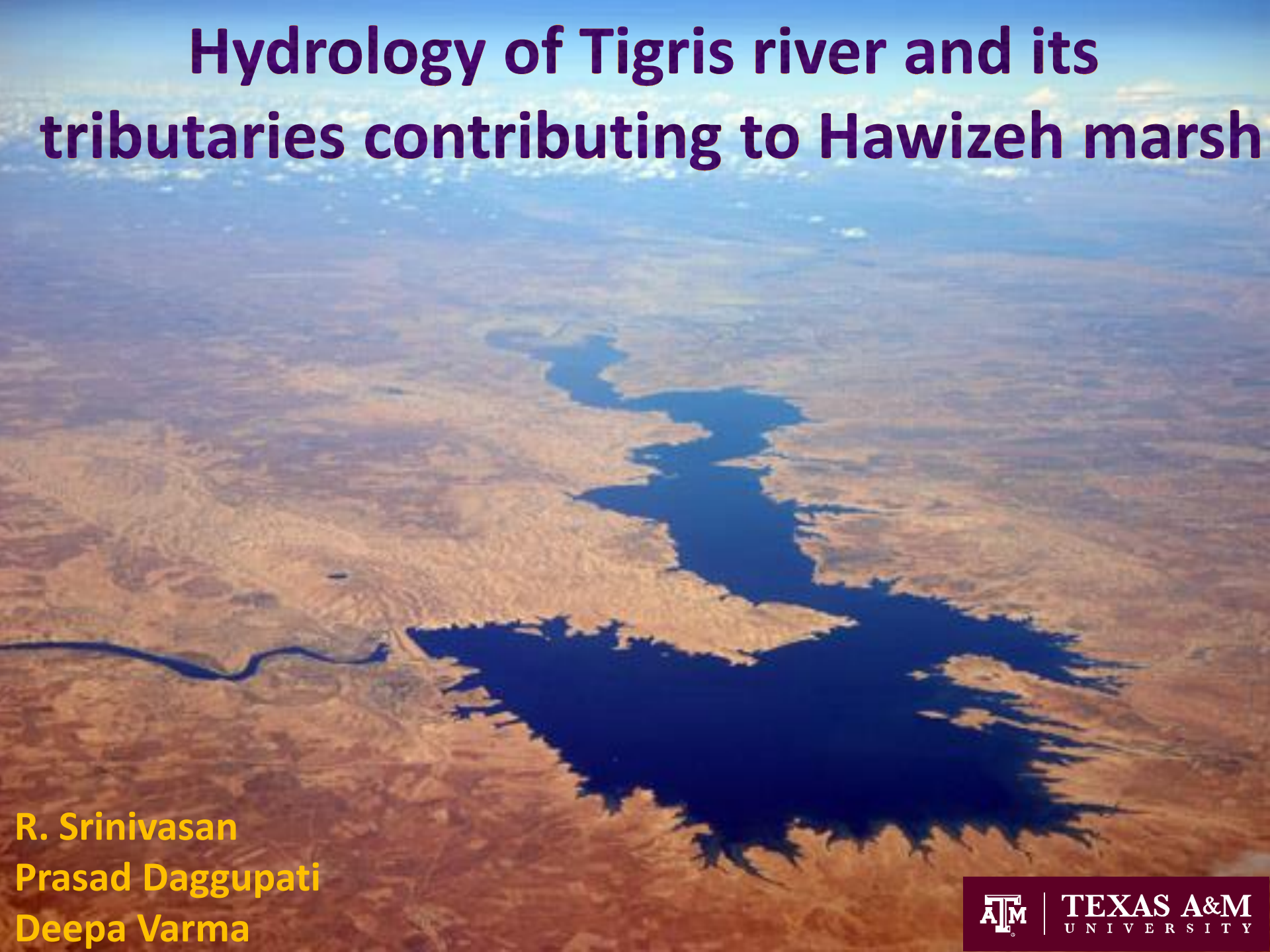
Hydrology of Tigris river and its tributaries contributing to Hawizeh marsh



R. Srinivasan
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Deepa Varma

TEXAS A&M UNIVERSITY

Outline

- Development of SWAT model in Tigris-Euphrates basin
- Hydrological analysis of flow in Tigris and its tributaries (including Karkheh river flowing from Iran) feeding to Hawizeh marsh
- Analysis and implications of dams/water control structures

Introduction

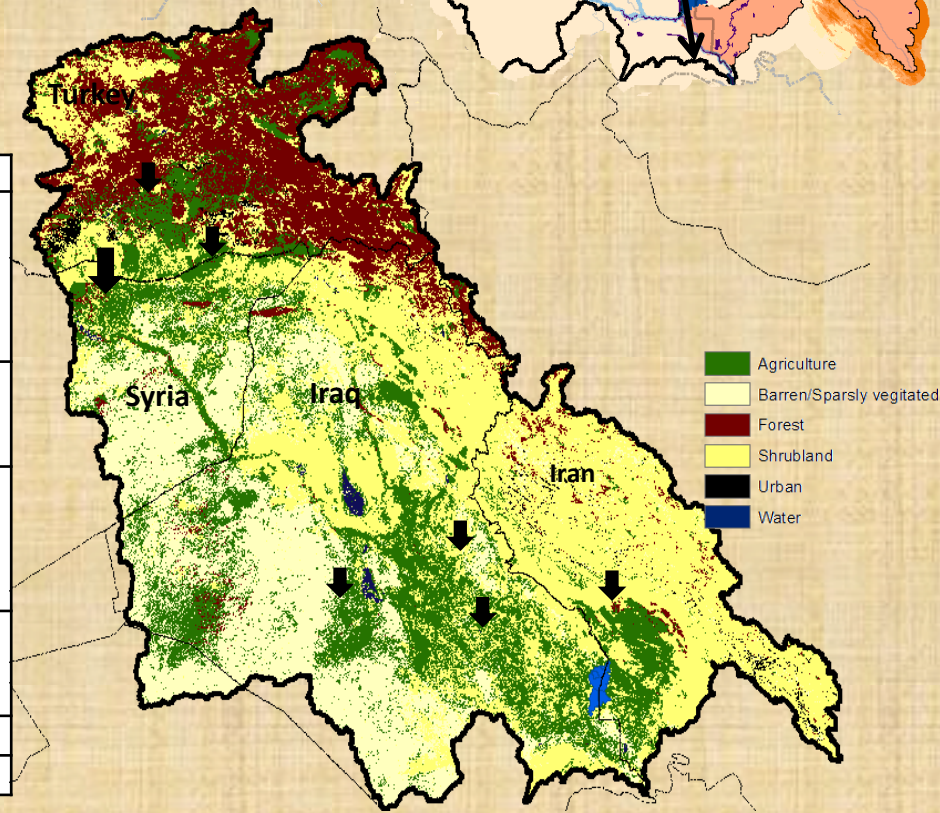
The Tigris Euphrates River Basin

- Area: 879790 km^2 - largest basin in the Middle East
  - Tigris: 304000 km^2
  - Euphrates: 503900 km^2
  - Karun: 71800 km^2

Country	Euphrates Basin		Tigris Basin*	
	% Area	% Flow	% Area	% Flow
Turkey	**21**	**98.5**	**18**	**53**
Syria	17	1.5	0.2	-
Iran	-	-	30	5.9
Iraq	49	-	53	40.7
Saudi Arabia	13	-	-	-

