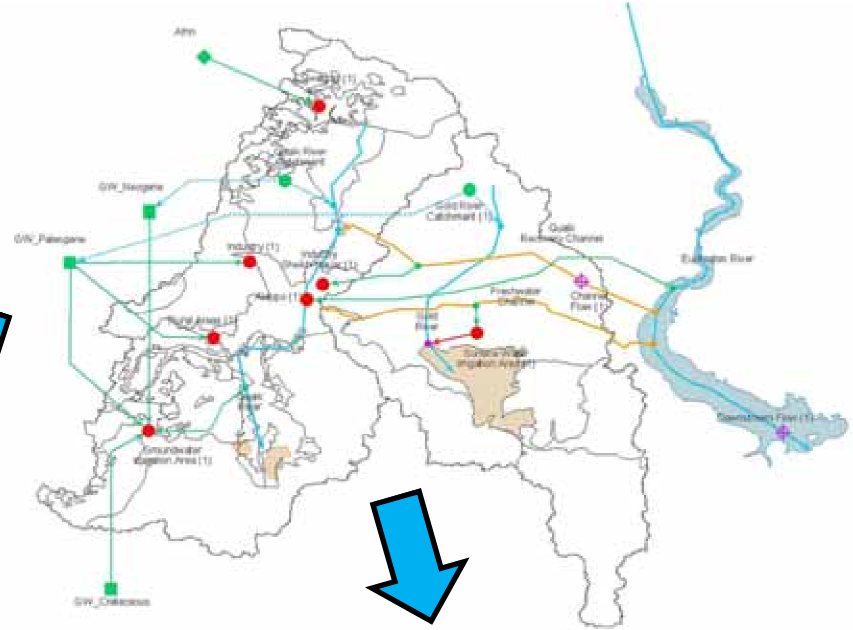
WEAP-System

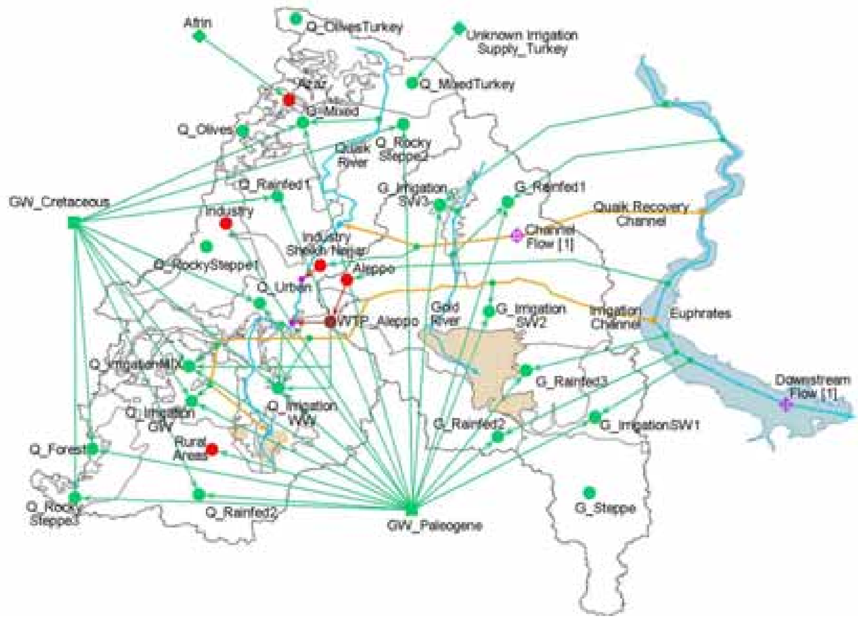


2. Data
1. Schematic
3. Results
4. Scenario Explorer
5 Views
5. Notes
WEAP: Aleppo Basin
Schematic
Data
Results
Scenario Explorer
Notes

