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Water, Food and Energy security in Shared River Systems

Case study Eastern Nile Basin

Lars Ribbe

8th Conference on Sustainable Development of Energy, Water and Environment Systems

Sept 24, 2013
Dubrovnik

Lars Ribbe

Research and Education in the area of „Integrated Land and Water Resources Management“

Outline

1. Sustainable Development and the NEXUS
2. Challenges in the Eastern Nile Basin
3. Outlook and Potential Solutions

1. NEXUS

RIO+20
the future we want

JOBS | ENERGY | CITIES | FOOD | WATER | OCEANS | DISASTERS

The Future We Want: Outcome document adopted at Rio+20

Secretary-General Ban Ki-moon shares the future he wants

1 2 3 4

What kind of future

News

#futurewewant

Challenge: „Understanding the Nexus“

Water, Energy and Food Security: Three pillars of sustainable development + social and political stability

Today 2012: 7 bn

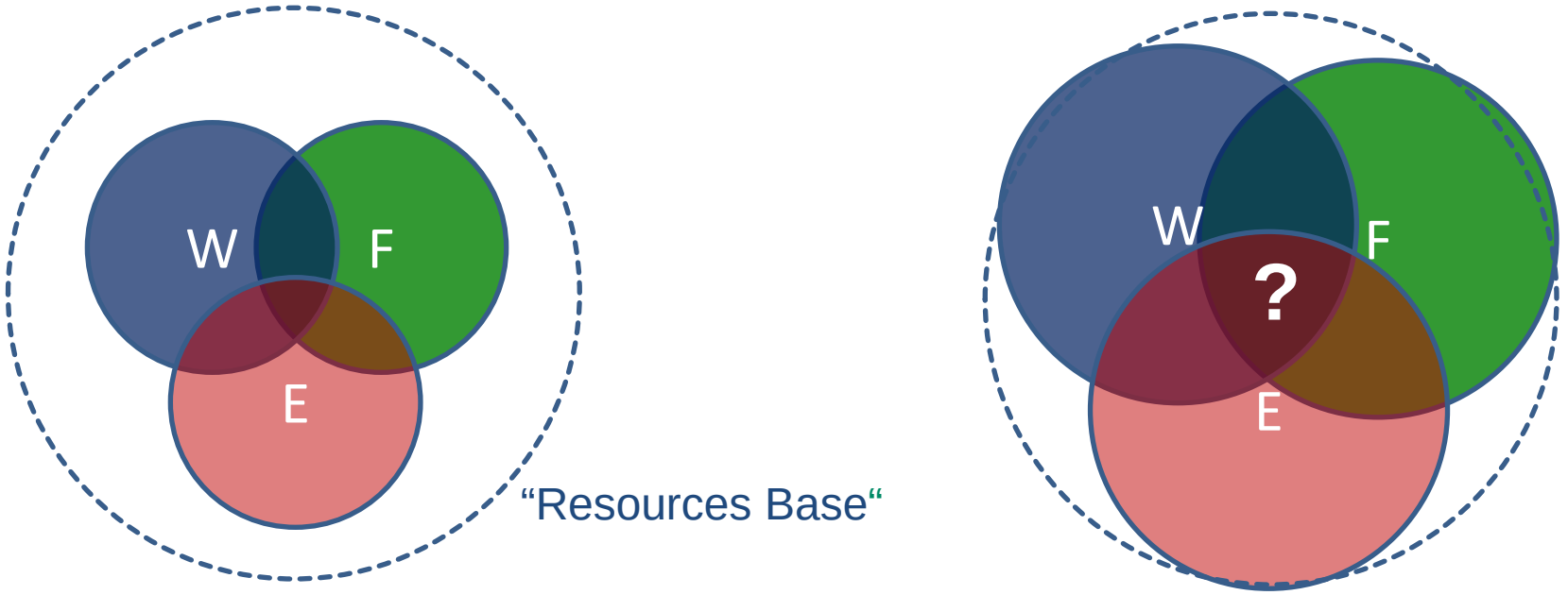
No access to…

safe water: 0.9 bn , electricity: 1.5 bn, sufficient food: 1 bn

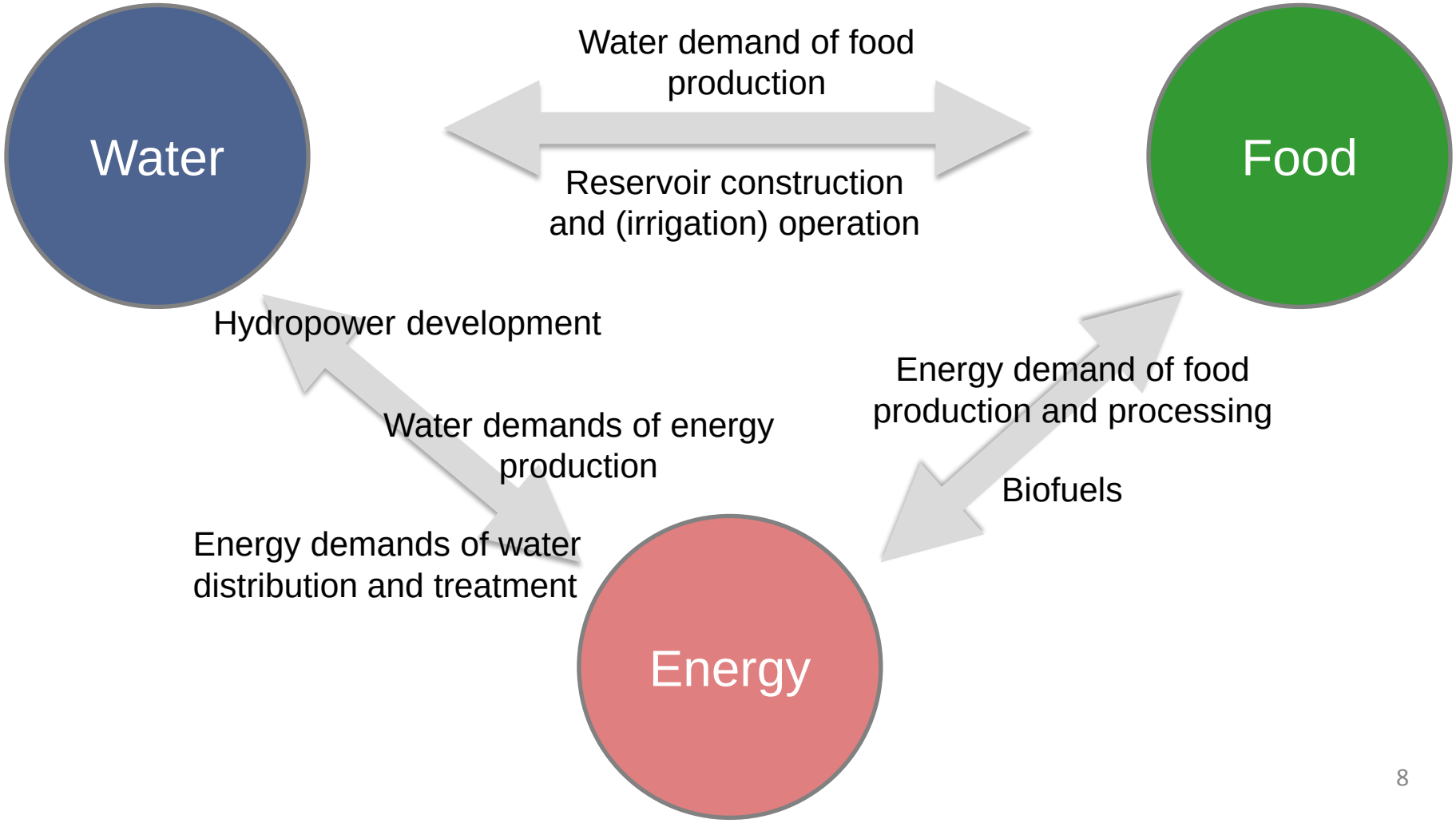
Tomorrow 2030: 8.5 bn?

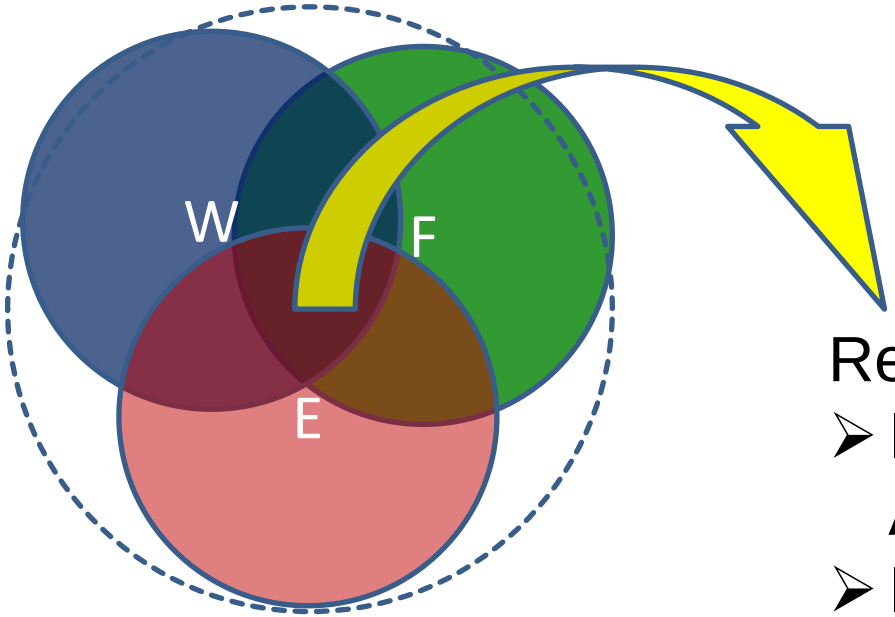
Compensate for current deficit + account for additional demand:

→ Supply of around 40 % water, energy, food additionally!



- Overlap: impact (tradeoffs, synergies)
- Increasing security in one sector may reduce security in another!


Water
Food
Energy
Water demand of food production
Reservoir construction and (irrigation) operation
Hydropower development
Water demands of energy production
Energy demands of water distribution and treatment
Energy demand of food production and processing
Biofuels



2030

Required:

- Intersectoral Approaches
- Interdisciplinarity
- International Cooperation

- …more research

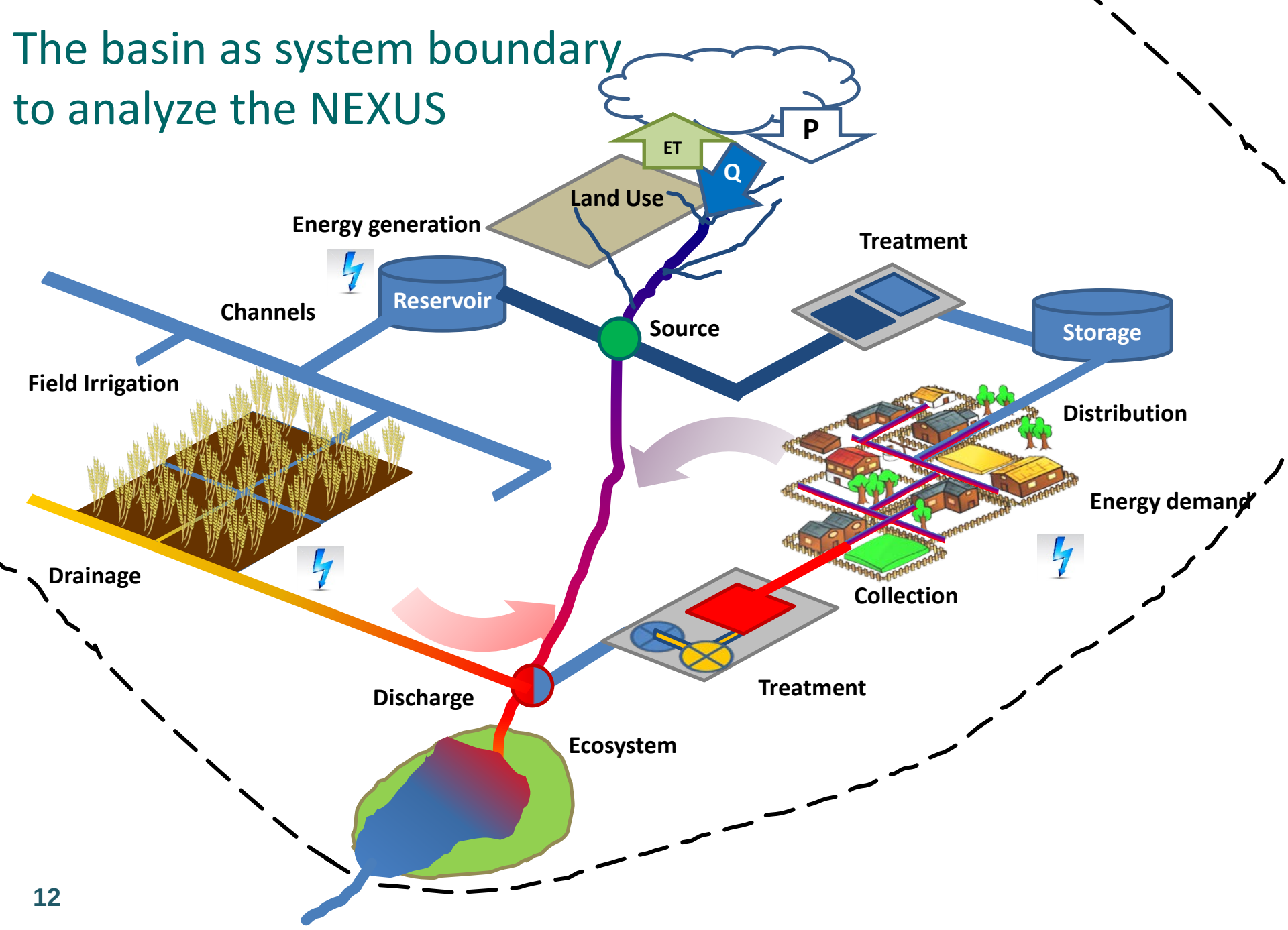
Which system level/scale is appropriate?

River basin level

Boundary for a local water system within which

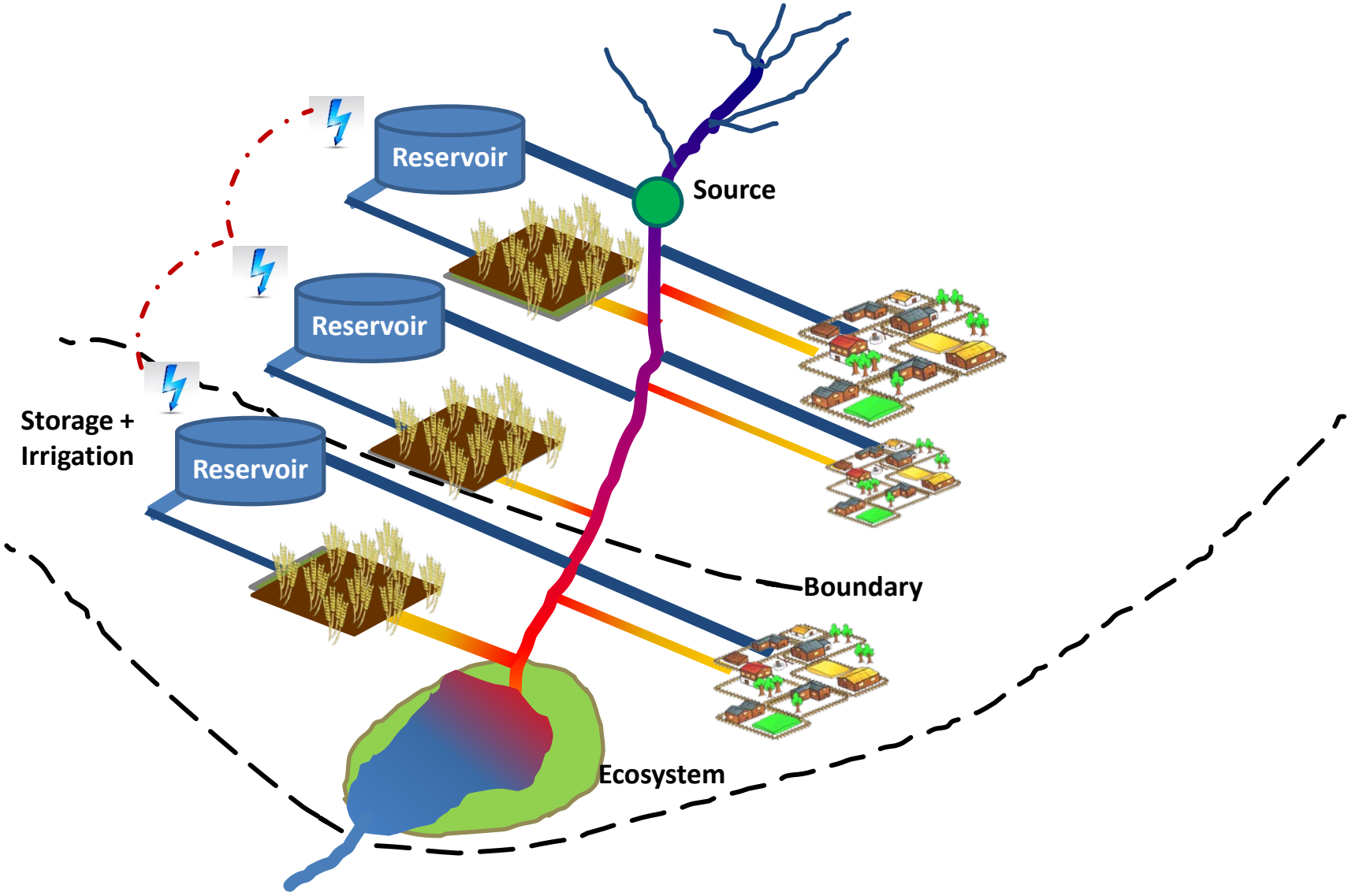
- …water can only be used once for food production or other consumptive uses
- …hydropower production impacts downstream users
- …“natural boundary“…often basis for political boundaries, traffic grids, energy grids…

The basin as system boundary to analyze the NEXUS



Multiple users…adding complexity

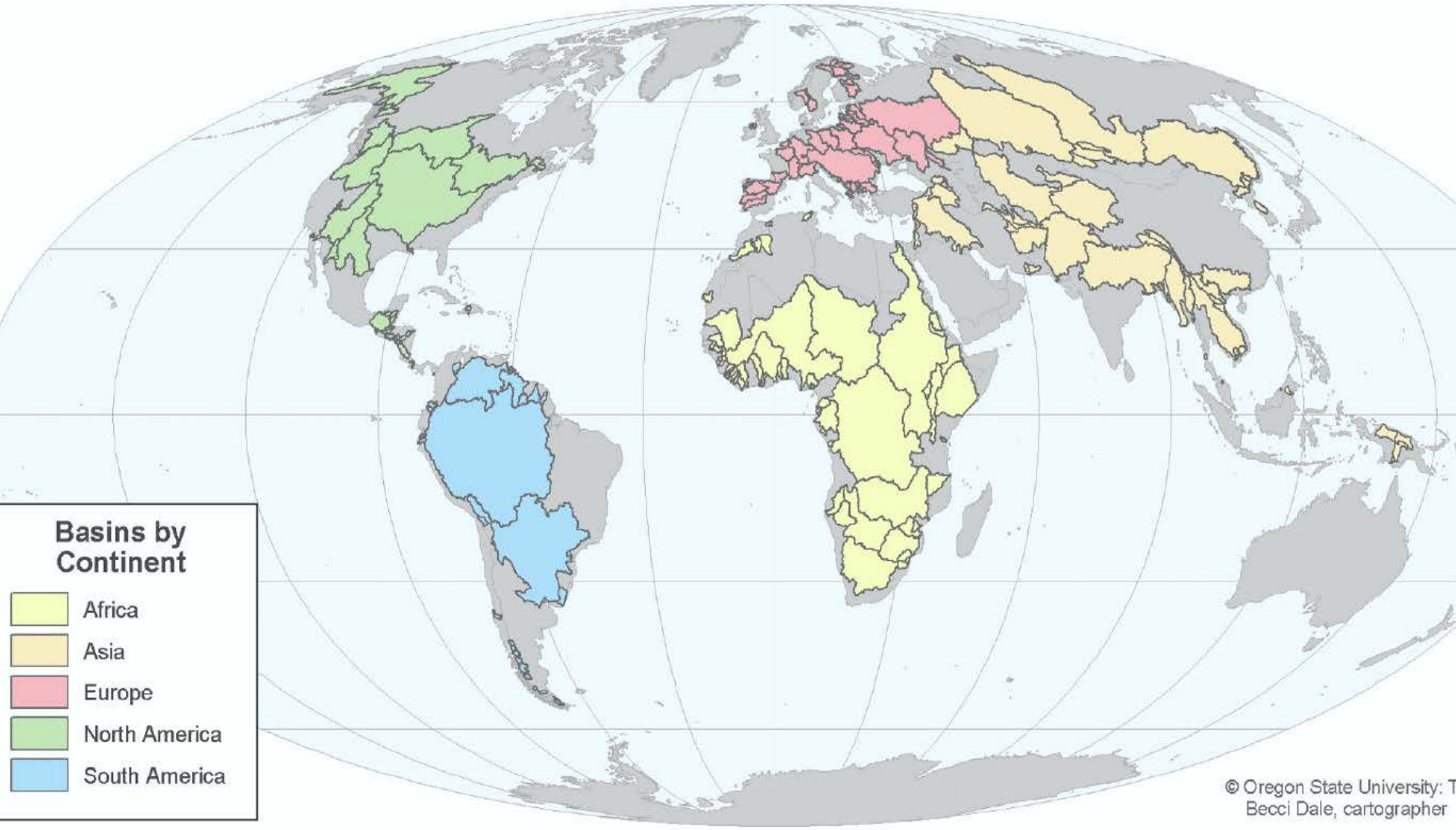
(in particular if political boundary crosses basin!)



