Modelling Future Water stress

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July 19, 2023

Importance of water

- You hear often: “ ….the most bitter conflicts in the next fifty years will not be over oil but water.
- Almost a billion people in the world live without access to clean water and water scarcity is growing
- Climate change is likely to worsen the situation.
- Water will increasingly dominate national and international politics and power.
- It is this thirst for water that may become critical for ensuring political, social, and economic stability. How we manage this valuable resource is, therefore, crucial for our future.

Fundamental role of water

- Should be seen as the `blood` of ecosystem structure and functions, and an engine of economic production.
- Our economy is ecosystems based.
- Proper functioning of the ecosystem is the fundament of our existence;
- Water security.

Some Global Water Flashpoints

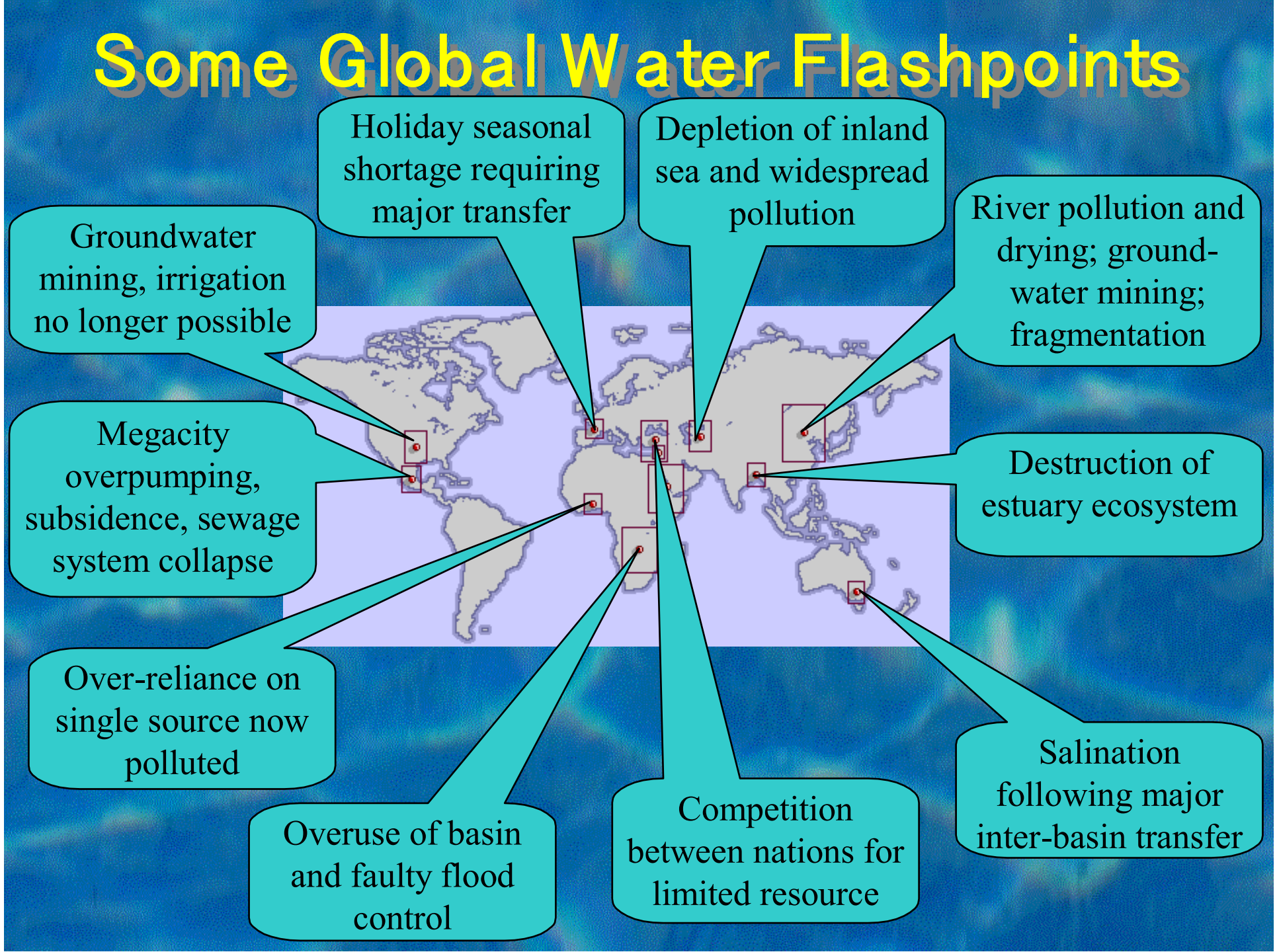
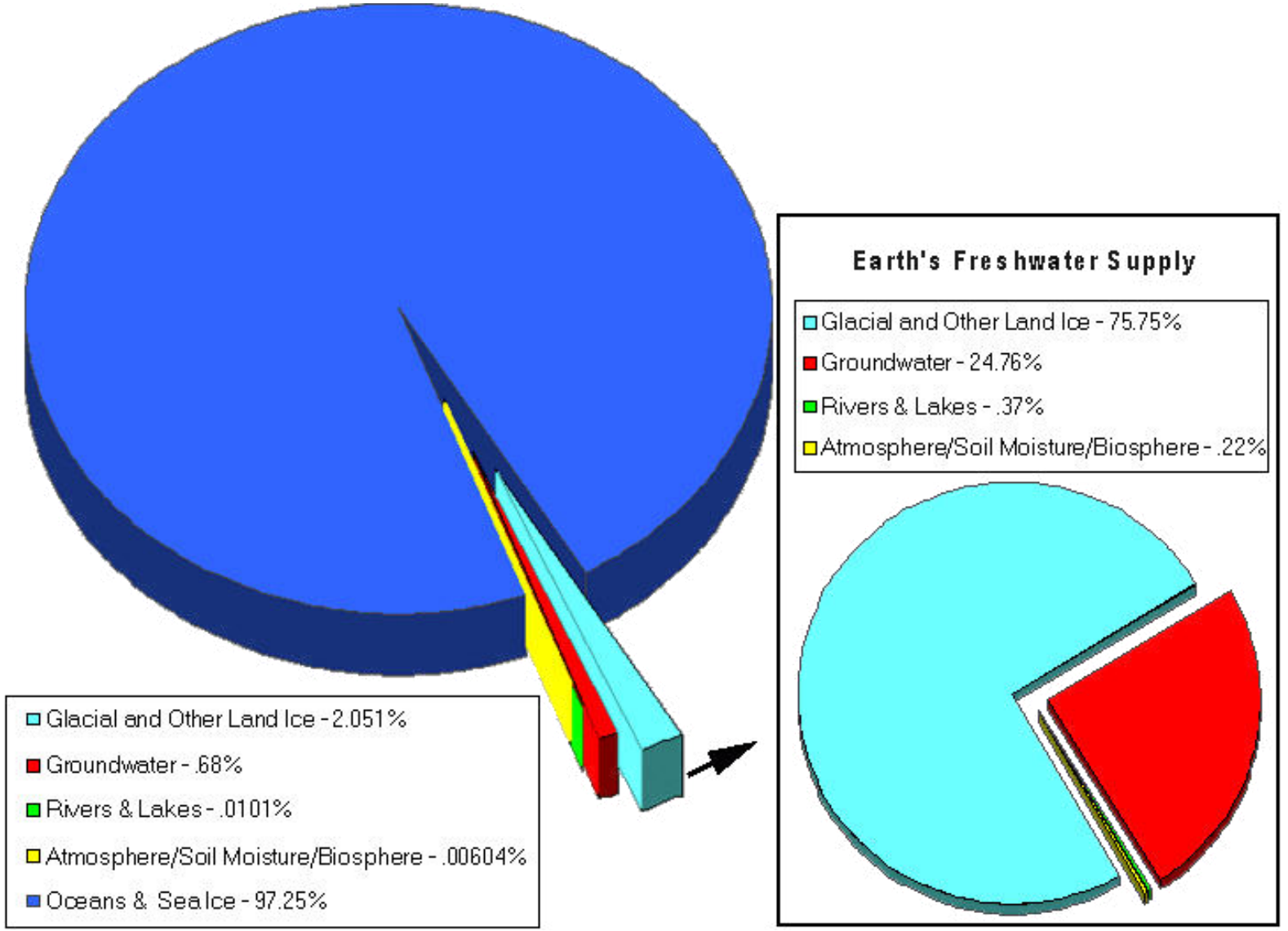


Fig. Water op Aarde

(http://www.henzel.org/globe/hydrology/HY_WHEREISWATER.HTML)



Tabel: Water op Aarde (na Chow et al., 1988)

	Area 10^6 km^2	Volume 10^3 km^2	% of total water amount	% of fresh water amount
Oceans	361.3	1338000	**96.5**	
Ground water				
Fresh	134.8	10530	**0.76**	30.1
Salty	134.8	12870	0.93	
Soil moisture	82	16.5	0.0012	0.05
Polar ice	16	24024	1.7	68.6
Other ice & snow	0.3	340.6	0.025	1
Lakes				
Fresh	1.2	91	0.007	0.26
Salty	0.8	85.4	0.006	
Marshes	2.7	11.5	0.0008	0.03
Rivers	148.8	2.1	**0.0002**	**0.006**
Biologic water	510	1.1	0.0001	0.003
Atmospheric water	510	12.9	0.001	0.04
Total water	510	1385985	**100**	
Fresh water	148.8	35029	**2.5**	100

Water occurrence in the world

Water occurrence	10^{12} m^3	Amount of water	
		% of water	% of fresh water
World oceans	1.300.000	97	
Salt lakes/seas	100	0.008	
Polar ice	28.500	2.14	77.6
Atmospheric water	12	0.001	0.035
Water in organisms	1	0.000	0.003
Fresh lakes	123	0.009	0.335
Water courses	1	0.000	0.003
Unsaturated zone	65	0.005	0.18
Saturated zone	8.000	0.60	21.8
Total fresh water	36.700	2.77	100
Total water	1.337.000	100	

Annual water balance of the world

Region	Area	Precipitation		Evaporation		Runoff	
	10^{12} m²	m/a	10^{12} m³/a	m/a	10^{12} m³/a	m/a	10^{12} m³/a
Oceans	361	1.12	403	1.25	449	-0.13	-46
Continents	149	0.72	107	0.41	61	0.31	46

Table 1.15: Annual water balance of World Oceans

Ocean	Surface area	P-E	Land runoff	Ocean exchange	P-E	Land runoff	Ocean exchange	
	10^{12} m²	mm/a	mm/a	mm/a	10^{12} m³/a	10^{12} m³/a	10^{12} m³/a	m³/s
Arctic	8.5	44	307	351	0.4	2.6	3	94544
Atlantic	98	-372	197	-175	-36.5	19.3	-17	-543466
Indian	77.7	-251	72	-179	-19.5	5.6	-14	-440739
Pacific	176.9	90	69	159	15.9	12.2	28	891318

Fluxes between stores (note that the ocean area is about twice the land area)

Evaporation from ocean	117 cm/yr
Precipitation onto ocean	107 cm/yr
Precipitation onto land	74 cm/yr
Evaporation from land	49 cm/yr
Runoff from land	25 cm/yr

Over the ocean, E > P

Over land, P > E. Suggests that the storage of water on land causes some kind of "resistance" to evaporation, so that some of the precipitated water "escapes" evaporation and survives to run off.