Model development

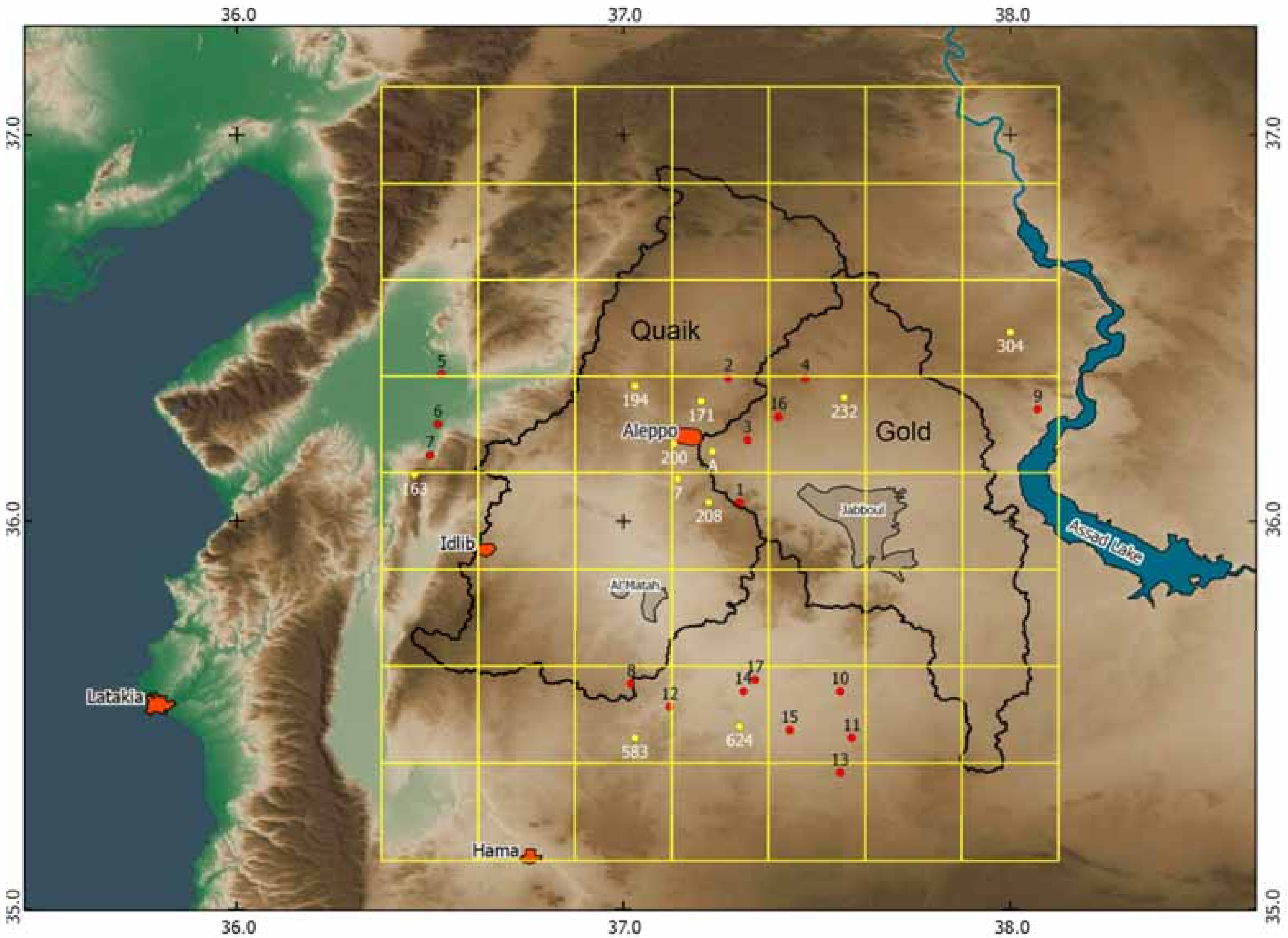




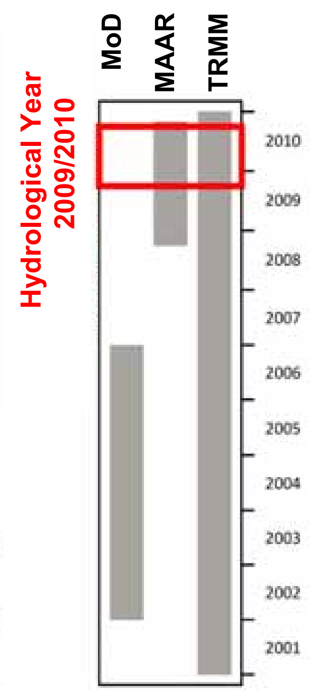


- Participatory approach
- Data availability determines model complexity

Input data: Rainfall



Data availability



MoD – Raingauge

MAAR – Raingauge

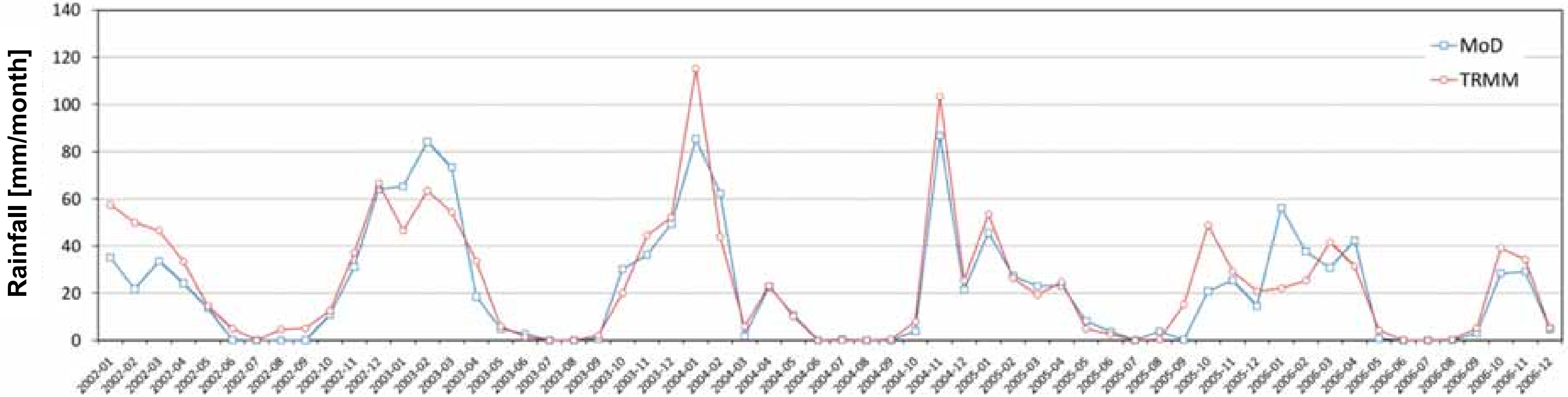
TRMM 0.25° Grid

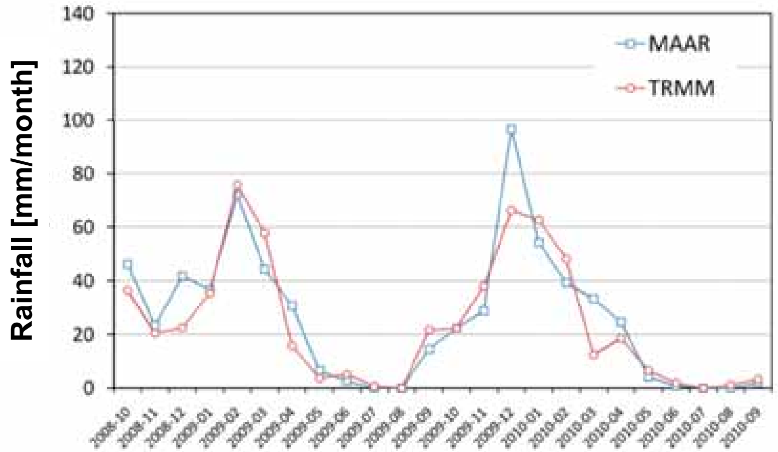
Project area

Sabkhas

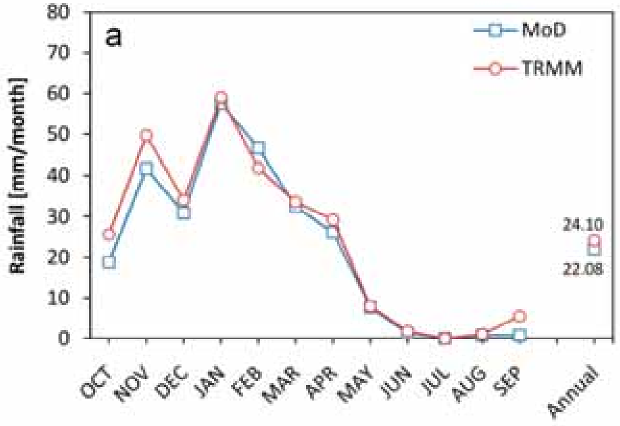
City

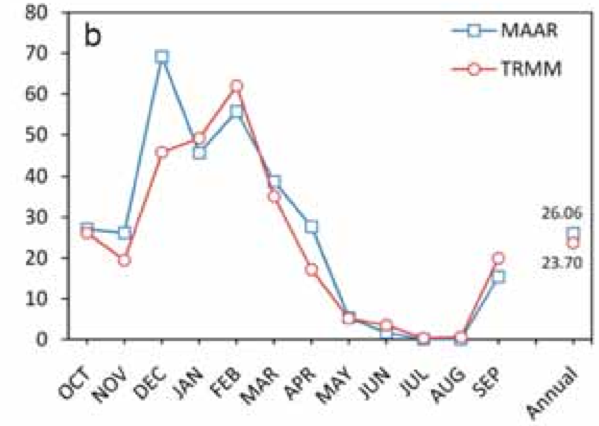
Input data: Rainfall





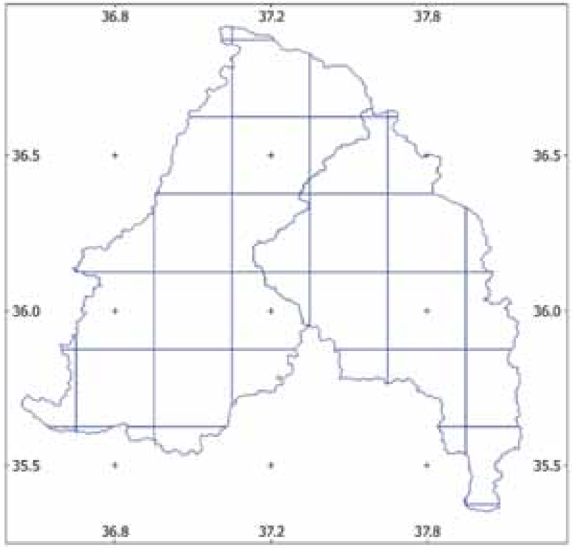
Input data: Rainfall

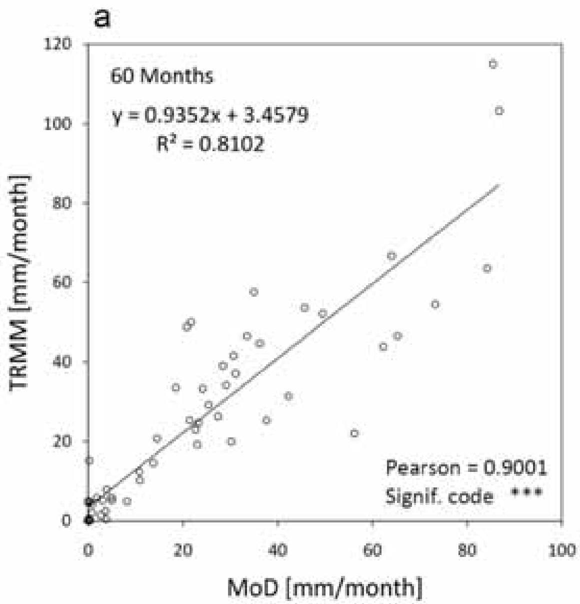


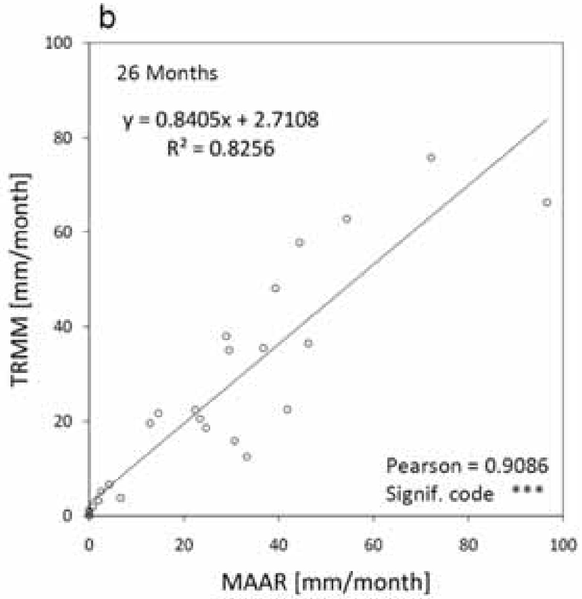


Comparison of mean annual cycles, ground measurements and TRMM-Data

Basin + TRMM-Grid Intersection