Scope and relevance of shared Basins

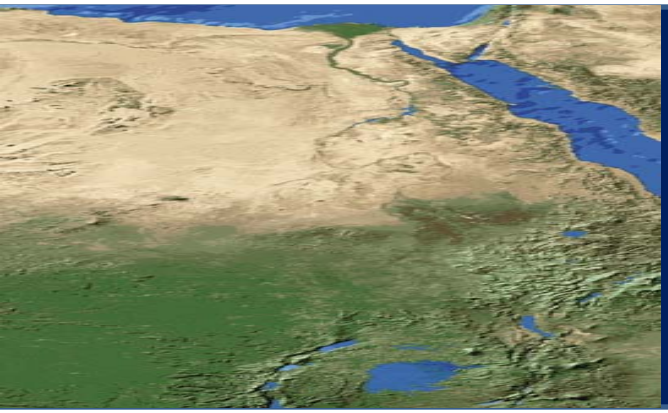
- Worldwide: 263 transboundary watersheds
- They represent
  - 40 % of world population,
  - 50 % of land area and
  - 60 % of runoff

Source: World Atlas of International freshwater agreements (Aaron Wolf, Oregon State University)

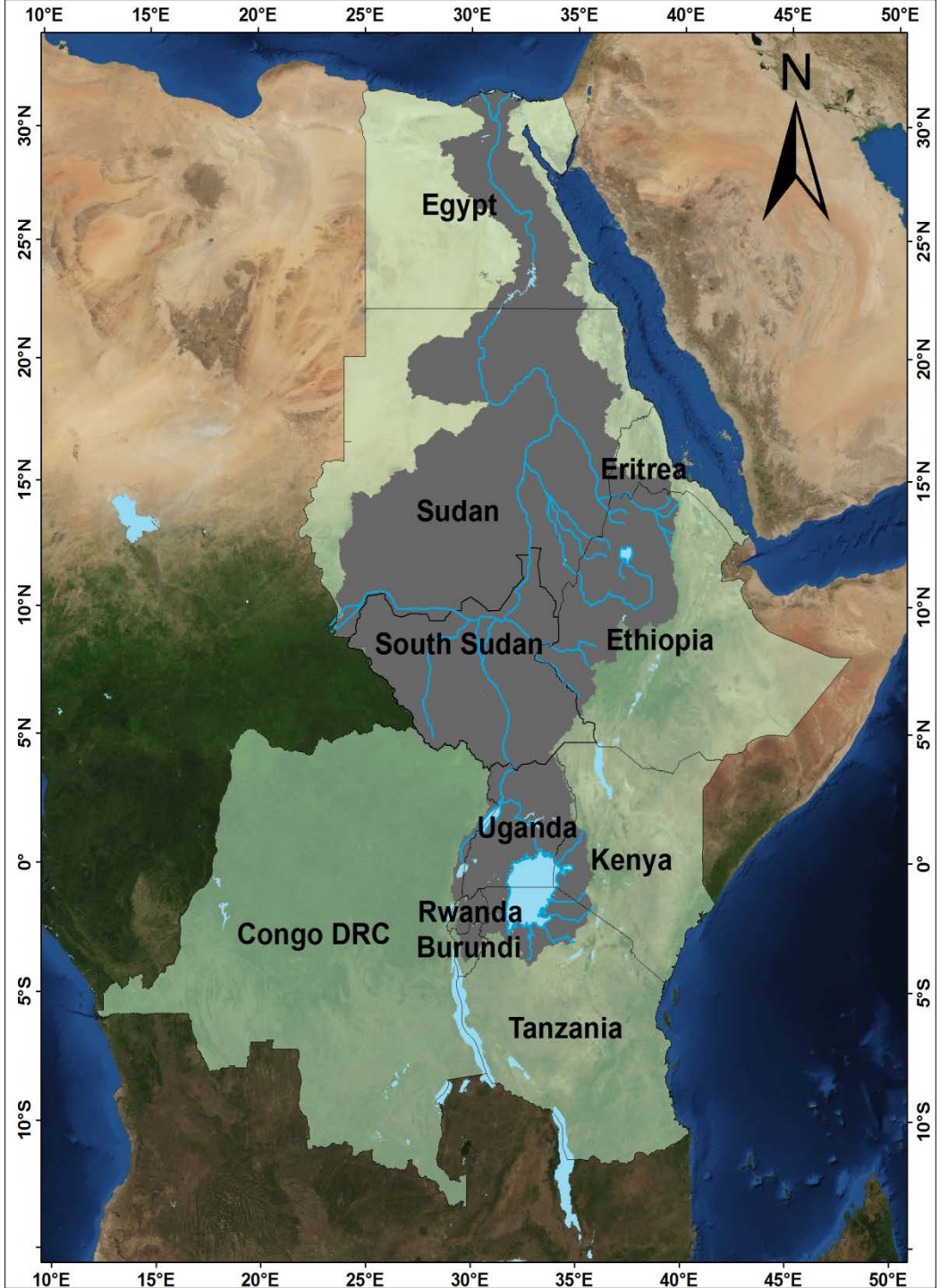

Basins by Continent
Africa
Asia
Europe
North America
South America
© Oregon State University: T
Becci Dale, cartographer

Why the Nile Basin?

- Large: 3 Mio km²
- Contested (scarce) resources
- Transboundary (11 riparians)
- Interesting: lower riparian „strongest“ country (vs Mekong, Euphrates…)



2. NILE BASIN



Legend

- Nile Basin
- Streams
- Water bodies
- Country border

Projection:
GCS_Geographic Coordinate System
Datum: D_WGS84
Prime Meridian: Greenwich
Angular Unit: Degree

0 500 1,000 2,000 Km

New “Treaty”: Cooperative Framework Agreement (CFA) 2010:

- “Disputed Nile agreement signed. Four African countries have signed a new treaty on the equitable sharing of the Nile waters despite strong opposition from Egypt and Sudan who have the major share of the river waters”
  (Al Jazeera, May 15, 2010)

- “Egypt’s share of the Nile’s water is a historic right that Egypt has defended throughout its history”
- "Egypt reserves the right to take whatever course it sees suitable to safeguard its share"
  (Mohammed Allam, Minister of Water Resources and Irrigation, Egypt April 18, 2010)

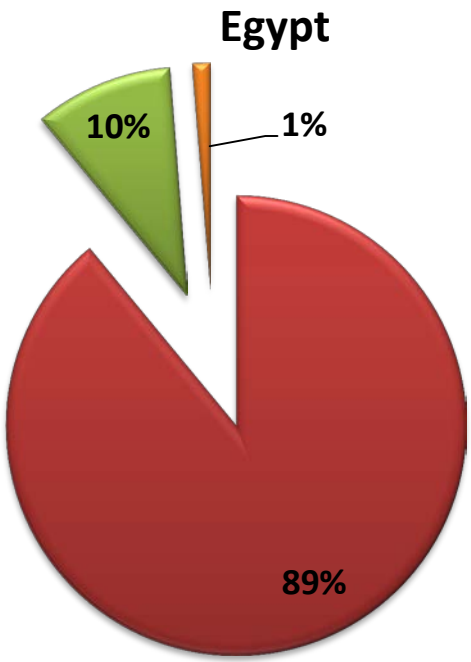
Egypt's dependency on the Nile water

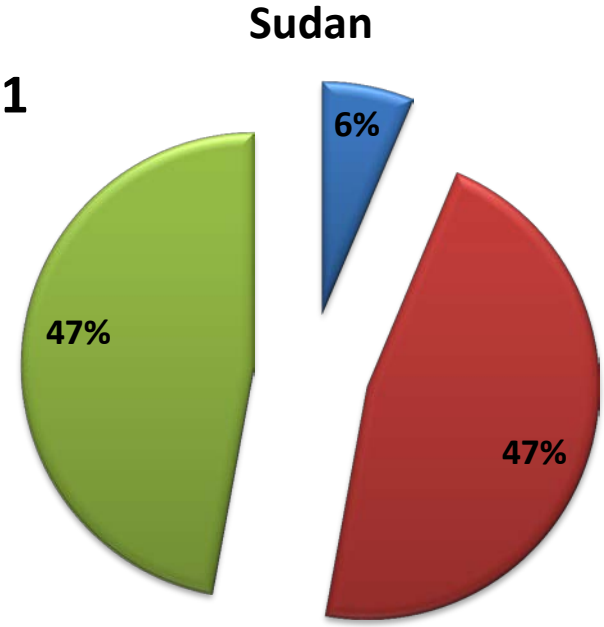
Nile assures water, wnergy and food Security:

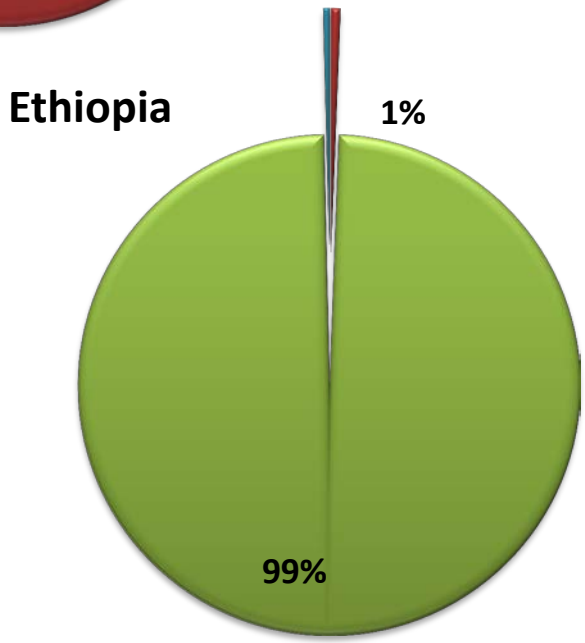
- National food production through irrigation
- Significant hydropower production (Aswan): 14 out of 121 billion KWh
- Supply of whole population and industry with water

Does only Egypt depend on the Nile?

Production of Electricity from different energy sources in 2011







- biofuels and waste, GWh
- fossil fuels, GWh
- hydro electricity, GWh
- electricity, GWh
- geothermal electricity, GWh
- solar, wind, tide, wave and other sources, GWh

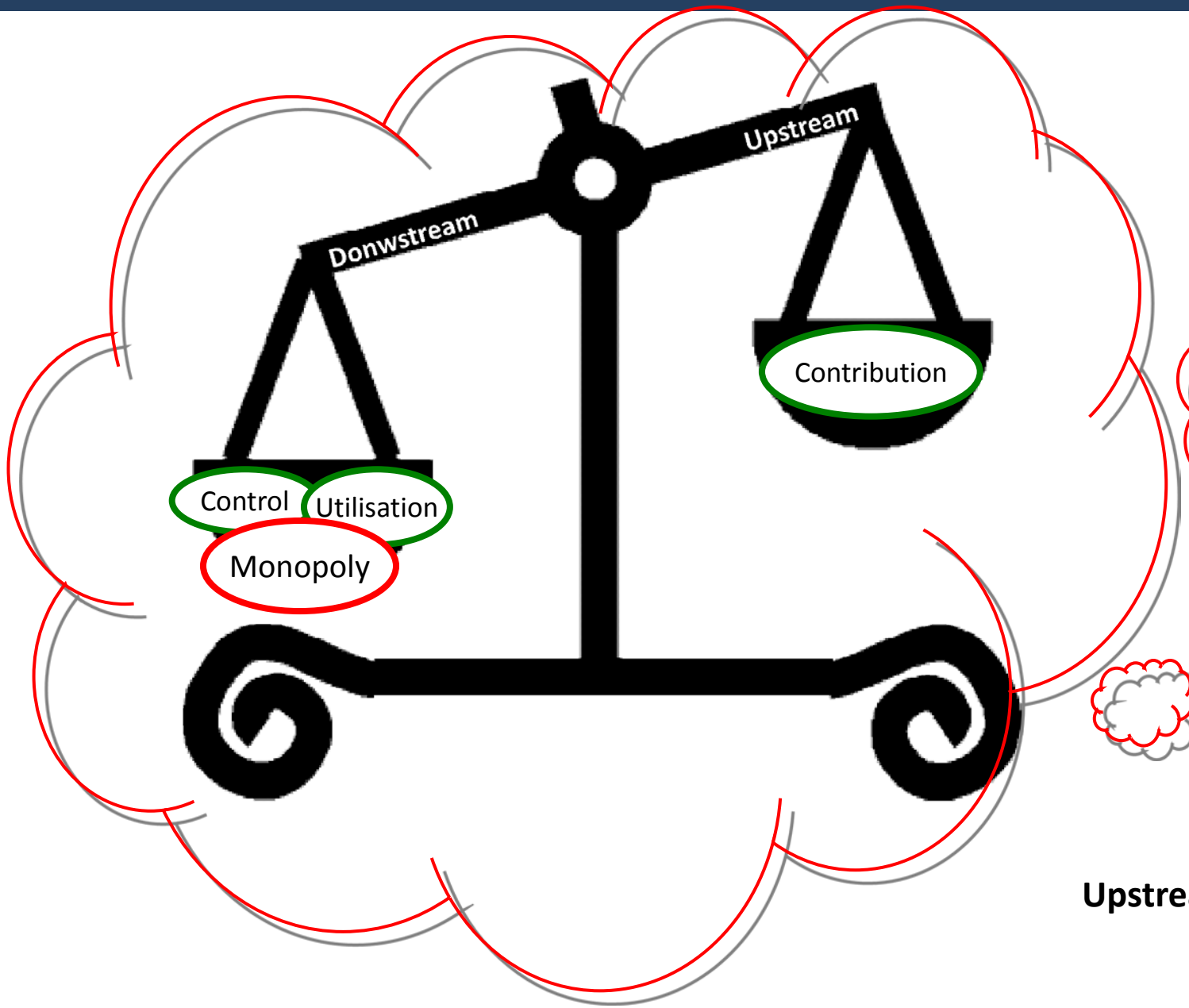
African Regional Energy Statistics, 2013

Past Agreements (current status)

1959:

Treaty between Egypt and Sudan after Sudan's independence (1956) and Aswan Dam planning (1952): **55.5** BCM/year for Egypt, **18** BCM/year for Sudan, **10** BCM/year for seepage and evaporation.

The Enduring Tension



JUST Egypt and Sudan!! What about us !!!?

Upstream

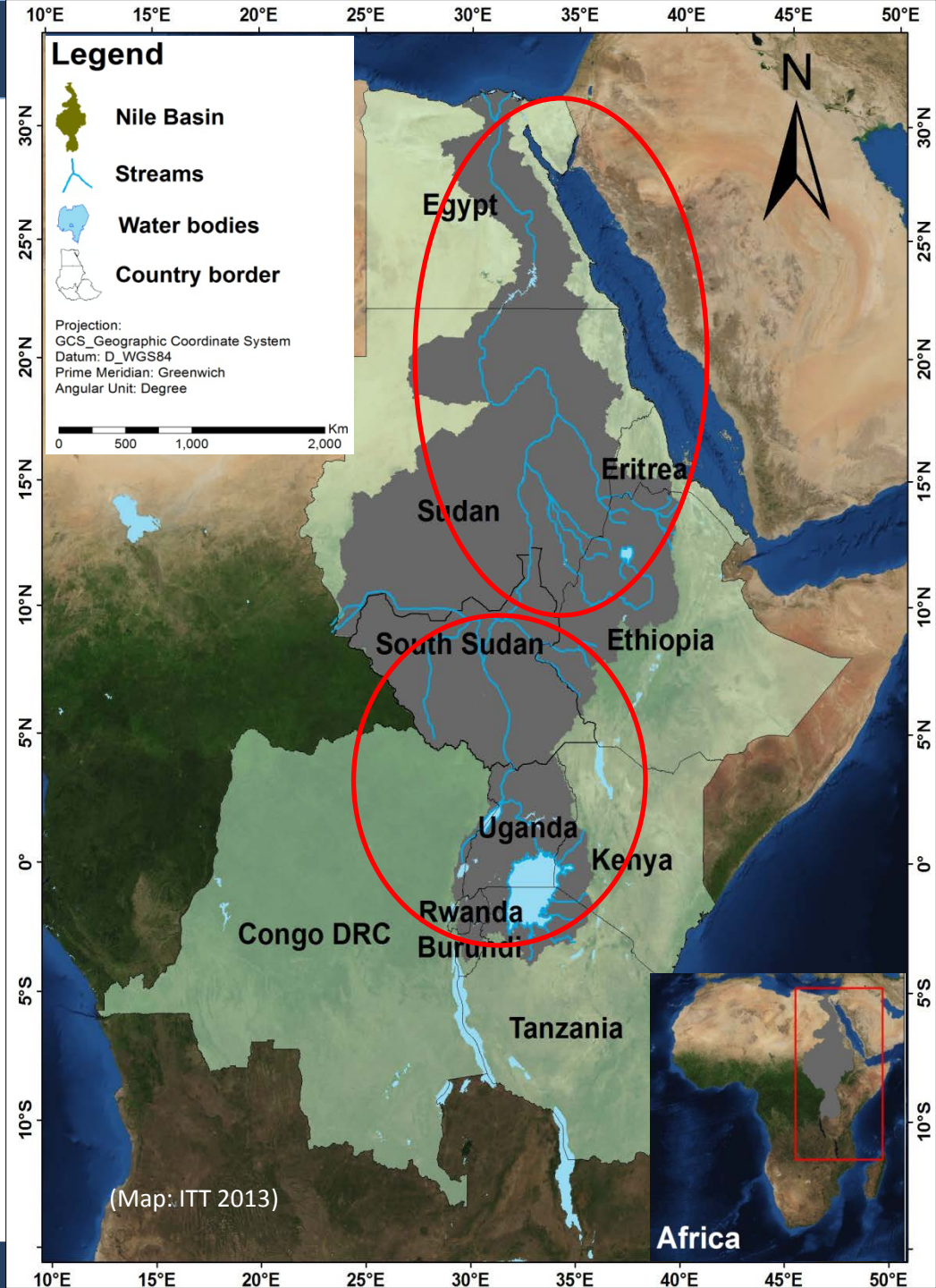
Nile Basin: A closer look

Basic Facts:

- 11 riparian countries,
- 160 (370) million people,
- 3.1 million km² (10 % of Africa),
- Past of poverty and conflicts, recent strong economic development

Two main sub-basins :

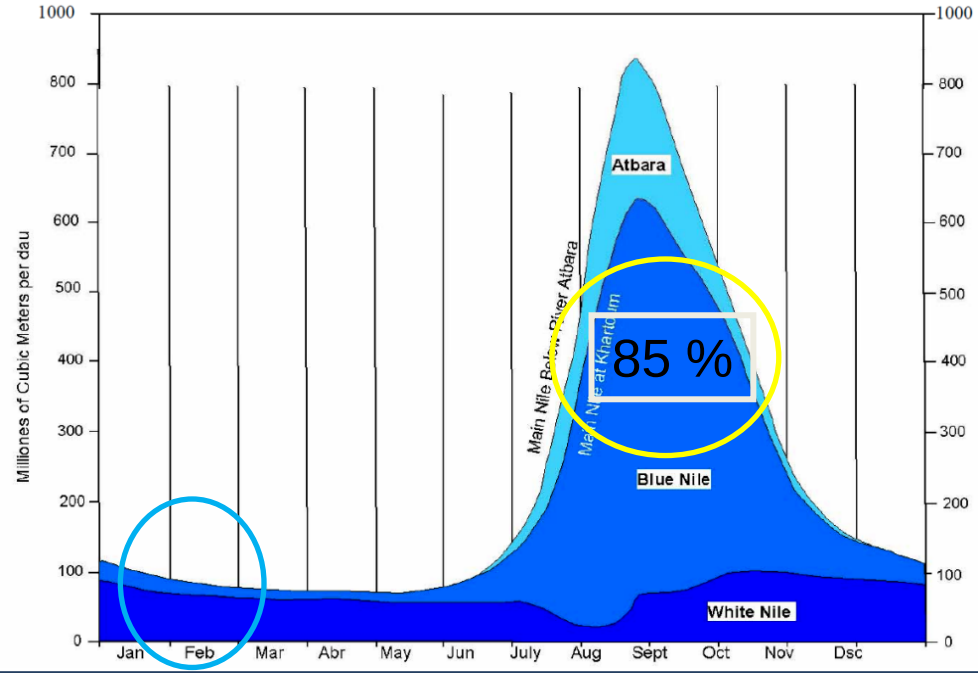
- **White Nile**, Equatorial Lake (15%) and,
- **Eastern Nile**, Egypt, Sudan, Ethiopia
  - > 80 % of area, 70 % of population, 60 % of cropland…80 % of GDP