* Data excludes Karun basin

Feeds Hawizeh Marsh

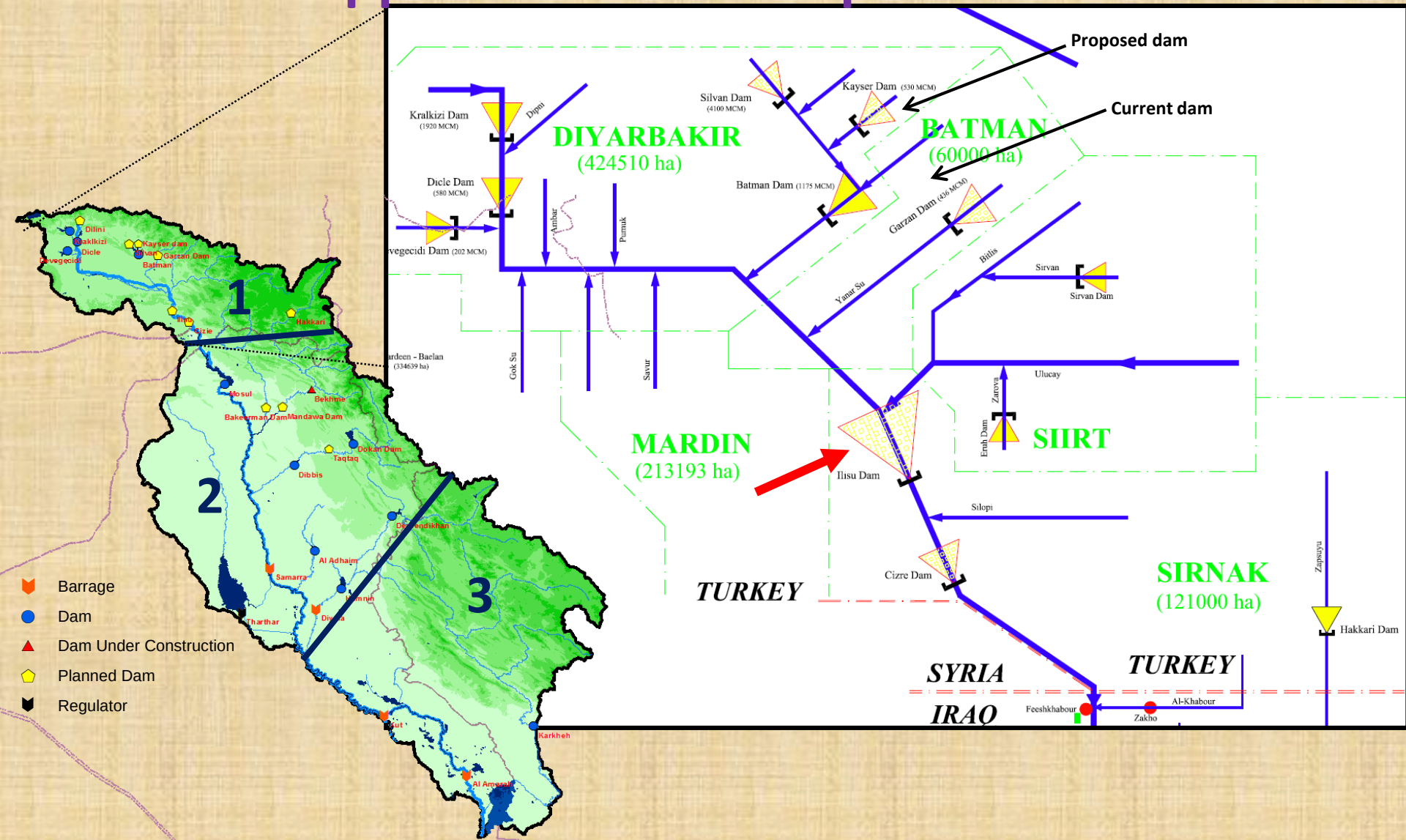


Landuse

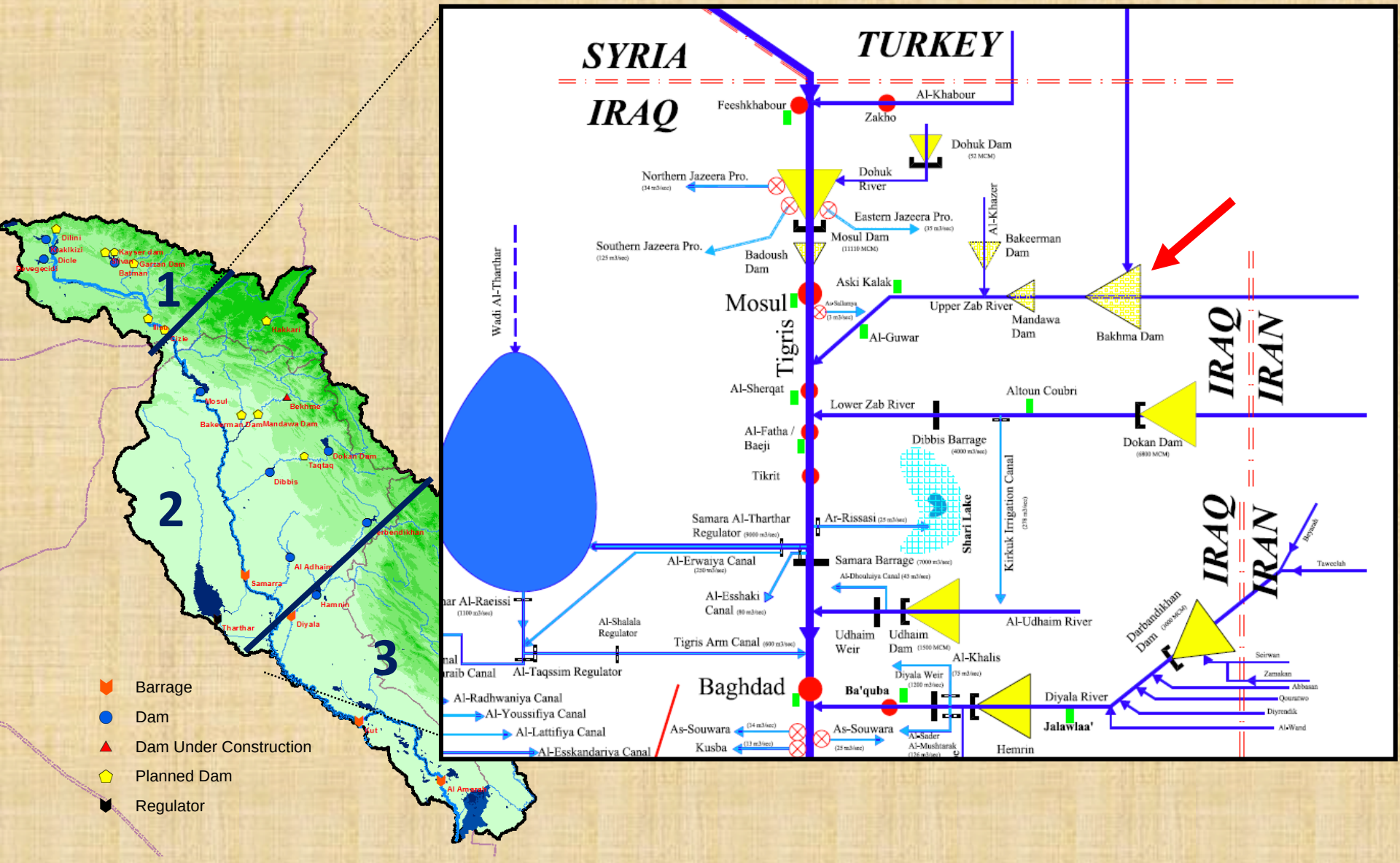
Landuse	SWAT categories	Area (KM2)	Area (KM2)	% Watershed
Forest	BROADLEAF FOREST	119809	119844	15%
	NEEDLELEAF FOREST	1		
	EVERGREEN FOREST	12		
	MIXED FOREST	21		
Shrubland	SHRUBLAND	309298	500608	62%
	BAREN/SPARSLY VEGETATED	191310		
Agriculture	Agricultural Land-Row Crops	181515	183270	23%
	RICE	5		
	Agricultural Land-Generic	1750		
Urban	Residential-Medium Density	6858	6931	1%
	Residential-Low Density	73		
Water	WATER	2486	2486	0%
Wetlands	Wetlands-Non-Forested	1073	1073	0%