Correlations and simple linear regressions for ground measurements and TRMM-data

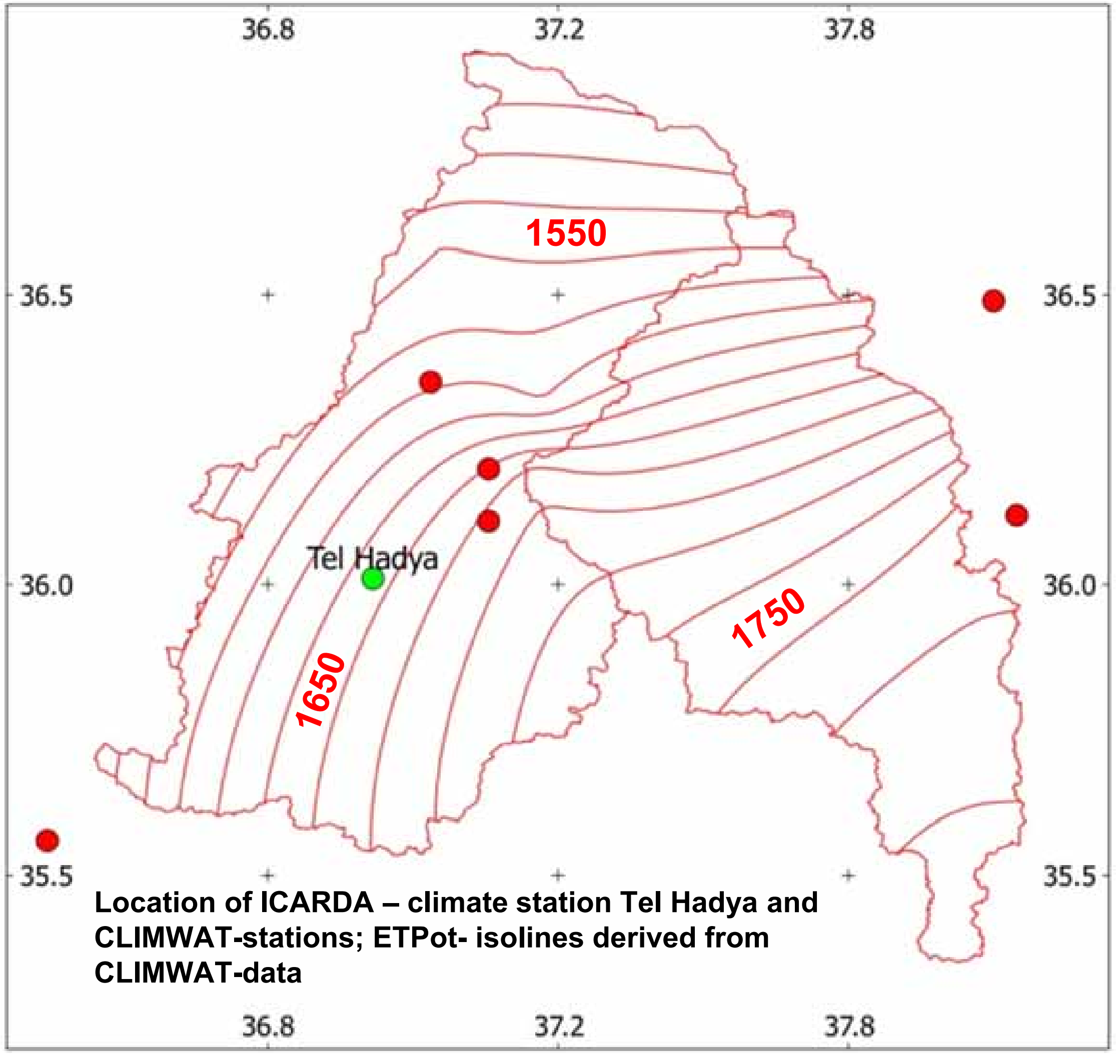
Input data: Potential Evapotranspiration

Average, long-term ETPot and respective regionalization factors for daily values at Station Tel Hadya

ETPot [mm/a]	ETPot [mm/d]	Regionalization-factor	
1470	4.02	0.89	
1490	4.08	0.90	
1510	4.13	0.92	
1530	4.19	0.93	
1550	4.24	0.94	
1570	4.30	0.95	
1590	4.35	0.96	
1610	4.41	0.98	
1630	4.46	0.99	
1650	4.52	1.00	**Tel Hadya**
1670	4.57	1.01	
1690	4.63	1.02	
1710	4.68	1.04	
1730	4.74	1.05	
1750	4.79	1.06	
1770	4.85	1.07	
1790	4.90	1.08	
1810	4.96	1.10	

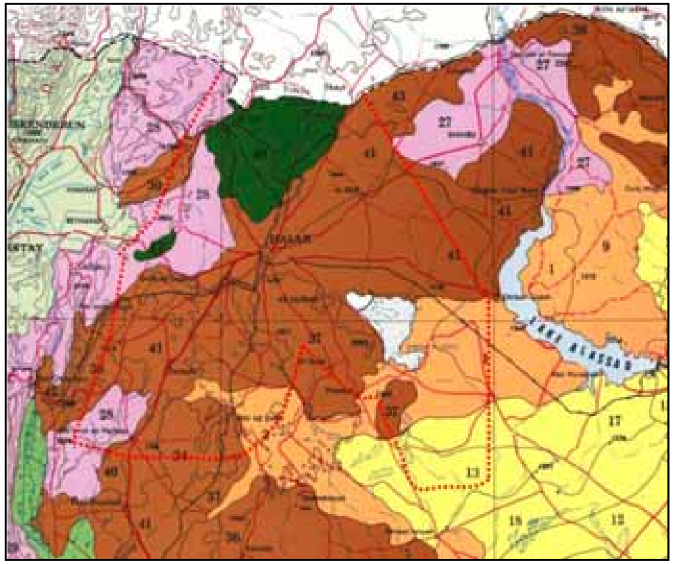
Tel Hadya Climate station

FAO – CLIMWAT-Station



Location of ICARDA – climate station Tel Hadya and CLIMWAT-stations; ETPot- isolines derived from CLIMWAT-data