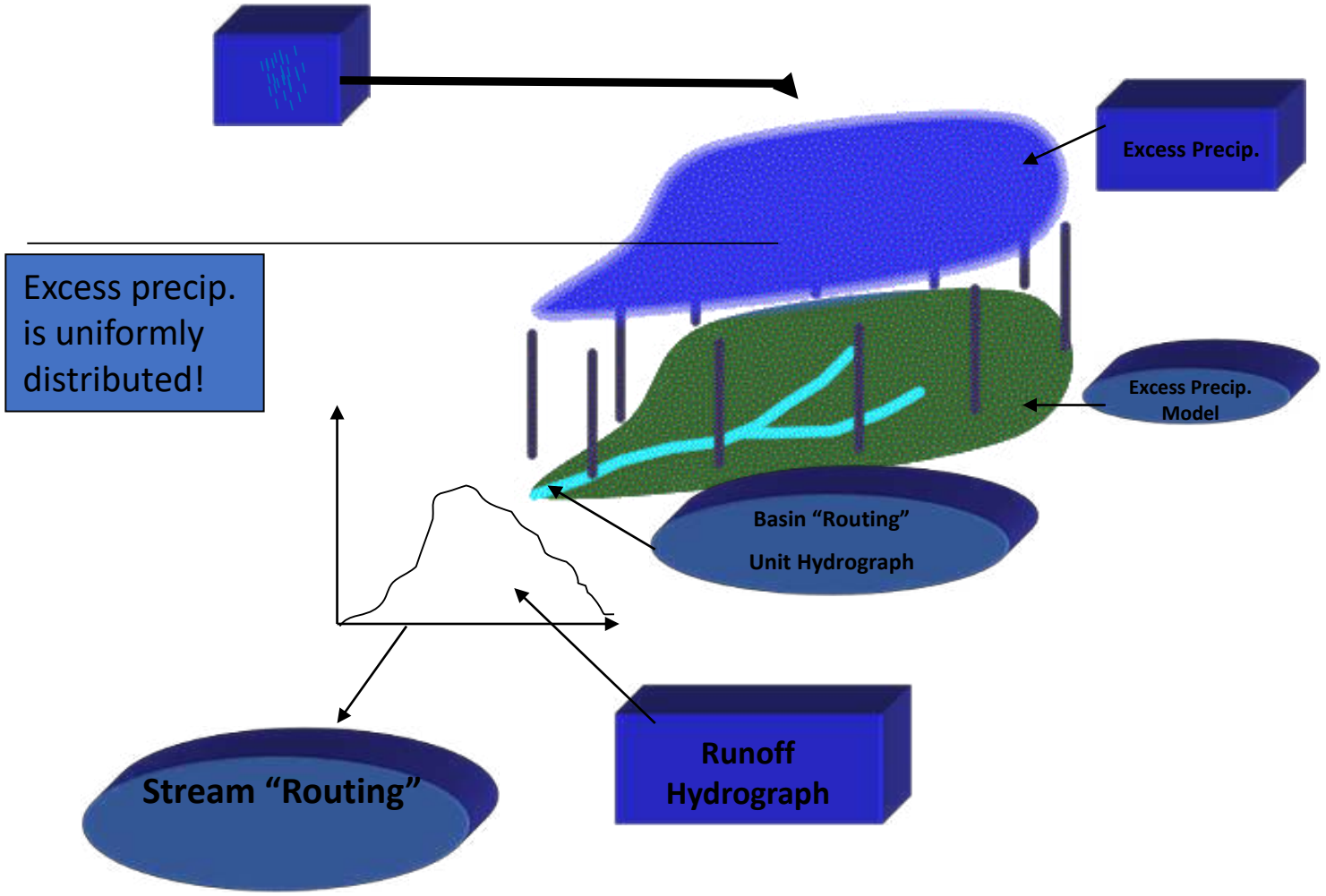
Tabel. Globale hydrologische kringloop (na Chow et al., 1988)

	Oceans		Land	
Area (10^6 km^2)	361.3		148.8	
	mm/yr	km^3/yr	mm/yr	km^3/yr
Precipitation	1270	458000	800	119000
Evaporation	1400	505000	484	72000
River runoff to oceans				44700
Ground water runoff to oceans				2200

Water use in the world

- Total global freshwater use is estimated at about 4,000 cubic kilometres (km^3) a year
- Another 6,400 km^3 of rainwater is also used ‘directly’ in agriculture.
- Nature is the most important user of water An estimated 70,000 km^3 of water a year are evaporated from forest, natural (uncultivated) vegetation and wetlands
- Evaporation from human-made reservoirs is difficult to estimate but is considerable in arid areas and is estimated to be about 200 km^3 a year

From A Basin View

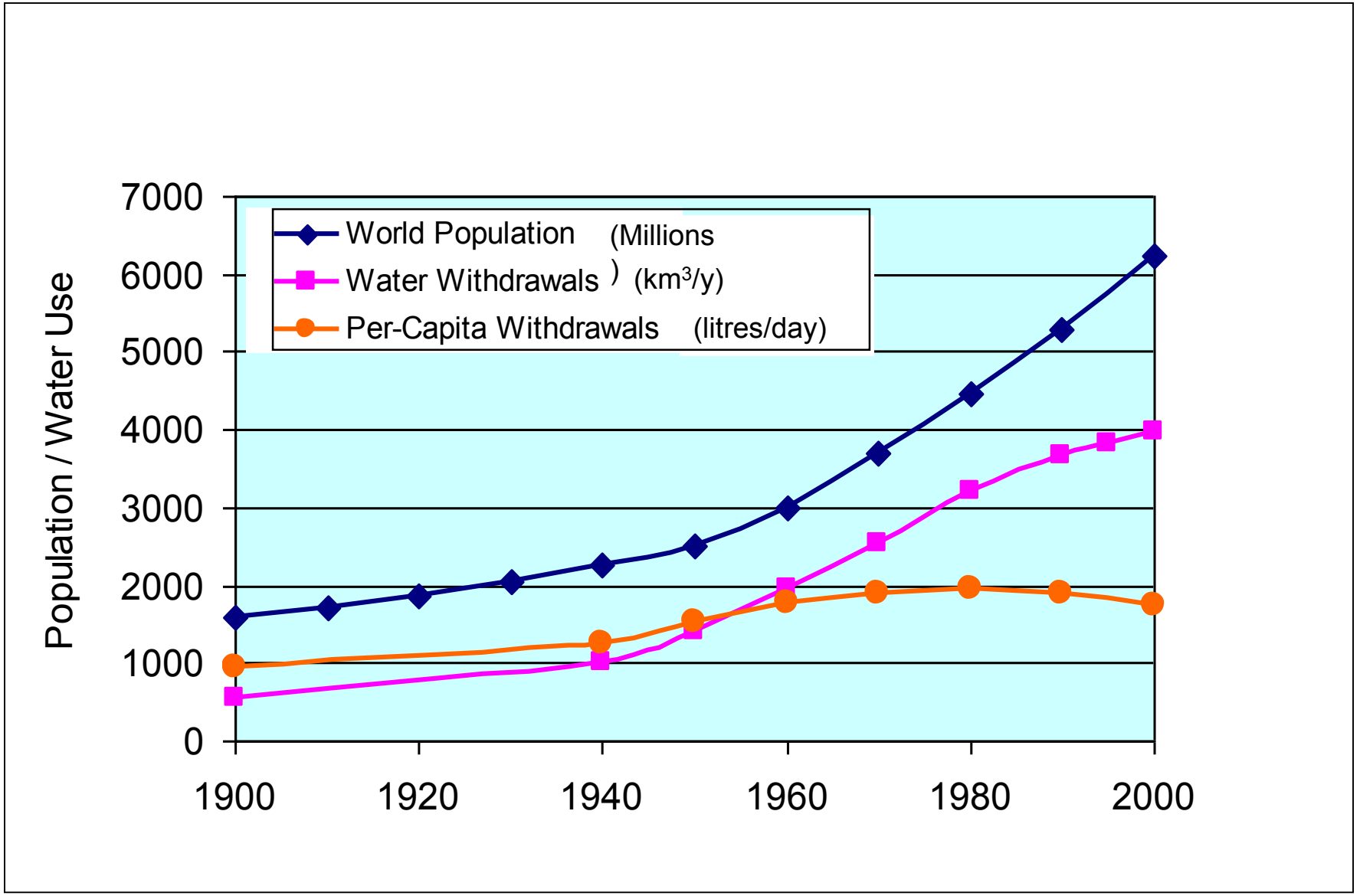


Indicative average annual water balances for drainage basins of some of the great rivers

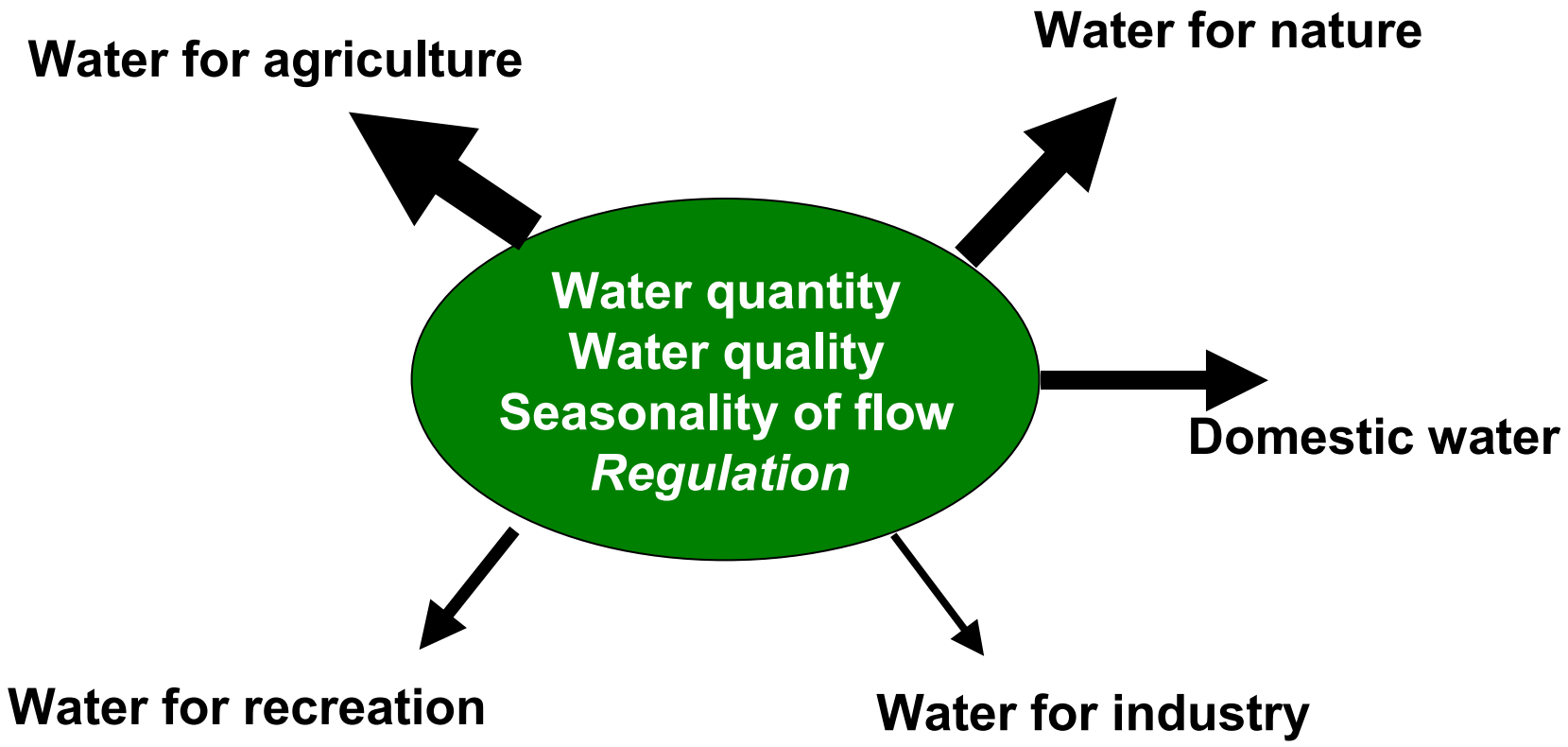
Table 1.16: Indicative average annual water balances for the drainage basins of some of the great rivers

River	Catchment	Rainfall size		Evaporation		Runoff		Runoff coefficient
	Gm^2	mm/a	Gm^3/a	mm/a	Gm^3/a	mm/a	Gm^3/a	%
Nile	2803	220	620	190	534	30	86	14
Mississipi	3924	800	3100	654	2540	142	558	18
Parana	975	1000	980	625	610	382	372	38
Orinoco	850	1330	1150	420	355	935	795	70
Mekong	646	1500	970	1000	645	382	325	34
Amur	1730	450	780	265	455	188	325	42
Lena	2430	350	850	140	335	212	514	60
Yenisei	2440	450	1100	220	540	230	561	51
Ob	2950	450	1350	325	965	131	385	29
Rhine	200	850	170	500	100	350	70	41
Zambezi	1300	990	1287	903	1173	87	114	12

