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Climate Change Scenarios of Rain and Flow and their Projection on Water Resources

Prof. Karima Attia

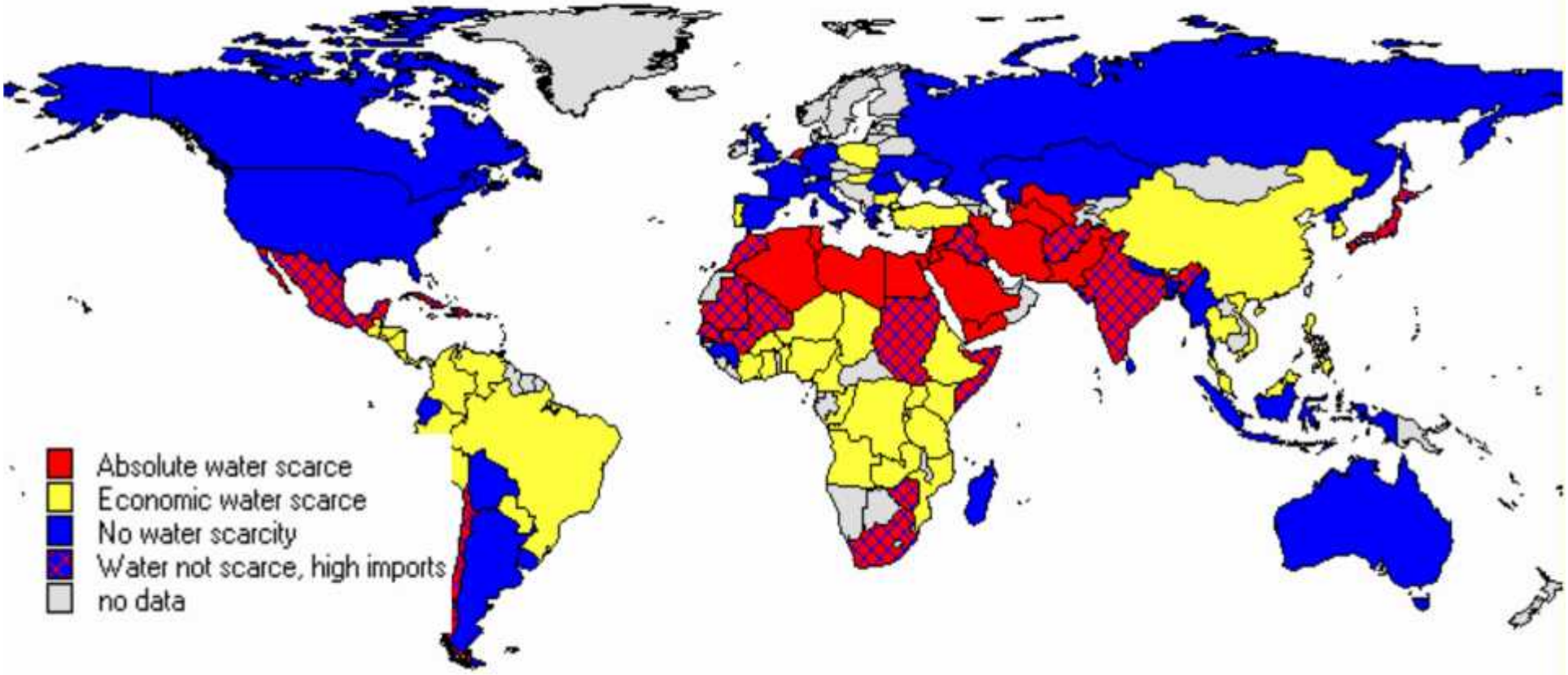
Director of Water Resources Research Institute

International Conference on Mitigating the Impact of Natural Risks in Africa Lessons from 1992 Cairo Earthquake
NRIAG - African Union- African Seismological Commission – UNESCO, 23-26 October 2017