Input data: Soil hydrological properties

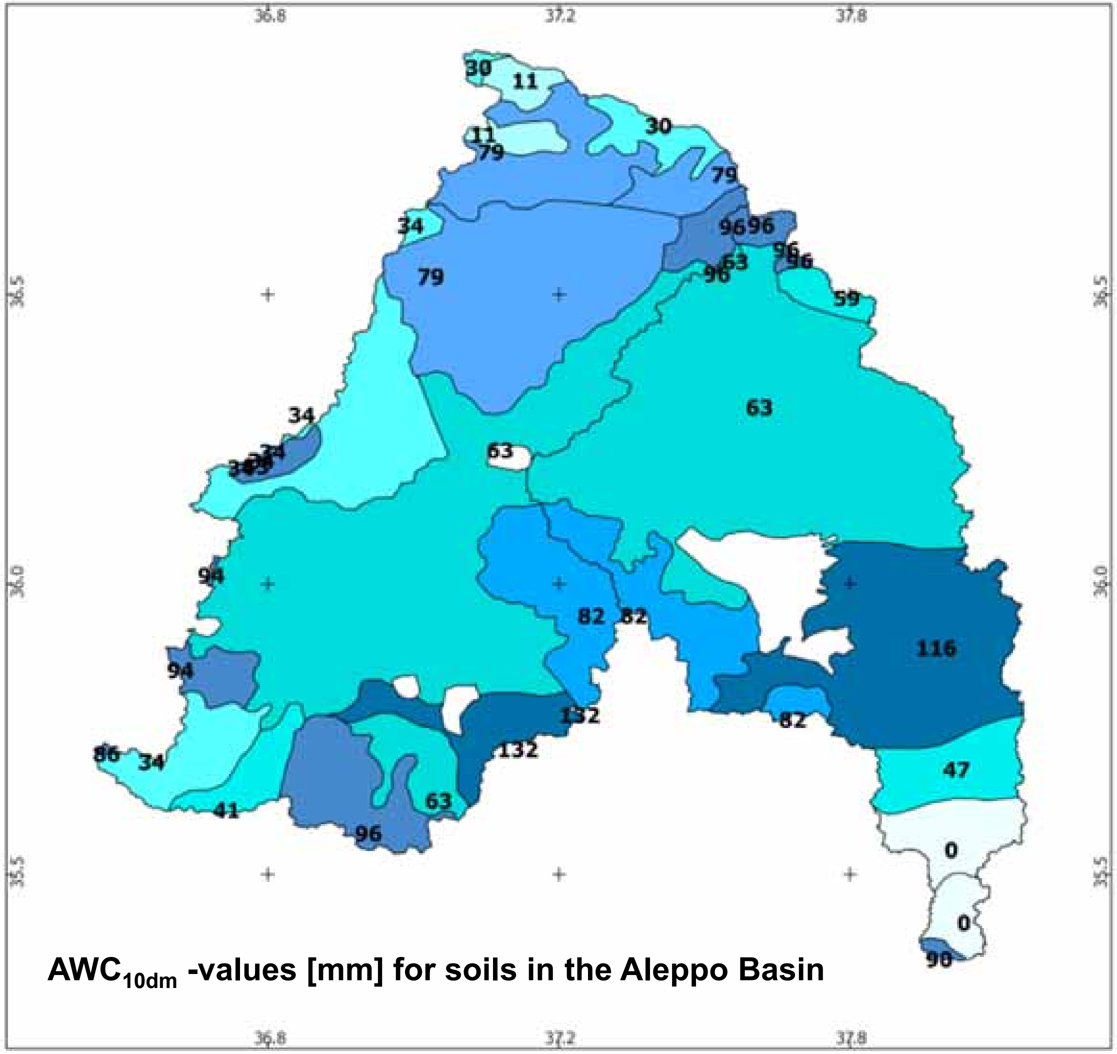


Soil map 1:1.000.000; Source: ACSAD 1985

Selected soil properties from internal ICARDA - report (VAN DE STEEG & DE PAUW 2002)

D: Depth [dm]
T: Textural Class [%]
S: Stone Content [%]
V: Empirical standardized AWC value based on Textural Class [mm/dm]

$$D * V * (Soil - S) = AWC$$



AWC$_{10dm}$ -values [mm] for soils in the Aleppo Basin

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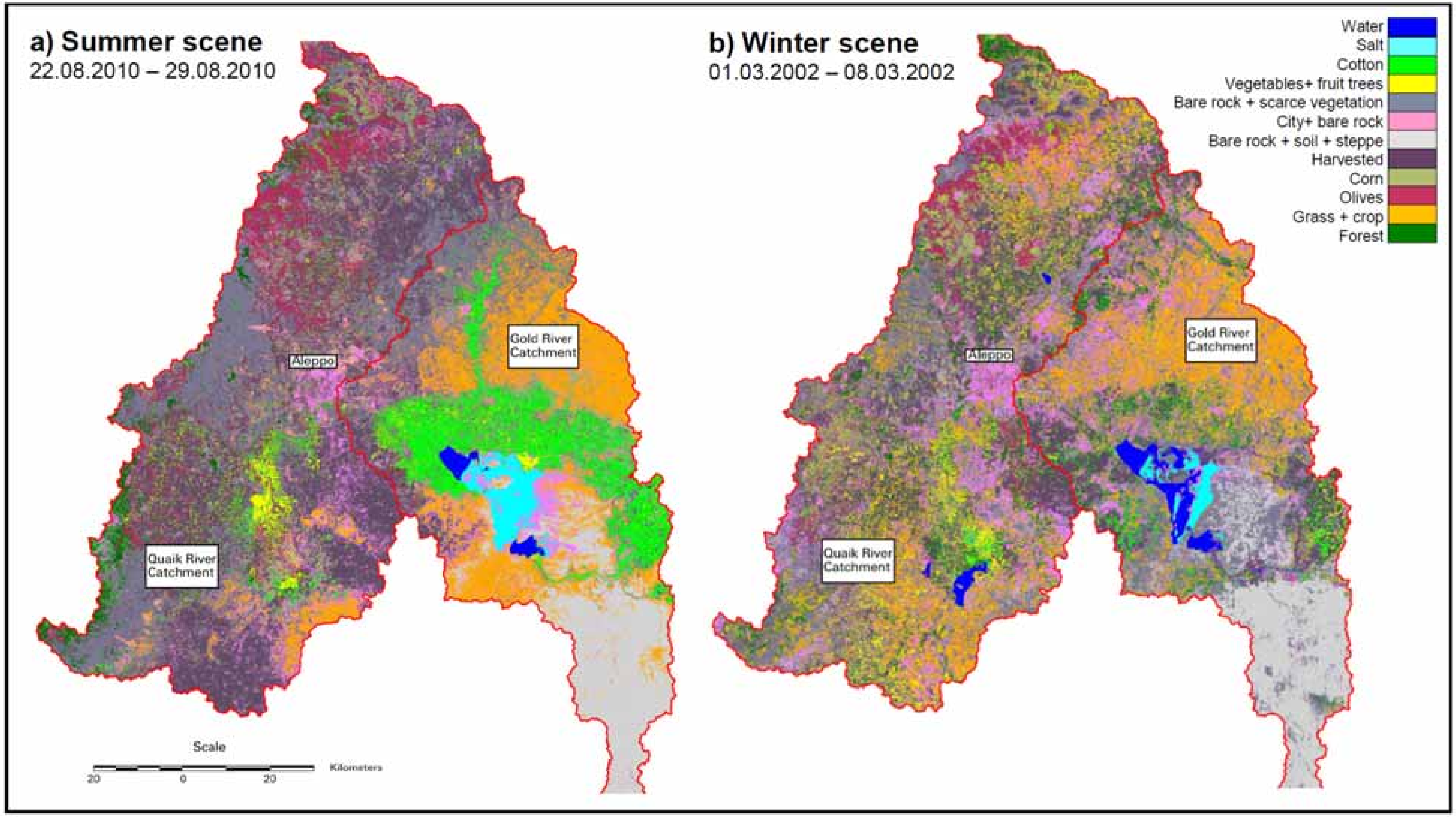
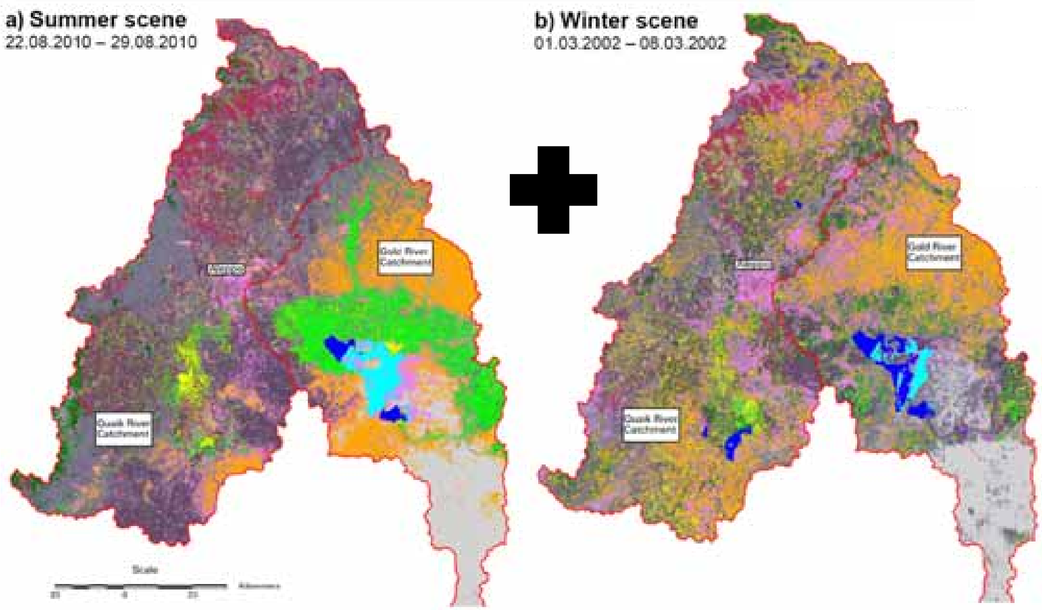
Input data: Land use

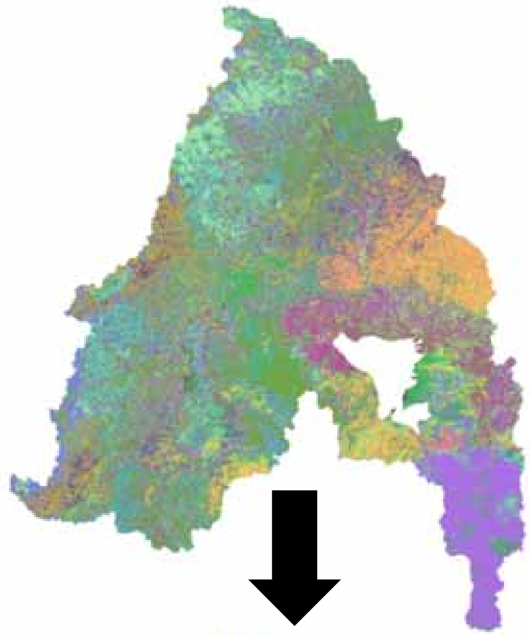


LANDSAT – TM5 / ETM7 Mosaics (30x30m – Pixel)