Overview of Tigris river, tributaries and water structures feeding Hawizeh marsh

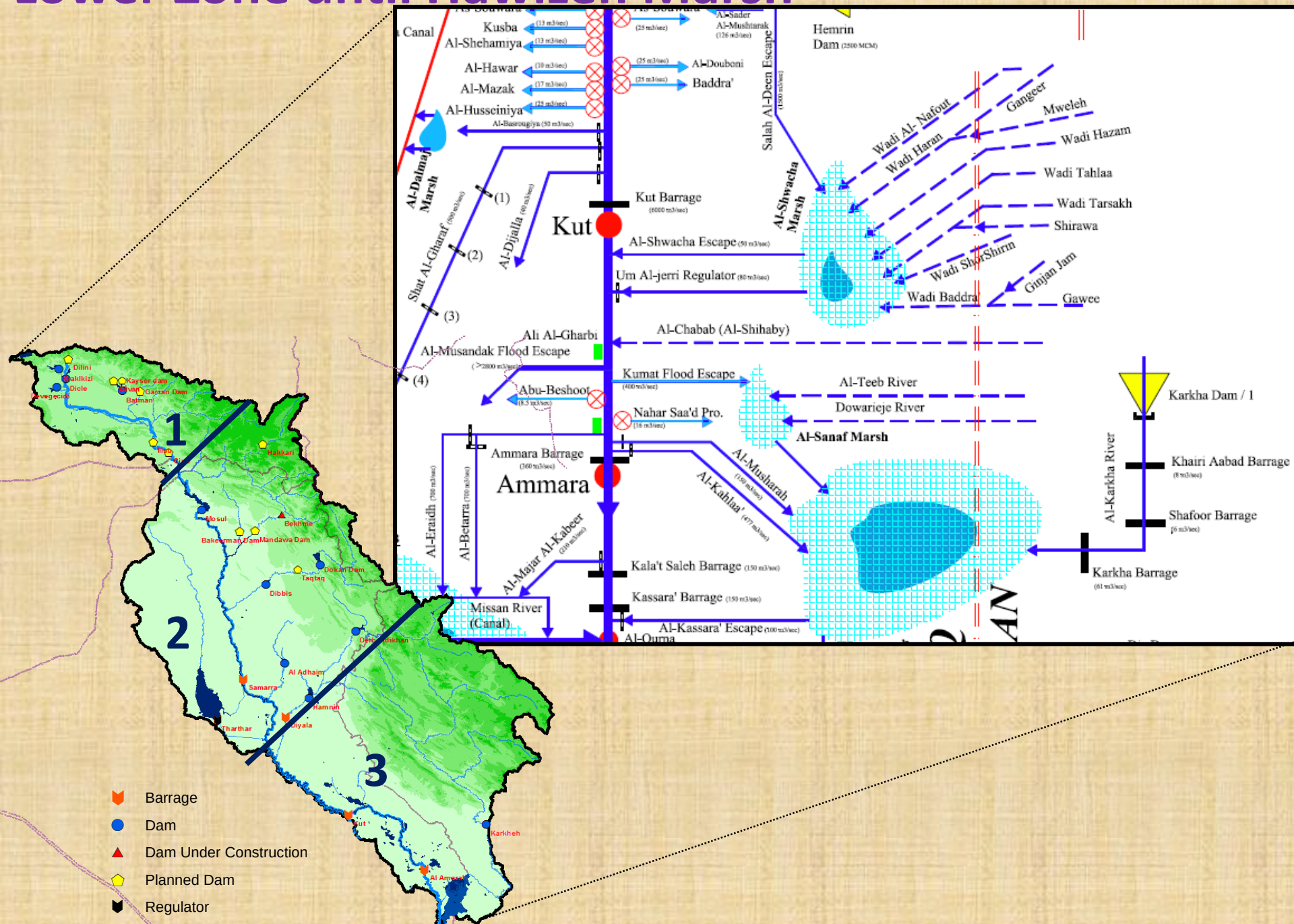
Upper Zone until Iraq border



Middle Zone until Bagdad

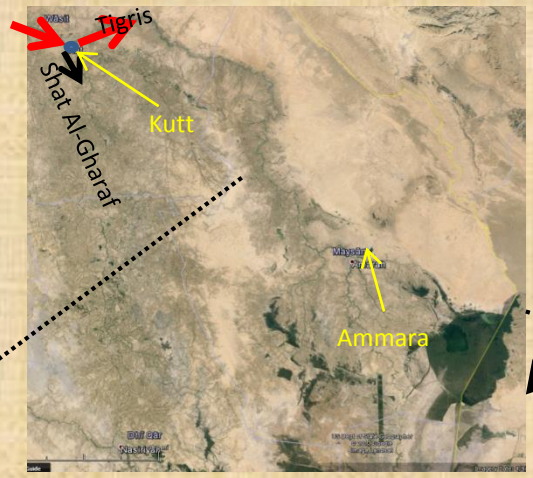


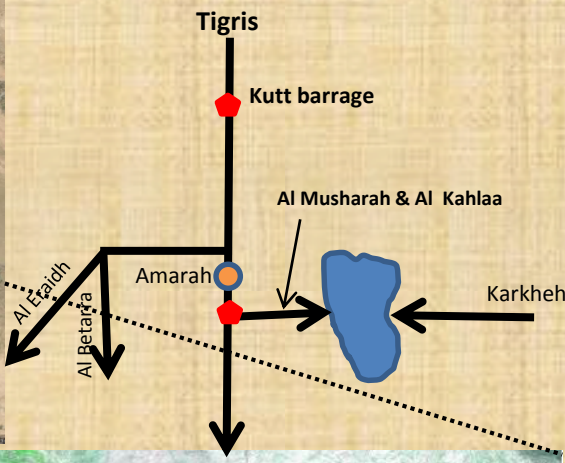
Lower Zone until Hawizeh Marsh



Downstream Tigris after Bagdad until Hawizeh Marsh

- Kutt barrage diverts water to Shat Al-Gharaf canal especially for irrigation
  - Final set of observed flow data available after kutt barrage
- Before Ammara barrage
  - Tigris river diverts water to 2 branches
    - Al- Eraidh (700cms) and Al Berata (700cms) to feed central marshes
- At Ammara barrage,
  - Tigris river divides into 3 branches
    - 2 branches (Al-Musharah(150cms) and Al-Kahlaa(477cms) feeds into Al-Hawizeh marsh
    - 1 branch (360cms) heads towards Basra where it meets Euphrates





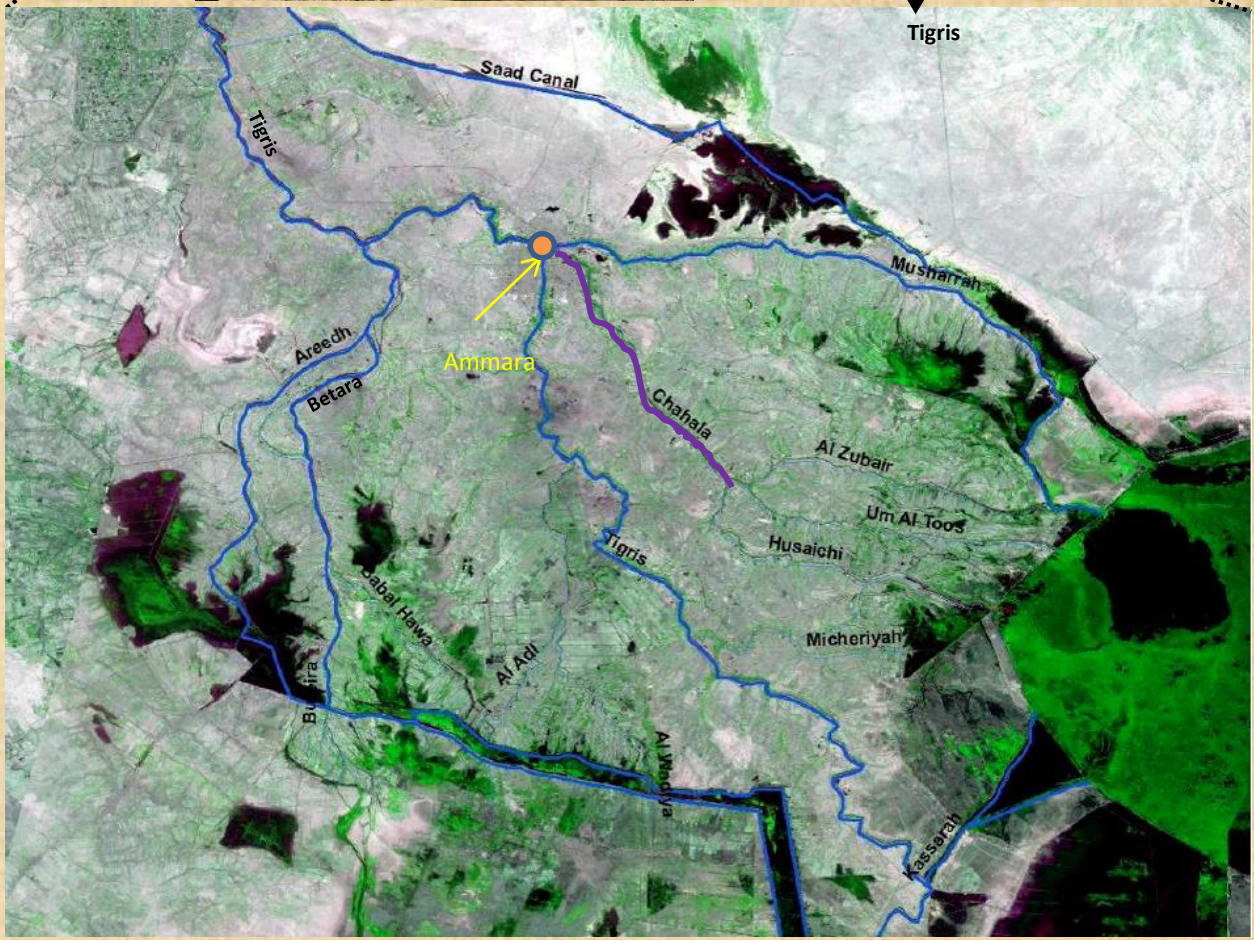


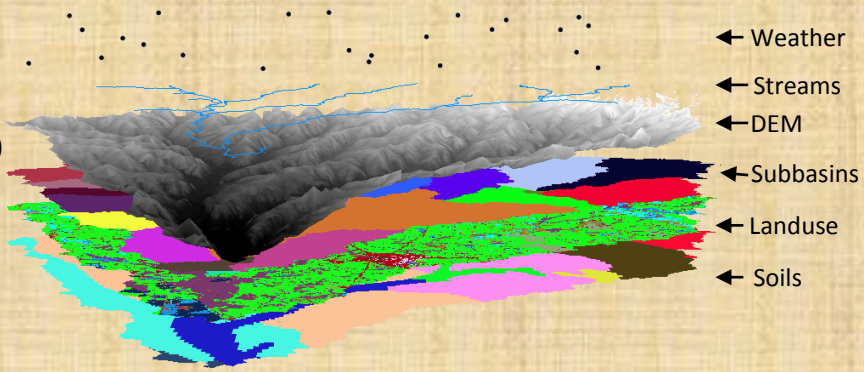
Image source: Nature iraq report

Methods

SWAT model development

Data inputs

- Watershed characterization
  - DEM
    - Resolution: 90 ×90 m
    - 940 subbasins in TU basin
      - **408 in Tigris**, 454 in Euphrates, 78 in Karun
  - Landuse landcover
    - Resolution: 100 ×100 m
    - Global landuse(based on year 2000) used
      - Manual editing to make sure spatial extent of agricultural fields are represented correctly (Appendix 2)
  - Soils
    - FAO soils used
    - Resolution: 1:5,000,000
  - Slope
    - 0-5% (67% of watershed), 5-12% (9% of watershed)and >12% (23% of watershed)
  - Weather
    - Global weather data @ 40 by 40 KM resolution
      - Daily data for 32-year period from 1979 to 2010
      - 1272 weather stations in the river basin
  - HRU delineation
    - 5/12/10% thresholds for landuse, soil, slope
      - All agricultural lands were exempt
    - Finally **9088 HRU's** in TU basin



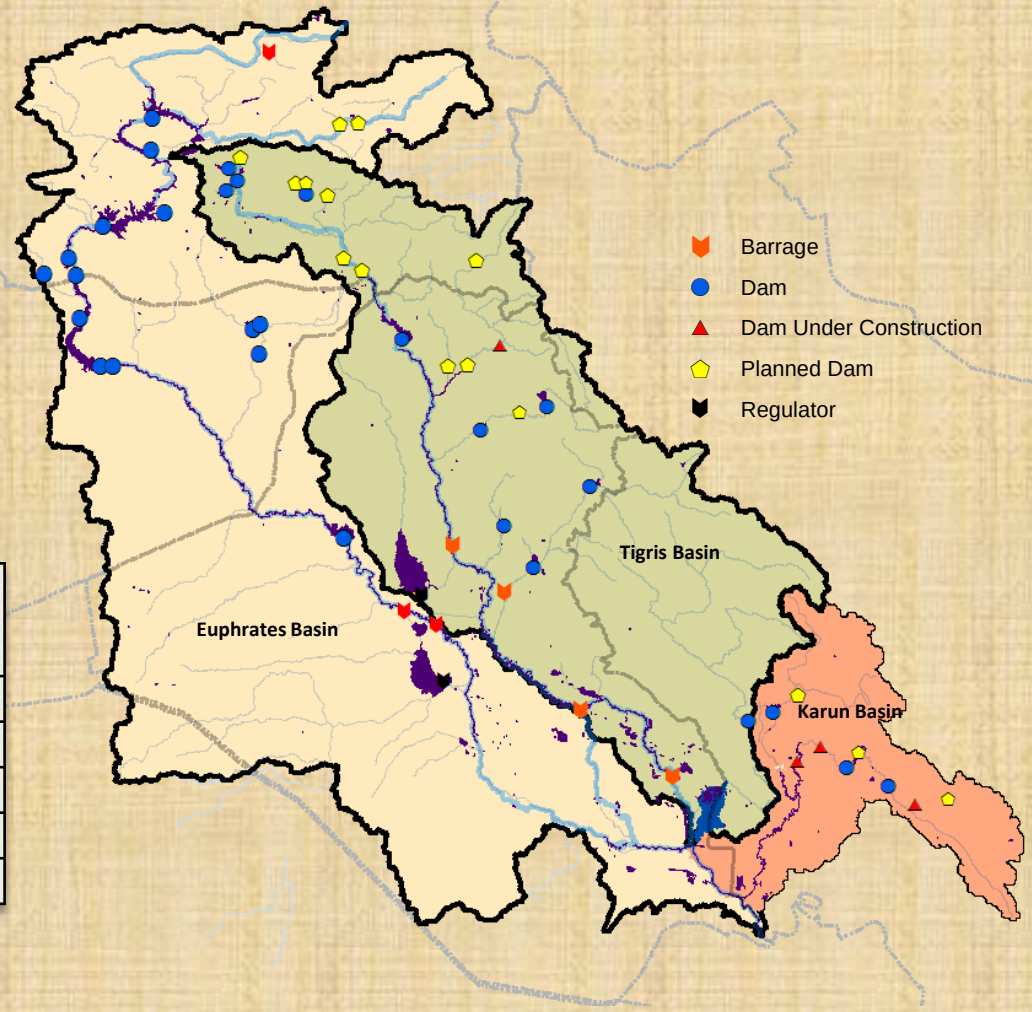
Appendix 1 gives information on SWAT model