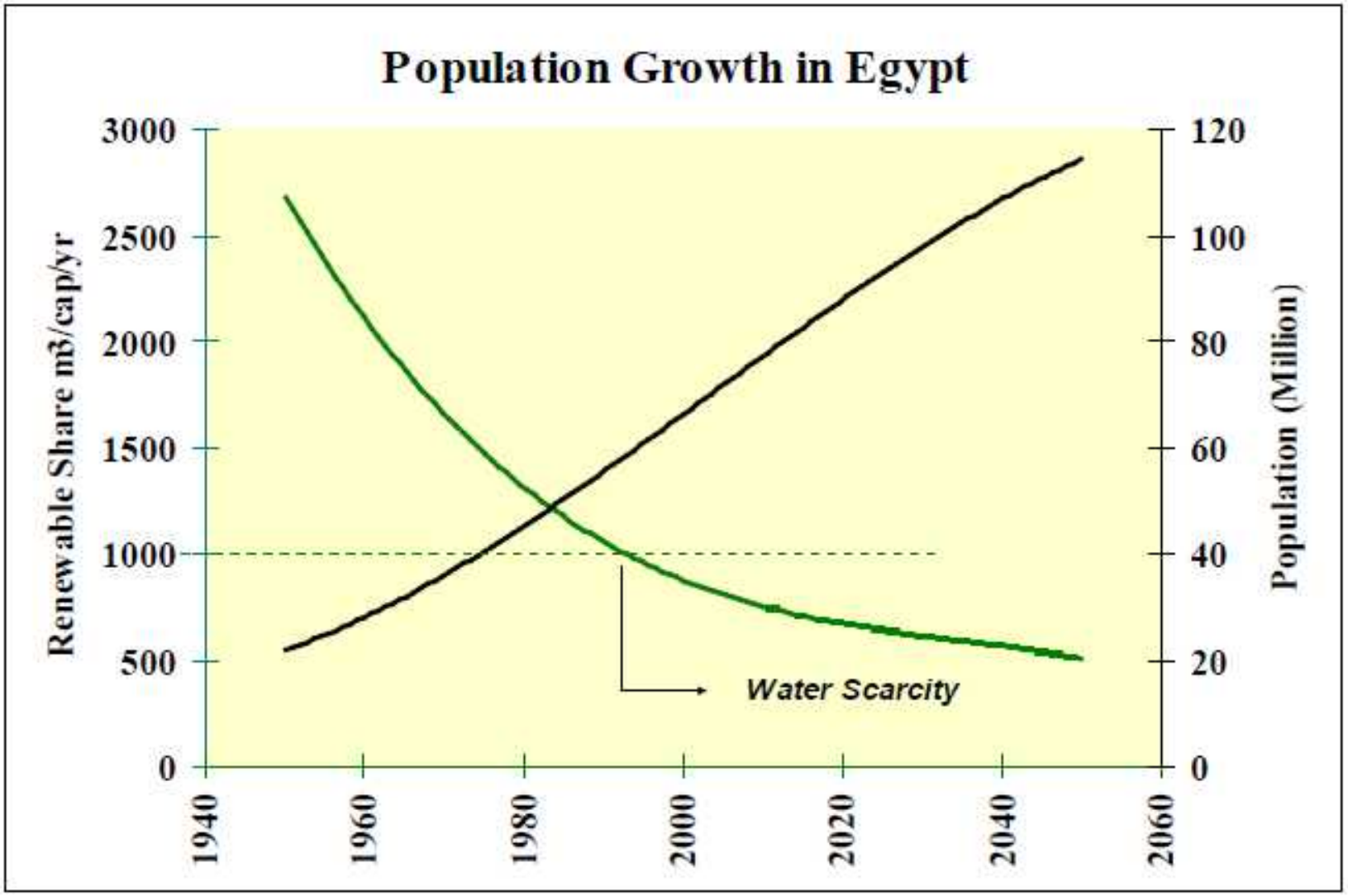
Content

- Water Resources in Egypt
- Challenges in Water Sector
- The Impact of Climate Change on Rainfall
- The Impact of Climate Change on the Nile Flow
- Climate Change Projection on Water Sector
- Conclusion & Recommendation