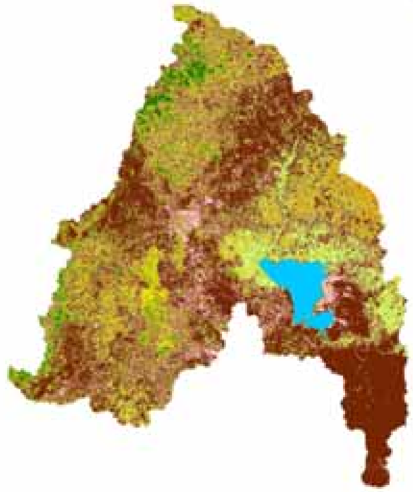
Input data: Land use

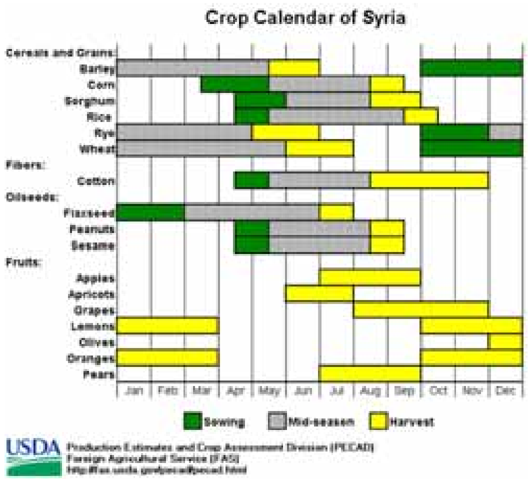


Winter-Summer Sequence
(83 Combination-classes)



Generalization / Reclassification (6 Land use classes)





Input data: Land use

Table 4: Correlation for generalized land use classes and MAAR-Data, Aleppo Basin

Land Use Class (RS[1])	Irrigation	Correlating MAAR Land Use Data Tables (2009)
Cereals	No	Cereals Rainfed
Cotton	Yes	Cotton Irrigated
Forest	No	Forest
Non Arable Land	No	Rocky and Sandy Land, Buildings and Public Utilities, Meadows and Pastures
Olives	No	Olives Rainfed
Vegetables[2]	Yes	Vegetables Irrigated, Vegetables Rainfed, Fruit Trees Irrigated, Fruit Trees Rainfed
	Yes	Cereals Irrigated

[1] Based on remote sensing data
[2] Includes fruit trees

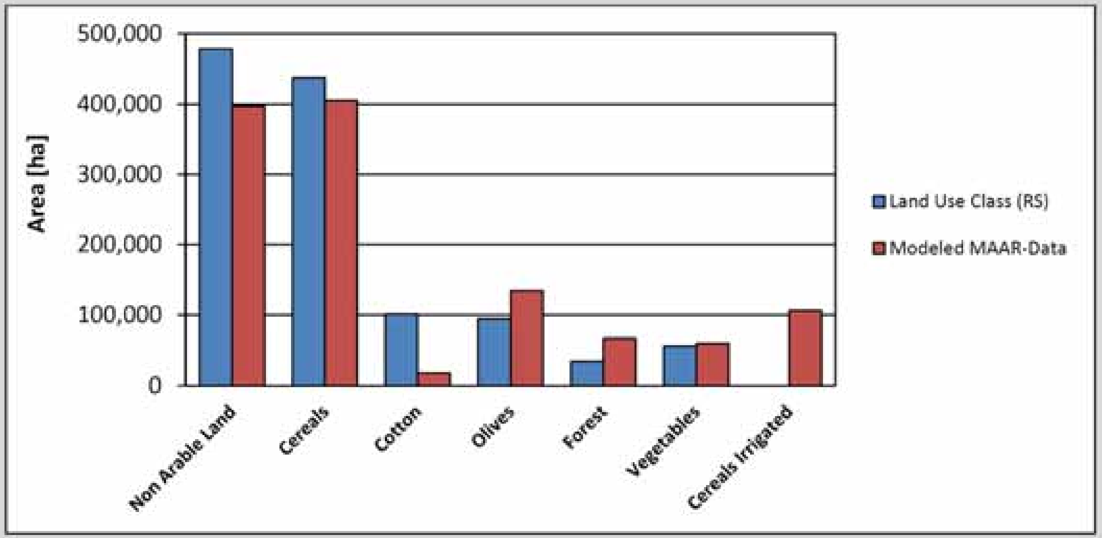
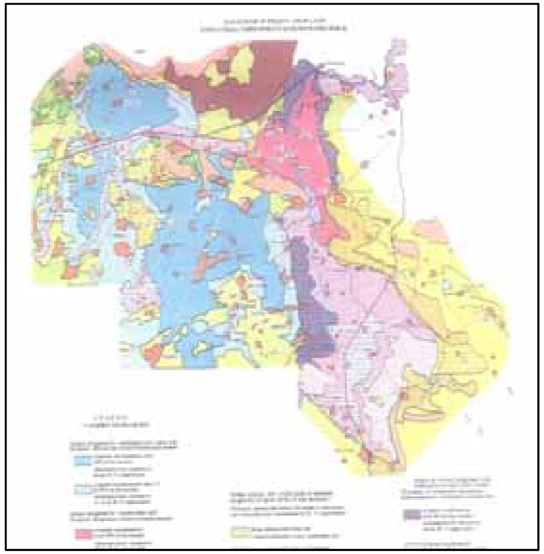


Fig. 6: Area comparison of generalized land use classes with modeled MAAR-Data, Aleppo Basin

Input data: Irrigation

Land use map of the Aleppo Governorate 1:200.000
Source: MAAR 2003



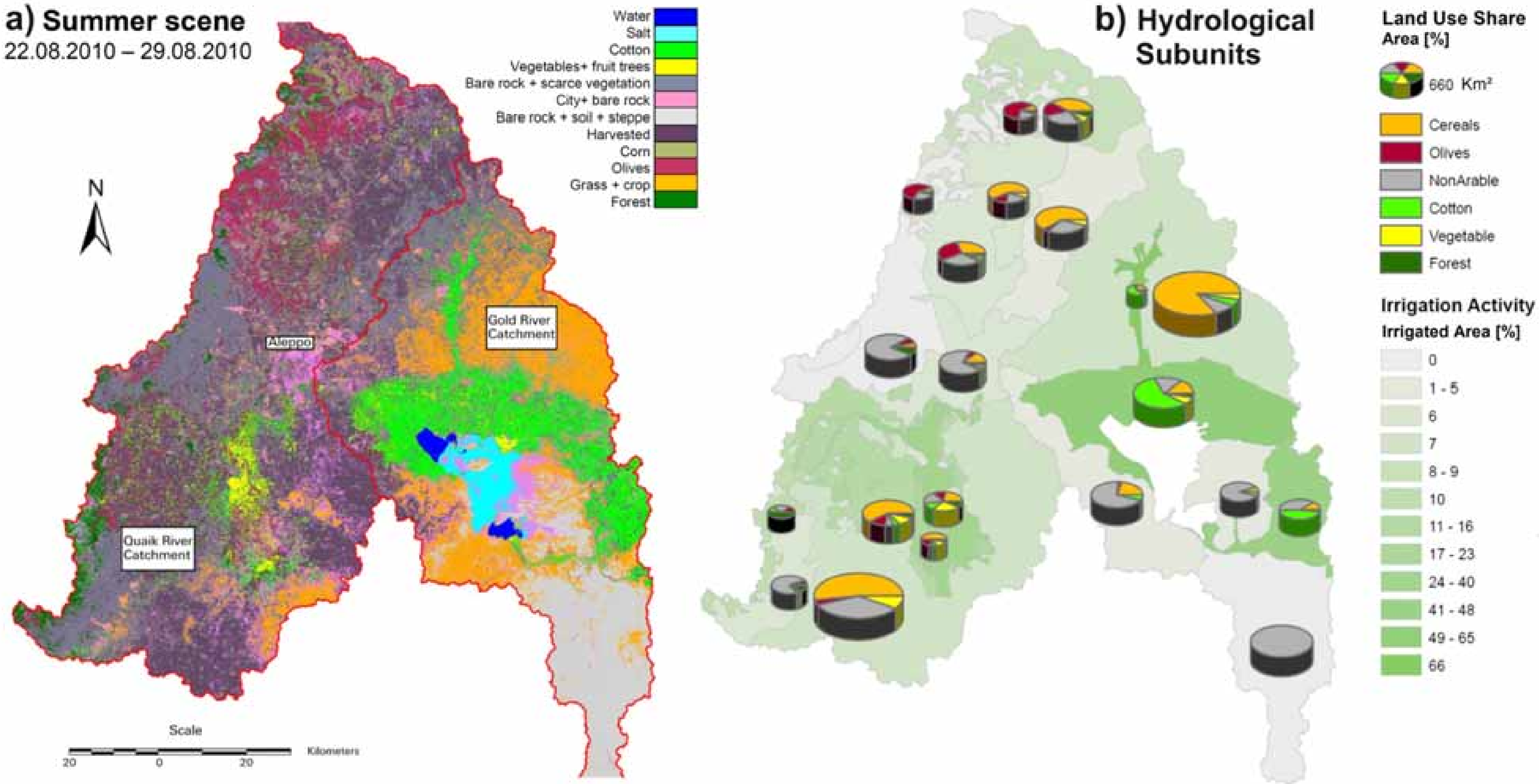
Map of *Southern Aleppo Lands* Irrigation Project
Source: MoI 2002