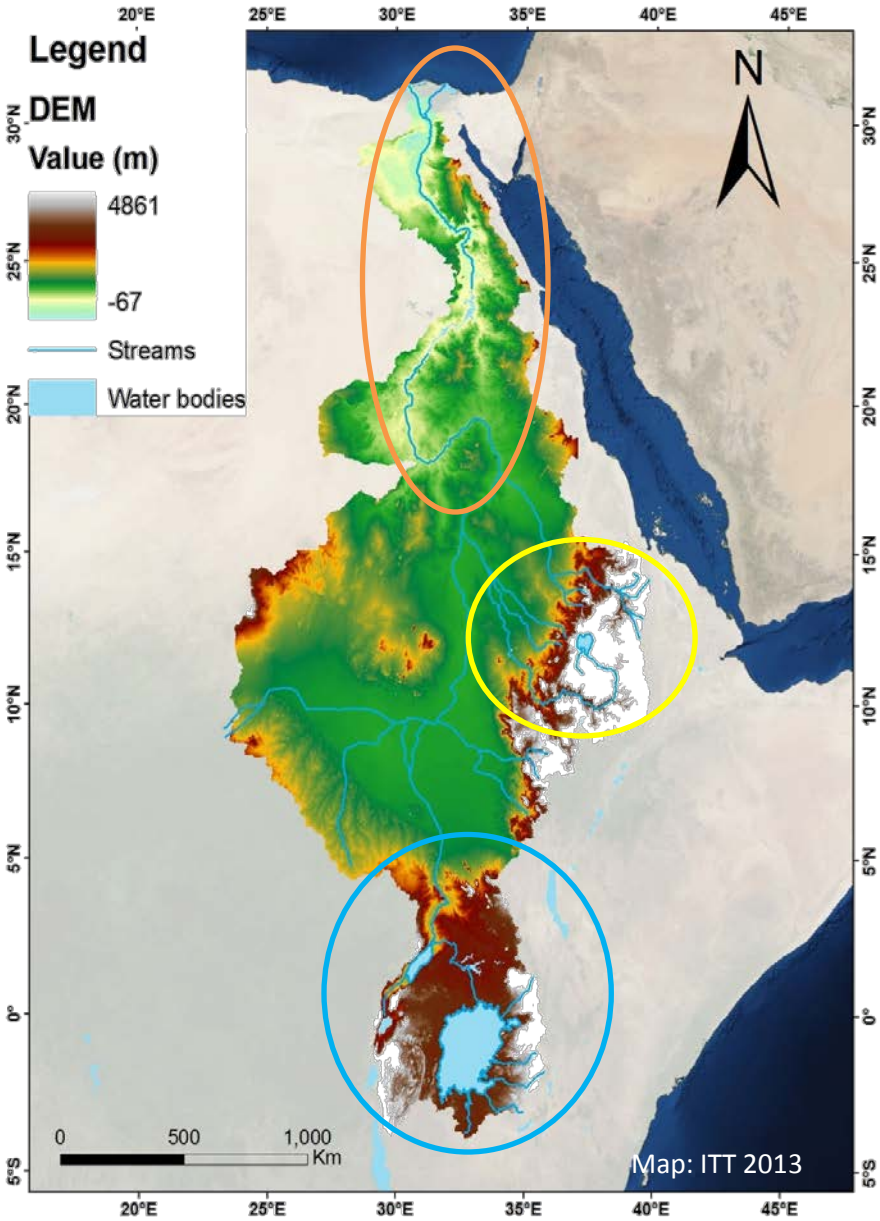


Nile Basin …

Topographic Zones:

1. **Lake Plateau :** Peaks 4,300 (m), slope gently
2. **Ethiopian Plateau:** Peaks 3,500 (m)
3. **North Sudan and Egypt:** Plain area < 400 (m)





Eastern Nile Basin

Issues on the ENB:

Ethiopia

- Generates 85 % water reaching Egypt's Aswan Dam
- Ethiopia only holds a limited "right" of exploration of the water resource
- most populated riparian state
- New hydropower dams

Eastern Nile Basin

Issues on the ENB:

Sudan

- 97 % of it's water resource used Agriculture sector
- 60% of Land Mass in Basin
- Sudd Swamp – Evap loss of >50% of all Water in White Nile
- South Sudan

Eastern Nile Basin

Issues on the ENB:

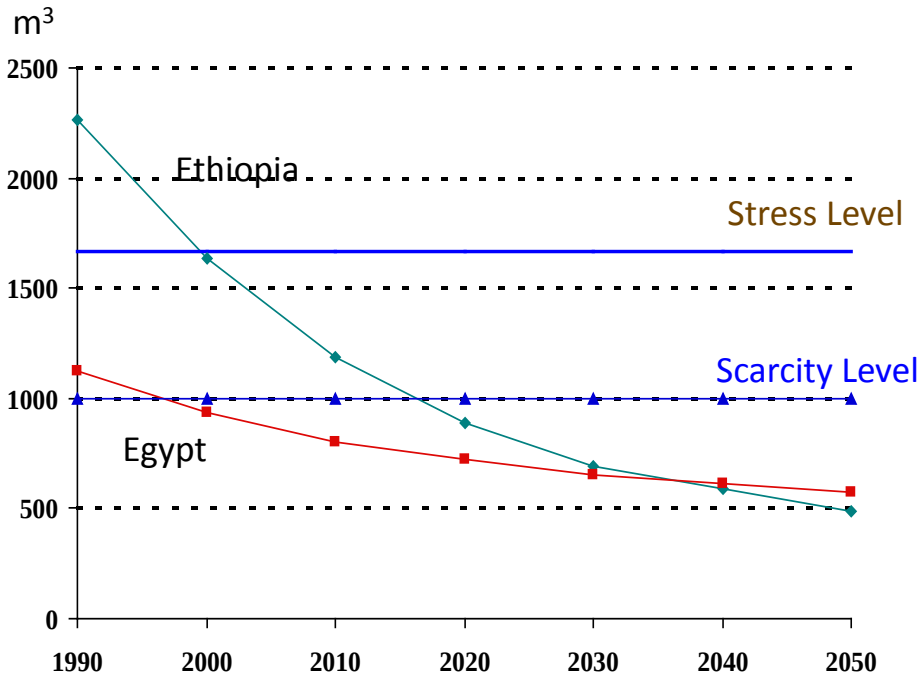
Egypt

- 96 % of population live in Nile Delta/Basin
- Entirely dependent on Nile waters (Only 4% from underground reserves)
- Water stressed Country (700 m^3/cap/y)

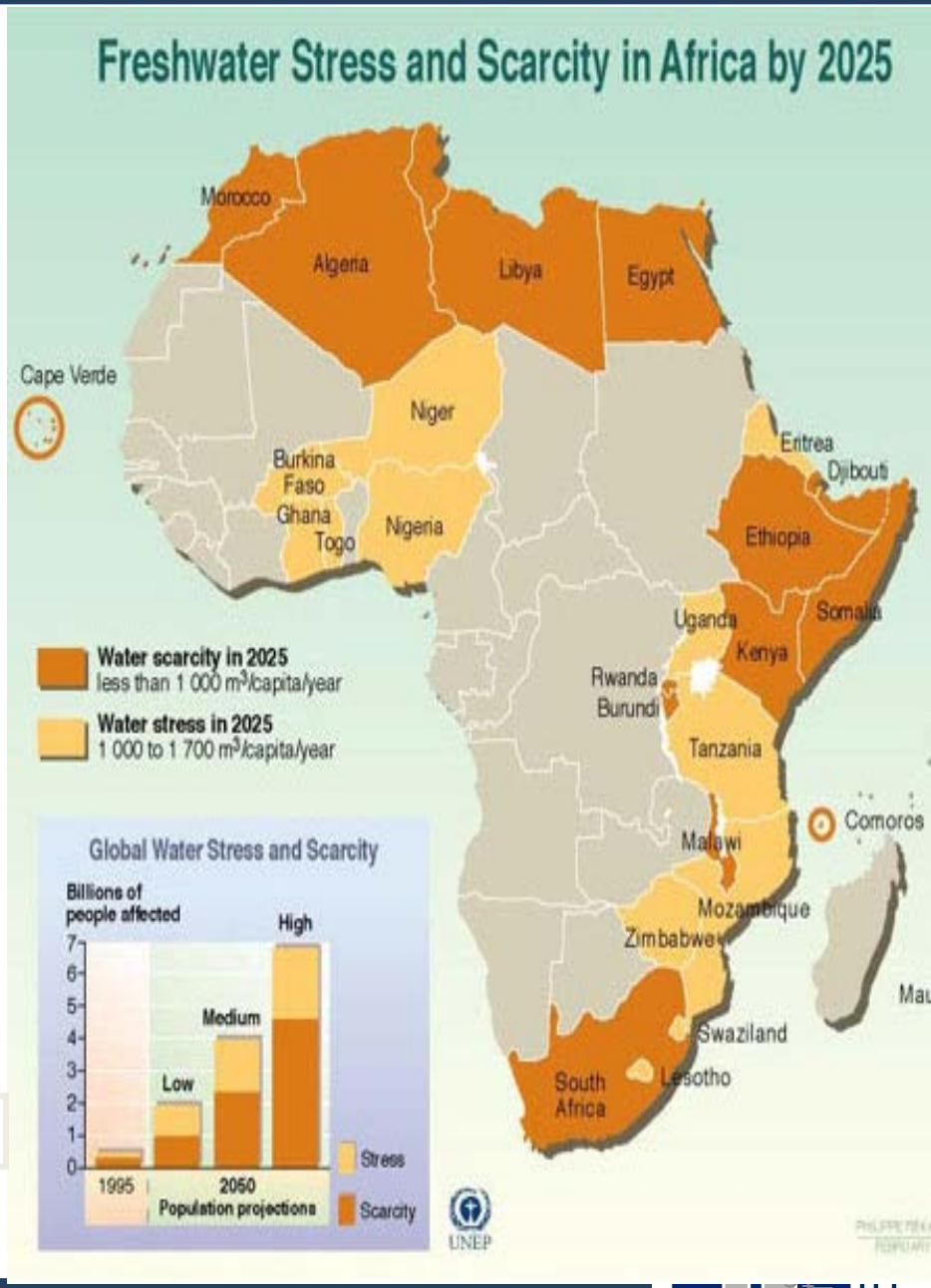
What will the future bring?

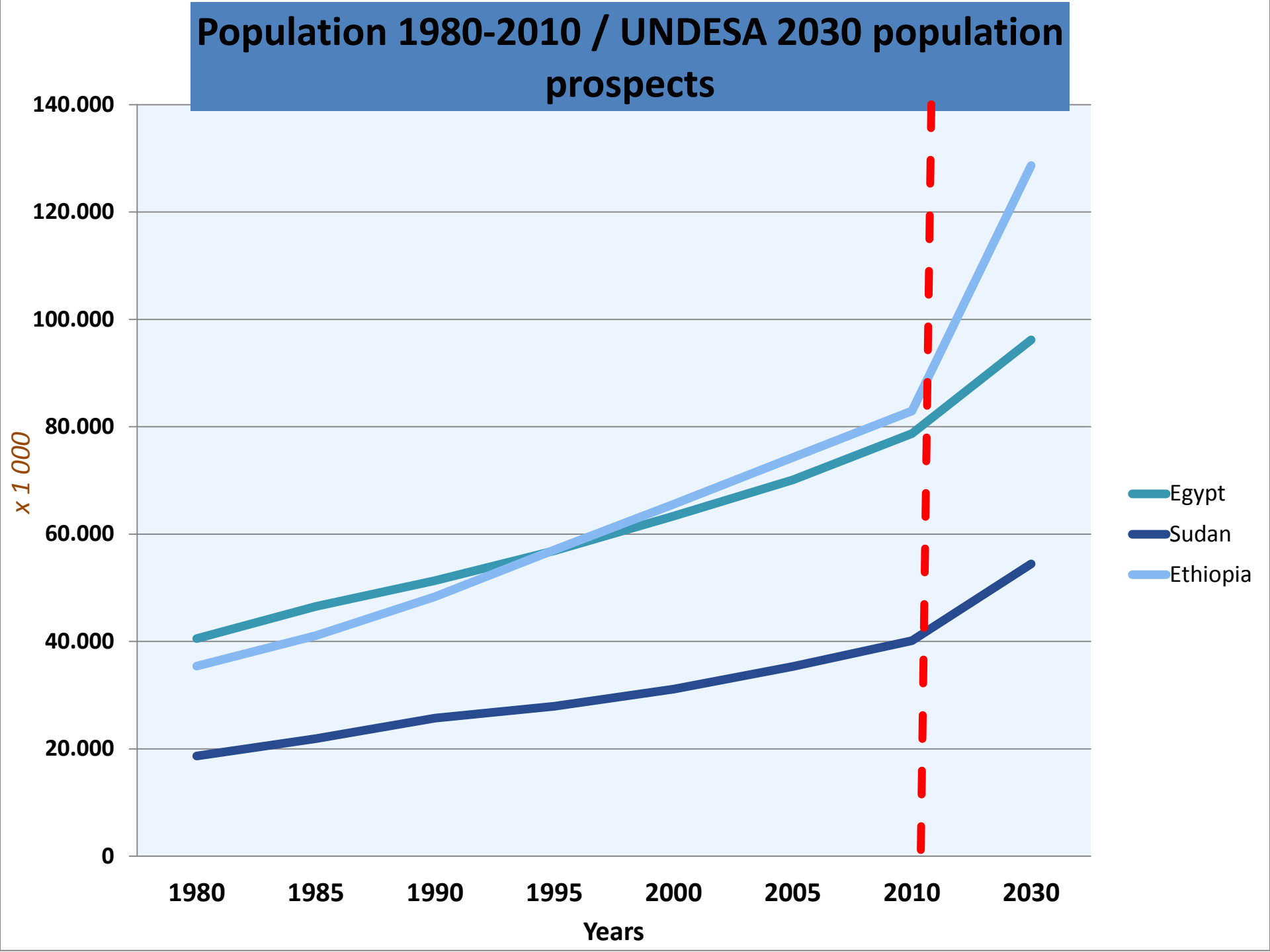
Water Demand

- Increasing water need for domestic use.
- Growing number of “water stressed” countries in the basin.

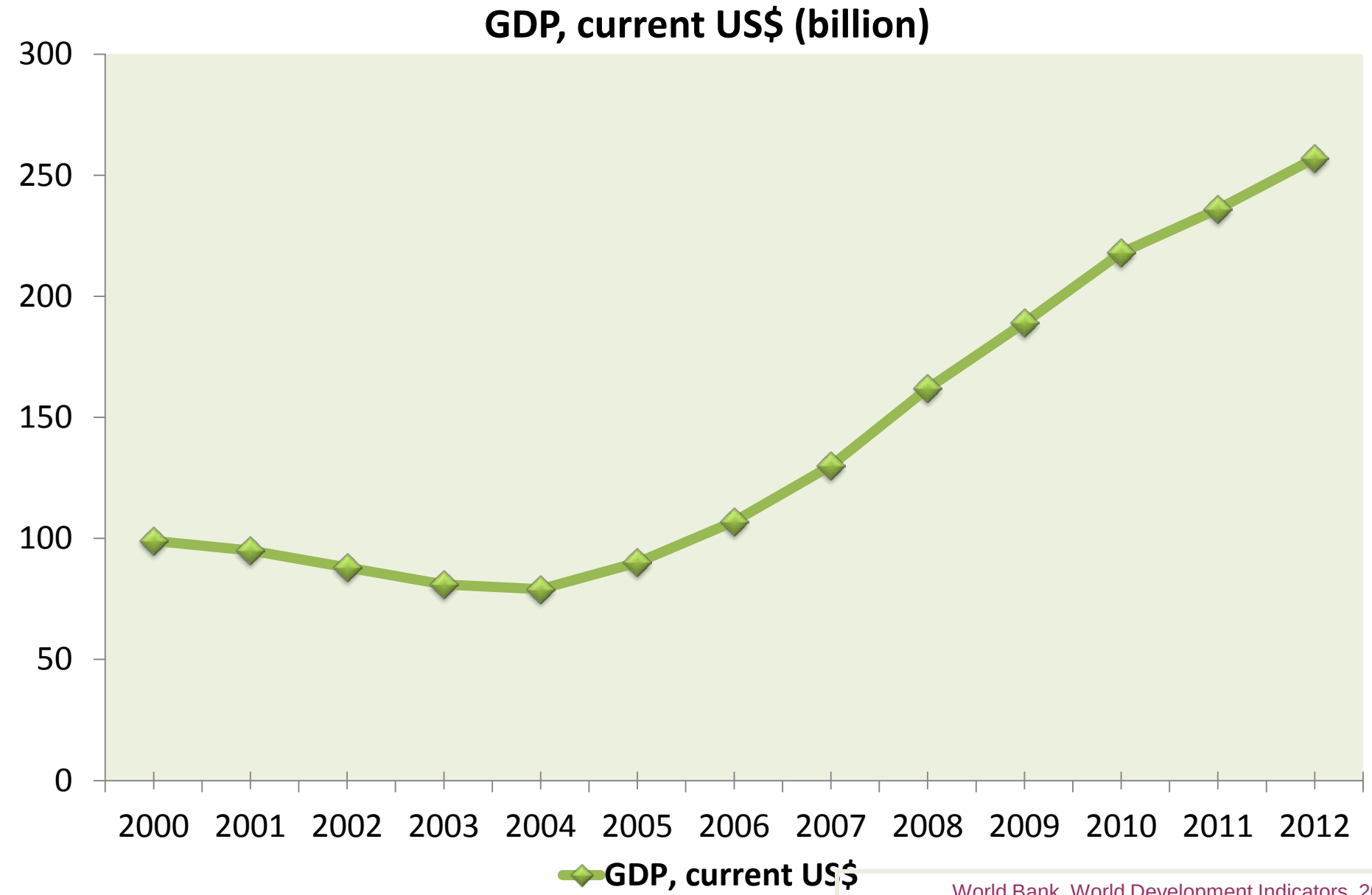


Water resources availability per capita (m^3)



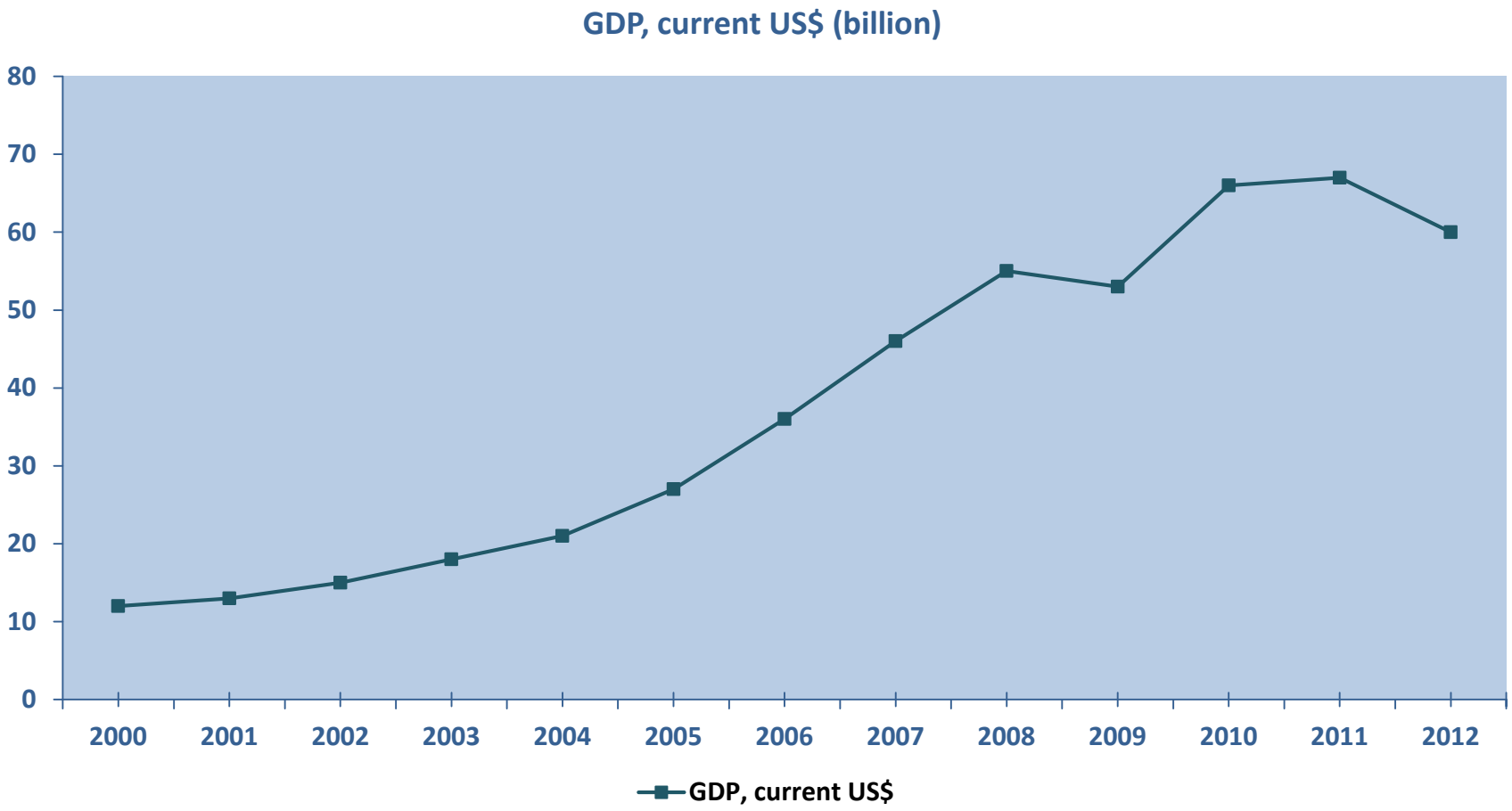

Population 1980-2010 / UNDESA 2030 population prospects
140.000
120.000
100.000
80.000
60.000
40.000
20.000
0
x 1 000
1980
1985
1990
1995
2000
2005
2010
2030
Years
Egypt
Sudan
Ethiopia