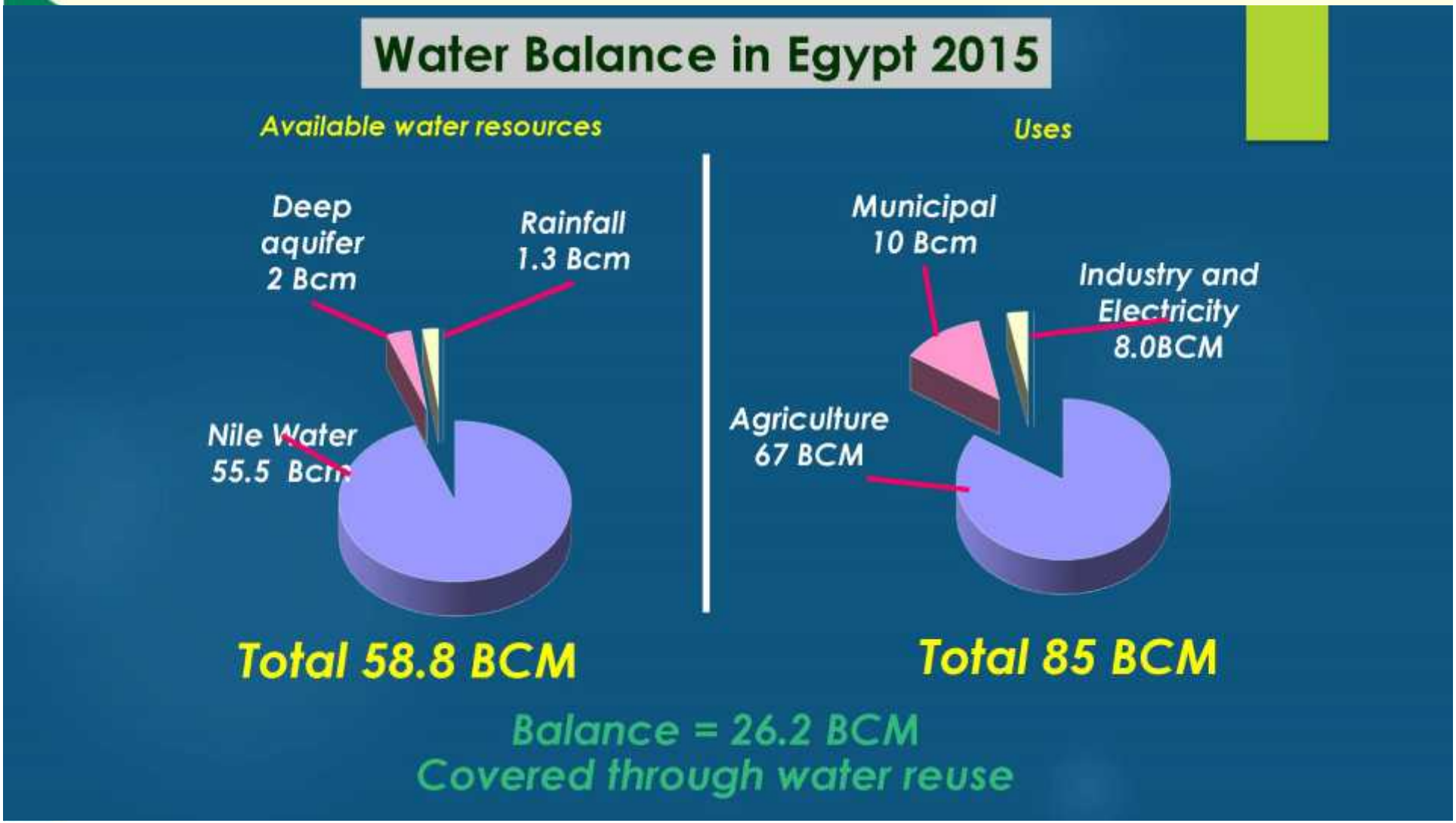
Water situation of countries up to 2025



Water scarcity in Egypt



Water Balance, available and demand

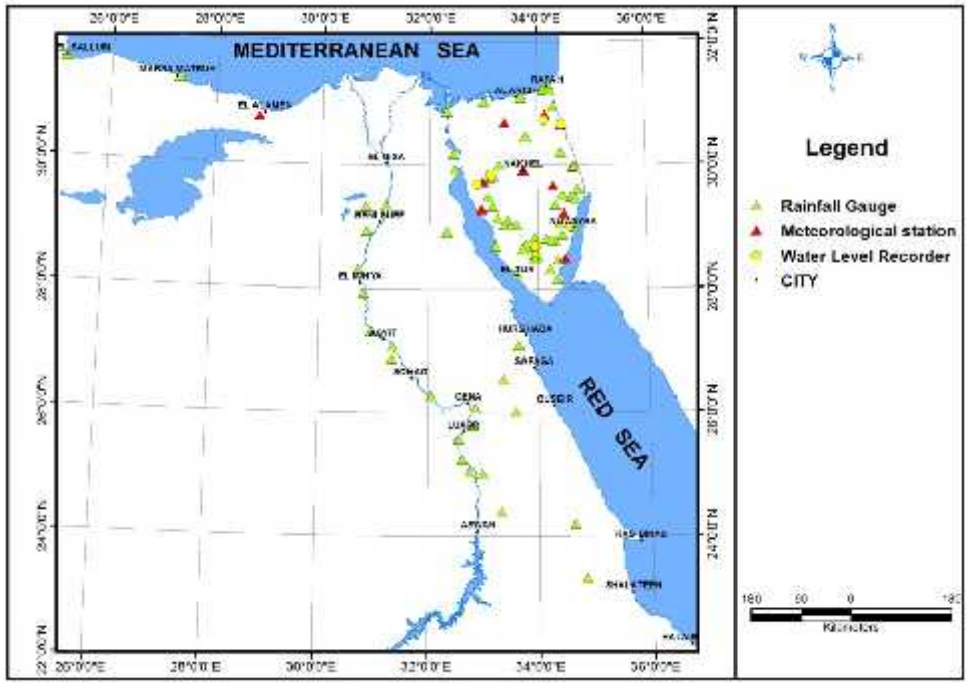


Challenges in Water Sector

1. Growing population and the related increased water demand
2. Expected Nile flow reduction
3. Expected impacts of climate change on the Nile flows and the different demands of the water sector
4. Water quality in the canals' network
5. The institutional setting of water management
6. Sea level rise that is threatening the coastal zones and the Nile delta in particular

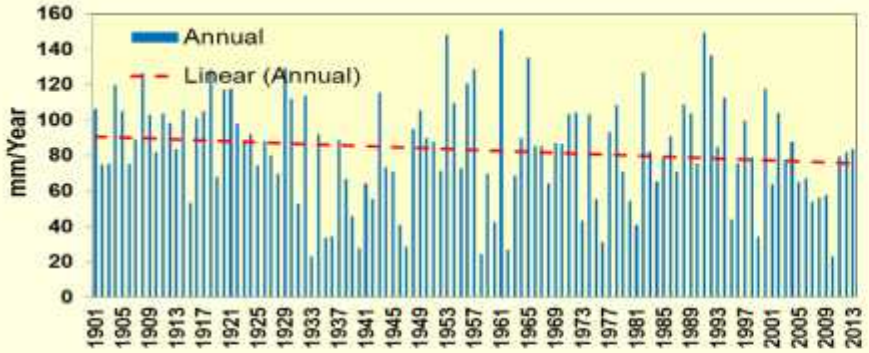
The Impact of Climate Change on Rainfall