Tab. 2: Angenommene Bewässerungsmengen im Aleppo Basin nach MARTIN (1999)

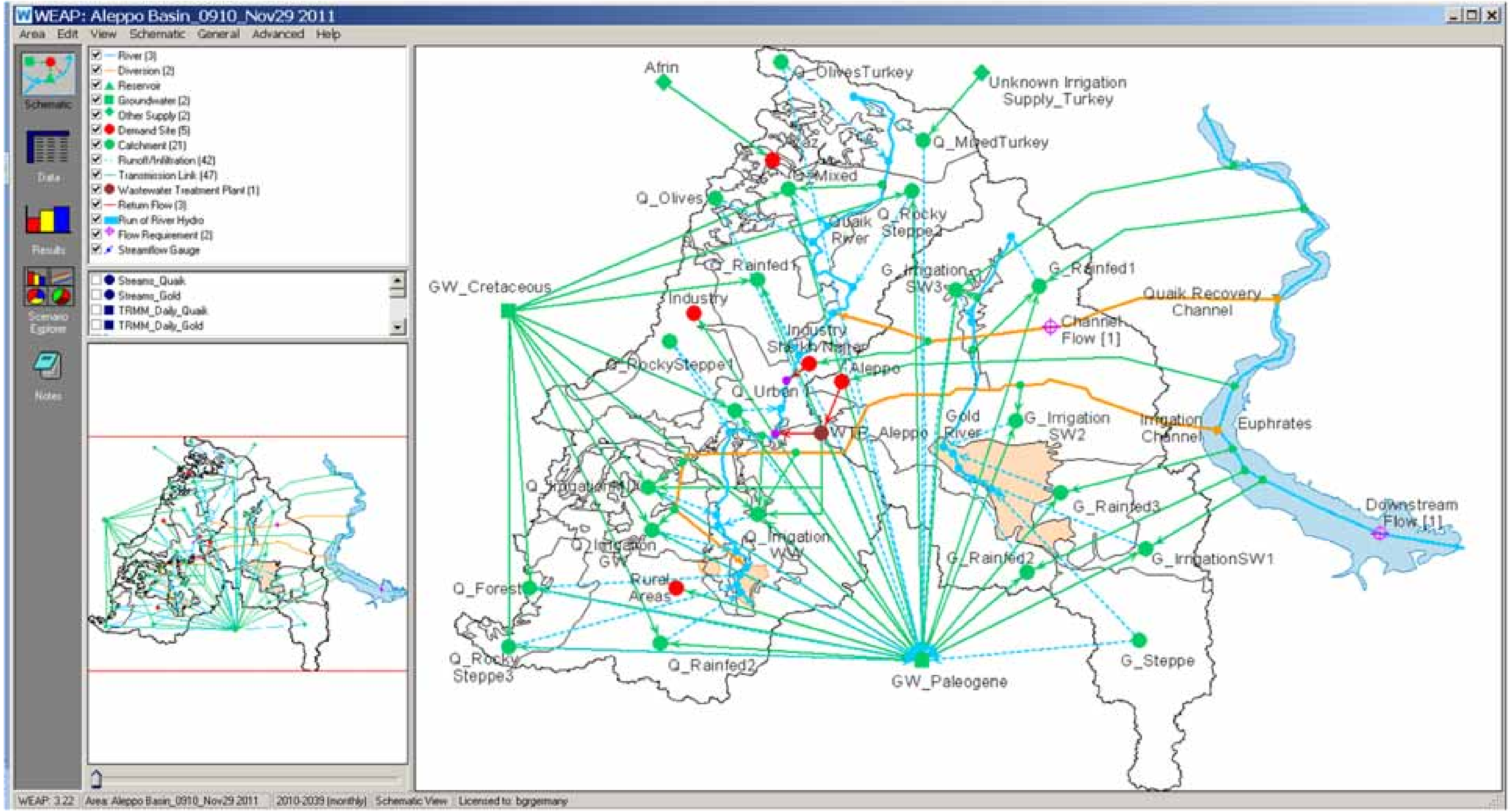
Kulturpflanzen	Bewässerungsmenge in mm/a
Sommerkulturen	
Baumwolle	1500
Weizen	500
Kartoffeln, Sommer	1000
Kartoffeln, Frühjahr	650
Kartoffeln, Herbst	600
Winterkulturen	
Ackerbohnen	350
Gerste	100
Weizen	400
Bäume	
Oliven	1050
Pistazien	850

Model Structure

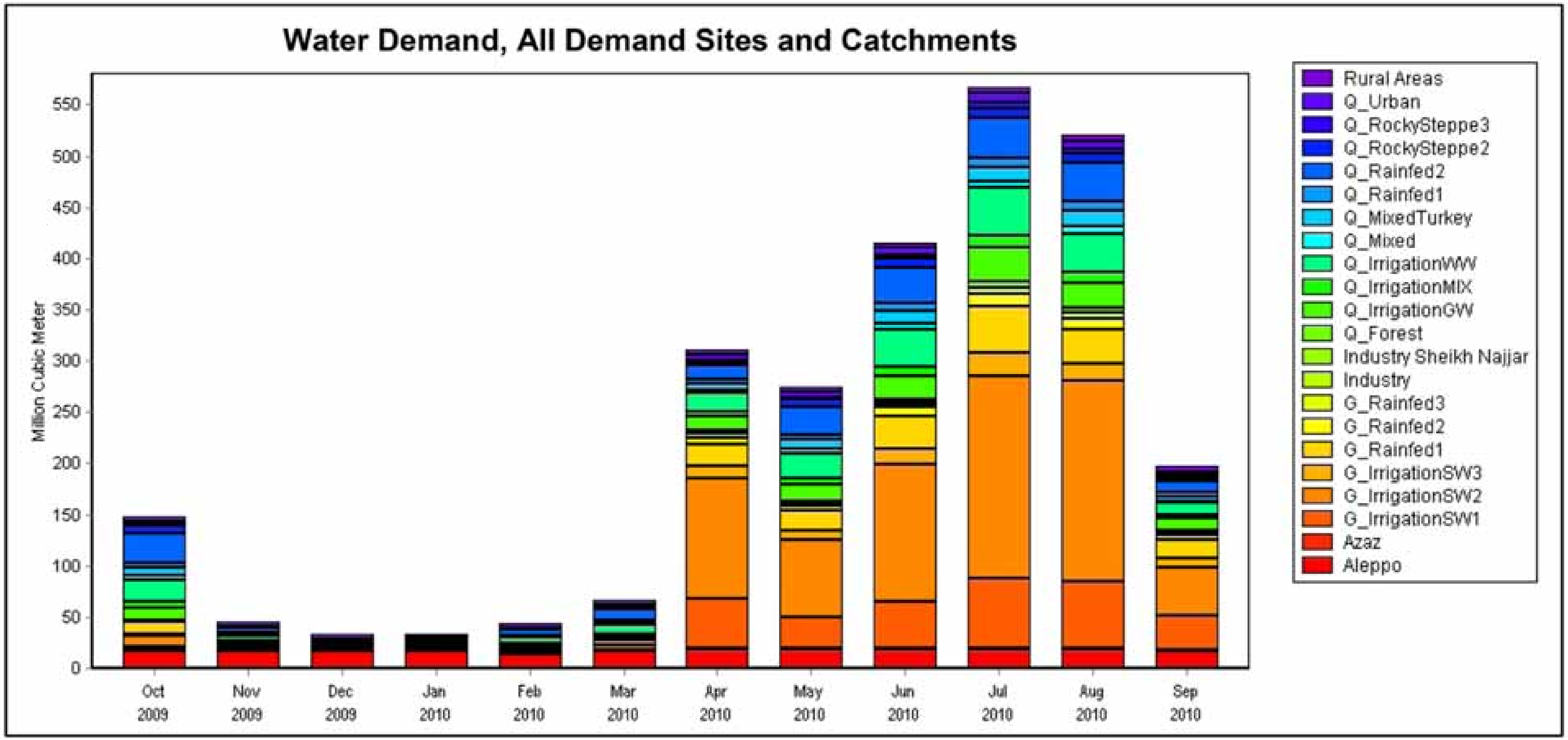
● Delineation of dominant **subsystems** in catchment's hydrological cycle