Dams

Water control structures	Euphrates	Tigris	Karun	Total
Dams	14	11	3	**28**
Planned dams	2	10	3	**15**
Dams under construction	0	1	3	**4**
Barrage/regulators	4	5	0	**9**
Total Dams	16	22	9	**47**
Total Barrage/regulators	3	5	0	**8**

Tigris basin	1950 - 1970	1971 -1979	1980-1989	1990-1999	2000-2010	2011 - 2020
	3	1	2	4	1	11

Water control structures in country	Euphrates		Tigris		Karun		Total
	current	planned	current	planned	current	planned	
Turkey	7	2	4	7	0	0	**20**
Syria	6	0	0	0	0	0	**6**
Iraq	4	0	11	4	0	0	**19**
Iran	0	0	1	0	3	6	**10**
Total	**17**	**2**	**16**	**11**	**3**	**6**	**55**



- Dam operational information
  - Start date, Surface area, volume, operational logistics
    - Wikipedia and other cited literature
  - Manual adjustments needed to be made
    - Some data in Wikipedia were wrong
      - Eg. Surface area of Tartar lake 2800 Sq.KM, however observation on aerial image shows 1800 Sq.KM

More information on dams is presented in appendix 3

Calibration

- Statistical and graphical evaluation

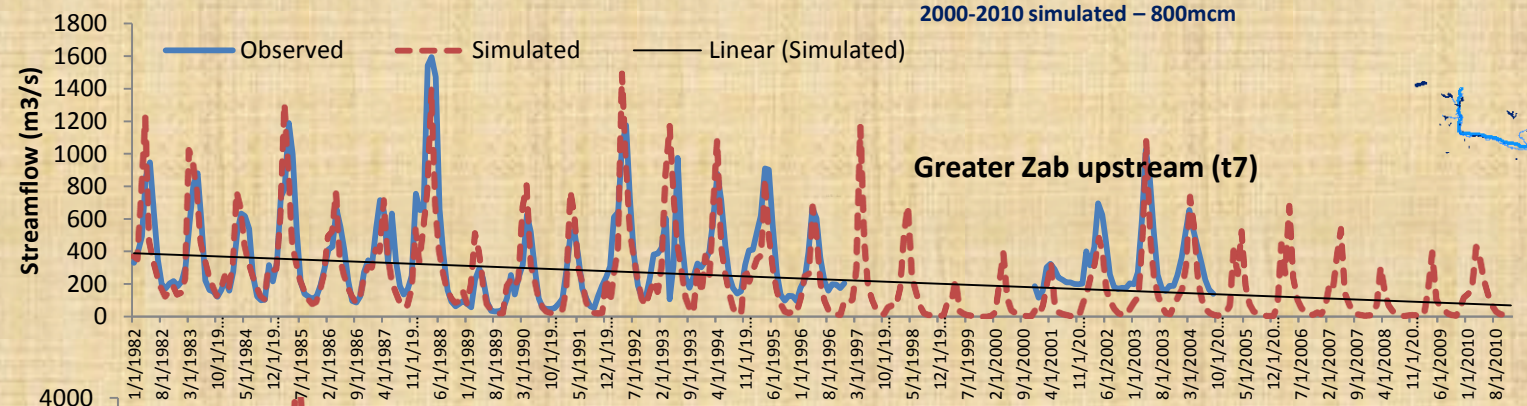
Gauge station	R2	NSE	PBIAS
Greater Zab upstream (1982-1990)*	0.67	0.65	9
Greateer Zab downstream (1982 –1990)	0.67	0.65	10
Lesser Zab upstream (1982-1990)	0.71	0.64	-25
Diyala upstream((1982-1990)	0.68	0.62	14
Karkheh below reservoir (1990 -1999)	0.68	0.62	14
Tigris below Mosul dam (1985-1994)	0.51	0.5	-13
Tigris before Samara barrage (1985-1994)	0.71	0.7	10
Tigris above Bagdad (1985-1994)	0.37	0.09	8
Tigris below Kutt barrage (1989-2001)	0.72	0.2	-14

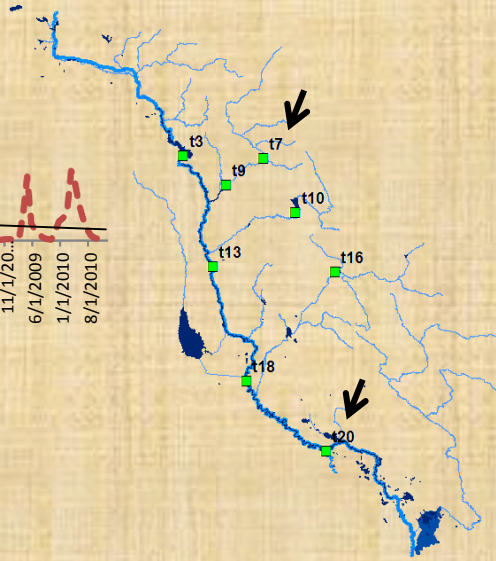
R2 > 0.6 ---> good
NSE > 0.5 ---> good
Pbias < 1 5%---> good

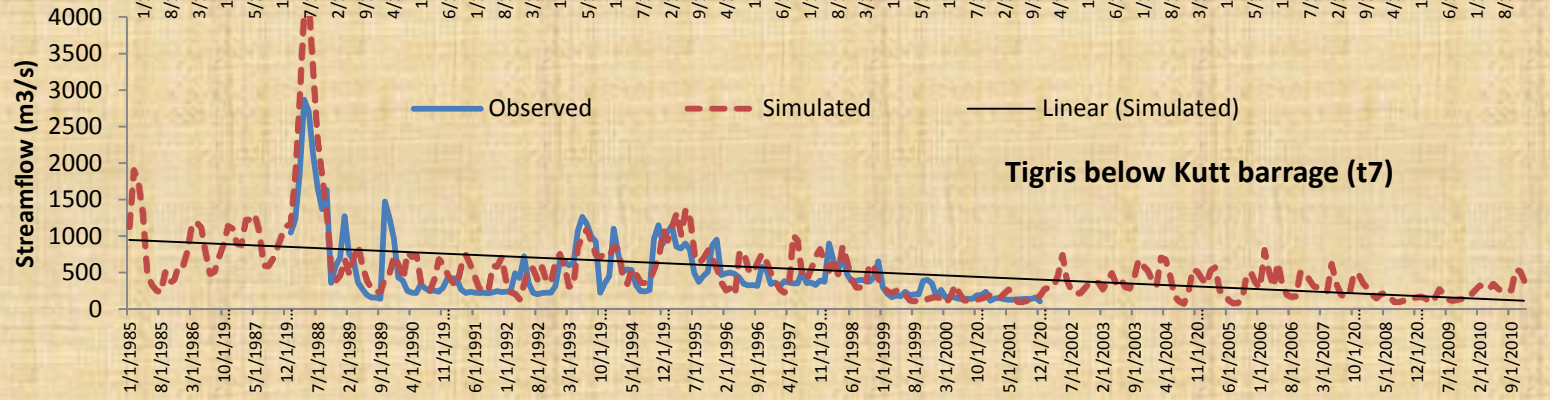
* Time period of calibration based on best observed data available without data interruptions

Monthly average (cms)		Monthly Standard Deviation (cms)	
Measured	Simulated	Measured	Simulated
688.8	616.7	303.4	367.7
461.2 (1100mcm)	524.2 (1300mcm)	351.2 (900mcm)	395.8 (1000mcm)