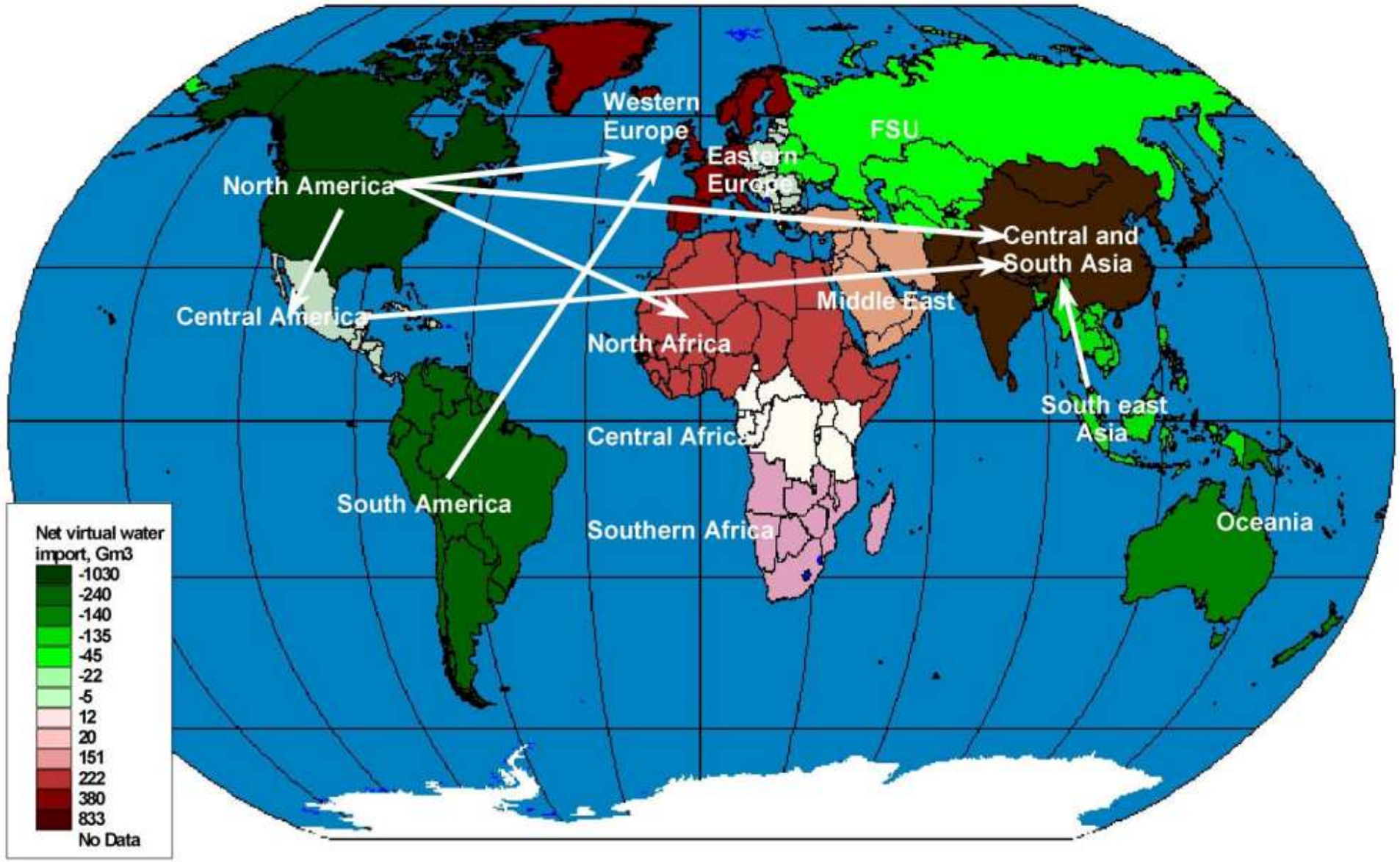
Global trends in the 20th century



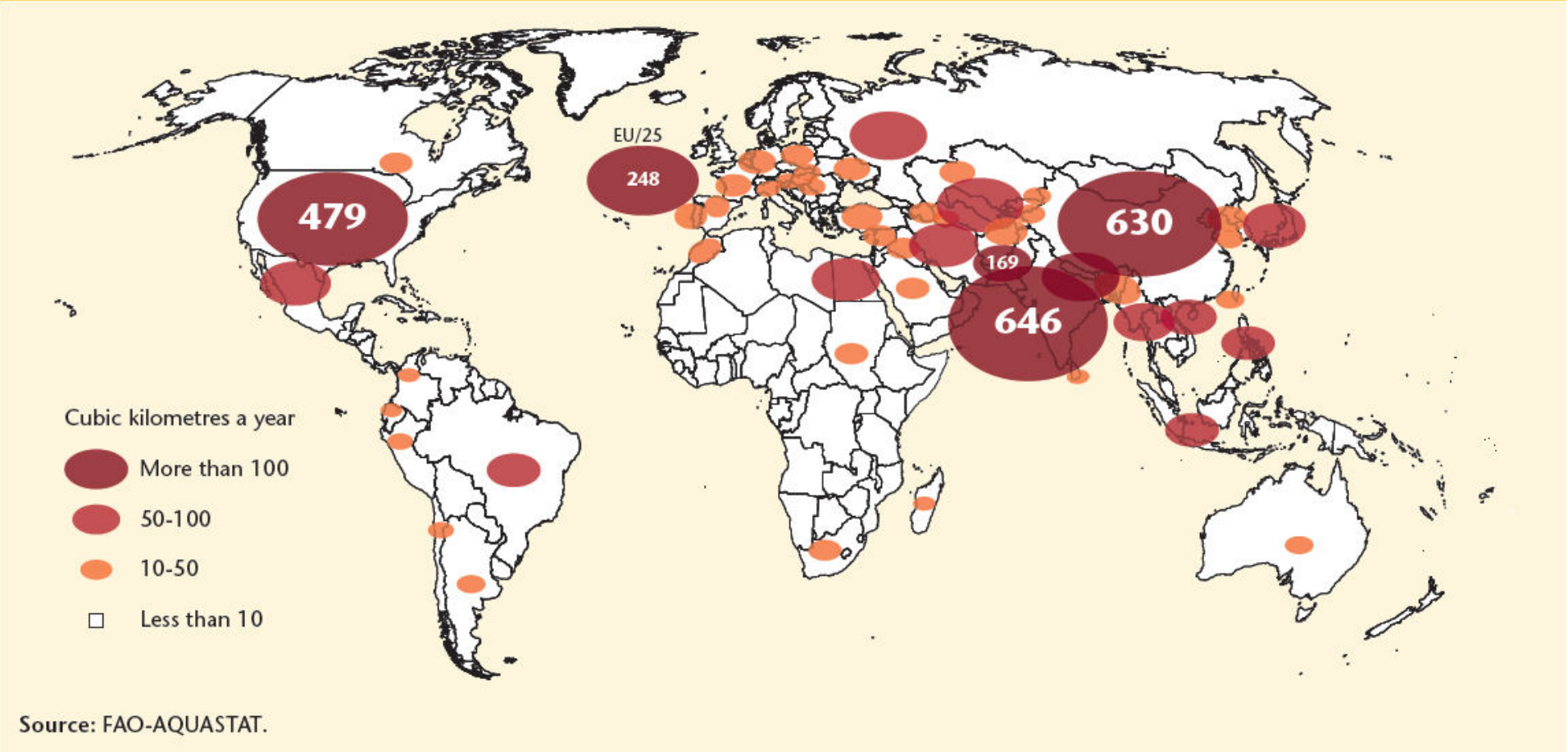
The Water Resource Sector
Water's "Trade-Off" Landscape



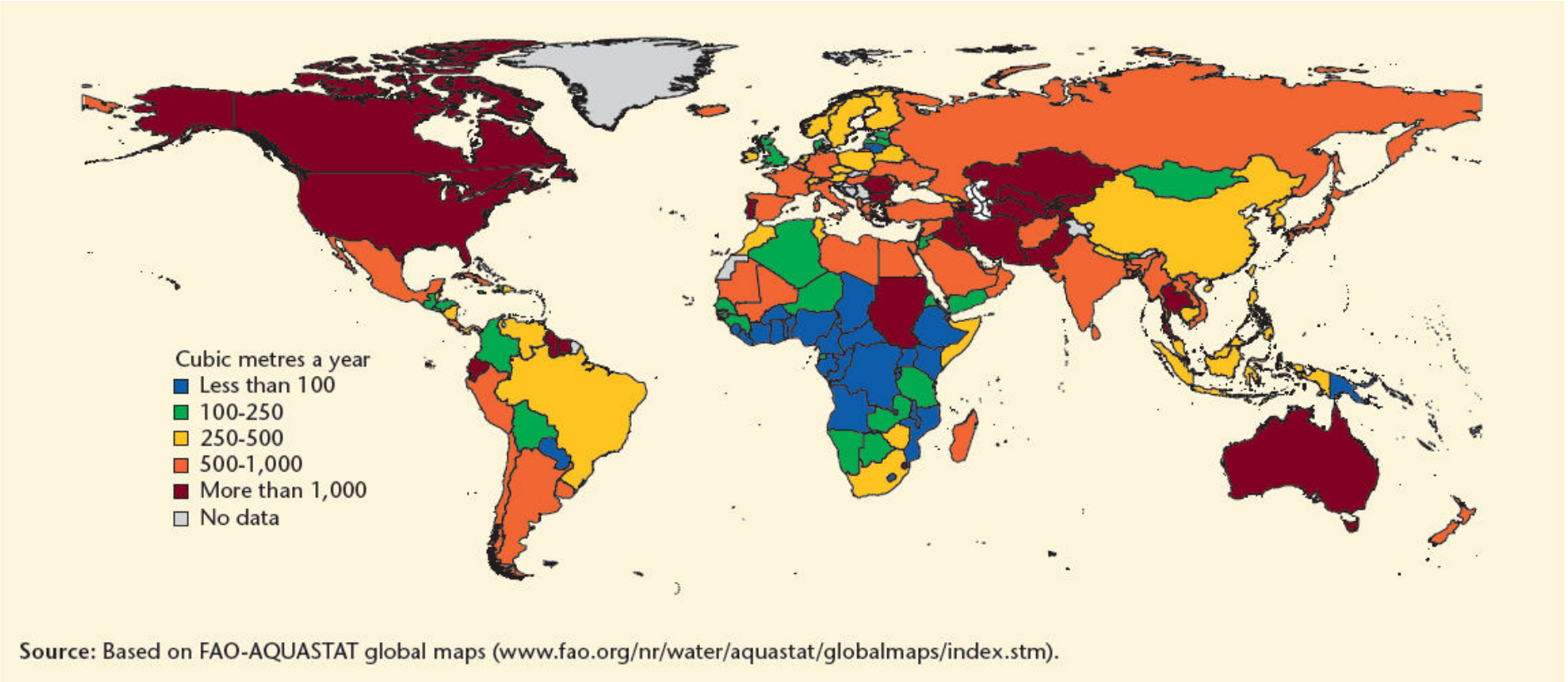
VIRTUAL WATER



Water withdrawals discrepancies between regions and between largest and smallest consumers around 2001