Model Structure



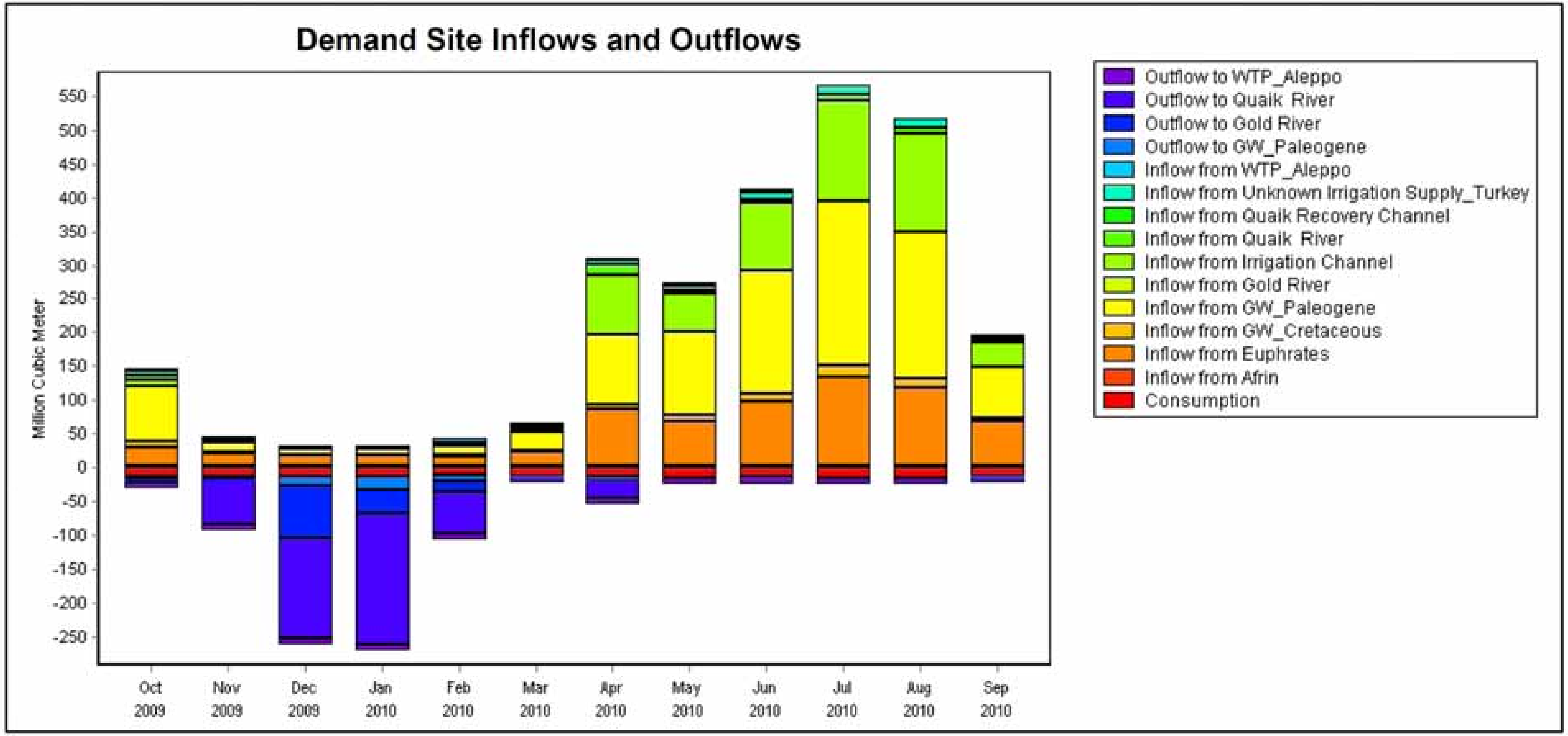
Model Results



Monthly water demand in the Aleppo-Basin, hydrological year 2009/10

Annual demand: 2.65 Billion m³

Model Results



Monthly flows in the Aleppo-Basin, hydrological year 2009/10

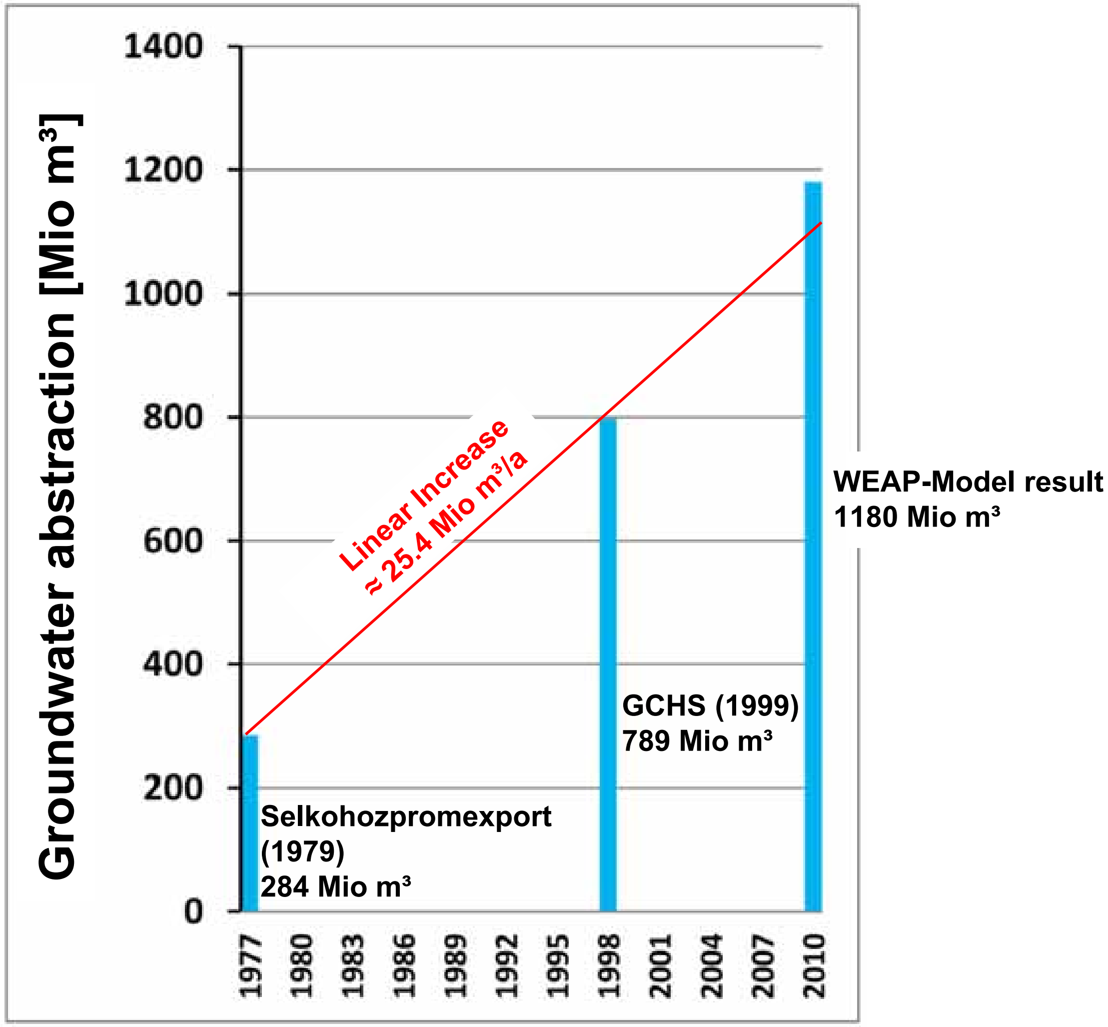
Model Results

Table 7: Aleppo Basin Demand Site Inflows and Outflows, Hydrological Year 2009/2010