Egypt



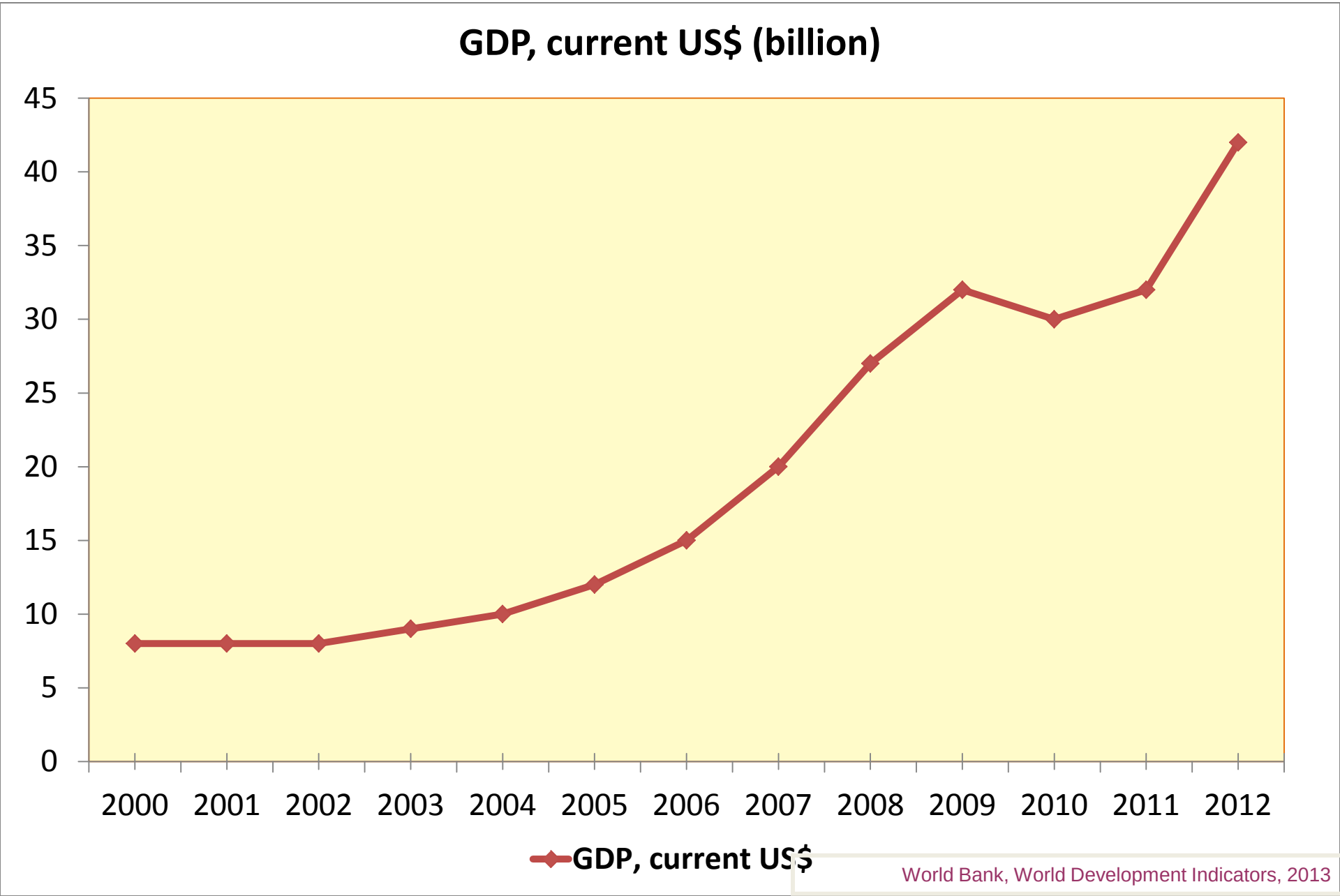
World Bank, World Development Indicators, 2013

Sudan



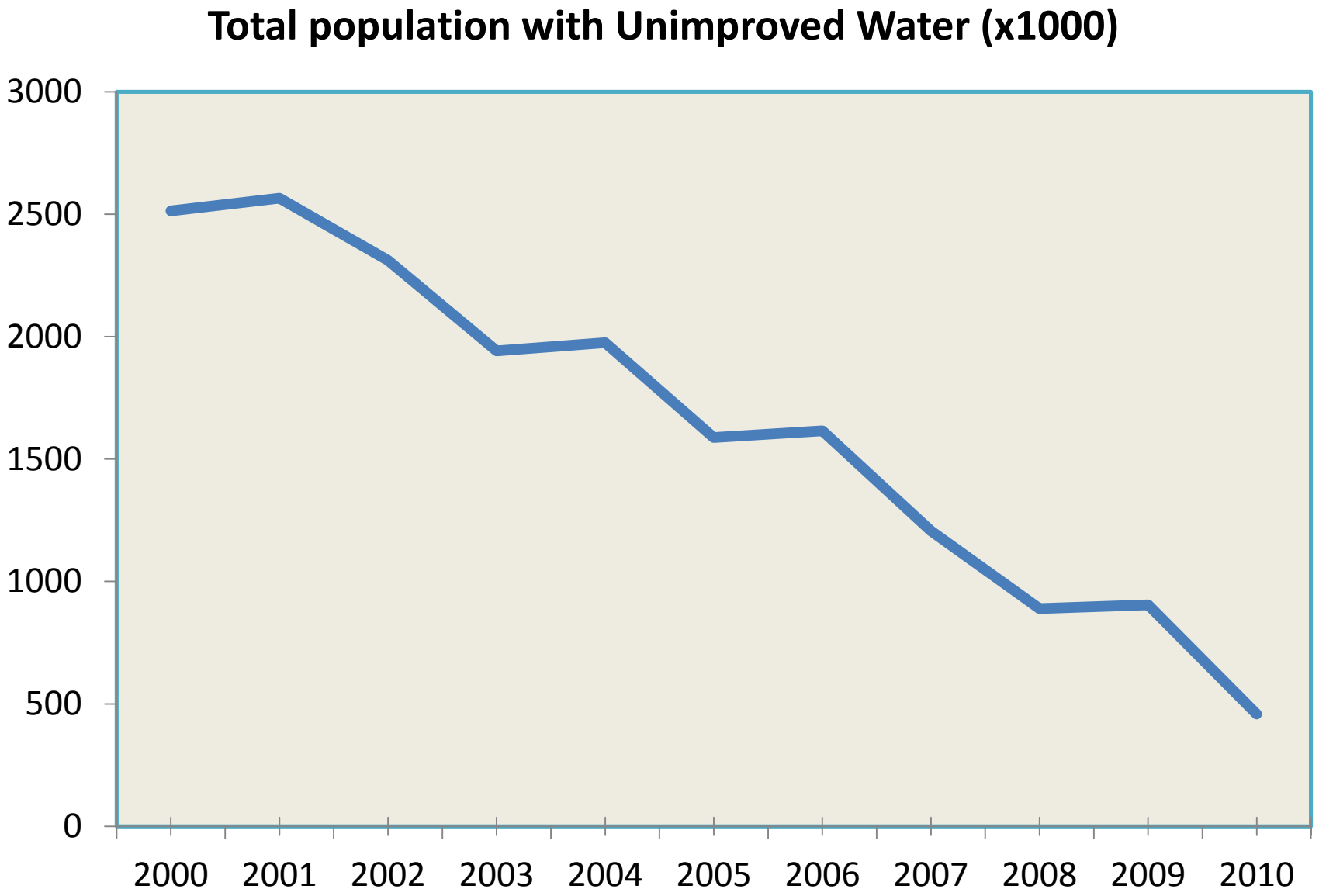
World Bank, World Development Indicators, 2013

Ethiopia



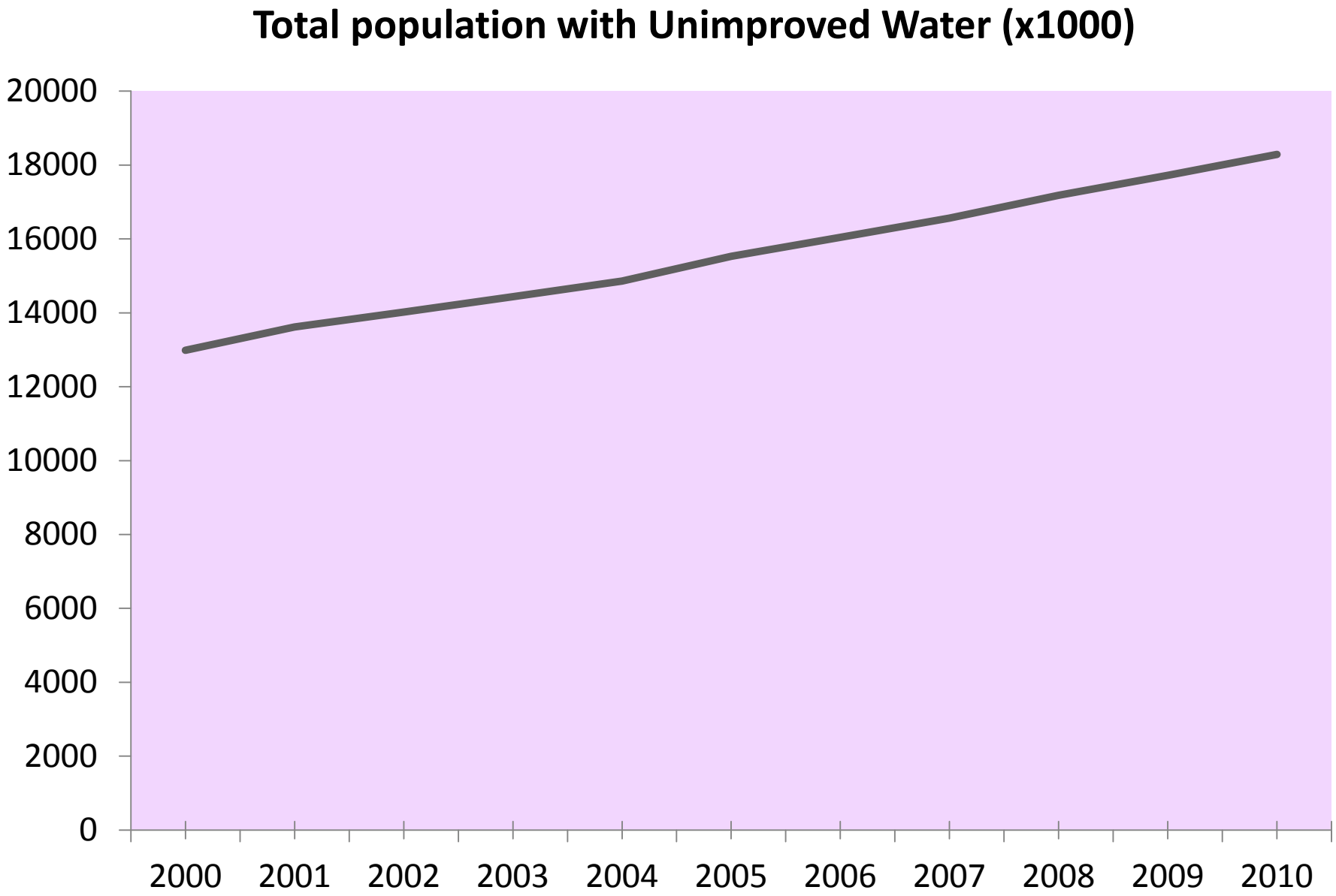
World Bank, World Development Indicators, 2013

Egypt



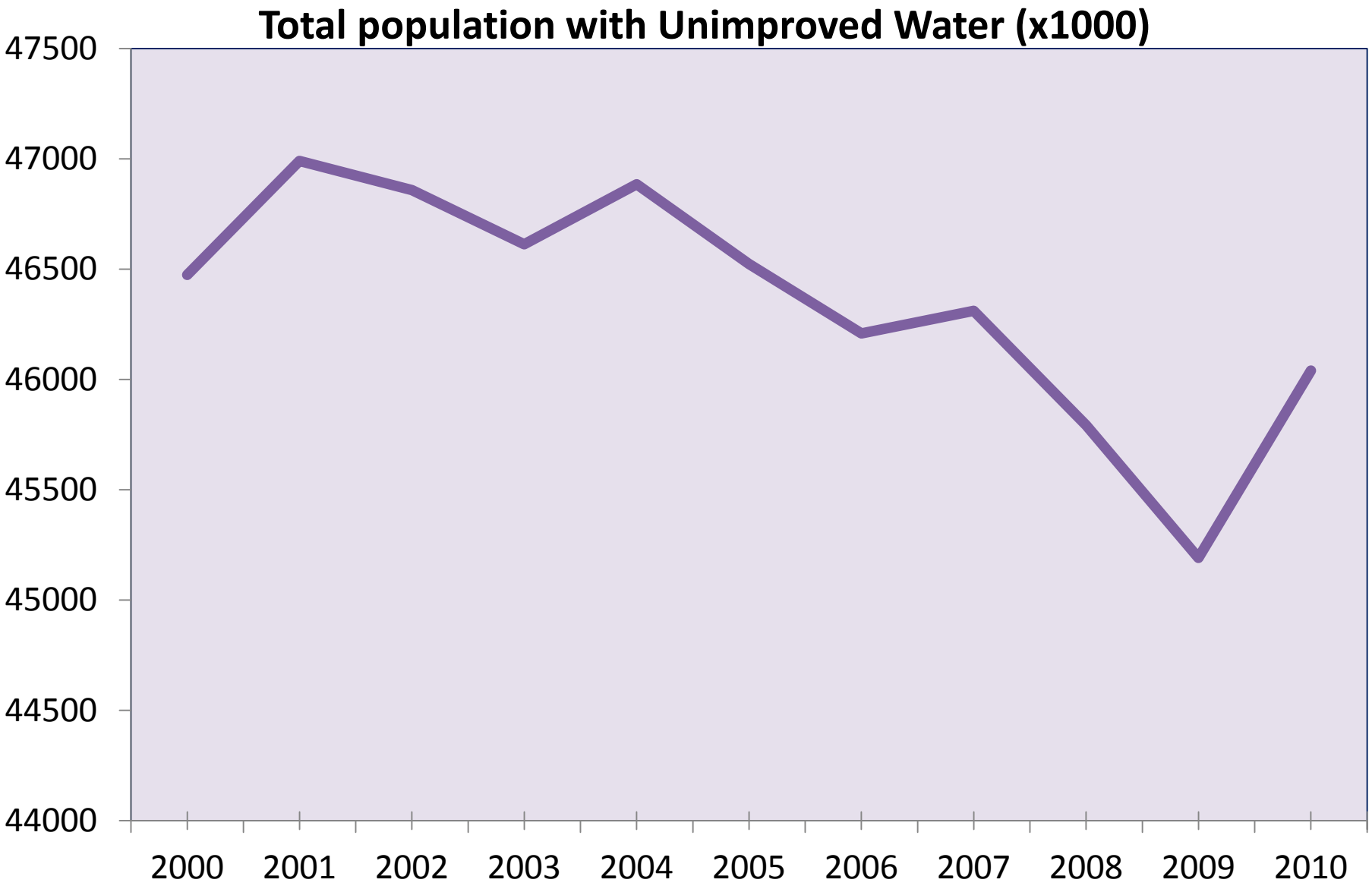
World Bank, World Development Indicators, 2013

Sudan

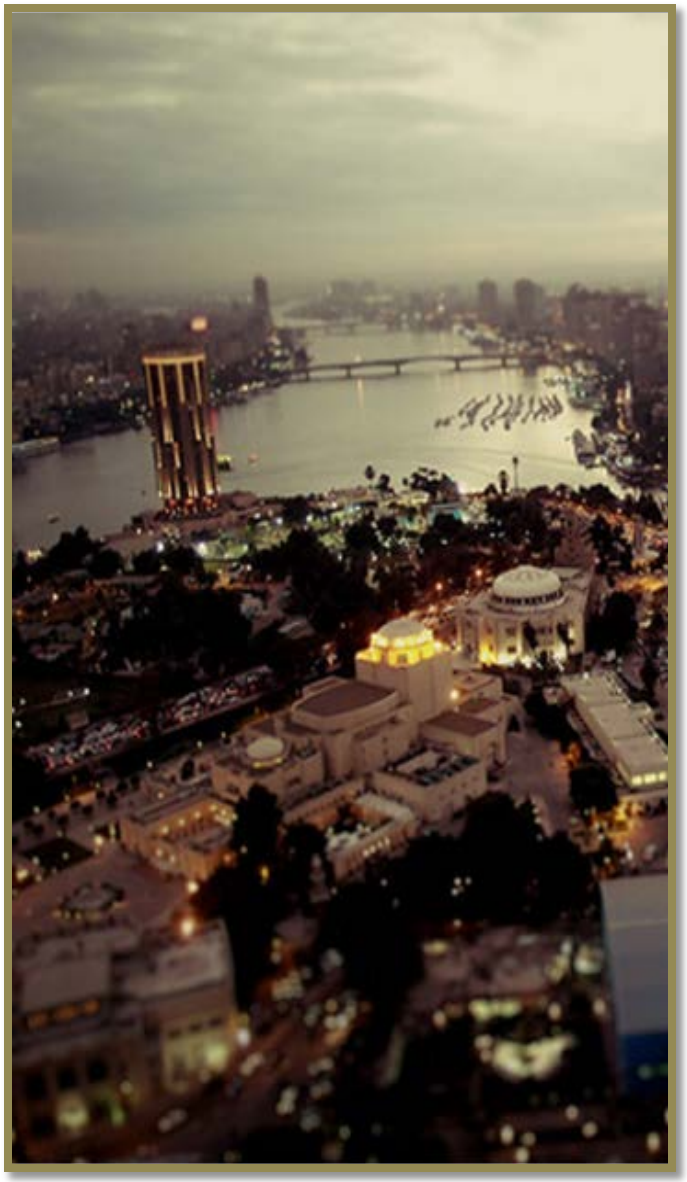


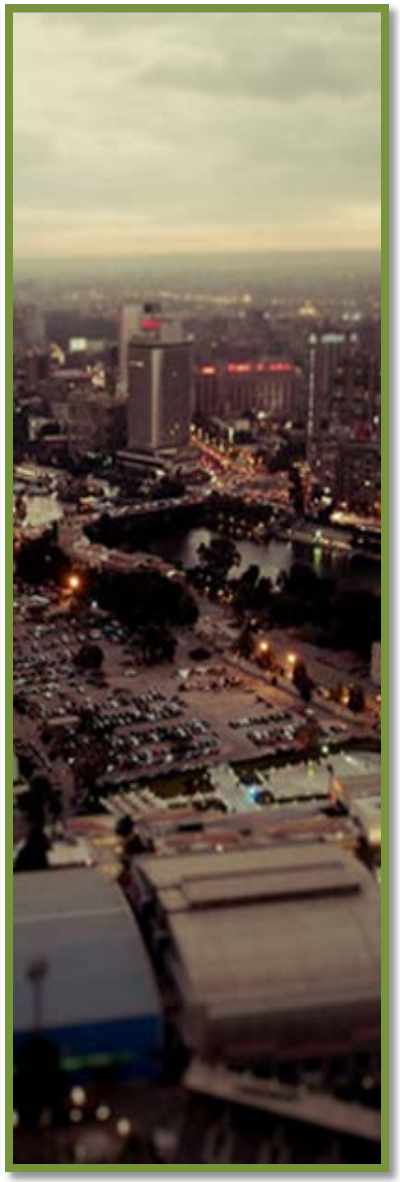
World Bank, World Development Indicators, 2013