2000-2010 simulated – 800mcm

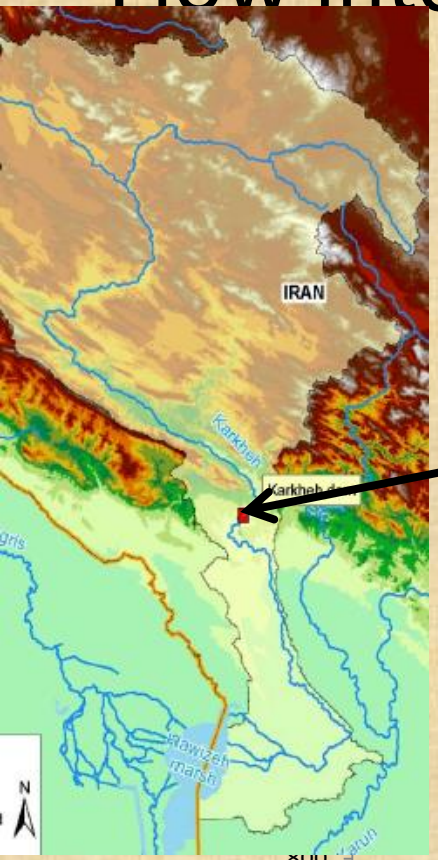


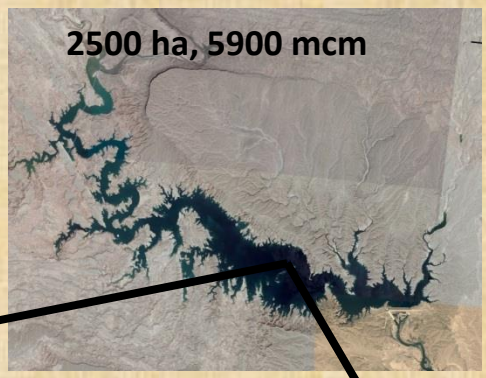


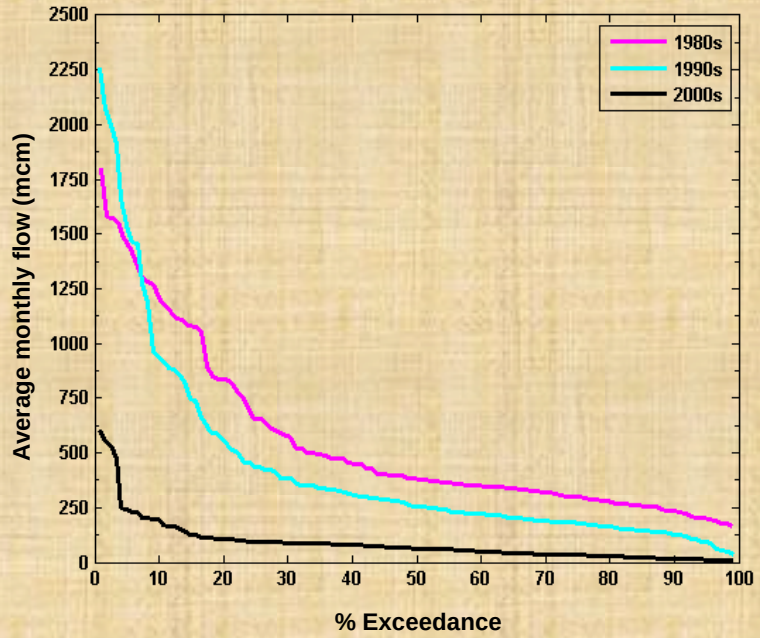


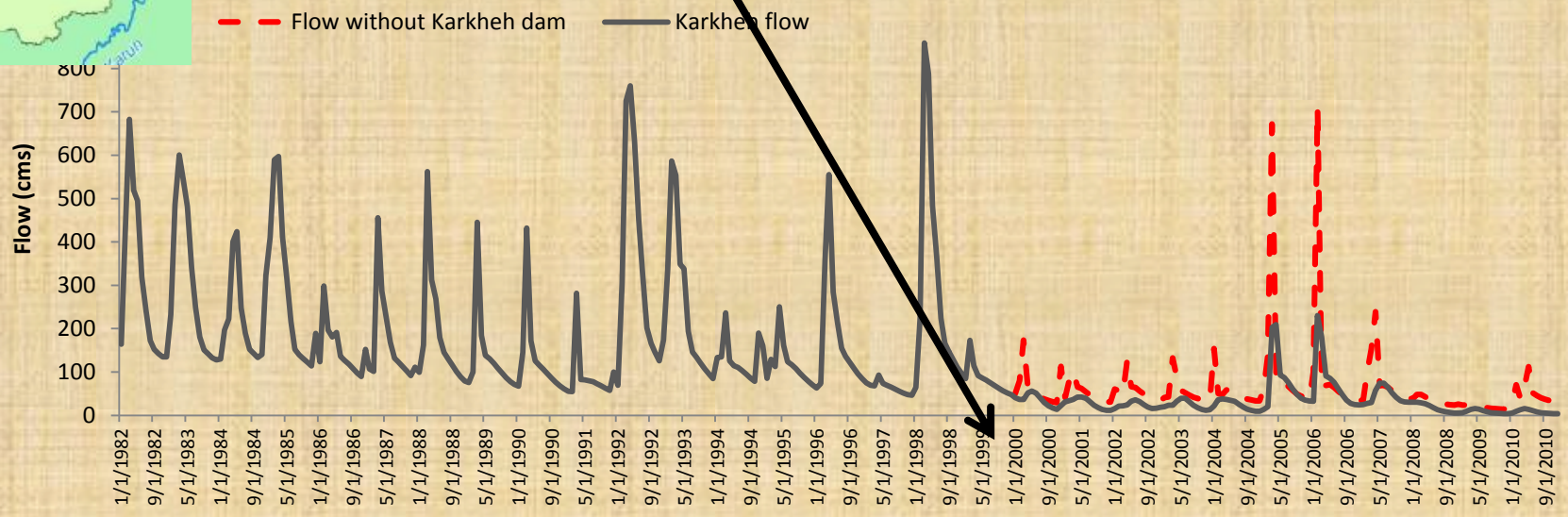
Results

- Flow into Hawizeh marsh from Karkheh River

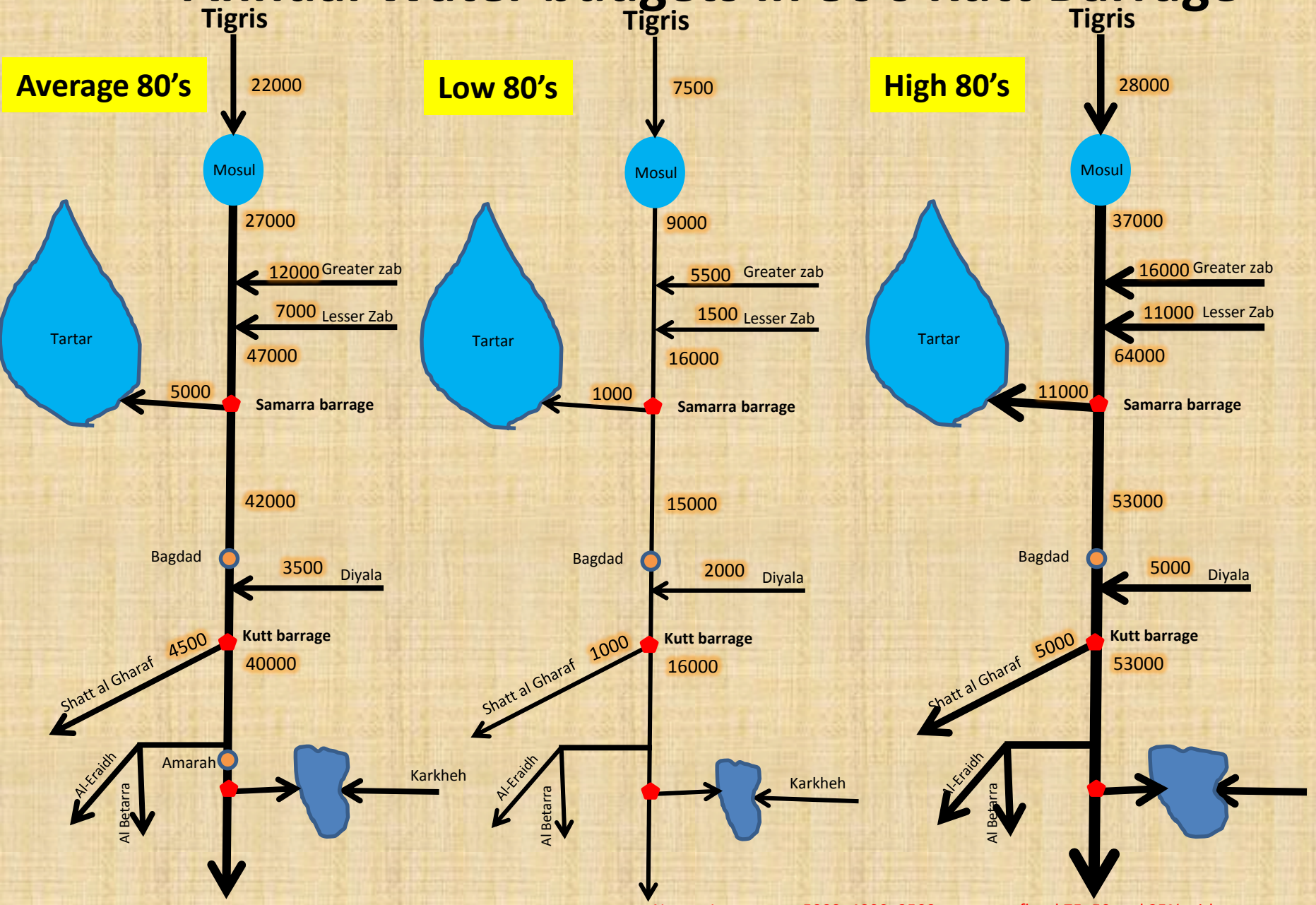








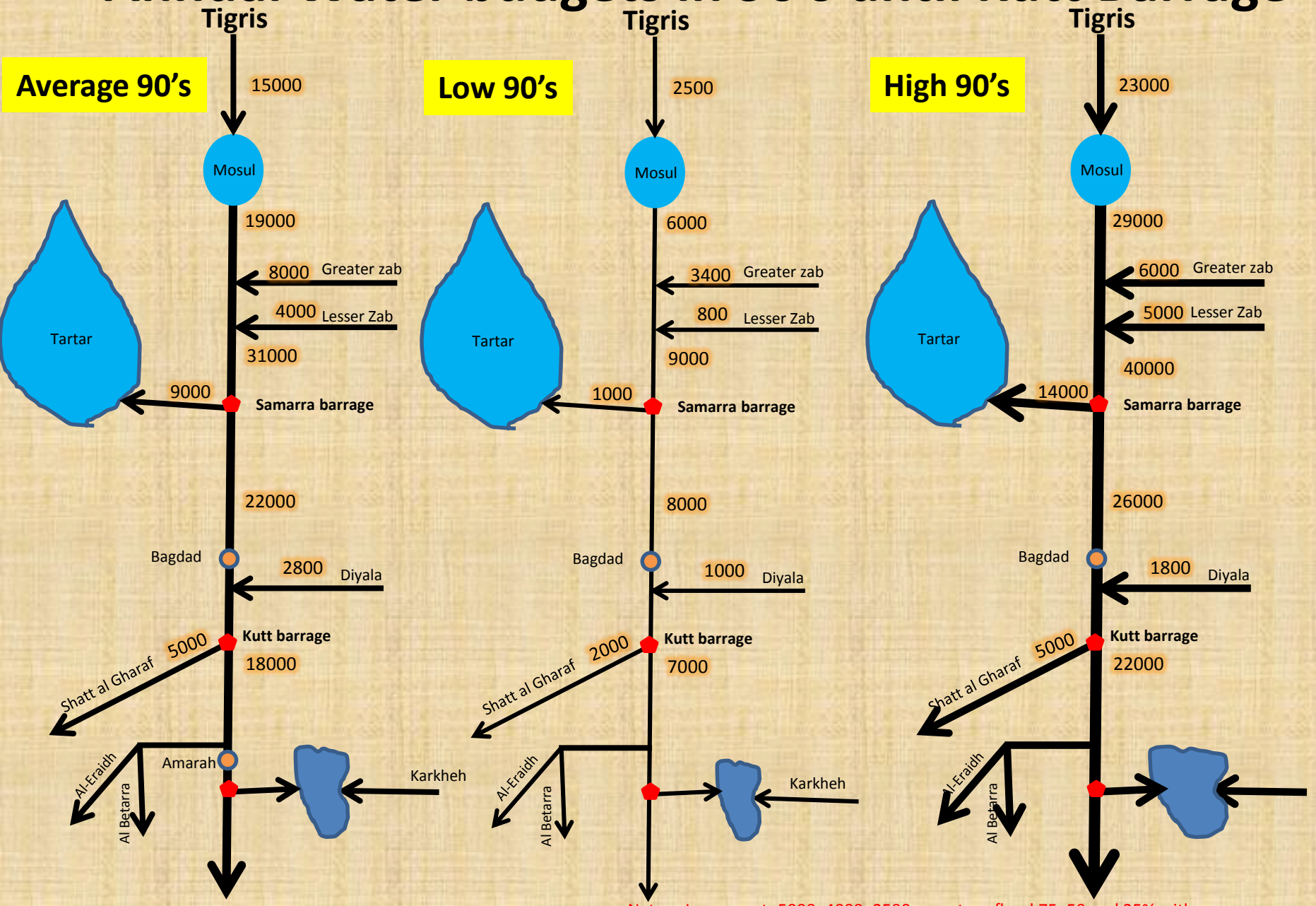
Annual Water budgets in 80's Kutt Barrage



All numbers above are average annual flow volume in mcm