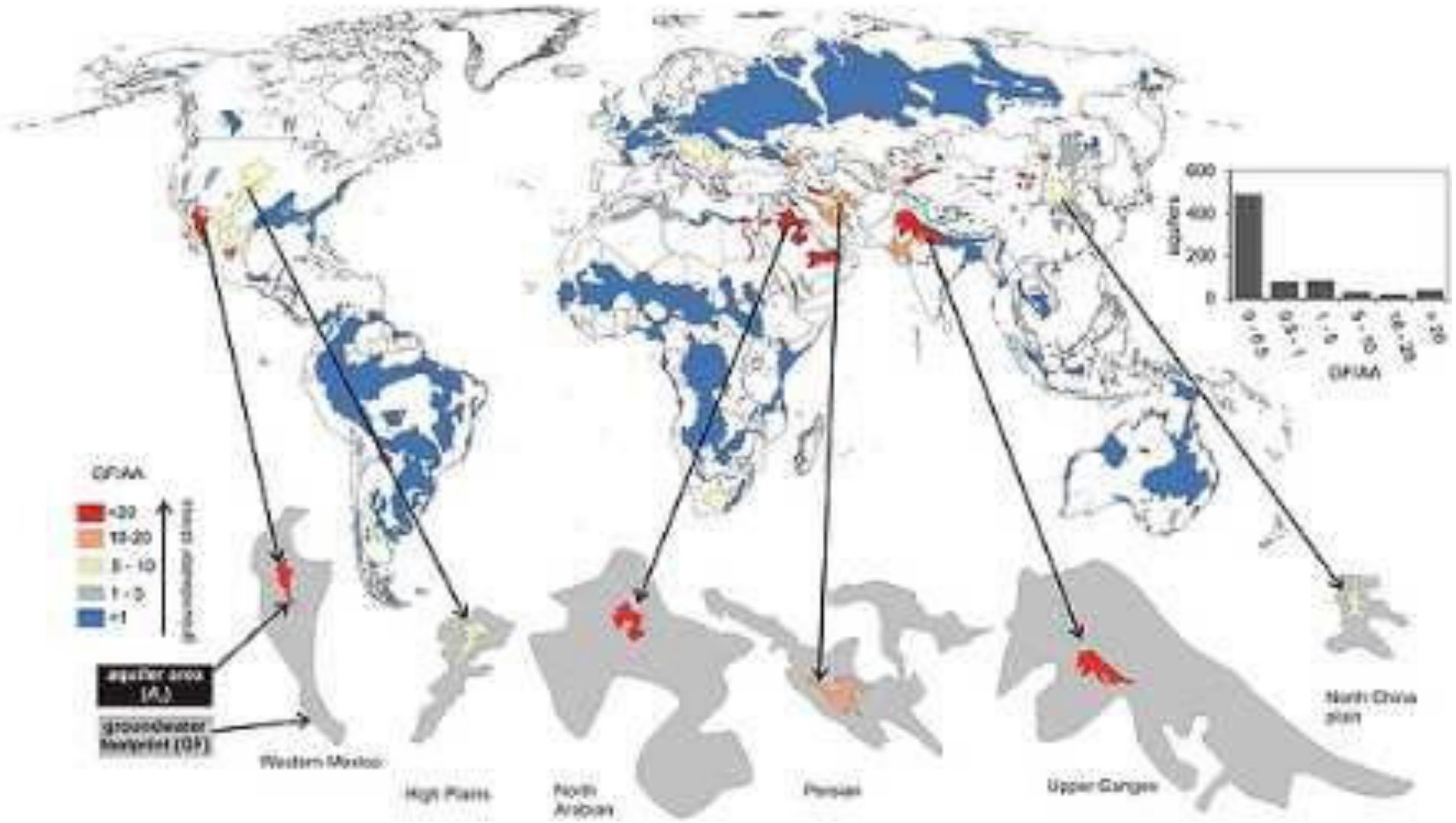


Annual Water withdrawals per person by country, world view 2000



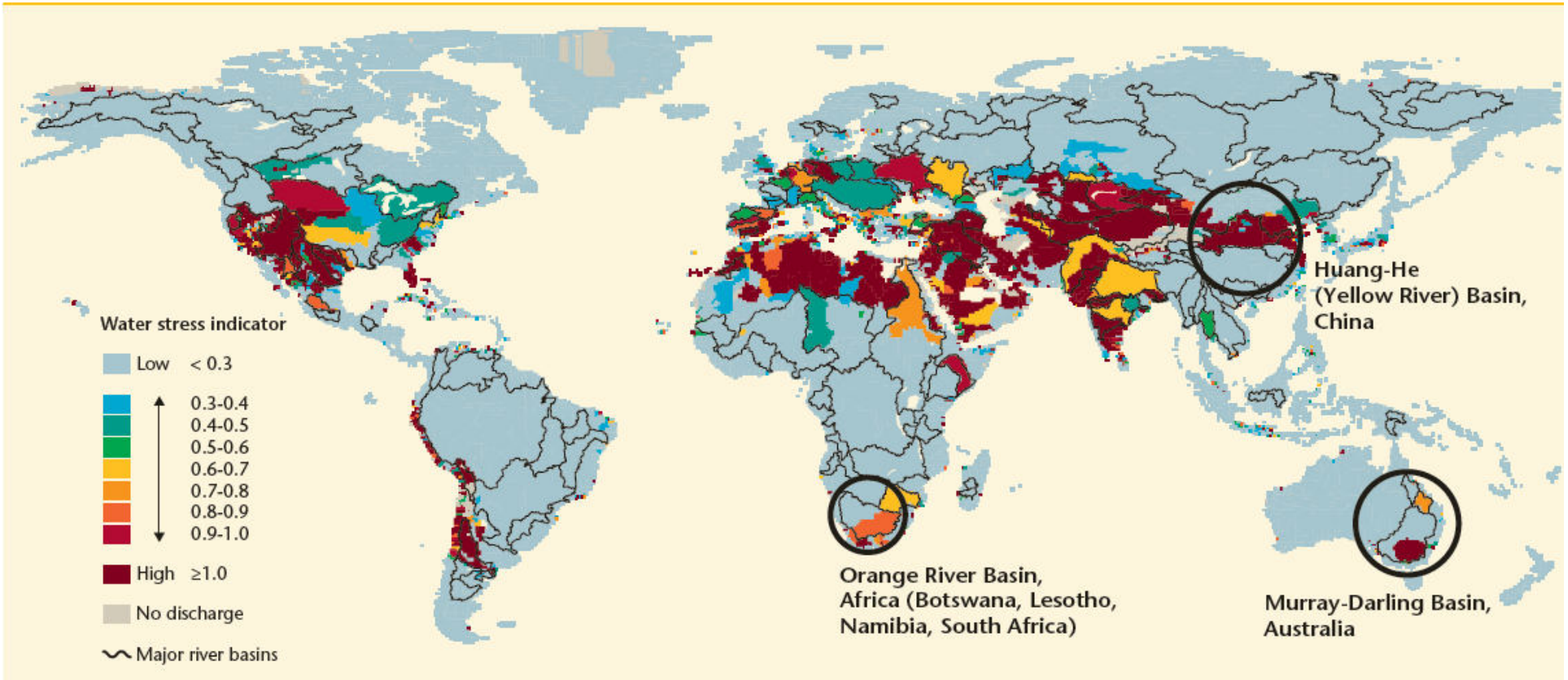
Source: Based on FAO-AQUASTAT global maps (www.fao.org/nr/water/aquastat/globalmaps/index.stm).

Groundwater depletes



http://www.kennislink.nl/publicaties/het-grondwater-raakt-op

Water stress level of Major river Basins, around 2002

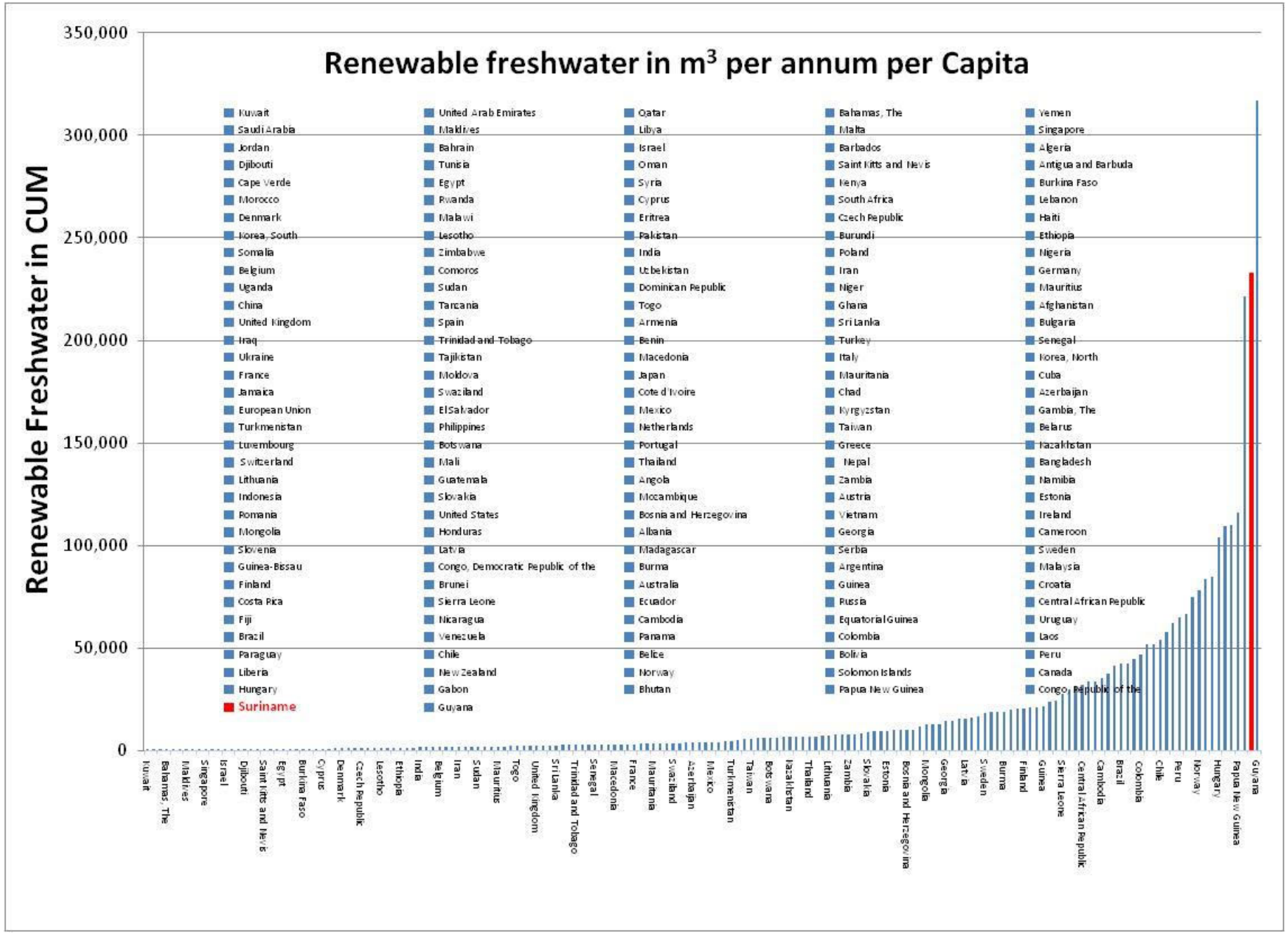


Source: the United Nations World Water Development Report 3 – Water in a changing world

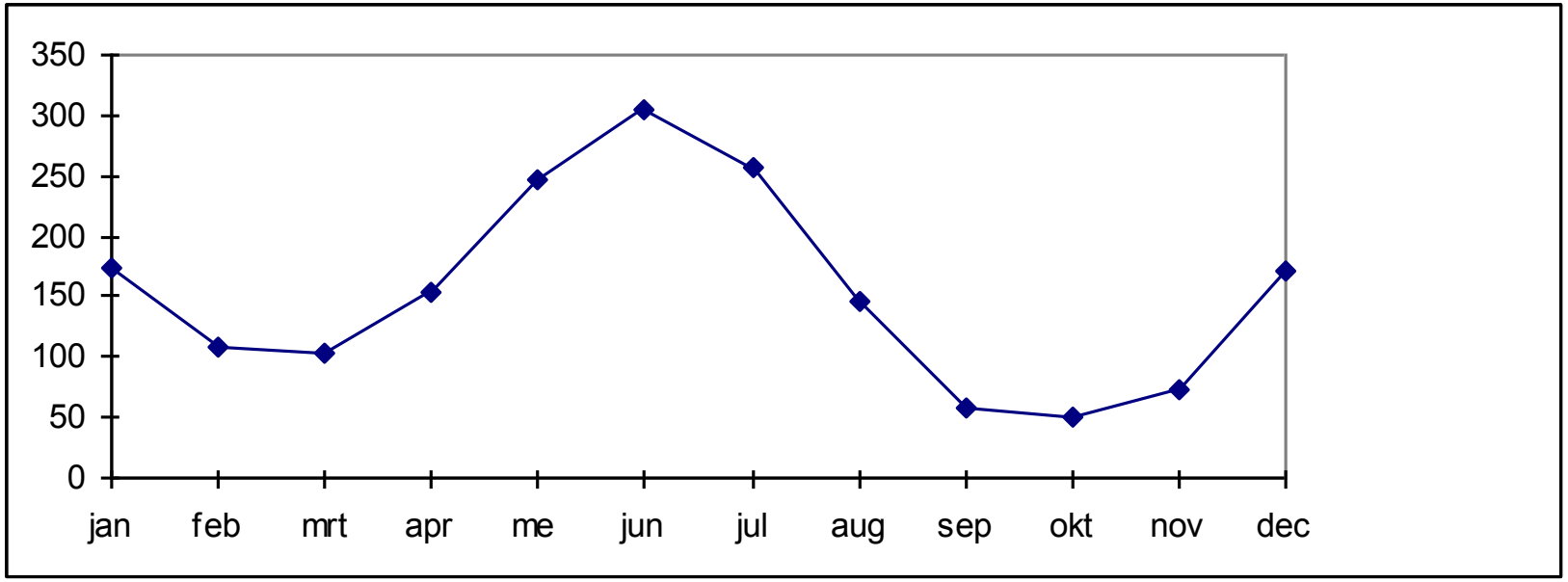
Source: Based on Smakhtin, Revenga, and Döll 2004.

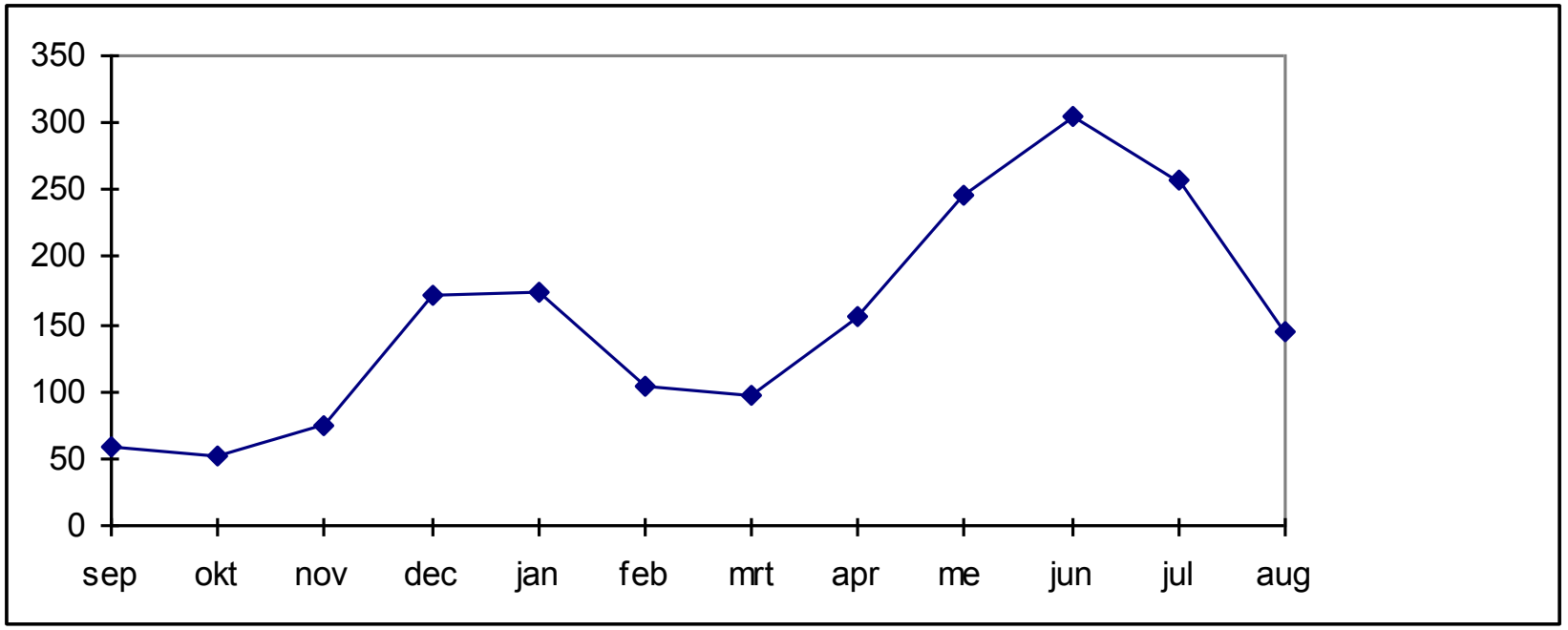
Water availability

- Suriname with a total of about 163,800 km^2 is an extremely rich area in regard to annual availability of fresh water.
- In general average rainfall in Suriname is 2,250mm and Evaporation - **1600mm**. Excess rainfall is about 650mm. That is 213,000m^3 per inhabitant.
- For Latin America is that about 33,500 m^3 per inhabitant