Ethiopia

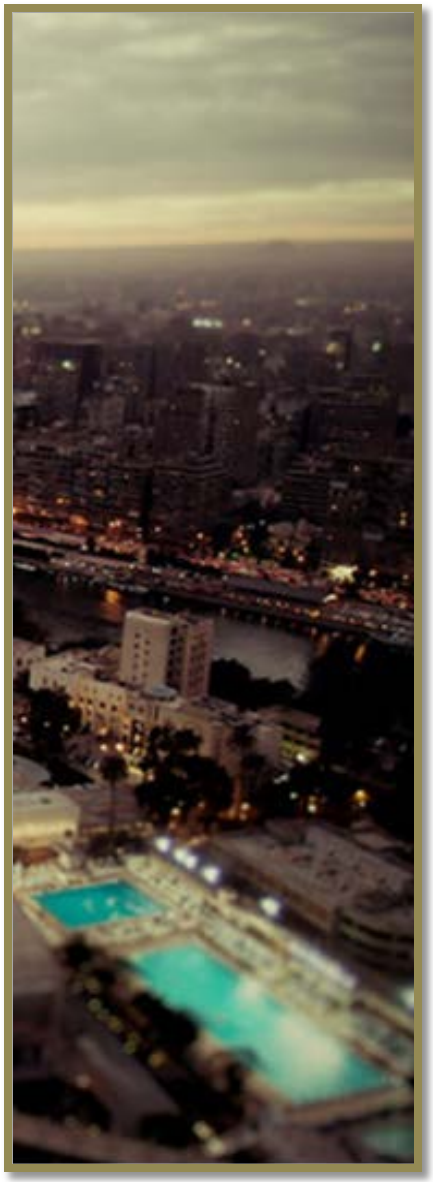


World Bank, World Development Indicators, 2013





Eastern
Nile
Countries



Economic Development

Power Demand

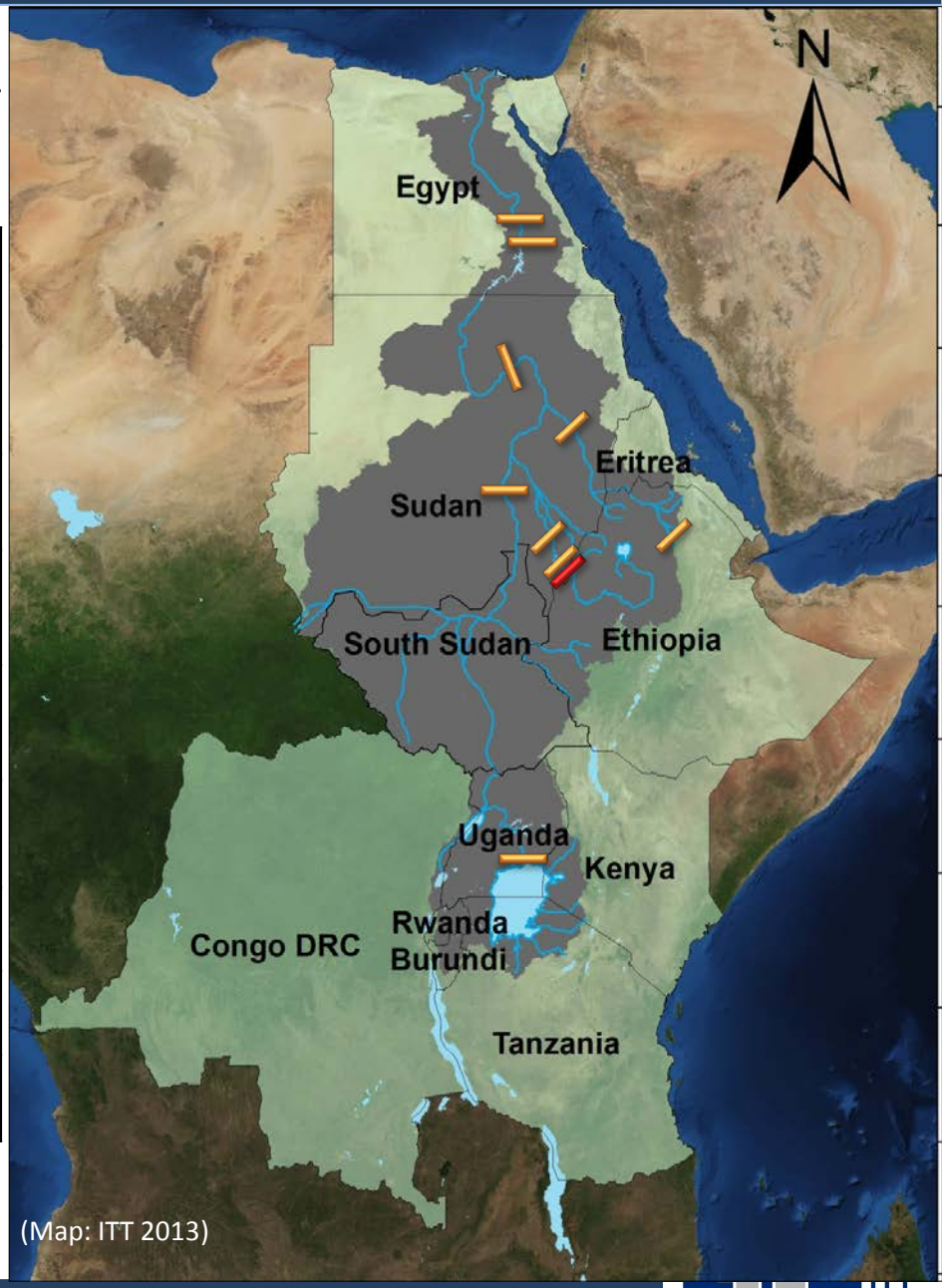
Demand Forecasts for 2005 through 2020

.Country	*Forecast 2005 (GWh)*	*Avg. incr. 2005 (%)*	*Forecast 2010 (GWh)*	*Forecast 2015 (GWh)*	*Forecast 2020 (GWh)*	*Avg. incr. 2020 (%)*
Burundi	156	6.0	195	253	335	5.0
Congo, Dem. Rep. East	331	16.0	405	653	917	8.7
Egypt	86,333	8.5	109,000	145,000	191,220	5.7
Eritrea	251	6.7	320	407	518	4.9
Ethiopia	2,011	7.5	2,640	3,367	4,285	5.3
Kenya	5,724	7.6	7,747	10,435	14,007	5.3
Rwanda	234	10.0	314	420	562	6.5
Sudan	4,246	18.8	6,417	9,550	14,212	10.2
Tanzania	4,346	14.2	5,709	7,384	9,442	7.1
Uganda	1,975	14.3	3,003	4,134	5,559	8.3
Total	105,607		135,750	181,603	241,057	

(World Bank, 2004)

Dams and Utilization Purposes

Country	Dam	River	Year of Const.	Storage Capacity (BMC)		Purpose
				Commis.	Current	
Egypt	Old Aswan Dam	Main Nile	1902	5	-	Irrigation, power
	Aswan High Dam	Main Nile	1971	162	90	Multi-purpose
Sudan	Sennar Dam	Blue Nile	1925	0.48	0.29	Irrigation, power
	Jebel Awlia Dam	White Nile	1937	3.50	3.50	Irrigation, power
	Khashm Elgirba Dam	Atbara	1964	0.617	0.37 (60%)	Irrigation, power
	Roseires Dam	Blue Nile	1966	2.12	1.59 (75%)	Irrigation, power
	Merowe Dam	Main Nile	2009	8.3	-	Power
Ethiopia	Tekeze	Upper Atbara	2008	9.3	-	Power
Uganda	Owen Falls	Lake Victoria	1954	-	-	Power



(Map: ITT 2013)

Basic figures of Grand Renaissance (Millennium) Dam

Total catchment area at dam axis (km^2) [1]	172,250
Reservoir surface area at full supply level (km^2) [2]	1,680
Storage capacity of the reservoir, Billion cubic Meter [2]	63
Areal average rainfall of the catchment (mm/year) [3]	1,230
Rainfall @dam site (mm/year) [4]	850
Net evaporation loss from Reservoir (mm/year) (After deducting rainfall on the reservoir) (5)	1080
Total Evaporation Losses (full supply); (km^3)	**1.84**
Mean inflow to the reservoir from 1911-2003 (m^3/sec) [1]	1,547
Max. Hydropower capacity (MW) / net generation (GWh) [6]	**6,000** / 15,000
Starting date [2]	April 2011
Completion date [2]	July 2017

Sources:

[1] Personal communication with personnel working on the dam project

[2] http://www.ethiopianconsla.org/Documents/BONDINFORMATION.pdf

[3] Value adopted from calculated areal rainfall of upper Blue Nile

[4] Adopted from near by meteorological station (Ethiopian Meteorological Agency)

[5] http://www.tigraionline.com/articles/article121230.html

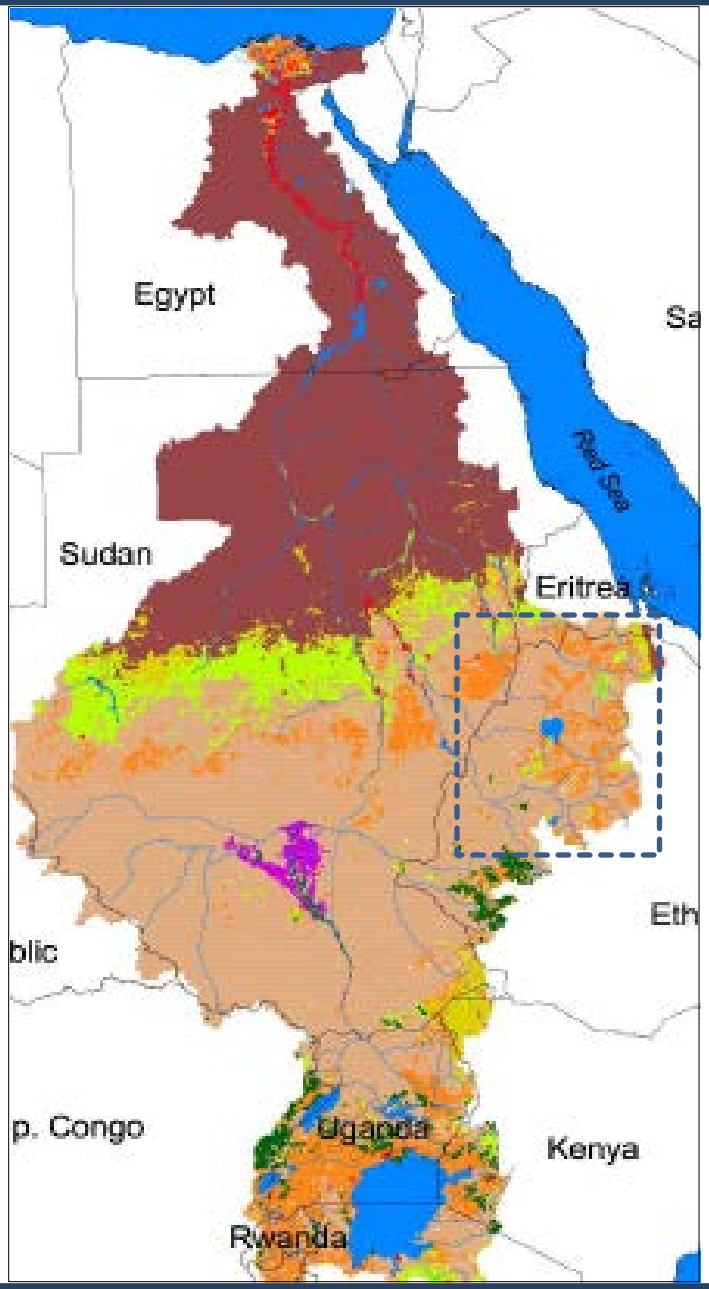
[6] http://www.water-technology.net/projects/grand-ethiopian-renaissance-dam-africa/

Impacts vs benefits?

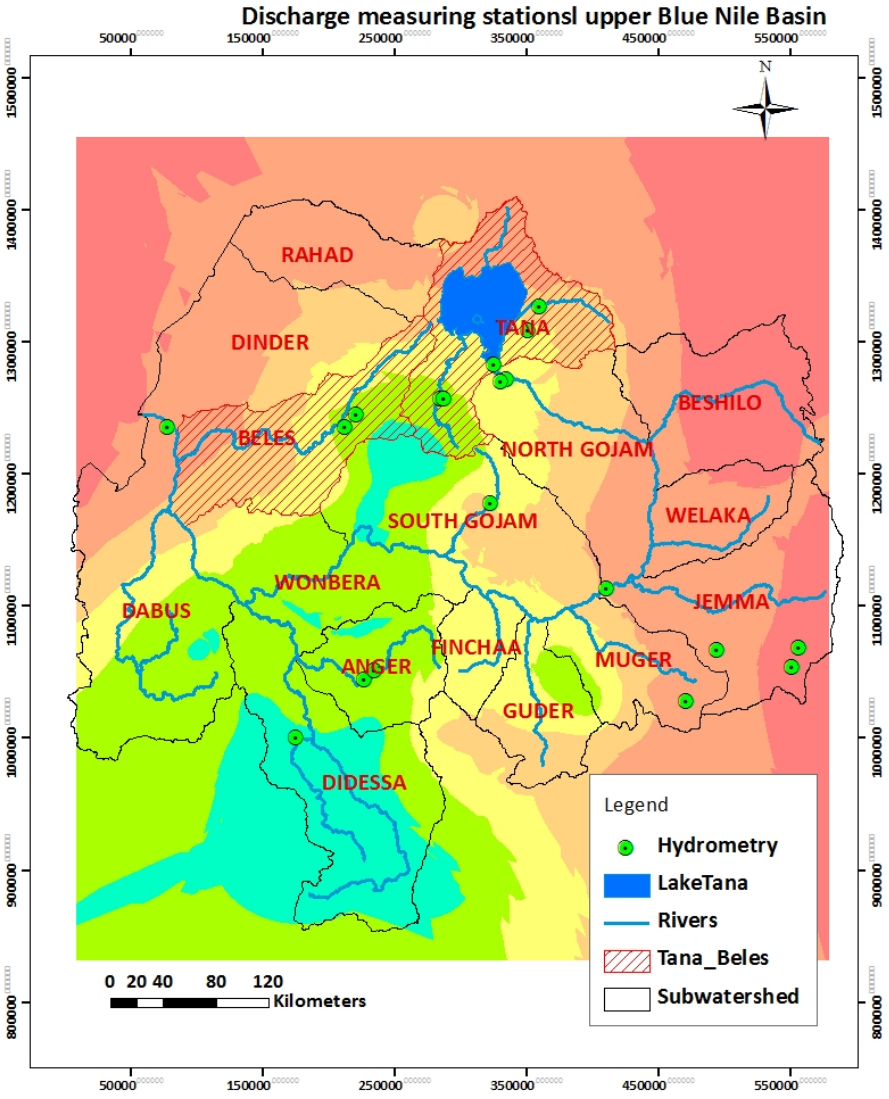
- Reduce water availability during filling
- Evaporation losses: 1.8 km^3
- Relocation of 5.000-20.000 people
- Increased life span of downstream dams (sediment trap)
- Flow regulation upstream instead of Aswan lake

Nile Basin …

Land Use:



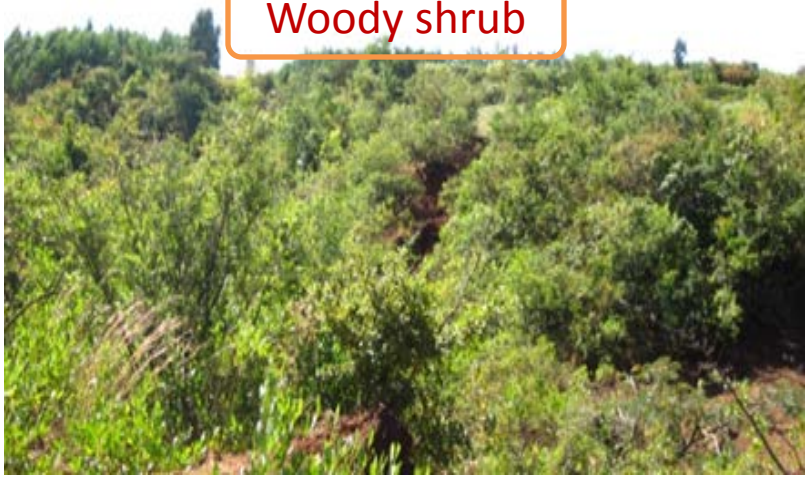
Land use dynamics



Eucalyptus

Open Grazing

Woody shrub



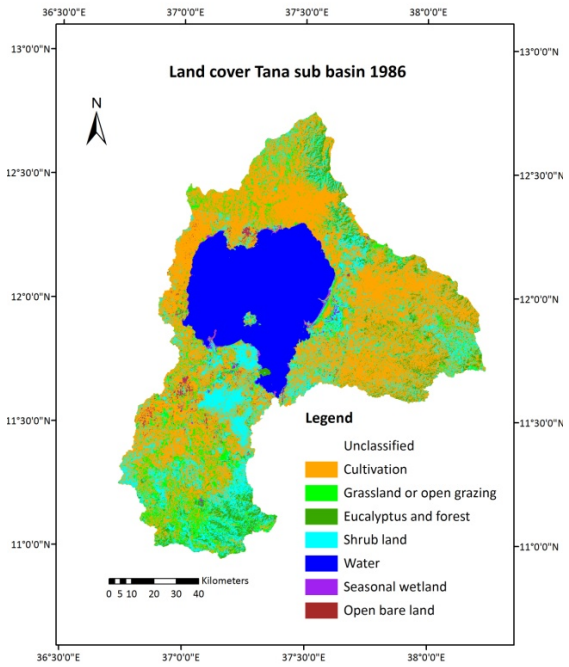
Crop land

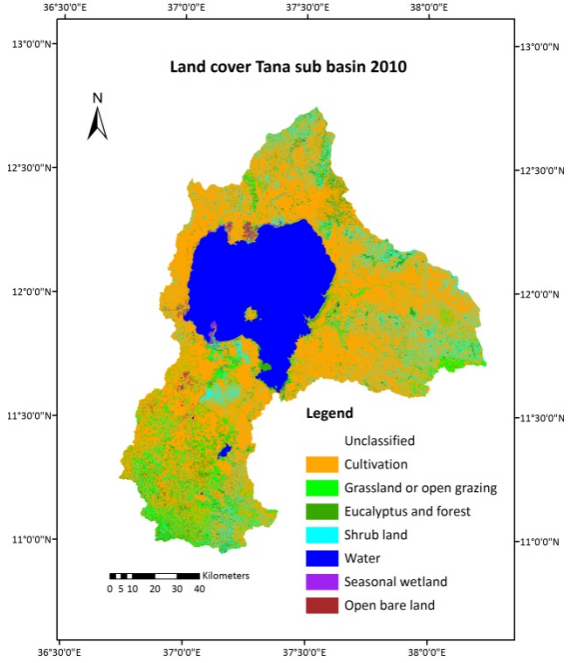
http://ethiopia2010.edublogs.org

1986

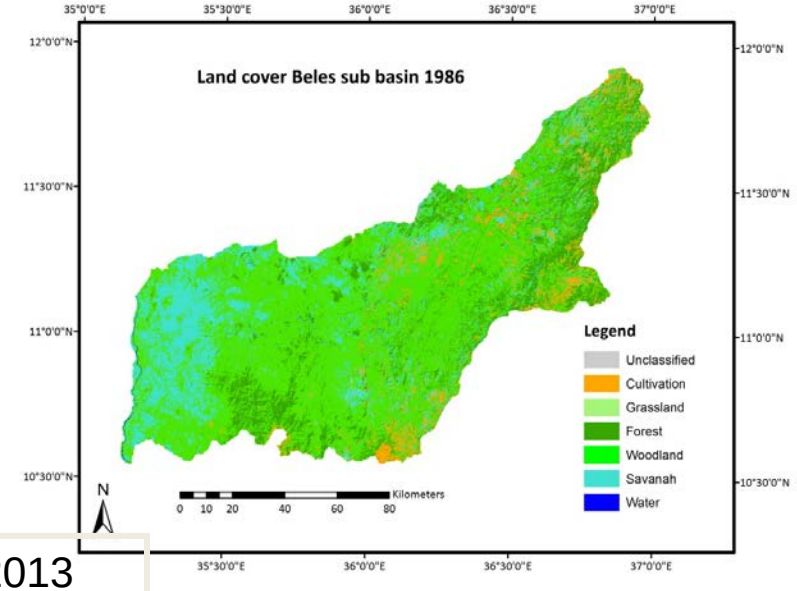
2010

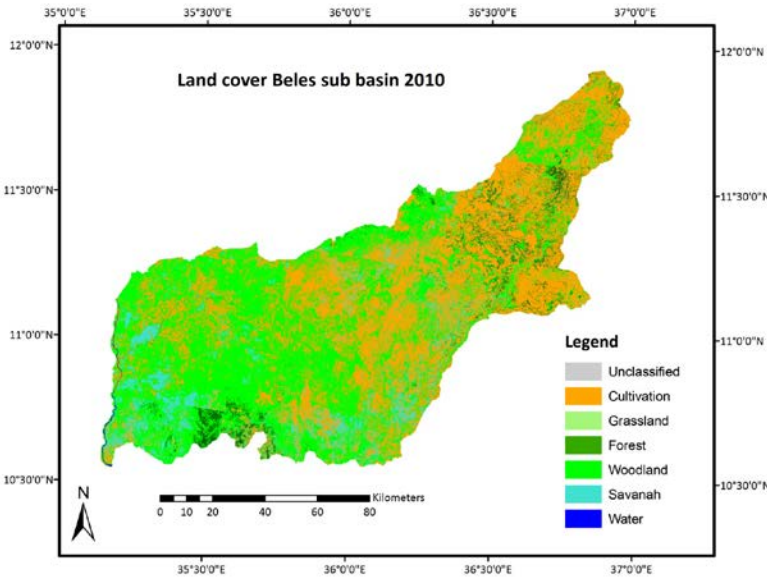
Tana Sub-basin



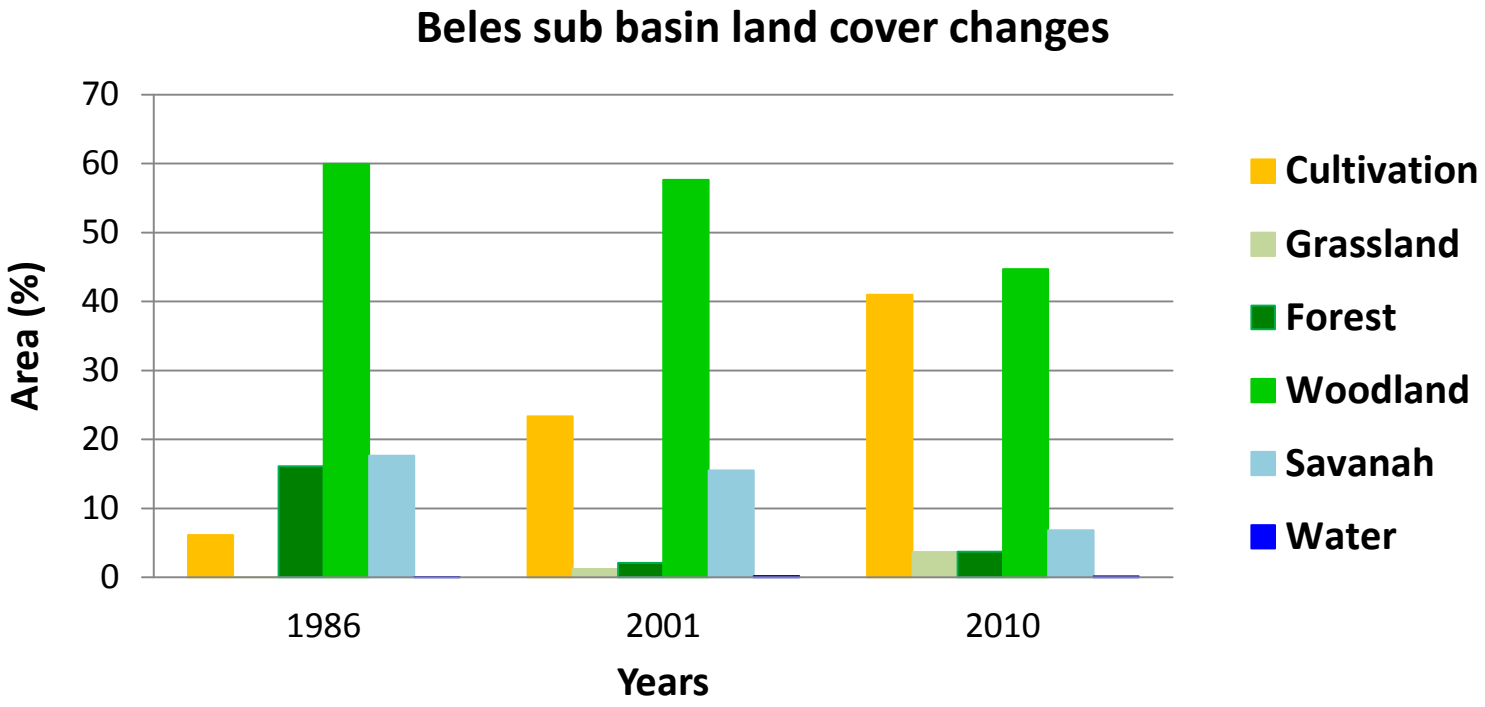


Beles Sub-Basin



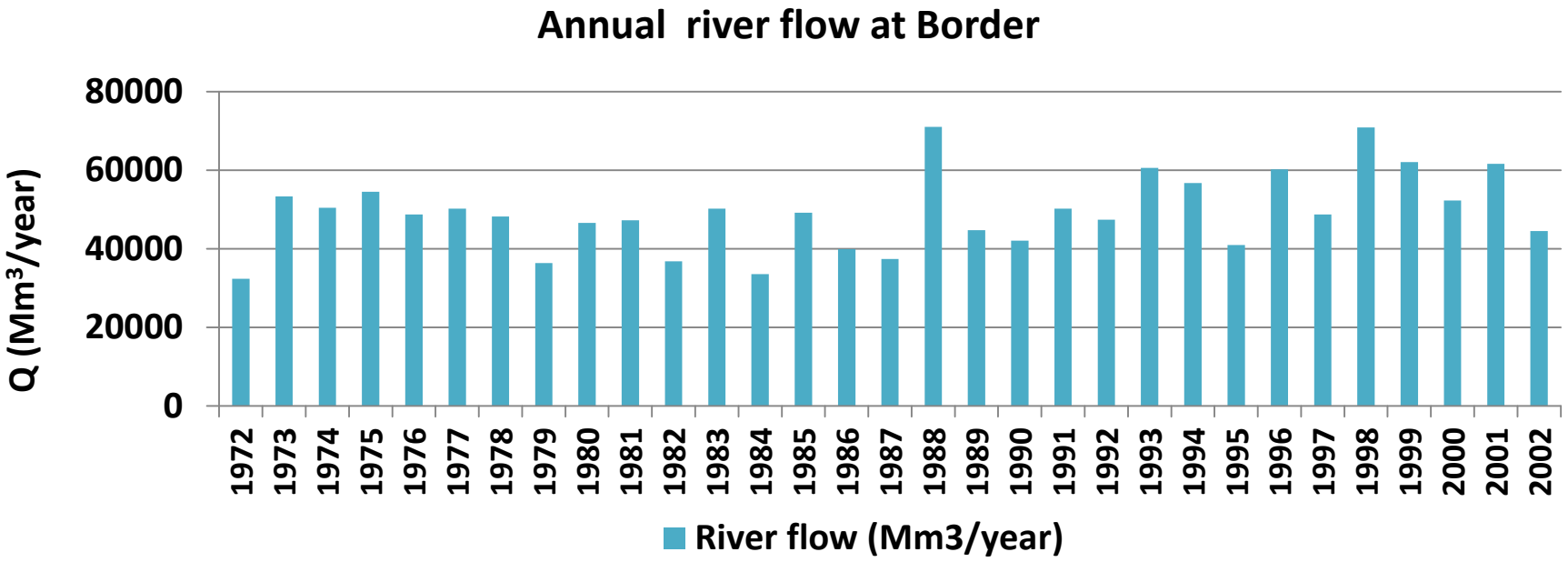


Woldesenbet, 2013



Woldesenbet, 2013

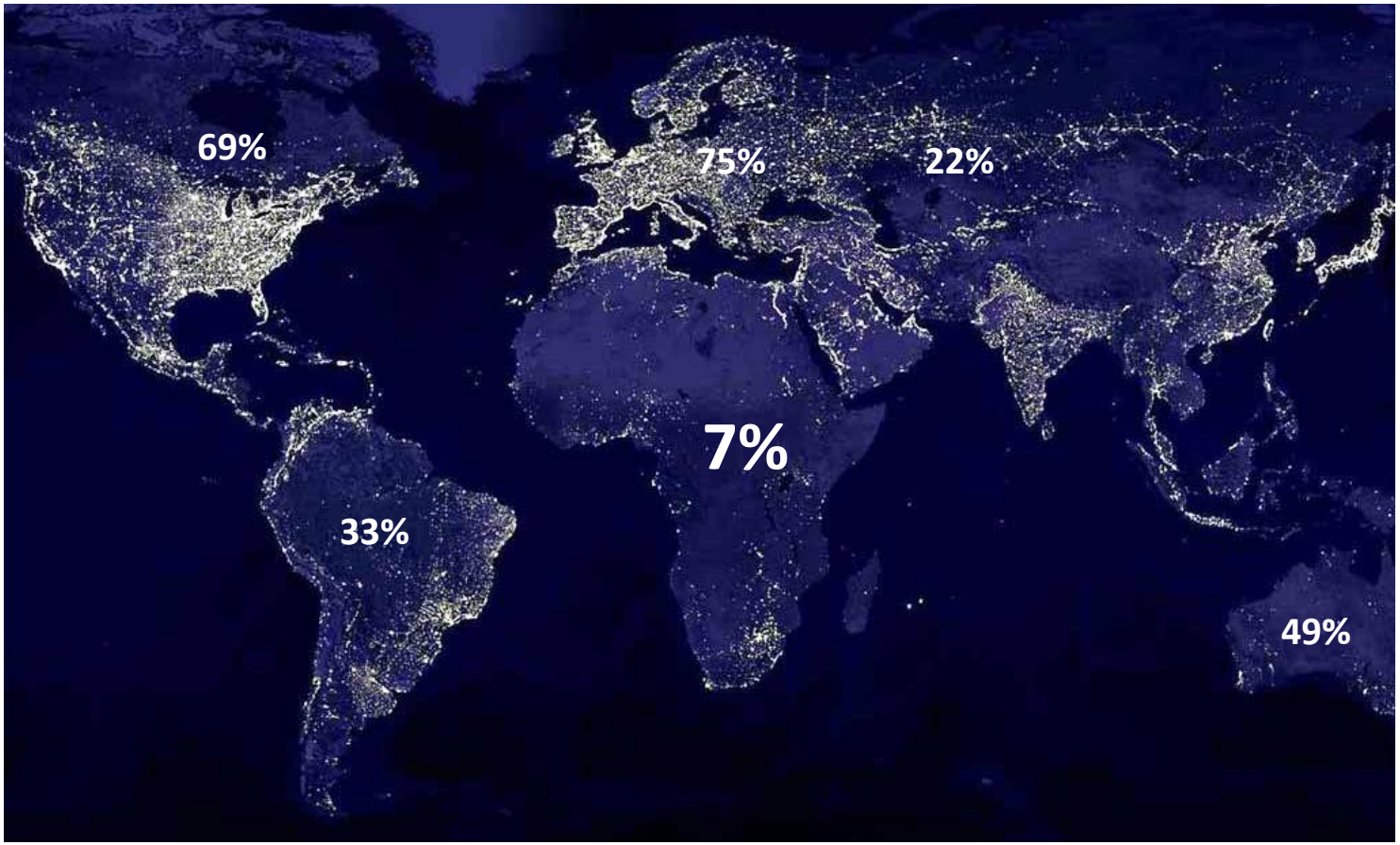
Hydro-meteorological Variability! Long term climate change???



Data source: Ethiopian Ministry of Water Resources

3. Outlook and Potential Solutions

Hydropower Potential



Percentage of technical and economic hydropower potential exploited
World Atlas of Hydropower & Dams, 2003

Ethiopias potential: 45 GW

(World Bank, 2004)

Potential Energy

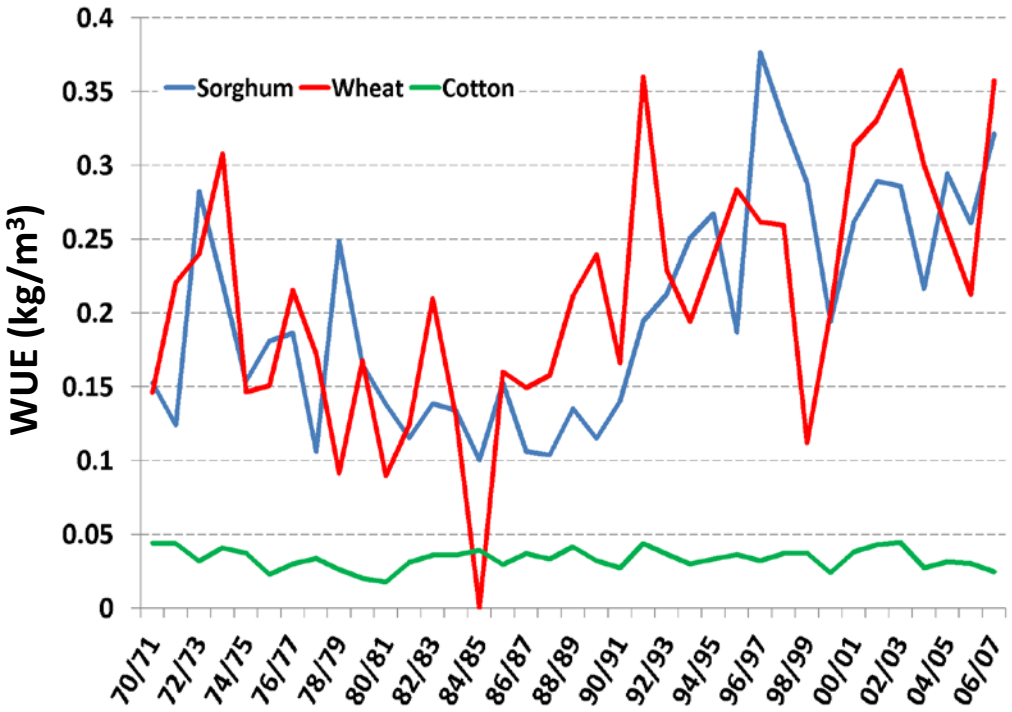
- Develop Renewable Resources!
  - hydropower…considering the impacts - developing „sustainable hydropower“
  - Solar Energy, Wind energy?!

- …realizing that energy efficiency is most potential energy source of the future

Food

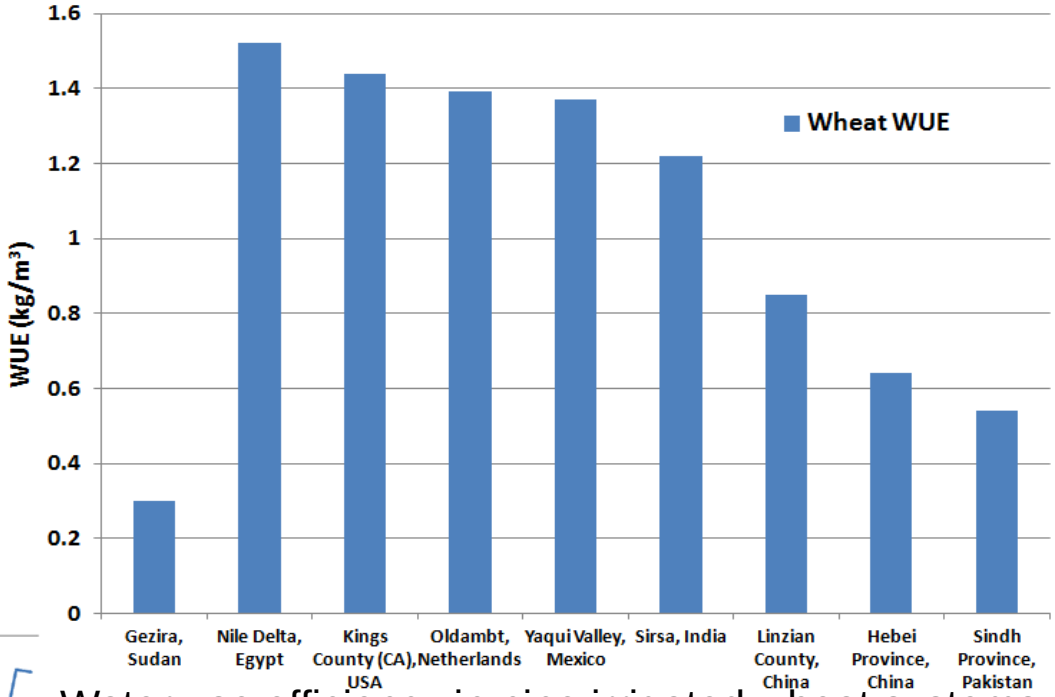
- Crop production: far below optimum efficiency (more crop per drop!)
- Import staple food from those countries which produce it efficiently (import of virtual water),
- produce high value crops for export

Low crop productivity in Gezira Scheme is possibly due to mismanagement of irrigation water at the field level.



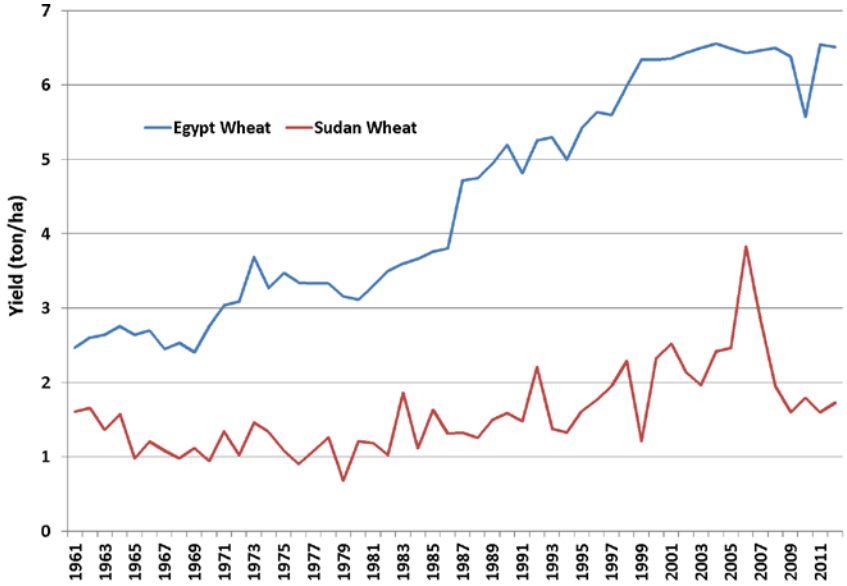
Water use efficiency for main crops in Gezira Scheme, Sudan (1970-2007)

Source: Sabry et.al., 2013



Water use efficiency in nine irrigated wheat systems

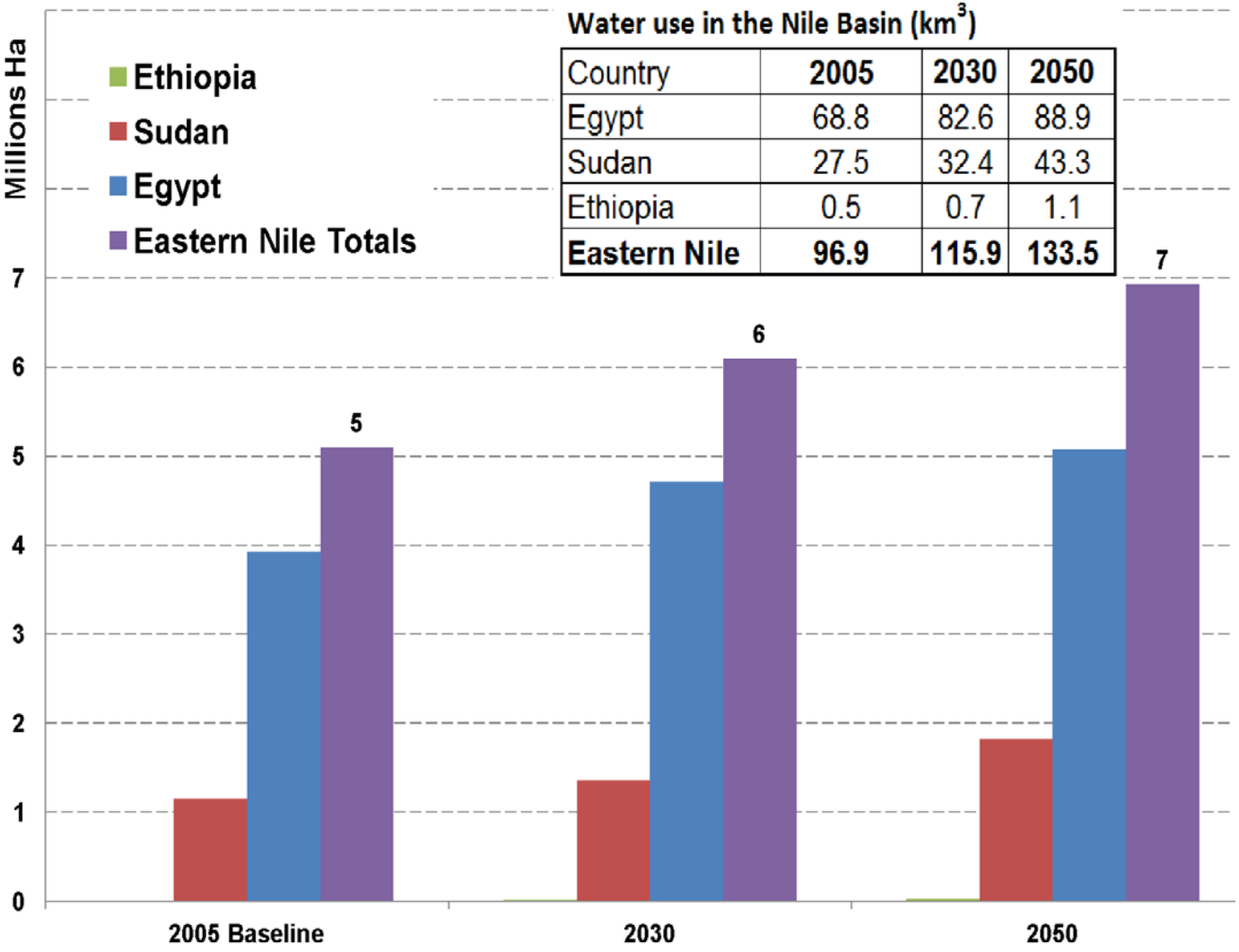
After: Zwart and Bastiaanssen (2007)