Nature Iraq report: 5000, 4000, 2500 mcm to reflood 75, 50 and 25% with evaporative demand of 3000, 2000, 1500 mcm and with constant outflow of 2000 mcm

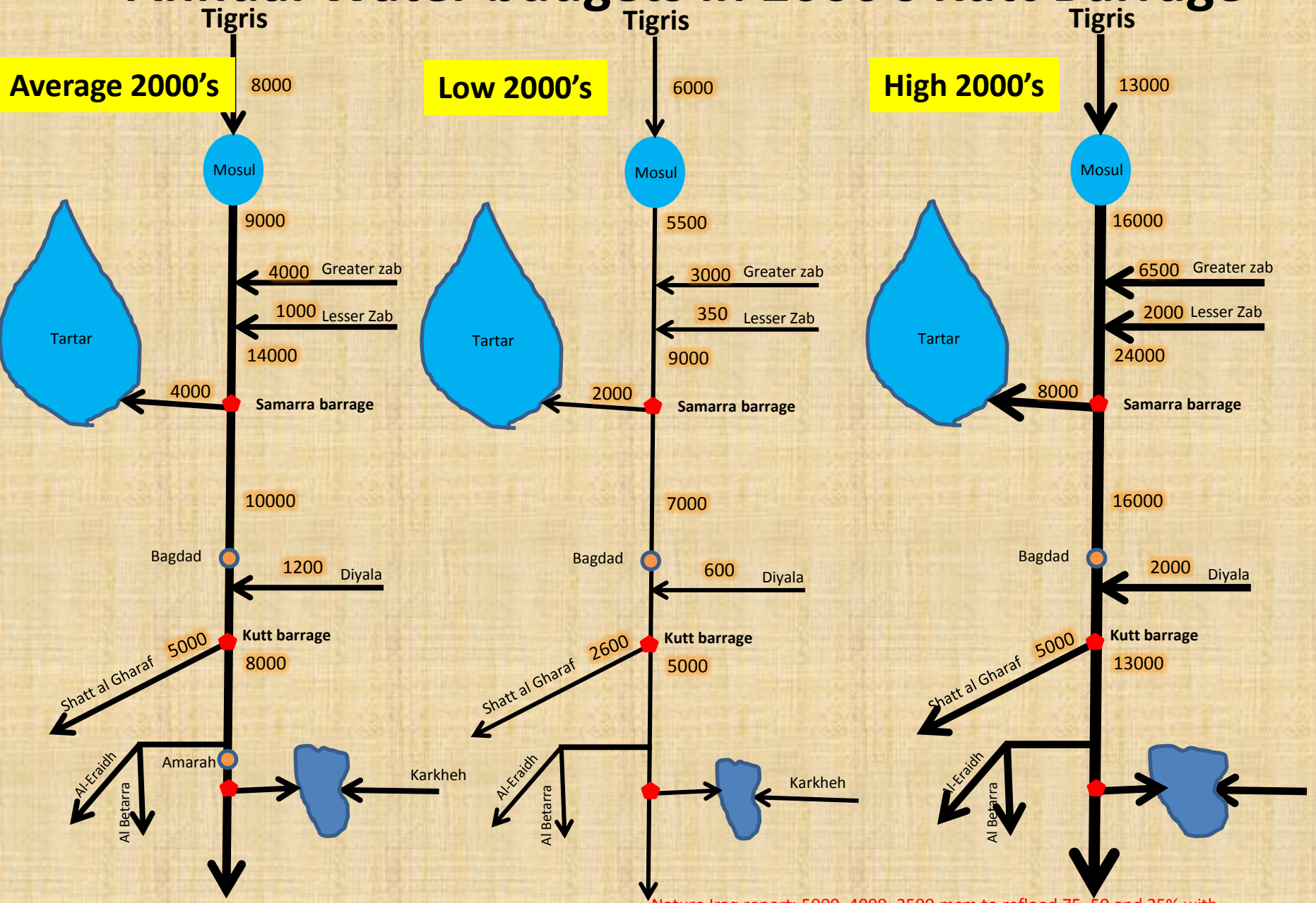
Annual Water budgets in 90's until Kutt Barrage



All numbers above are average annual flow volume in mcm

Nature Iraq report: 5000, 4000, 2500 mcm to reflood 75, 50 and 25% with evaporative demand of 3000, 2000, 1500 mcm and with constant outflow of 2000 mcm

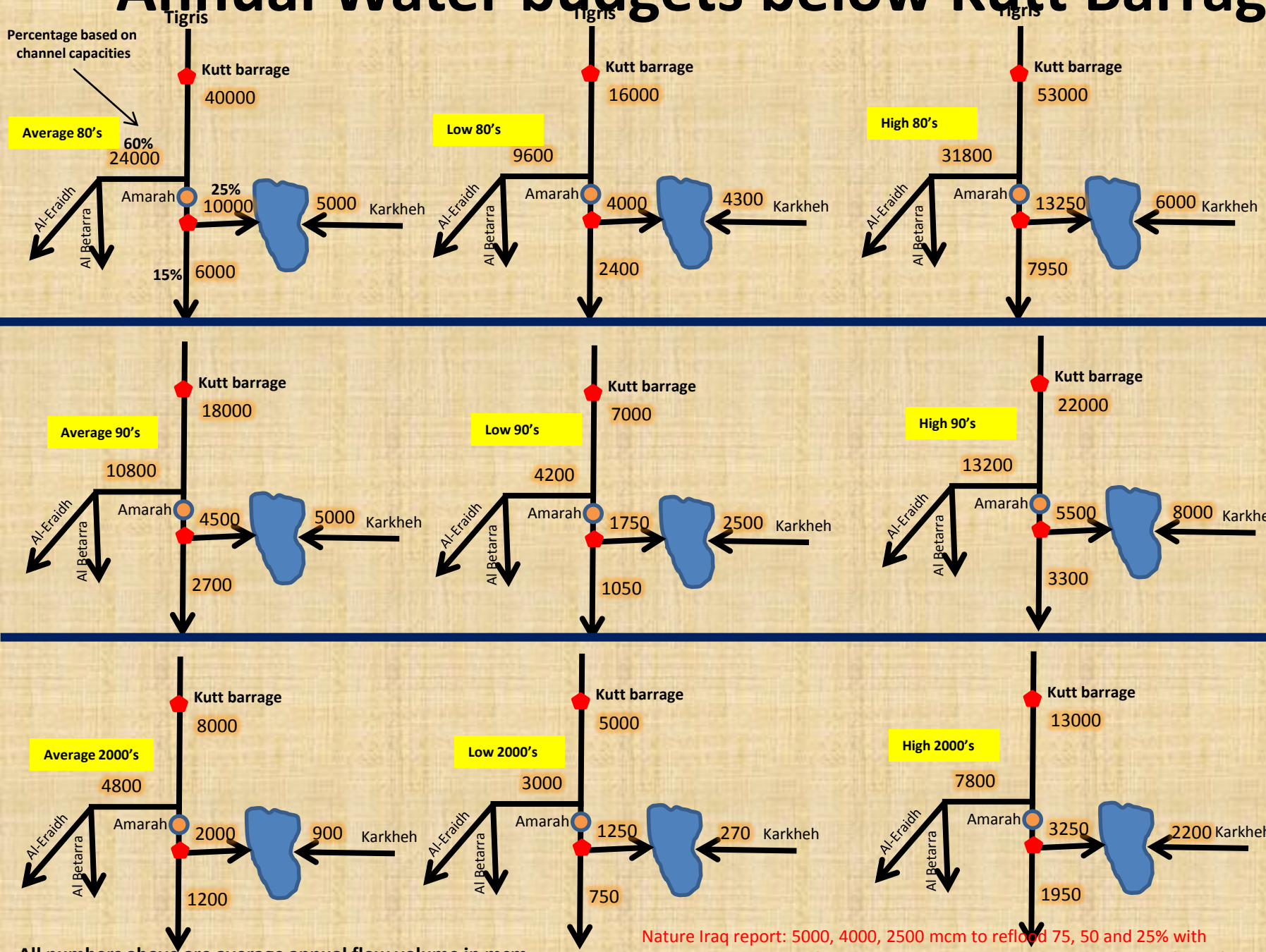
Annual Water budgets in 2000's Kutt Barrage