Renewable freshwater in m3 per annum per Capita
Renewable Freshwater in CUM
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Kuwait
Saudi Arabia
Jordan
Djibouti
Cape Verde
Morocco
Denmark
Korea, South
Somalia
Belgium
Uganda
China
United Kingdom
Iraq
Ukraine
France
Jamaica
European Union
Turkmenistan
Luxembourg
Switzerland
Lithuania
Indonesia
Romania
Mongolia
Slovenia
Guinea-Bissau
Finland
Costa Rica
Fiji
Brazil
Paraguay
Liberia
Hungary
Suriname
United Arab Emirates
Maldives
Bahrain
Tunisia
Egypt
Rwanda
Malawi
Lesotho
Zimbabwe
Comoros
Sudan
Tanzania
Spain
Trinidad and Tobago
Tajikistan
Moldova
Swaziland
El Salvador
Philippines
Botswana
Mali
Guatemala
Slovakia
United States
Honduras
Latvia
Congo, Democratic Republic of the
Brunei
Sierra Leone
Nicaragua
Venezuela
Chile
New Zealand
Gabon
Guyana
Qatar
Libya
Israel
Oman
Syria
Cyprus
Eritrea
Pakistan
India
Uzbekistan
Dominican Republic
Togo
Armenia
Benin
Macedonia
Japan
Cote d'Ivoire
Mexico
Netherlands
Portugal
Thailand
Angola
Mozambique
Bosnia and Herzegovina
Albania
Madagascar
Burma
Australia
Ecuador
Cambodia
Panama
Belize
Norway
Bhutan
Bahamas, The
Malta
Barbados
Saint Kitts and Nevis
Kenya
South Africa
Czech Republic
Burundi
Poland
Iran
Niger
Ghana
Sri Lanka
Turkey
Italy
Mauritania
Chad
Kyrgyzstan
Taiwan
Greece
Nepal
Zambia
Austria
Vietnam
Georgia
Serbia
Argentina
Guinea
Russia
Equatorial Guinea
Colombia
Bolivia
Solomon Islands
Papua New Guinea
Yemen
Singapore
Algeria
Antigua and Barbuda
Burkina Faso
Lebanon
Haiti
Ethiopia
Nigeria
Germany
Mauritius
Afghanistan
Bulgaria
Senegal
Korea, North
Cuba
Azerbaijan
Gambia, The
Belarus
Kazakhstan
Bangladesh
Namibia
Estonia
Ireland
Cameroon
Sweden
Malaysia
Croatia
Central African Republic
Uruguay
Laos
Peru
Canada
Congo, Republic of the
Kuwait
Bahamas, The
Maldives
Singapore
Israel
Djibouti
Saint Kitts and Nevis
Egypt
Burkina Faso
Cyprus
Denmark
Czech Republic
Lesotho
Ethiopia
India
Belgium
Iran
Sudan
Mauritius
Togo
United Kingdom
Sri Lanka
Trinidad and Tobago
Senegal
Macedonia
France
Mauritania
Swaziland
Azerbaijan
Mexico
Turkmenistan
Taiwan
Botswana
Kazakhstan
Thailand
Lithuania
Zambia
Slovakia
Estonia
Bosnia and Herzegovina
Mongolia
Georgia
Latvia
Sweden
Burma
Finland
Guinea
Sierra Leone
Central African Republic
Cambodia
Brazil
Colombia
Chile
Peru
Norway
Hungary
Papua New Guinea
Guyana


Trinidad
and Tobago
Anna Regina
Georgetown
Nieuw Nickerie
Paramaribo
Guyana
Brokopondo
Cayenne
French
Guiana
Suriname
Lethem
Boa Vista
RORAIMA
AMAPÁ


350
300
250
200
150
100
50
0
jan
feb
mrt
apr
me
jun
jul
aug
sep
okt
nov
dec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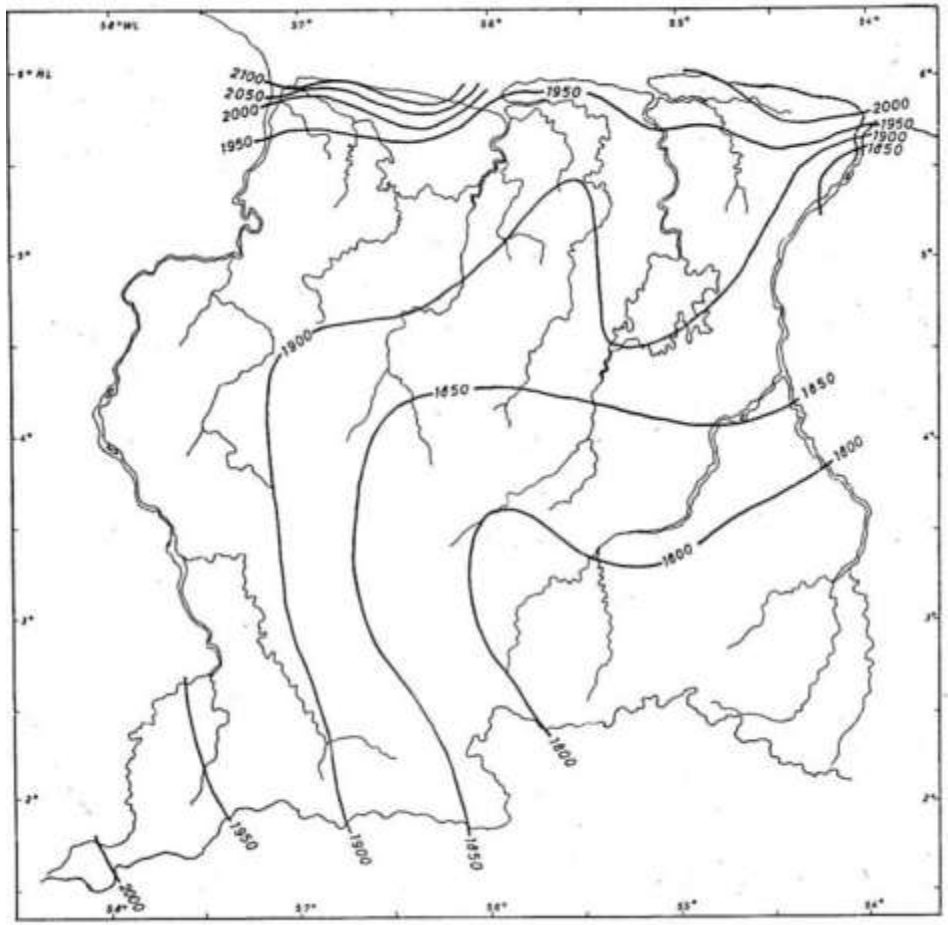
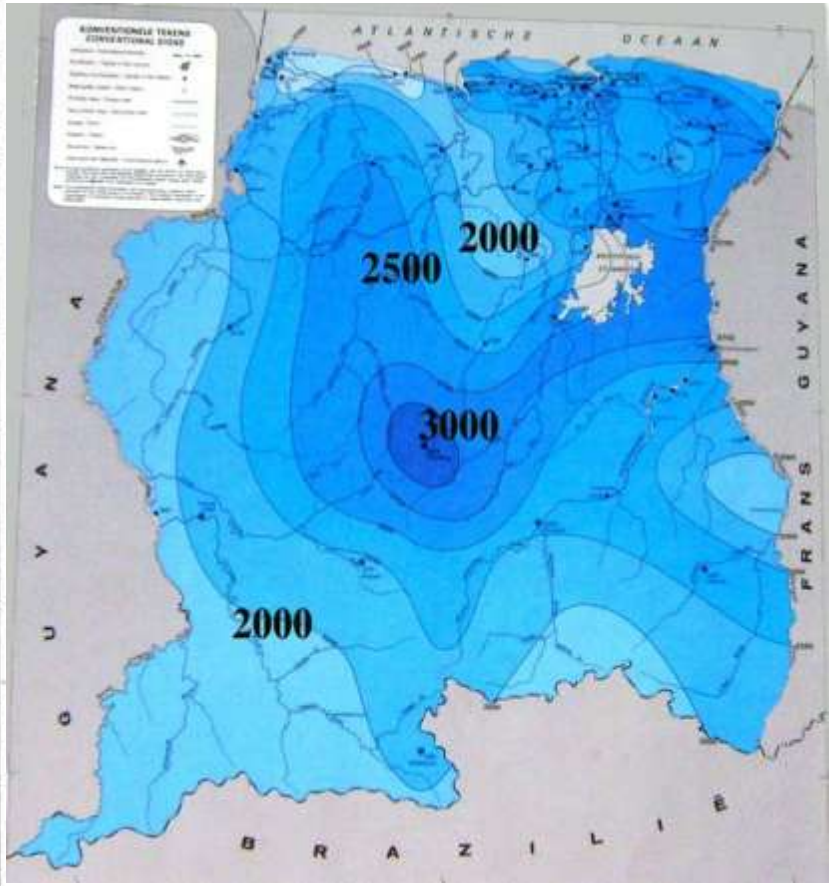
Climate