Wheat yield from 1961 to 2011

Source: FAOSTAT 2013

Irrigation Scenarios



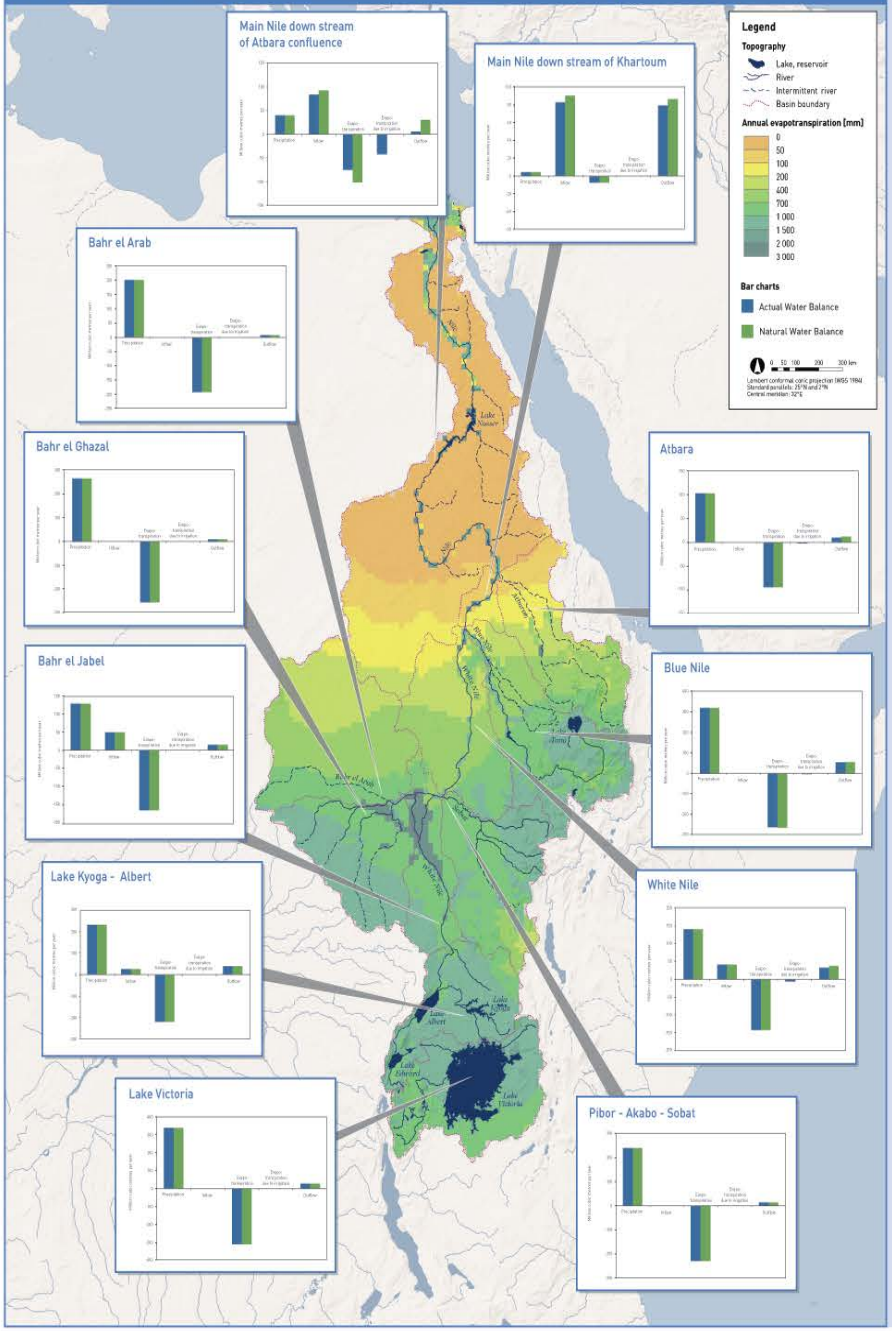
Water use in the Nile Basin (km^3)

Country	2005	2030	2050
Egypt	68.8	82.6	88.9
Sudan	27.5	32.4	43.3
Ethiopia	0.5	0.7	1.1
Eastern Nile	**96.9**	**115.9**	**133.5**

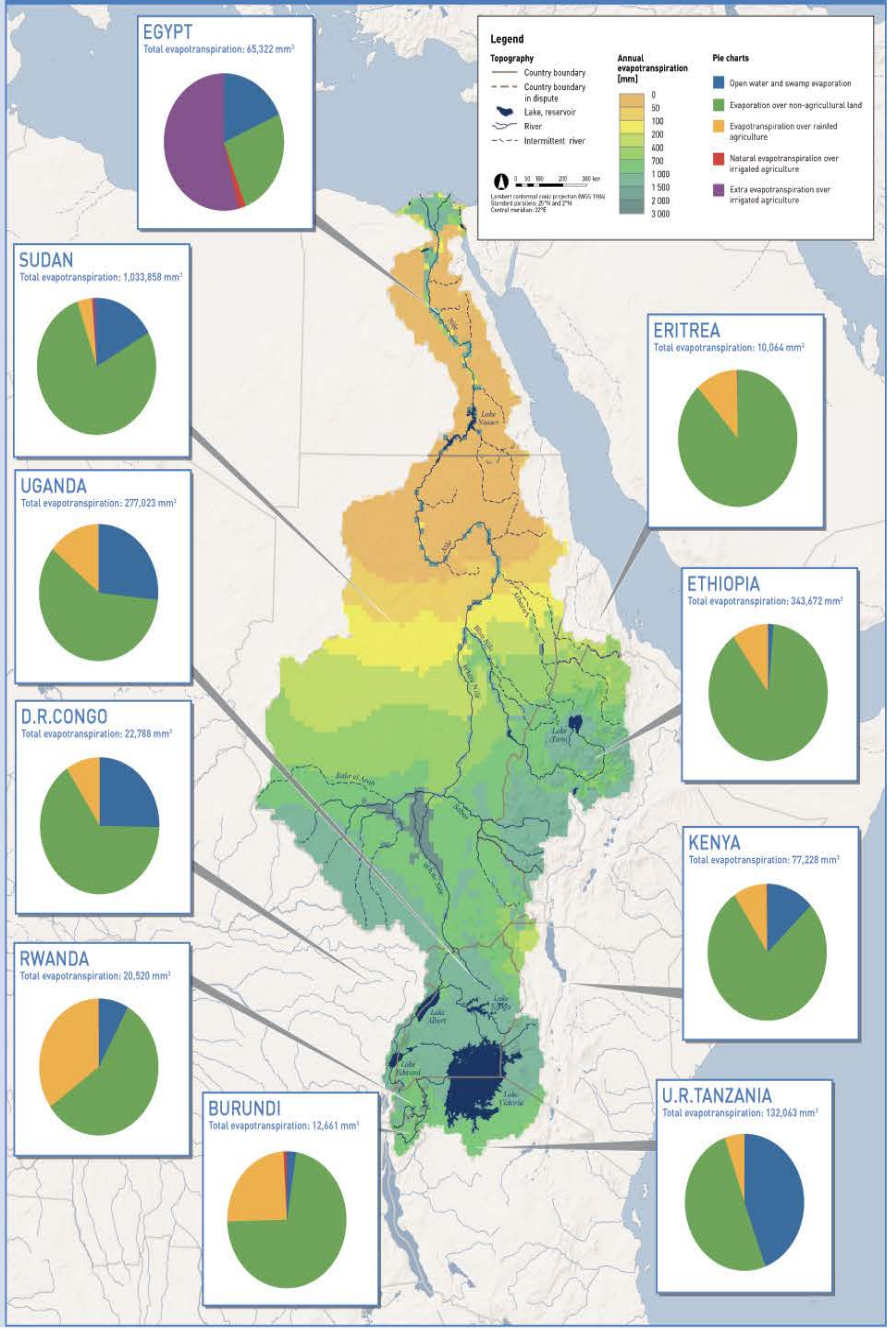
Projection of harvested areas of the Nile basin (Ha)

Source: FAO 2011

Nile basin actual and natural water balance by **river basin**



Nile basin actual and natural water balance by **country**



Potential: rainwater

- How much water falls on the basin?
  - ca 1800 * 10^9 m^3
- How much water flows into Egypt?
  - ca 55 * 10^9 m^3

- …rainwater harvesting!
- Storing more rainwater - under ground, -in smaller reservoirs, - in soil ?!!

„smart storage“

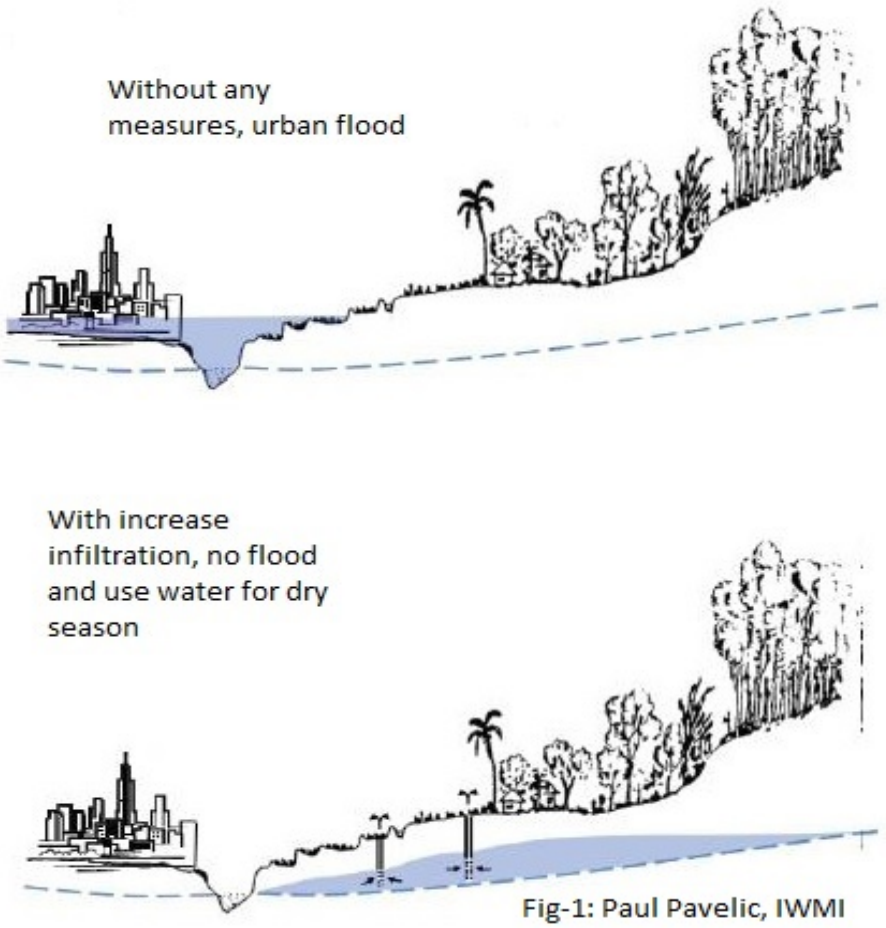


Fig-1: Paul Pavelic, IWMI

Benefit Sharing

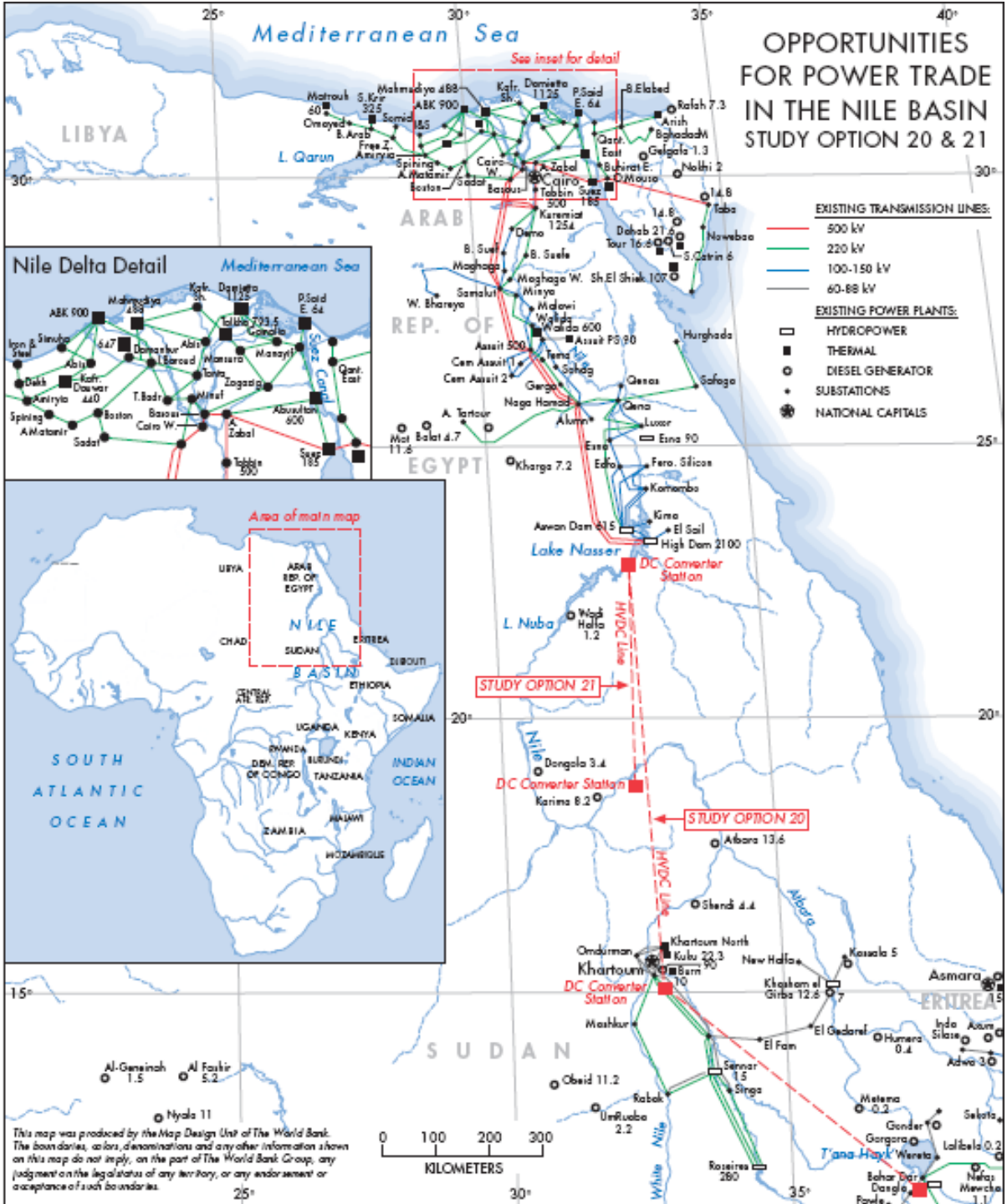
General Concept:

Share the benefits resulting from the development of the water resources in order to satisfy the needs of the concerned populations.

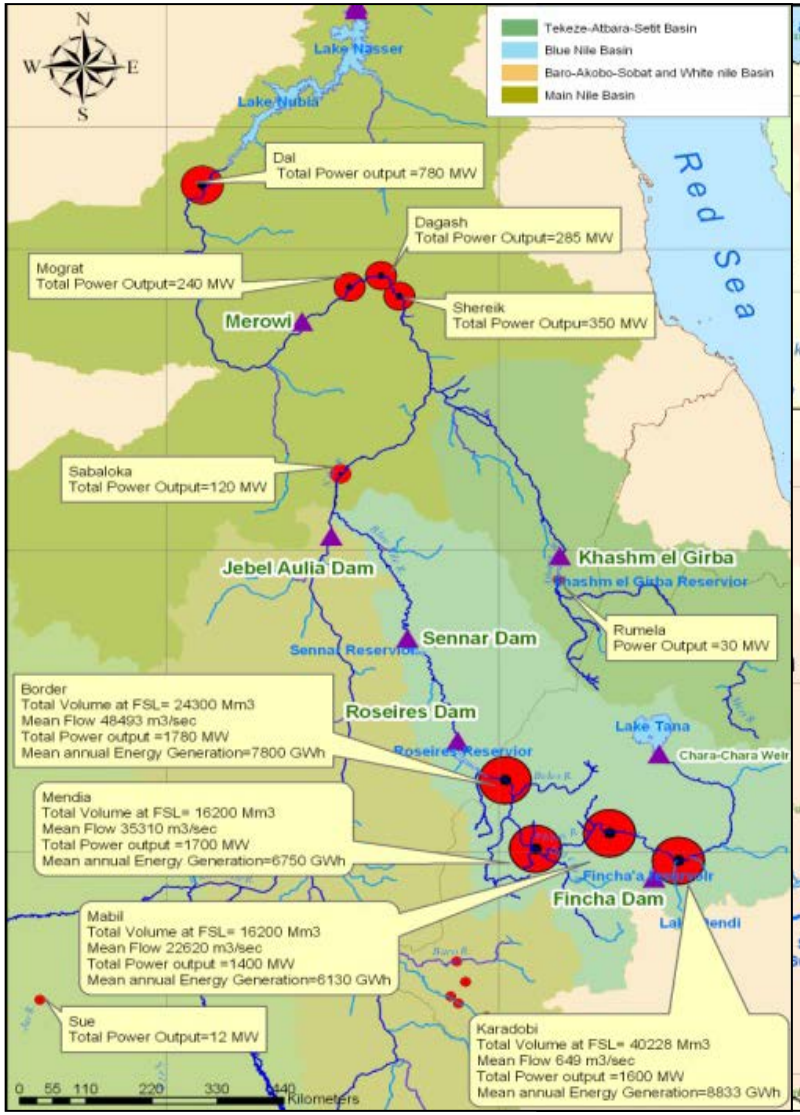
Transboundary Benefit Sharing:

- A common management of water resources generates net benefits compared to the unilateral development of the water resources.
- The concept is about the cooperation of riparian states for the use, protection, or joint development of shared water bodies (transboundary rivers, lakes and aquifers), whereby the riparian states focus on the benefits from water cooperation and the win-win options instead of a potentially conflicting water sharing
- Non-cooperation = economic losses

Future high voltage transmission lines?!



Opportunities



Hydropower

Protected Areas and Parks

Irrigation

Current Cooperation in the Nile Basin

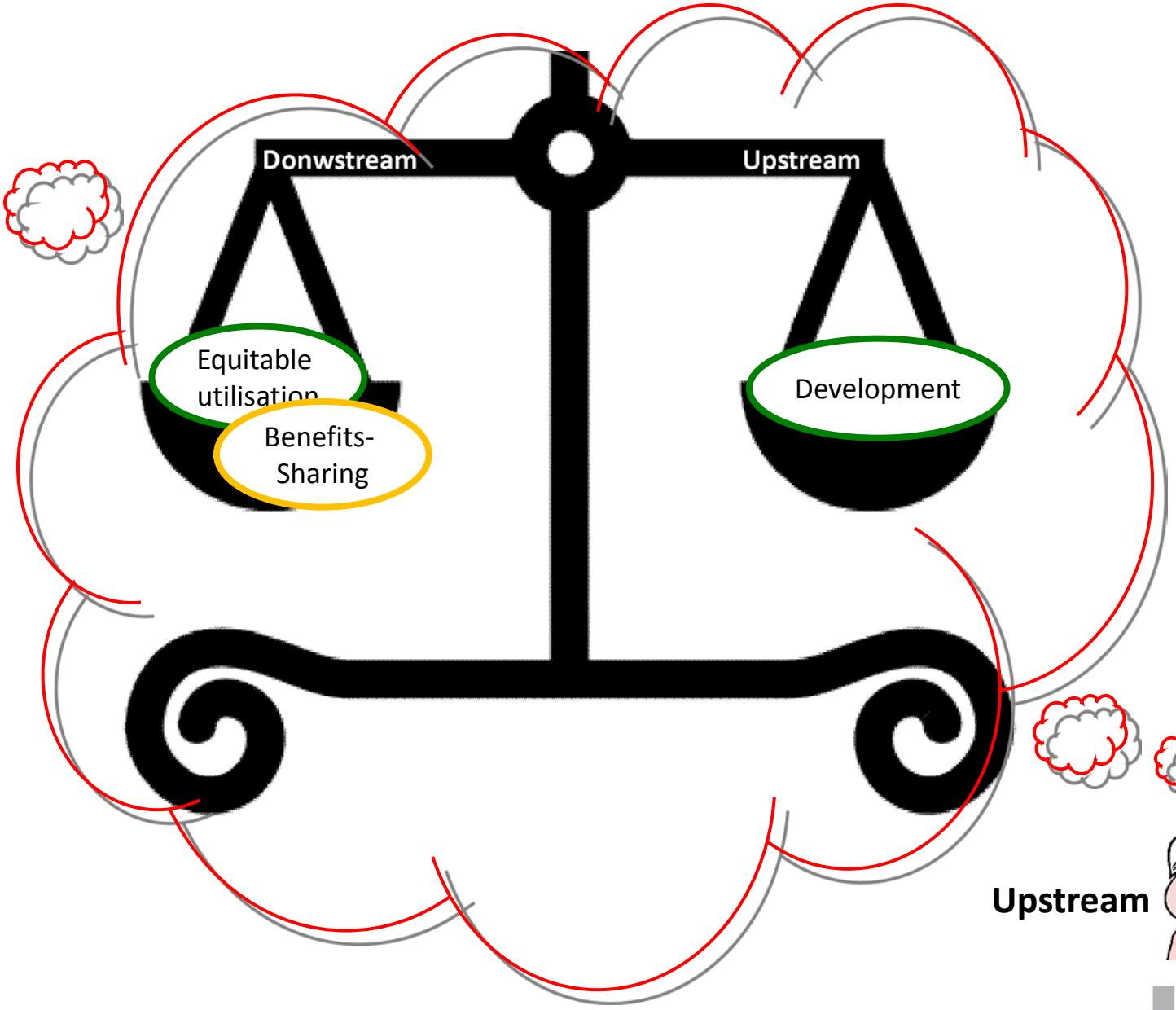
1990
TECCONILE, CIDA
↓
Nile-COM
↓
Nile-TAC
↓
Nile-SEC
↓

↓
NB Commission?