All numbers above are average annual flow volume in mcm

Nature Iraq report: 5000, 4000, 2500 mcm to reflood 75, 50 and 25% with evaporative demand of 3000, 2000, 1500 mcm and with constant outflow of 2000 mcm

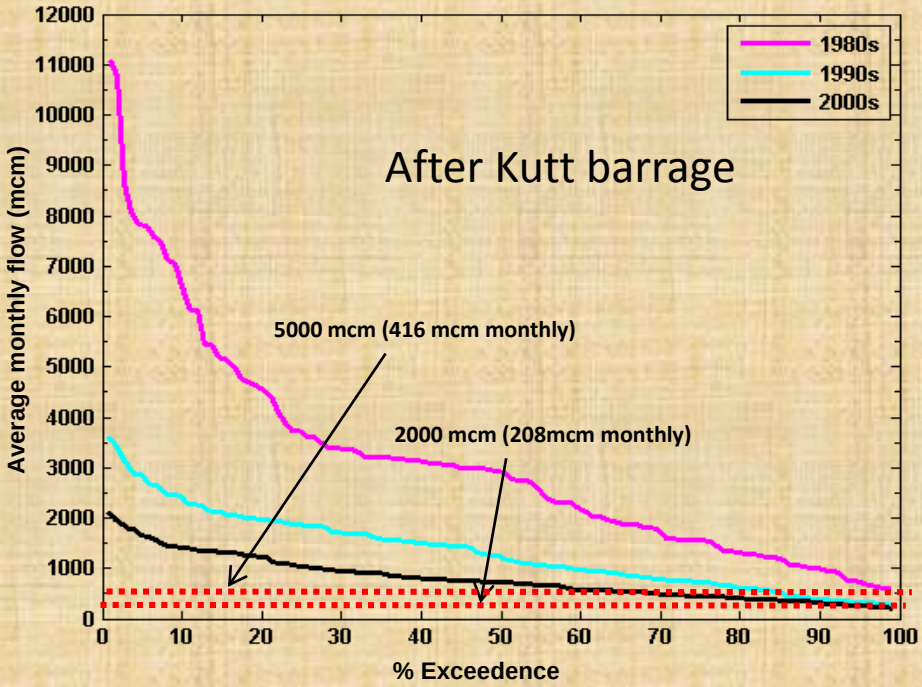
Annual Water budgets below Kutt Barrage

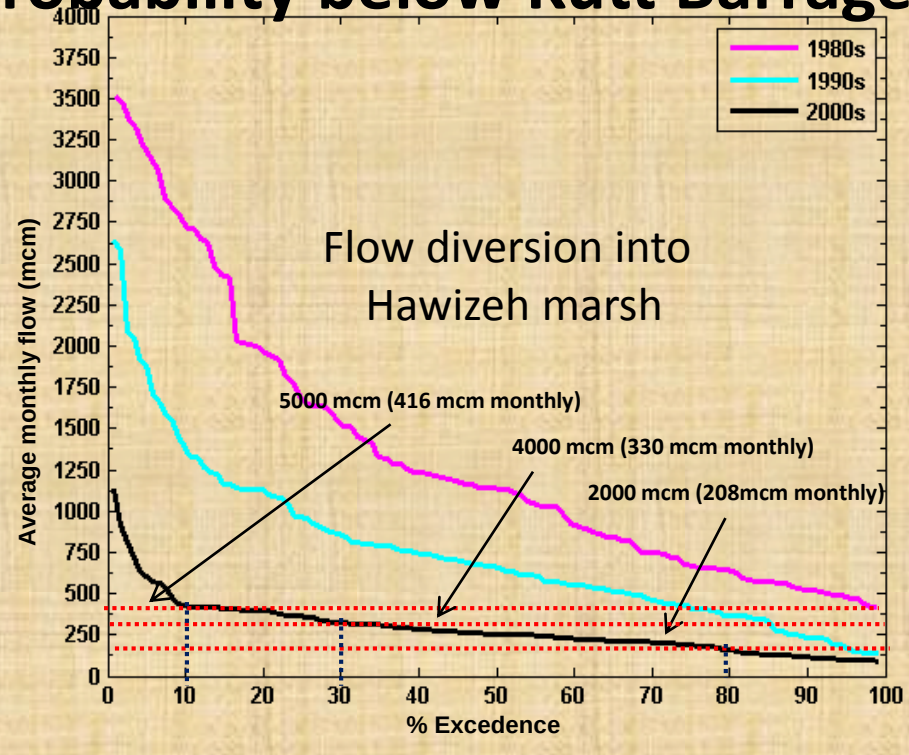


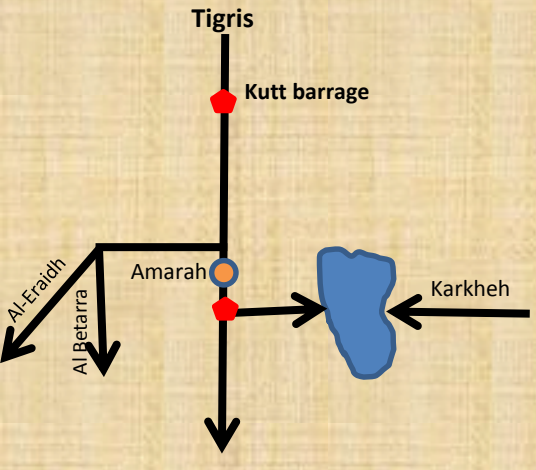
All numbers above are average annual flow volume in mcm

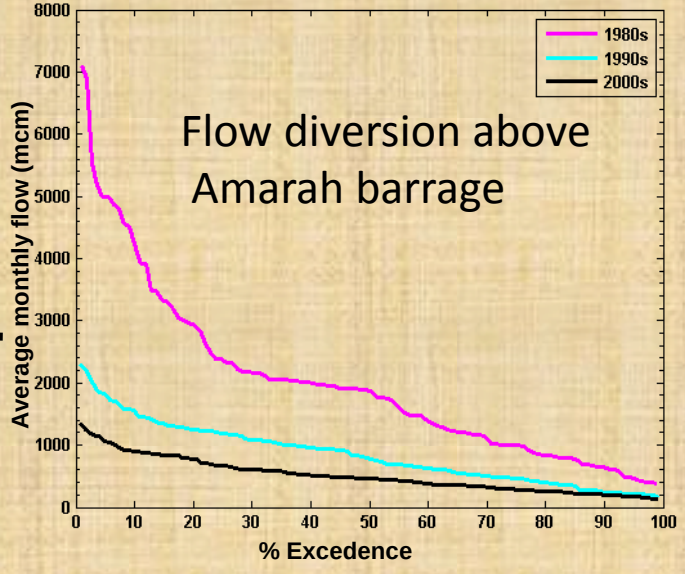
Nature Iraq report: 5000, 4000, 2500 mcm to reflood 75, 50 and 25% with evaporative demand of 3000, 2000, 1500 mcm and with constant outflow of 2000 mcm

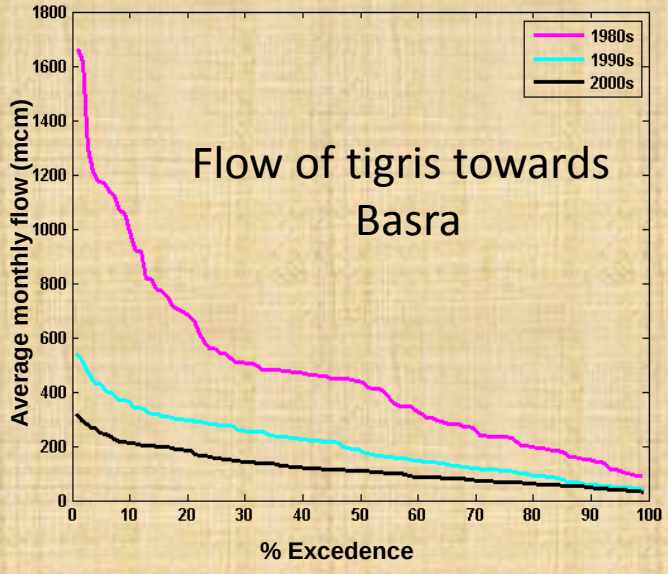
Flow intensity, duration, probability below Kutt Barrage