Open water Evaporation



Rainfall



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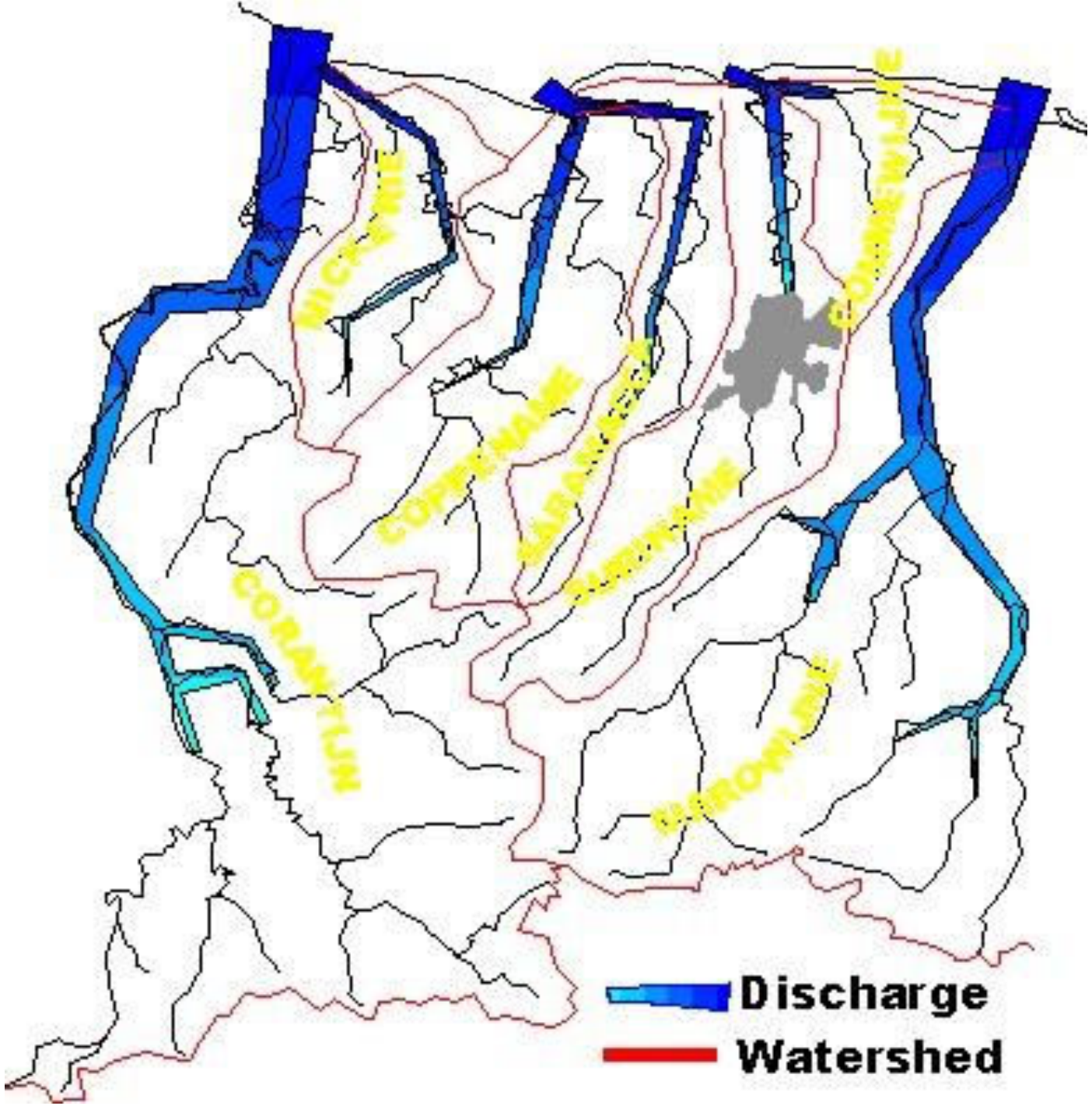
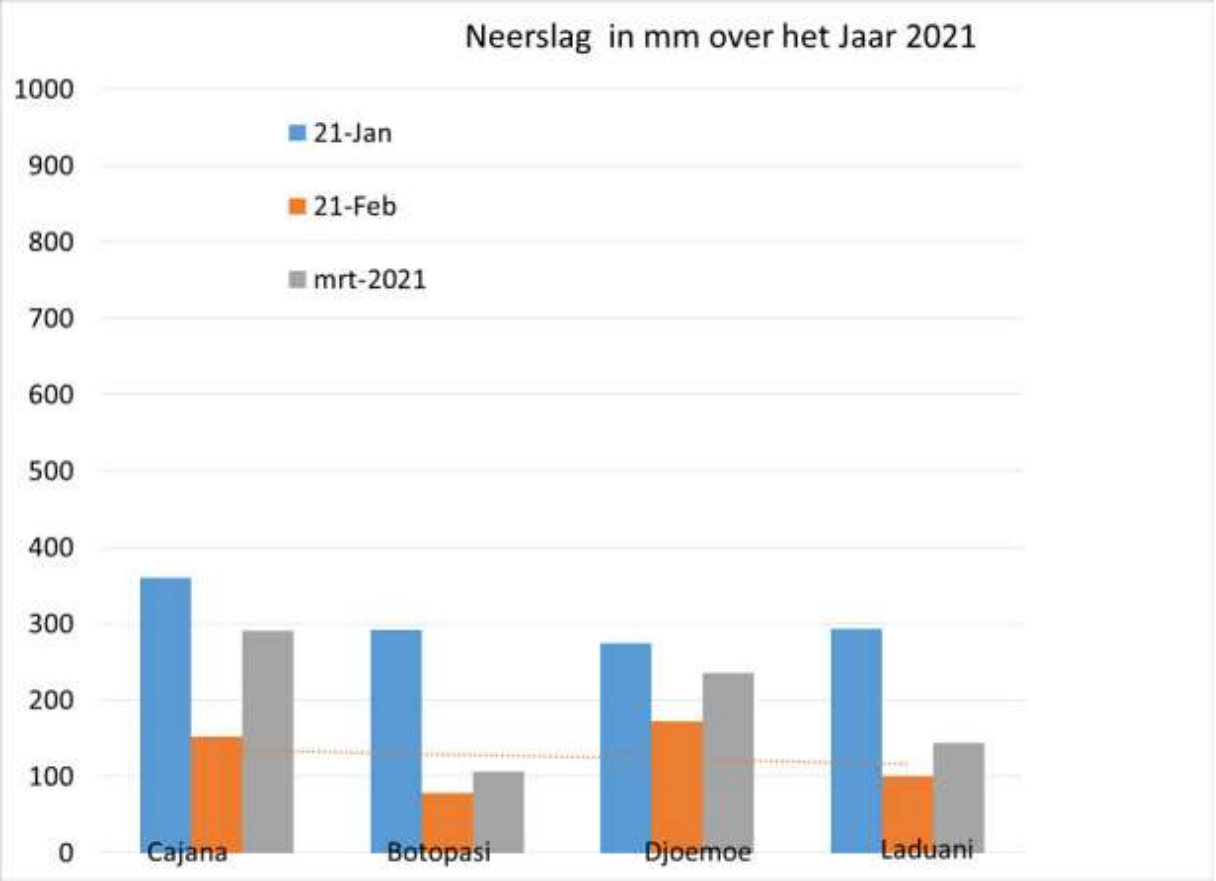
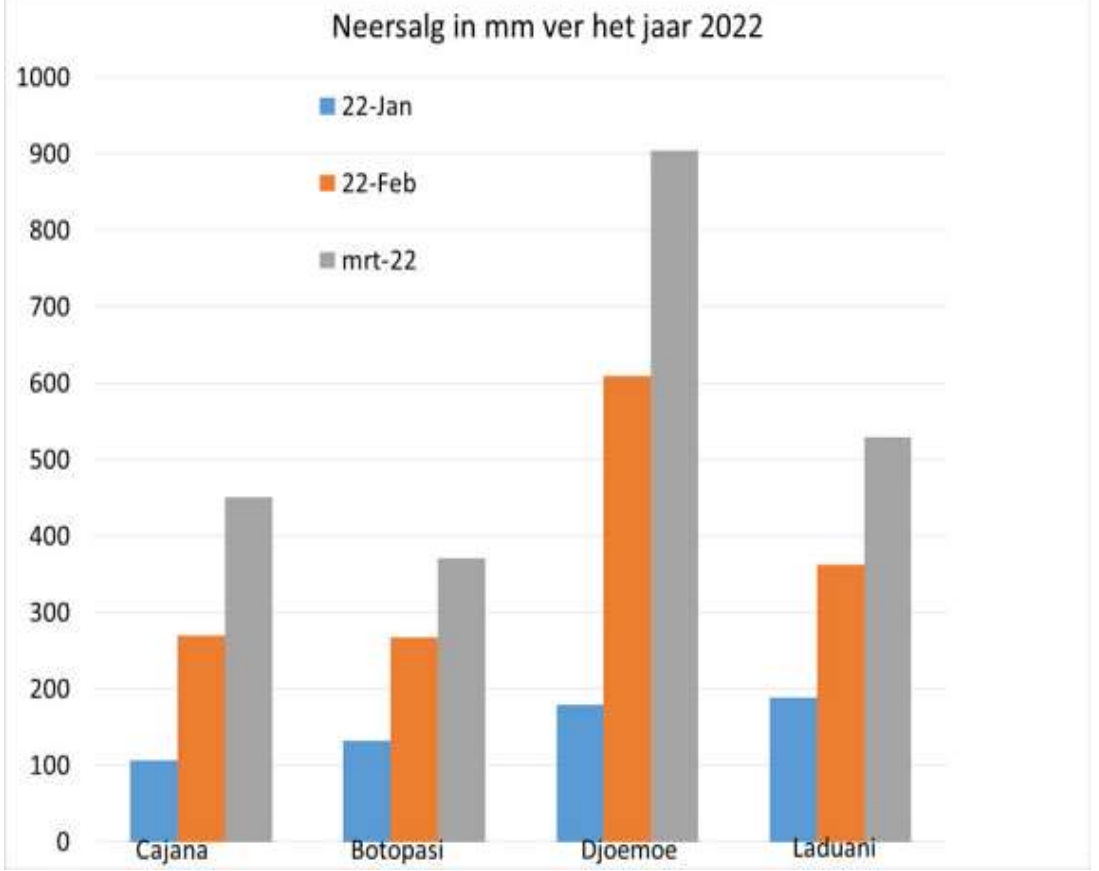

Discharge
Watershed


Neerslag in mm over het Jaar 2021
1000
900
800
700
600
500
400
300
200
100
0
21-Jan
21-Feb
mrt-2021
Cajana
Botopasi
Djoemoe
Laduani


Neersalg in mm ver het jaar 2022
1000
900
800
700
600
500
400
300
200
100
0
22-Jan
22-Feb
mrt-22
Cajana
Botopasi
Djoemoe
Laduani