- Established in 1999 to promote **cooperation** between all the Nile riparians (transitional)
- Goal: "Achieve sustainable socioeconomic development through the **equitable utilisation** of, and benefit from, the common Nile Basin water resources"
- *Modus operandi*: create **enabling environment** for the implementation of cooperative projects
- Strong support by international donors
- "NBI is a transitional arrangement until a permanent framework will be in place"

Towards Cooperation

Downstream



Upstream

Please visit us! in Cologne or at: water-energy-food-nexus.info/ ☺

Firefox | Nexus | www.water-energy-food-nexus.info

Nexus
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The Water, Energy and Food Security Nexus

Research Focus of the Cologne University of Applied Sciences

Search ...

ABOUT THE RESEARCH FOCUS

The Nexus Research Focus aims at promoting scientific cooperation and developing joint projects and activities of participating institutes and faculities. The Nexus project is

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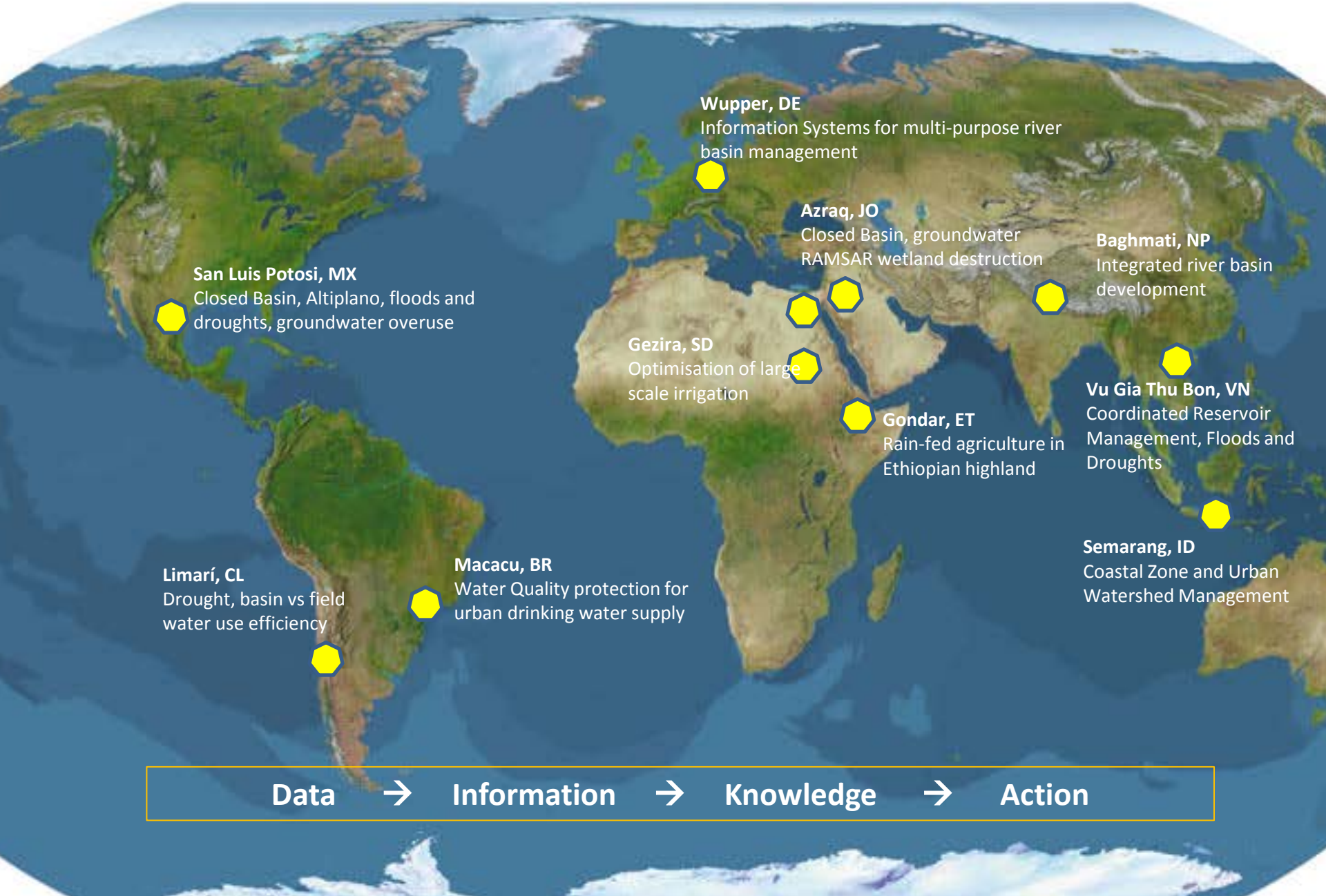
Basin Case Studies developed together with partners of ITT

Learning from real life problems – Natural Labs



Thank you for your attention !

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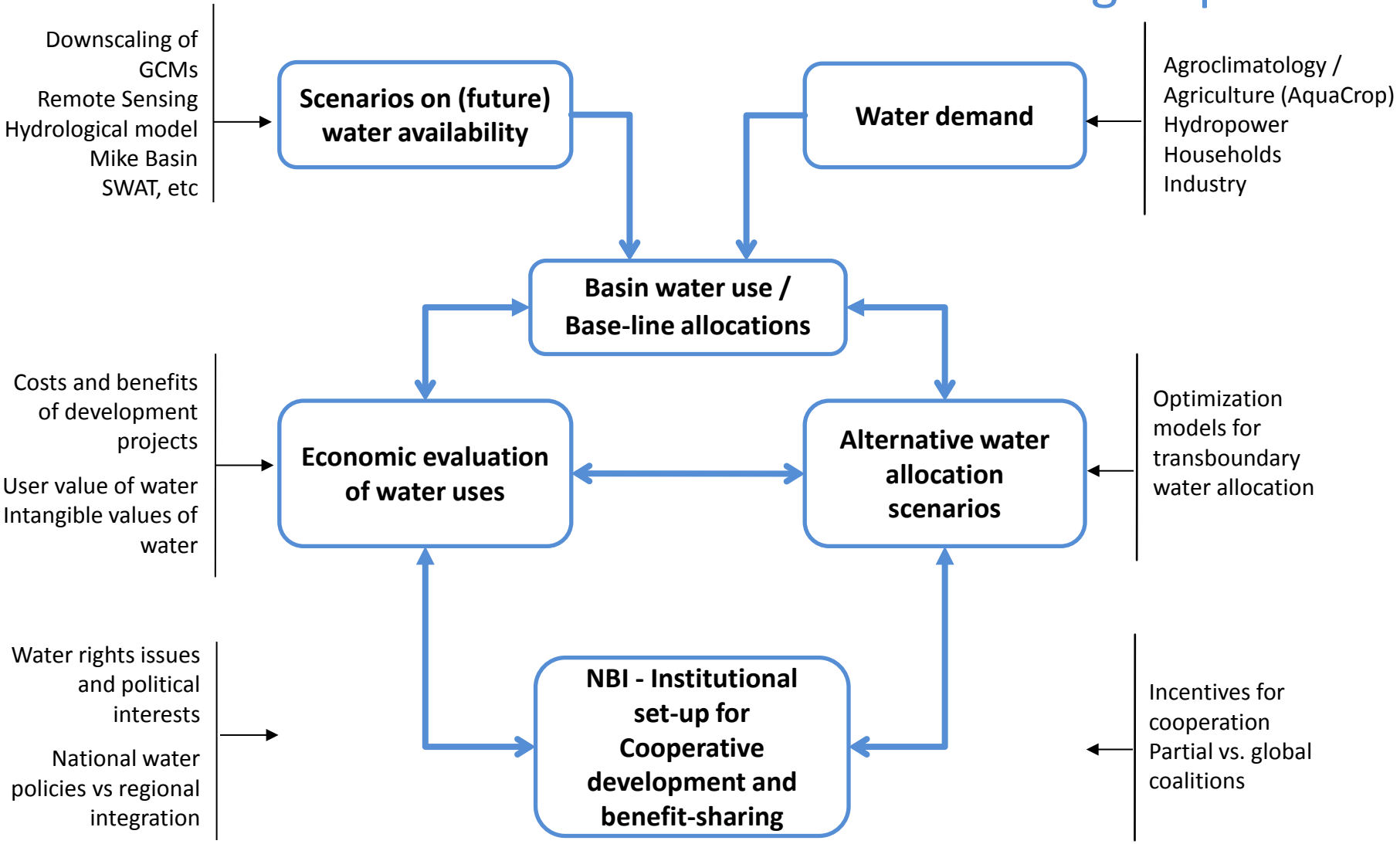
Director of ITT, Cologne University of Applied Sciences

Additional Information

Research Overview of the Nile Basin Research group at ITT



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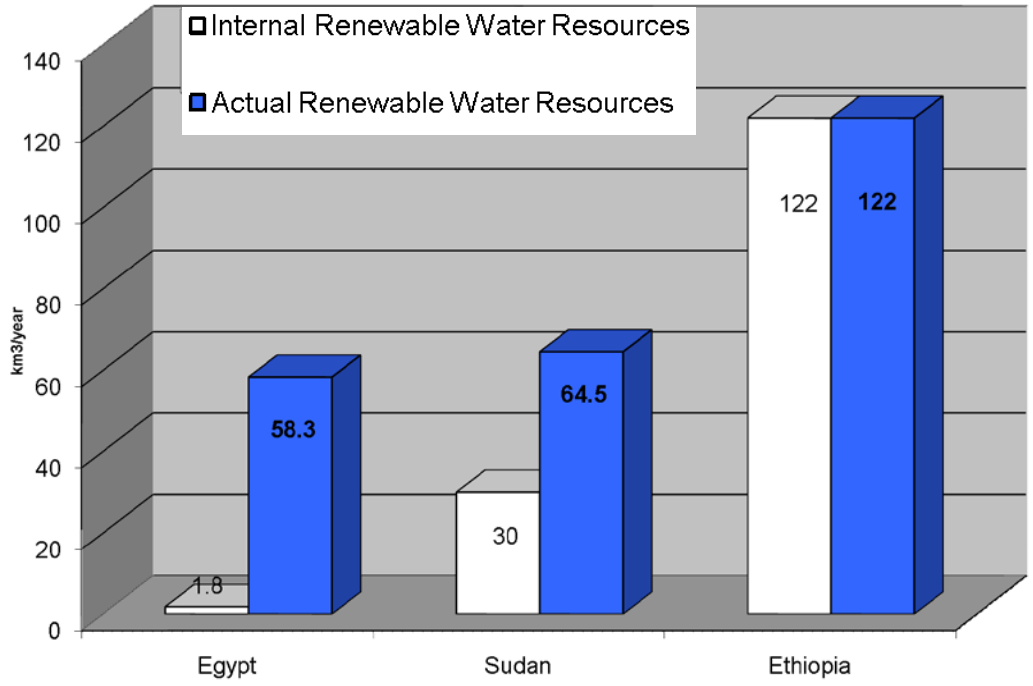
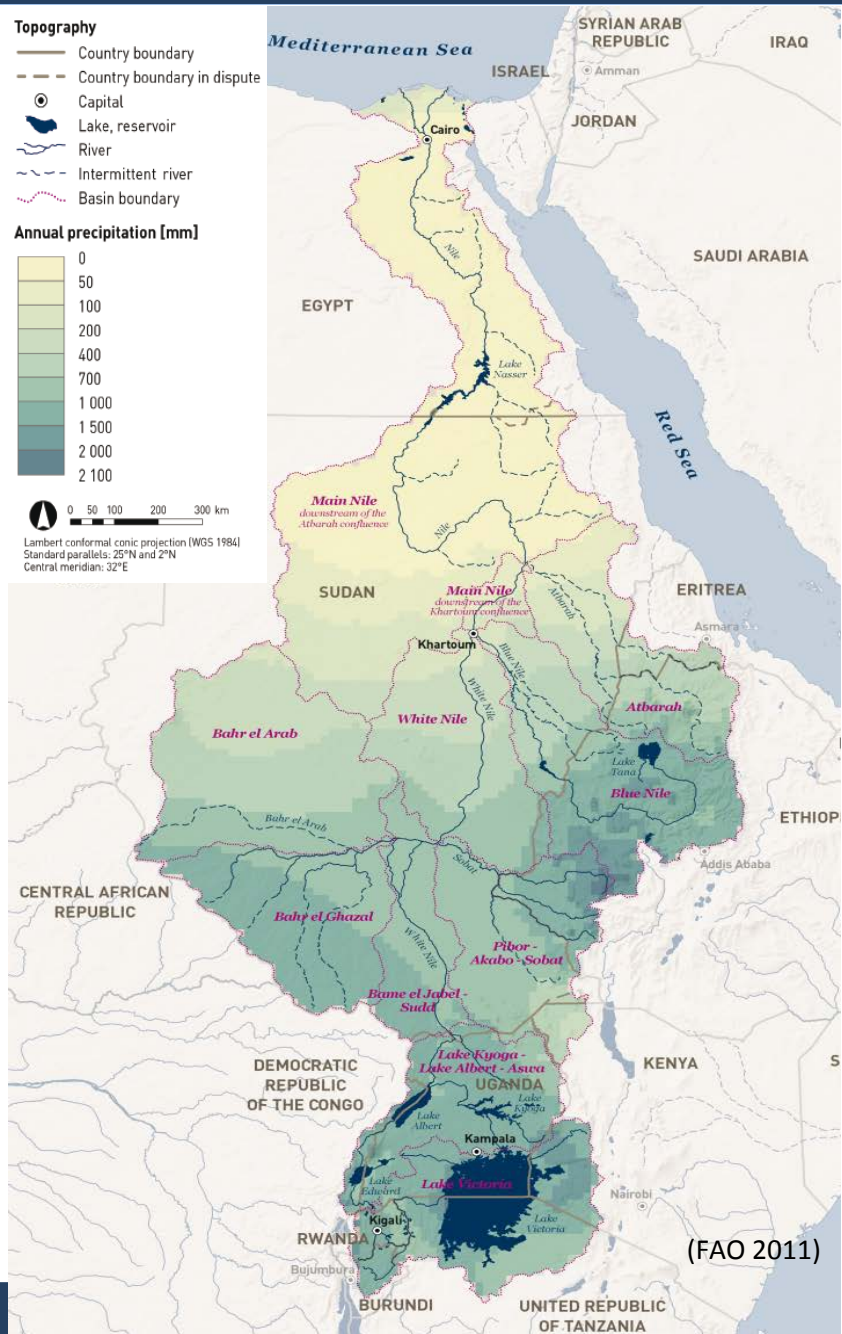
Water Resources



(World Resources Institute, 2003)



(FAO 2011)

Existing Dams in the Eastern Nile Basin

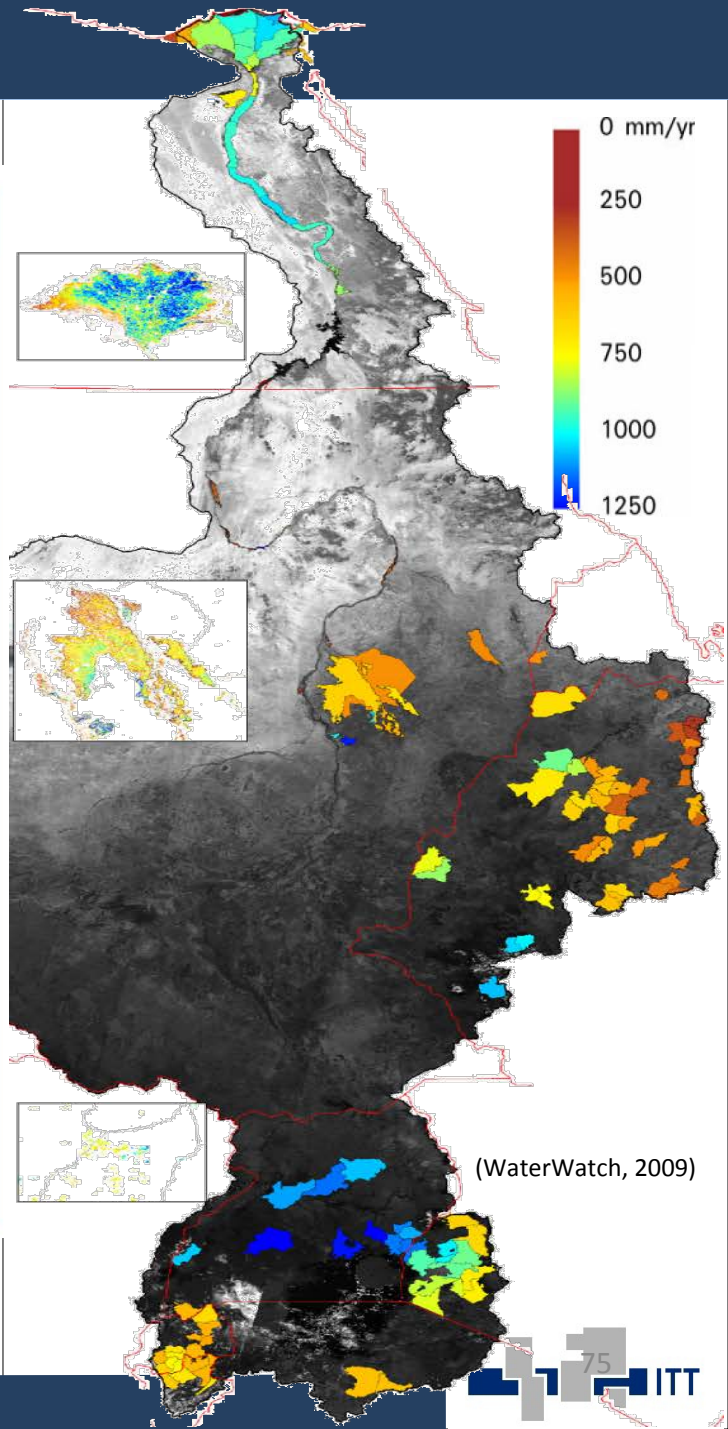
FAO-Nile Basin Project (2004-2009)

Dam name	Country	Crest Height (m)	Reservoir Capacity (km3)	Purpose	Power Generation (MW)	Operational Since
Esna barrage	Egypt	16	NA	Irrigation/Flood control/Hydropower	85.68	1970
High Aswan Dam	Egypt	111	162	Irrigation/Flood control/Hydropower	2100	1970
Old Aswan Dam	Egypt	53	5	Irrigation/Hydropower	592	1930
Tana Beles	Ethiopia	Run of river	-	Hydropower	460	2010
Tekezze	Ethiopia	185	3	Hydropower	300	2009
Tis Abay I+II	Ethiopia	Run of river	3.5	Hydropower	84.4	1953/2001
Jabel Aulia	Sudan	22	3.5	Irrigation/Hydropower	30	1937
Khashm El Gibra	Sudan	35	1.3	Irrigation/Hydropower	10	1964
Merowe	Sudan	67	12.5	Irrigation/Hydropower	1250	2009
Roseires	Sudan	60	3	Irrigation/Hydropower	280	1966
Sennar	Sudan	48	0.93	Irrigation/Hydropower		1925

Irrigation and Food Security

Farming areas in the Nile basin countries

Country	Area (ha)	Area (% of total)	Population (1000)	Population density (inhab/km2)	Population (% of total)	Cropland (ha)	Cropland (% of total)	Cropland (% of area)	Cropland per inhabitant (ha/pers.)
Burundi	1 317 330	0	3 646	277	2	620 593	2	47	0.17
Congo	2 002 430	1	1 843	92	1	421 966	1	21	0.23
Egypt	29 860 540	9	64 925	217	40	3 132 713	9	10	0.05
Eritrea	2 455 572	1	917	37	1	542 466	2	22	0.59
Ethiopia	36 247 347	12	23 575	65	14	7 048 279	20	19	0.30
Kenya	6 983 005	2	11 920	171	7	1 321 842	4	19	0.11
Rwanda	2 057 680	1	6 200	301	4	916 229	3	45	0.15
Sudan	197 741 261	63	21 957	11	13	14 251 596	40	7	0.65
Tanzania	11 959 925	4	6 760	57	4	1 457 554	4	12	0.22
Uganda	23 721 630	8	22 211	94	14	6 257 572	17	26	0.28
Total	314 346 720	100	163 954	52	100	35 970 810	100	11	0.22



(WaterWatch, 2009)