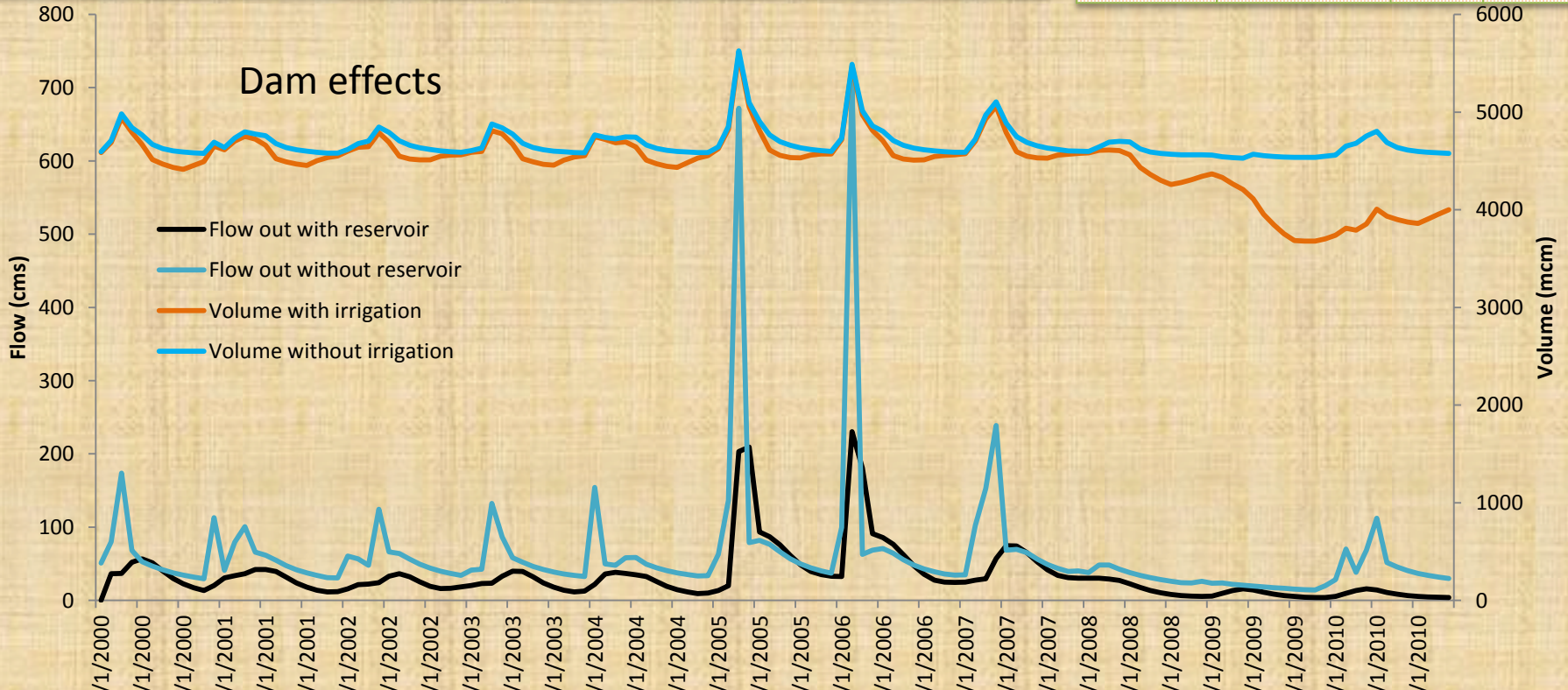




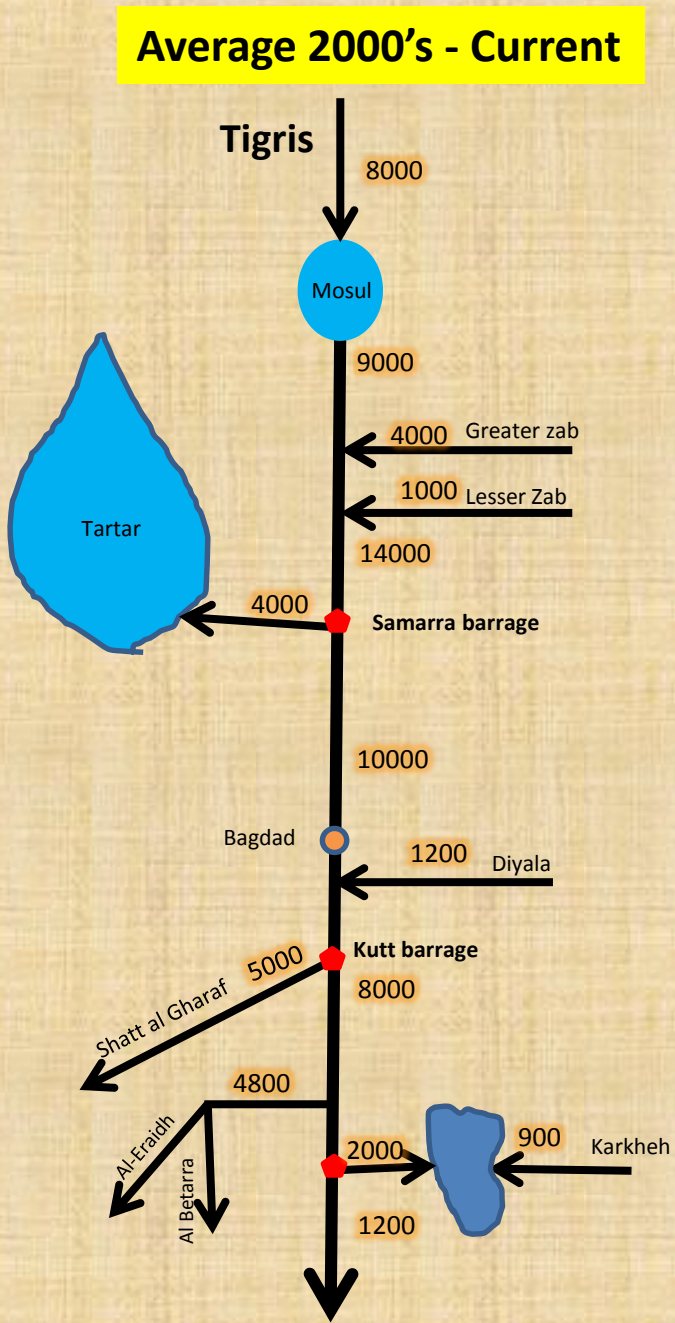
Dams

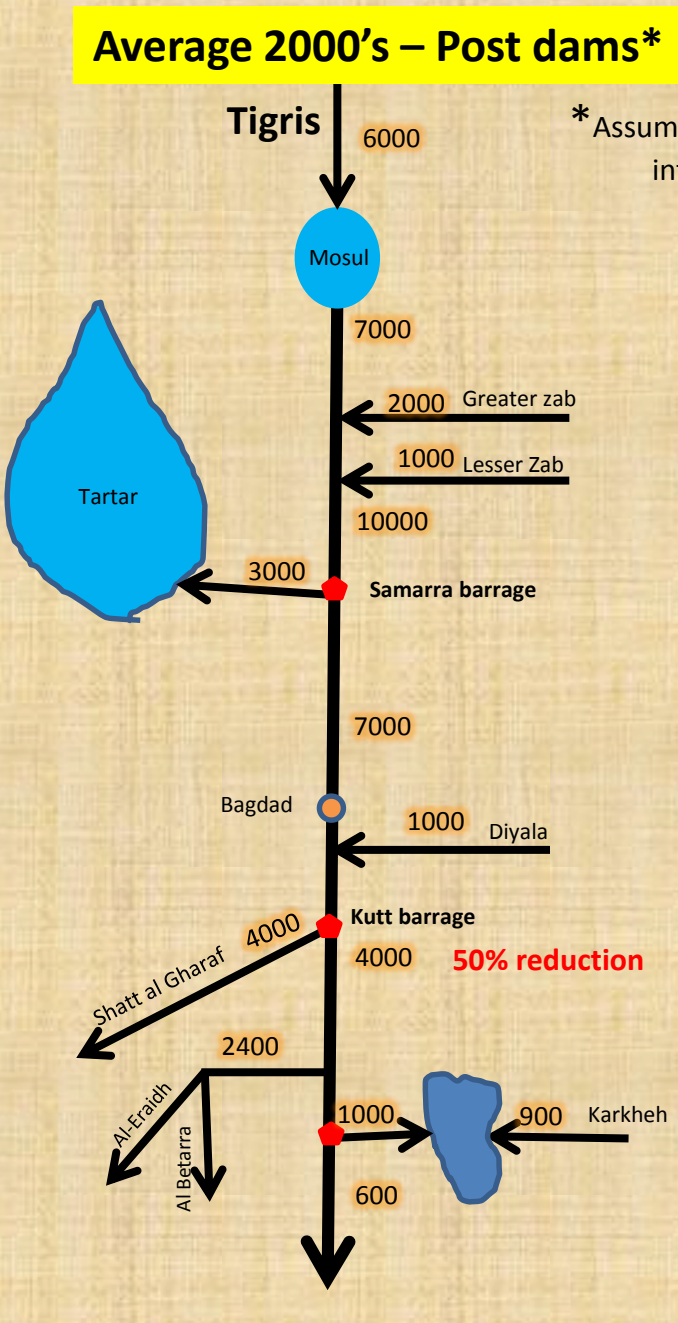
Current Dam	Volume (mcm)	Inflow (mcm)	Outflow (mcm)	% reduction	Evaporation (mcm)	evap/vol
Batman	1100	1105	874	21%	50	5%
Dicile	580	674	659	2%	24	4%
Kralkize	1920	342	305	11%	54	3%
Mosul	11110	18799	17972	4%	416	4%
Dokan	6800	5799	4587	21%	309	5%
Dibbis	4000	4953	3932	21%	154	4%
Hemrin	2500	3318	2670	20%	78	3%
Derbinkhan	3000	3250	2866	12%	142	5%
Karkheh	5900	1978	1086	**45%**	40	1%
Tartar	11000	9000	-	-	**2260**	**21%**
Total	**47910**	49219	35519		**3529**	

Future Dams	River	Country	Volume
Taqtaq	Lesser Zab	Iraq	2858
Bekhme	Greater zab	Iraq	8300
Bakeerman	Greater zab	Iraq	500
Mandava	Greater zab	Iraq	2000
Hakkari	Greater zab	Turkey	2000
Garzan	Trib upper tigris	Turkey	145
Kayser	Trib upper tigris	Turkey	1970
Dilini	Trib upper tigris	Turkey	200
Silvan	Trin upper tigris	Turkey	1175
Cizie	Upper tigris	Turkey	200
Illisu	Upper tigris	Turkey	10410
			27777



Current and Post Dams





*Assumptions based on current dam sizes, inflow and outflow calculations

Summary

- Decreasing trend of flow in tributaries and main stem
  - 65% and 80% decrease below kutt barrage in 90's and 2000's compared to 80's
  - 0% and 82% decrease in Karkheh in 90's and 2000's compared to 80's
    - Decrease mainly due to decrease in rainfall and construction of water structures such as dams and water diversions
- 10%, 30 % and 80% of water available to flood the Hawizeh marsh to 75% , 50% and 25% of original size in 2000's
- Current and proposed dams plays a major role in water availability to Hawizeh marsh
  - Evaporation in current dams is equivalent to water needed to re-flood marshes close to 50% of original size
  - Karkheh dam reduces flow by 45%
  - Future dams such as Illusu on Tigris; bekhme, hakkari and mandava on Greater Zab will have huge impacts
    - Roughly 50% reduction compared to 2000 and 90% compared to 80's
- Proper management of dams, water diversions and irrigation will help in improving water availability to Hawizeh marsh


Thank you