Djumu & Omgeving

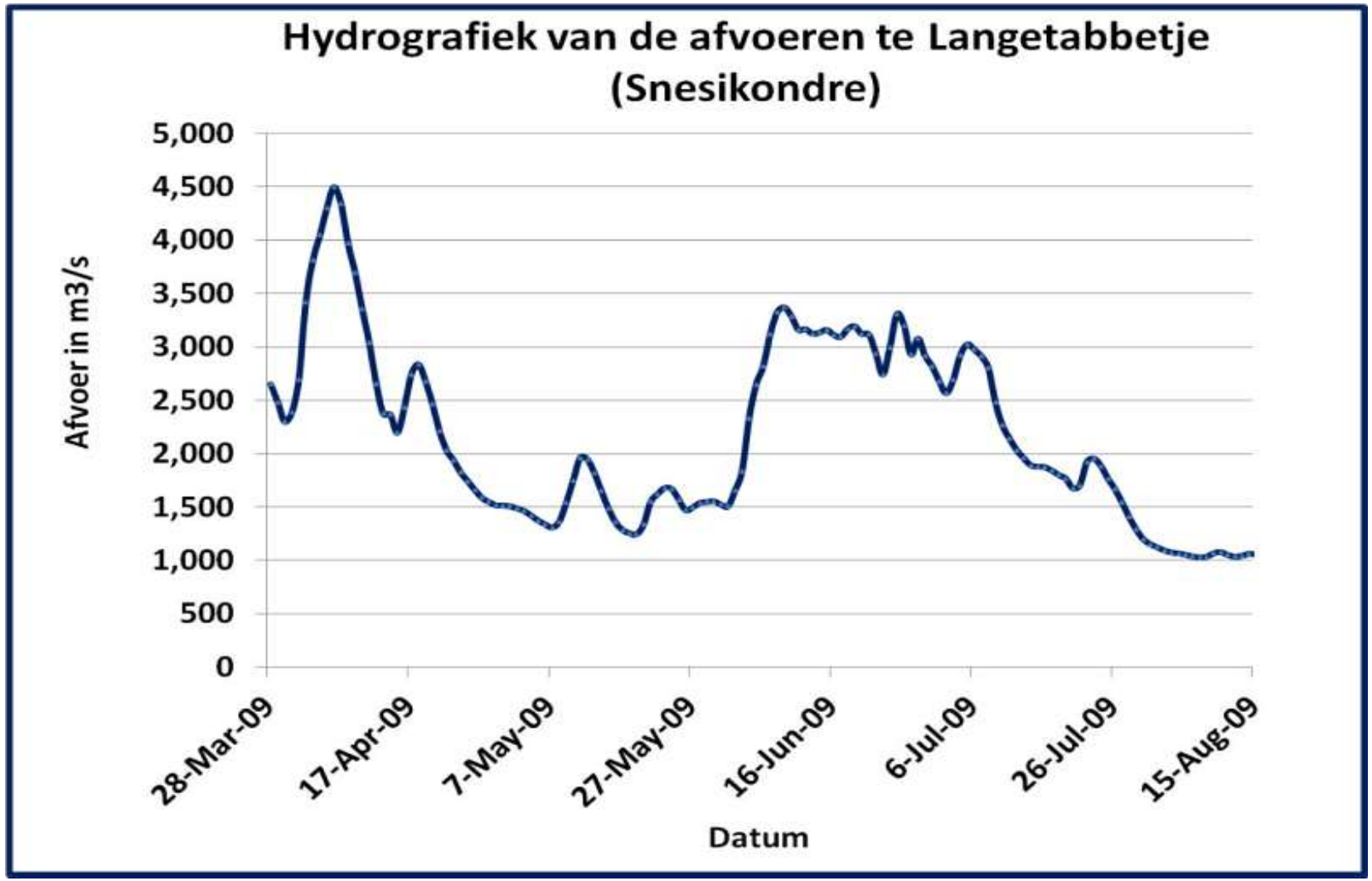

Foto SN 2006-05 -14: Semoisie


Foto : NCCR


Foto SN 2006-05 -14:Djumu

31

The same is valid for other parts of Suriname / Guiana Shield



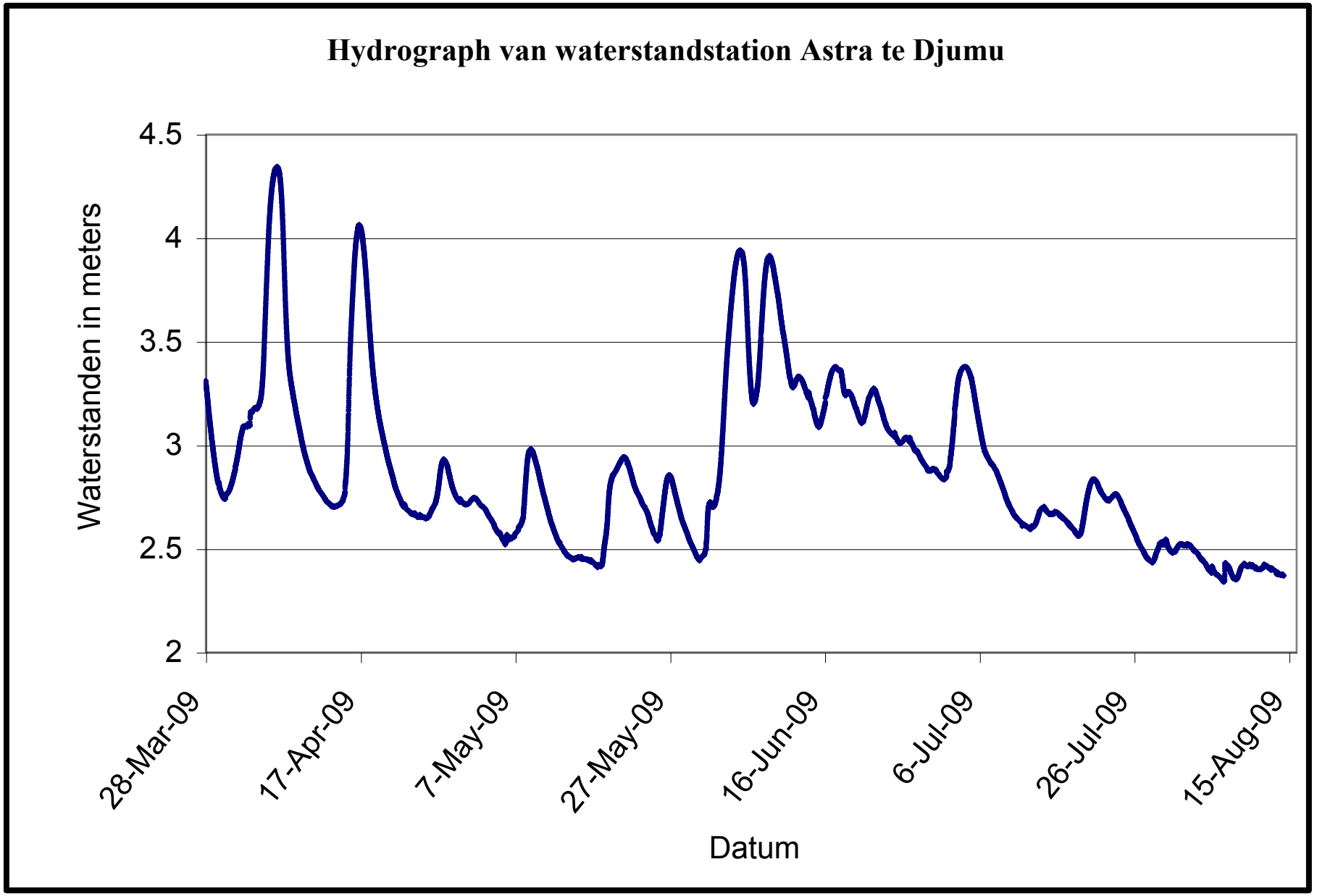
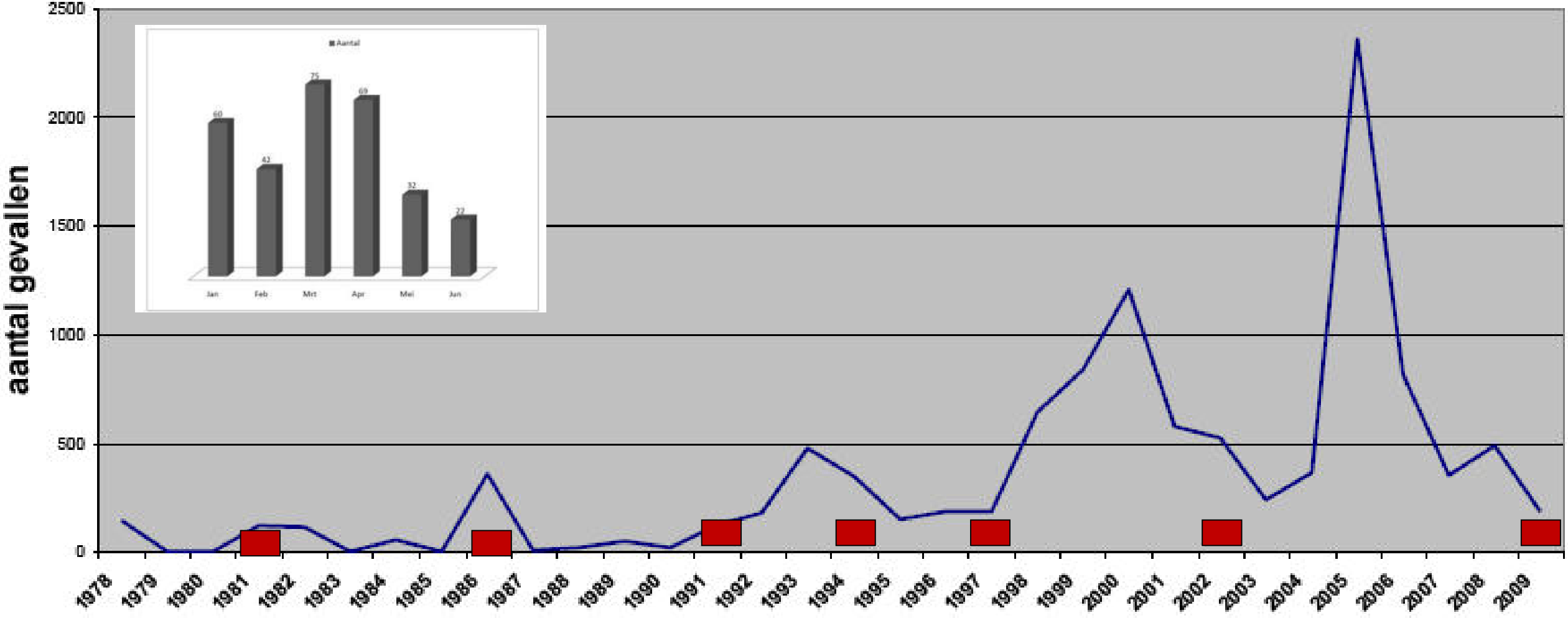

Hydrograph van waterstandstation Astra te Djumu
Waterstanden in meters
4.5
4
3.5
3
2.5
2
28-Mar-09
17-Apr-09
7-May-09
27-May-09
16-Jun-09
6-Jul-09
26-Jul-09
15-Aug-09
Datum

Foto: SN : Coronie zwamp noord in brand
2011-09-20

Extreme droge periode zorgt ook voor veel schade

Bigi Pan december 2004

Dengue in Suriname



El Niño year

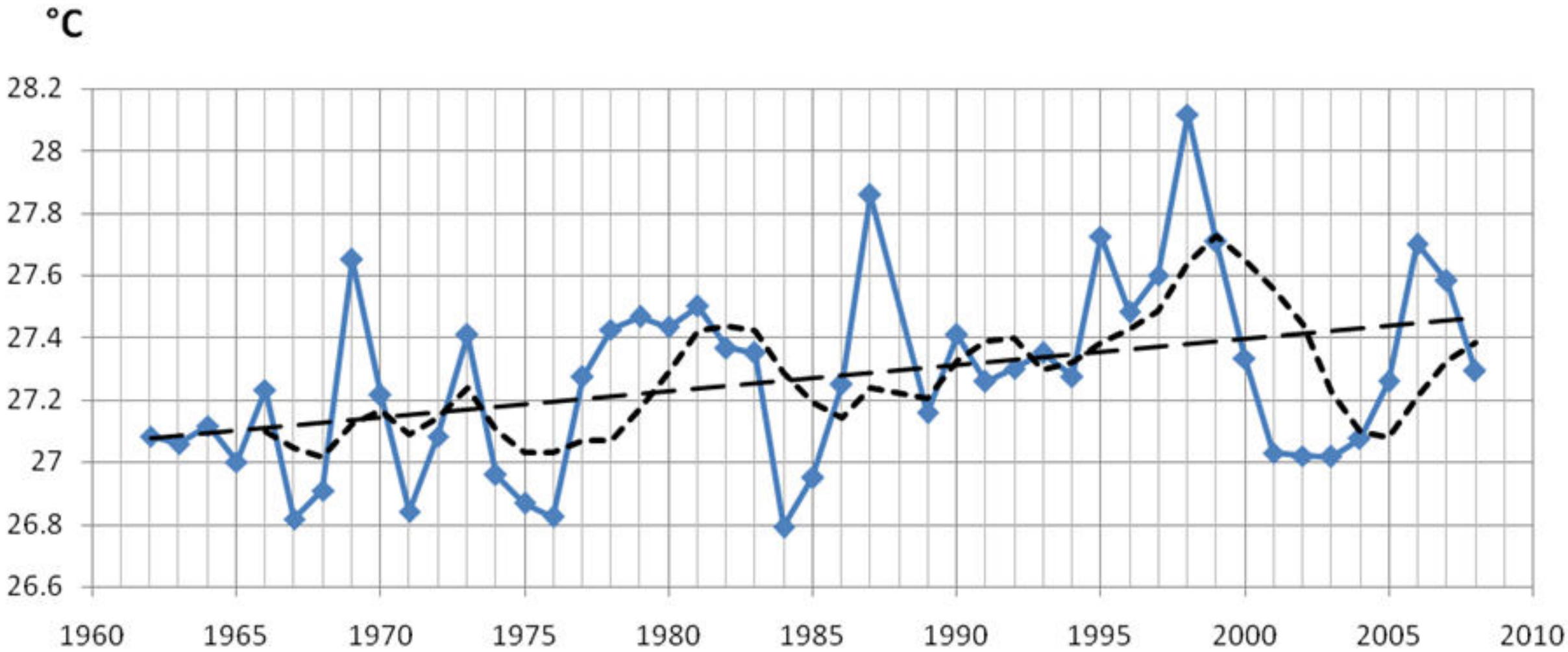

16 November 2013


07 09 2014

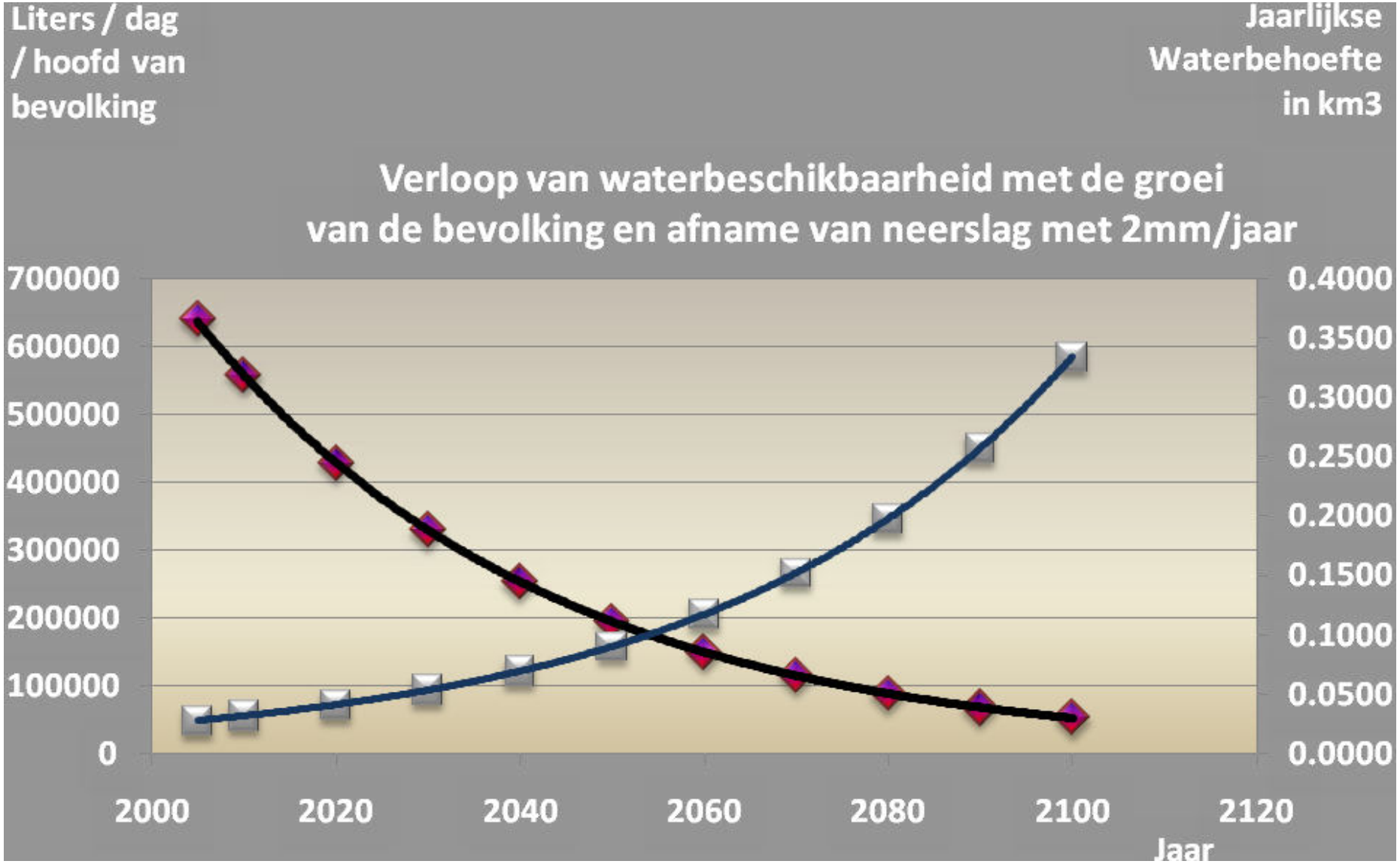
Stein Glacier in 2006 (left) and 2015 (right)

Urner Alps in the canton of Berne in Switzerland

Gemiddelde jaarlijkse temperatuur van Nw. Nickerie over de periode 1978--2008



Bron: Amatali



Relatie waterbeschikbaarheid versus bevolkingsgroei

Treated water: from left to right: incoming water from the intake (swamp water), middle result, final result of the treatment.