Demand Site Inflows and Outflows	Water Volume [BCM]
Inflow from Euphrates	0.68
Inflow from Irrigation Channel (Euphrates)	0.59
Inflow from Afrin	0.02
Inflow from Unknown Irrigation Supply_Turkey	0.07
Inflow from Quaik Recovery Channel[1]	0.00
Total Interbasin Water Inflow	**1.36**
Inflow from GW_Paleogene	1.10
Inflow from GW_Cretaceous	0.08
Total Groundwater Abstraction	**1.18**
Inflow from Quaik River	0.06
Inflow from Gold River	0.00
Inflow from WTP_Aleppo[2]	0.03
Total Accessible Internal Water Resources	**0.09**
Outflow to Quaik River	0.50
Outflow to Gold River	0.13
Total Surface Water Runoff	**0.63**
Outflow to WTP_Aleppo	0.11
Consumption	0.17
Outflow to GW_Paleogene from Catchments	0.06
Outflow to GW_Paleogene from River Channels (Quaik + Gold)	0.37
Total Groundwater Recharge	**0.43**

[1]Active from August 2011 [2]Origin of water is Euphrates River

Model Validation



Model Validation

Comparison of annual WEAP-MABIA – Groundwater Recharge Rates (GWR) results for Quaik River Catchment (Aleppo Basin) and PTF – GWR - estimates, hydrological year 2009/2010

WEAP- Intra-Basin-Subunit	Precipitation [mm/a]	Potential Evapotrans-piration [mm/a]	AWC per soil profile [% of volume]	AWC per soil profile [mm/10dm]	GWR - Wheat		GWR - Olives	
					WEAP-MABIA [mm/a]	PTF [mm/a]	WEAP-MABIA [mm/a]	PTF [mm/a]
Q_OlivesTurkey	263	1551	6.50	78.00	0	0	0	0
Q_MixedTurkey	258	1558	7.80	93.60	0	0	0	0
Q_Olives	414	1616	7.50	90.00	47	54	55	58
Q_Mixed	235	1601	8.25	99.00	0	0	0	0
Q_RockySteppe2	239	1621	8.60	103.20	0	0	0	0
Q_Rainfed1	282	1628	8.25	99.00	0	0	0	0
Q_RockySteppe1	293	1638	8.55	102.60	0	0	0	0
Q_Urban	144	1694	9.83	117.96	0	0	0	0
Q_IrrigationGW	248	1682	9.83	117.96	0	0	0	0
Q_IrrigationWW	202	1735	9.83	117.96	0	0	0	0
Q_IrrigationMIX	225	1705	9.93	119.16	0	0	0	0
Q_Forest	382	1631	9.20	110.40	8	0	15	0
Q_RockySteppe3	351	1650	8.80	105.60	5	0	12	0
Q_Rainfed2	214	1731	9.00	108.00	0	0	0	0

PTFs: linear models based on
- precipitation
- potential evapotranspiration
- available water capacities (data from 44 meteorological stations)

Model Validation

1. Calibrated discharge: ≈ 80 Mio m³/a

Table 1.3.2-1: Comparison of Figures for the Qweik Catchment

Name of Study	Name of River Gauge	Size of Catchment [km²]	Long-Term Average Discharge [10^6 m³/a]
Wolfart (1966)	Muslimiya	3,520	15
	Upstream Aleppo	n/a	79
Selkhozpromexport (1979)	Muslimiya	1,800	35
ACSAD (1984)	Muslimiya	2,000	35
JICA (1997)	n/a	n/a	0
ACSAD (1994) in Martin (1999)	n/a	n/a	168
DHV Water BV (2002)	n/a	n/a	32
FAO (2003a)	n/a	n/a	95
ICARDA (in prep.; b)	n/a	n/a	90

Quelle: BMZ 2004

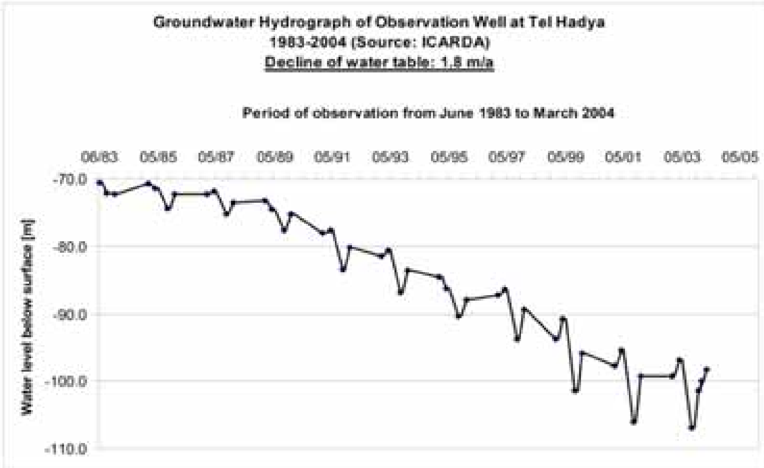


Figure 1.3.3-4: Groundwater Hydrograph of Observation Well at Tel Hadya, June 1983 to March 2004 showing a Decline of Groundwater Table by 1.8 m/a (Source: unpubl. data of ICARDA; the well is roughly 150 m deep and taps the Helvetian limestone aquifer according to Luijendijk 2003: p. 45)

2. Modeled drop of groundwater table: ≈ 2 m/a
-> Compliance with Logger-data from 2009/10

Table 6: Paleogene and Cretaceous Aquifer Properties (Rother & Helms 2011)

Aquifer	Area [km²]	Average Thickness of Groundwater Bodies within Aquifer Strata [m]	Effective Storage [%]	Storage Capacity / Initial Storage [BCM]
Paleogene	8.000	100	2	17 / 16
Cretaceous	12.371	240	1	30

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Scenarios

Table 8: WEAP Model Scenarios

Scenario Name	**Parameter Modification**
CropChange_50	Reduction of Cotton Area by 50%
CropChange_100	No Cotton
IrrigationChannel Extension	Irrigation Channel Extension into western part of the Basin (Quaik River Catchment), operation start 2012.

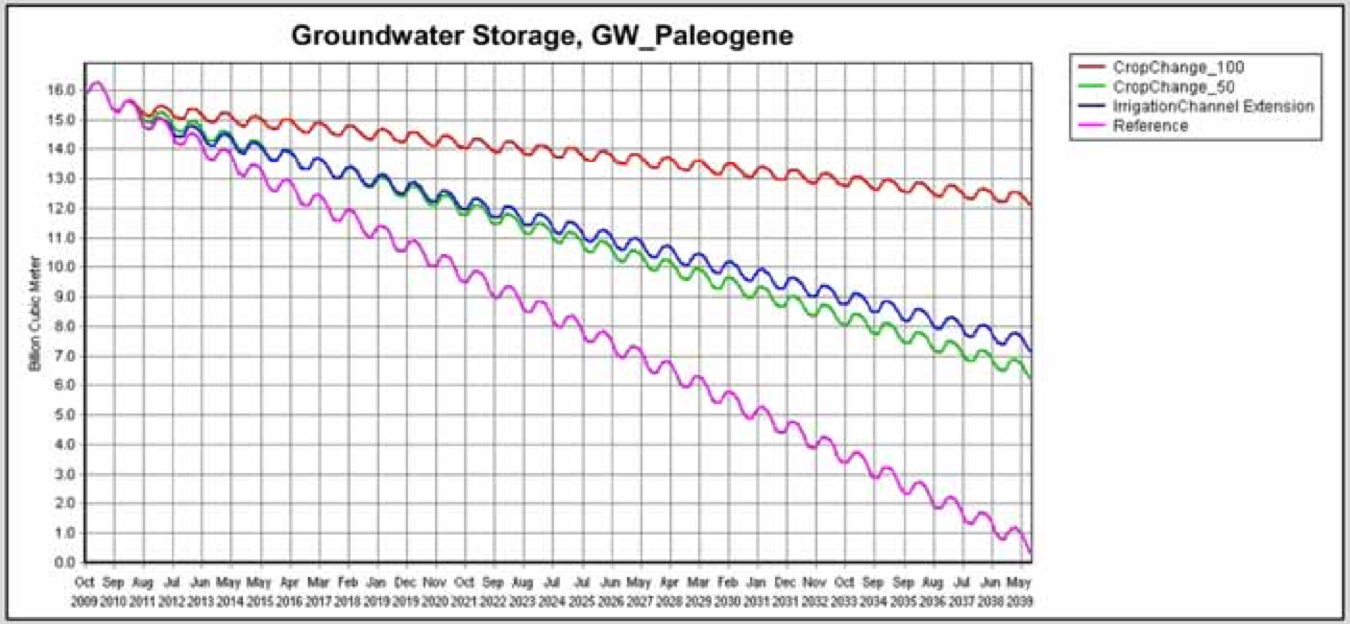

Fig. 11: Change in groundwater storage of Paleogene aquifer, different scenarios

Thank you for your attention!