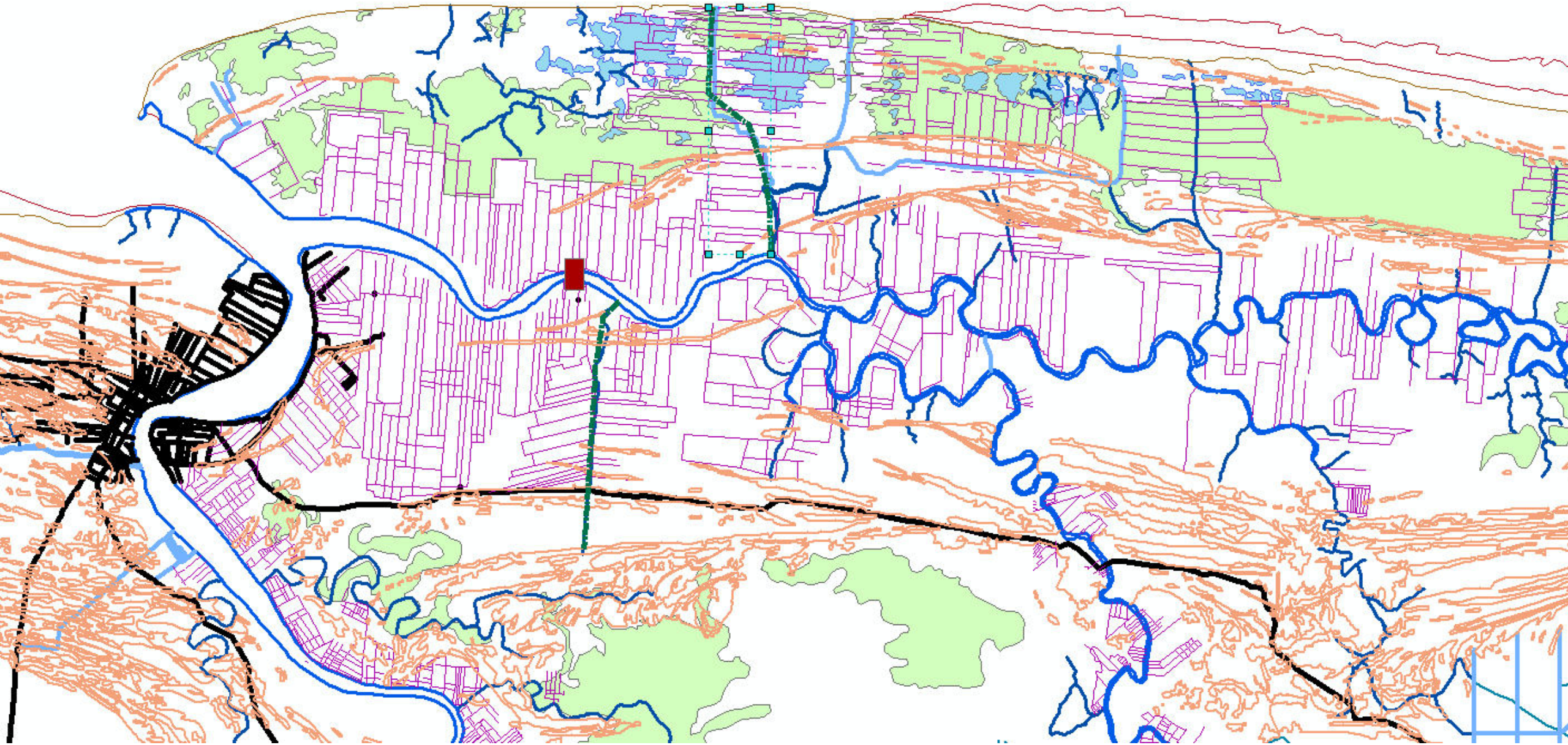

REAR

The various inlets and outlet to and from the filter in the Container.

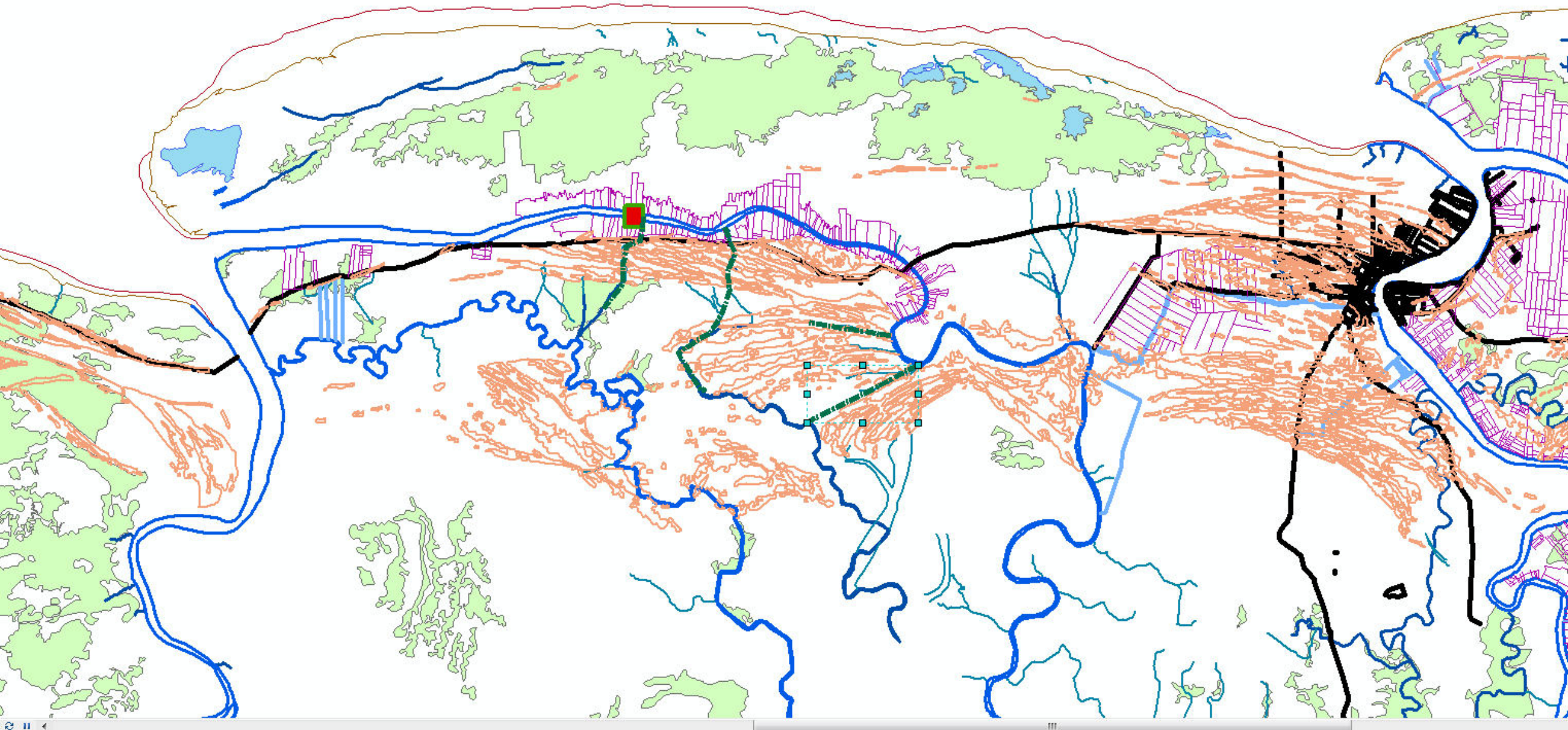
d.d. June 12

Oplossingen

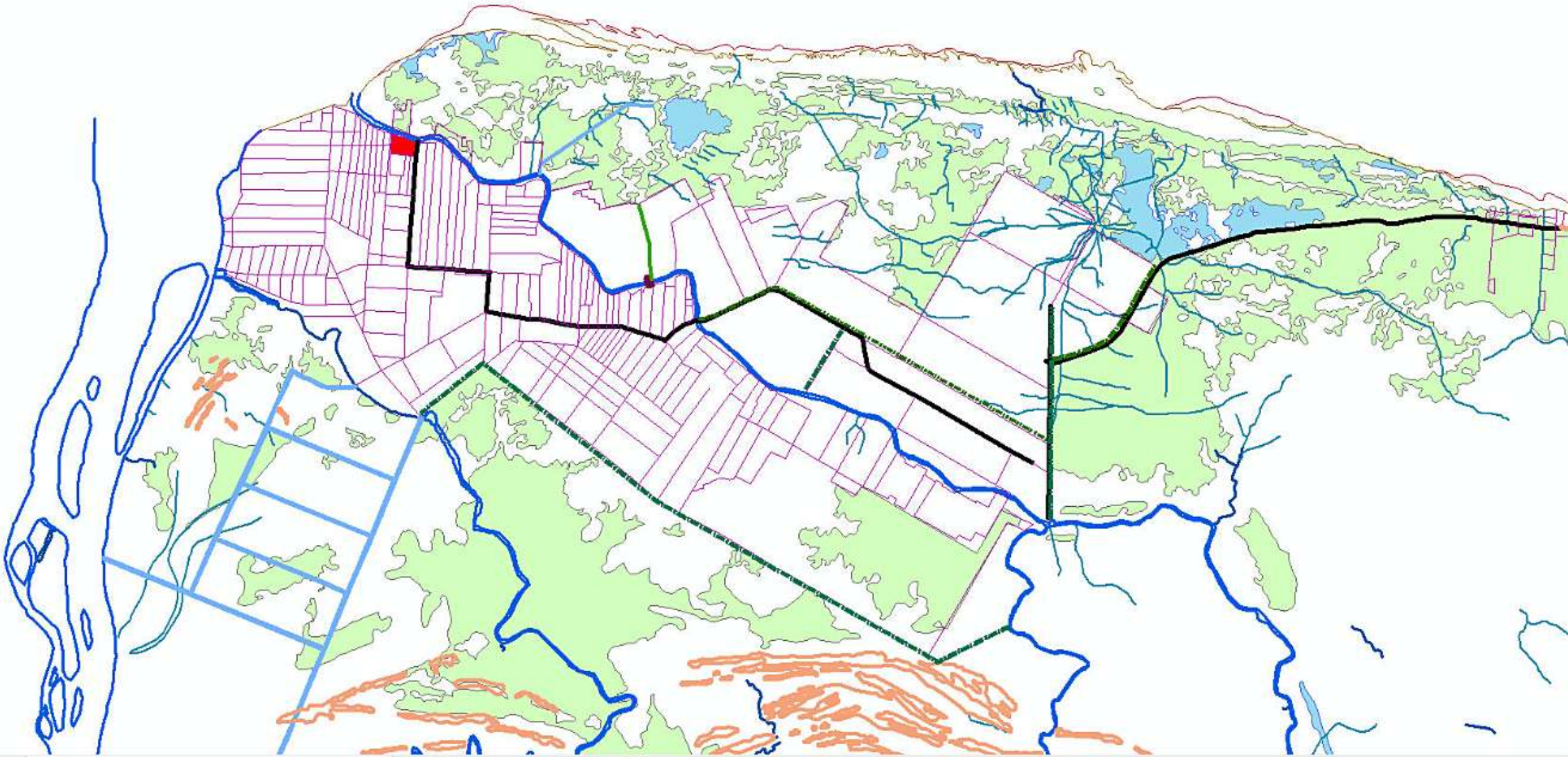
- ……
- ……
- ……
- ……



Bron: Leerstoel Klimaat verandering en Water



Bron: Leerstoel Klimaat verandering en Water



Bron: Leerstoel Klimaat verandering en Water

Rijstbouw is de grootste afnemer van Zoetwater in Suriname

Water withdrawal

- We are deriving water in Suriname for the following purposes:
    - Agriculture (mainly for Rice and Banana, following by horticulture, …)
    - Domestic uses
    - Industry
    - Energy (purposes…..)

- Water withdrawal produces conflicts

Conclusie(s)

- We staan er niet goed voor
- Verandering in het klimaat gaat hard
- De uitdagingen zijn enorm
- Beperkte tijd over
- Niets doen is geen optie; geïntegreerde maatregelen zijn nodig
- Maatregelen die de weerbaarheid (resilience) kunnen opvoeren