- The rain gauge stations record length is too short
- There is a need to use reference data (Reanalysis, statistical or estimated data from satellite images)
- Three reference data are evaluated during the period (2004-2014) comparing with available observed data for the same period:
  - Climate Research Unit Data (CRU)
  - Global Precipitation Climate Center Data (GPCC)
  - European Centre for Medium-Range Weather Forecasts (ECMWF) interim reanalysis (ERA-Interim)

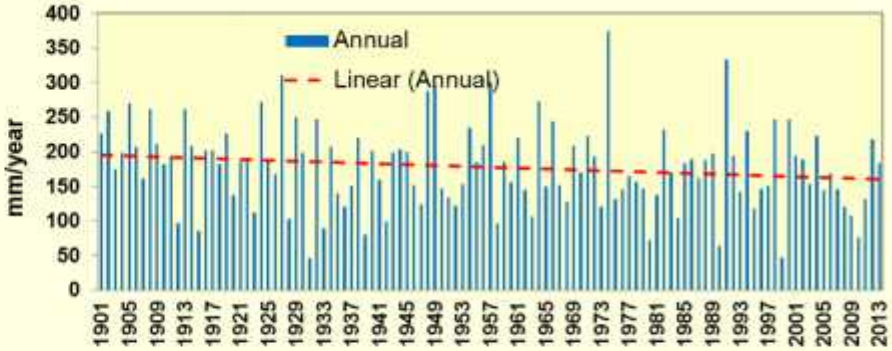


Stations	RMSE (mm)	R^2	MAE (mm)
El_Tour	0.70	0.90	0.25
Abo_erdies	0.99	0.82	0.33
Sueiz	1.06	0.74	0.52
Gardaqa	0.95	0.70	0.23
El_Qusser	0.69	0.75	0.16
Dahab	1.64	0.40	0.47

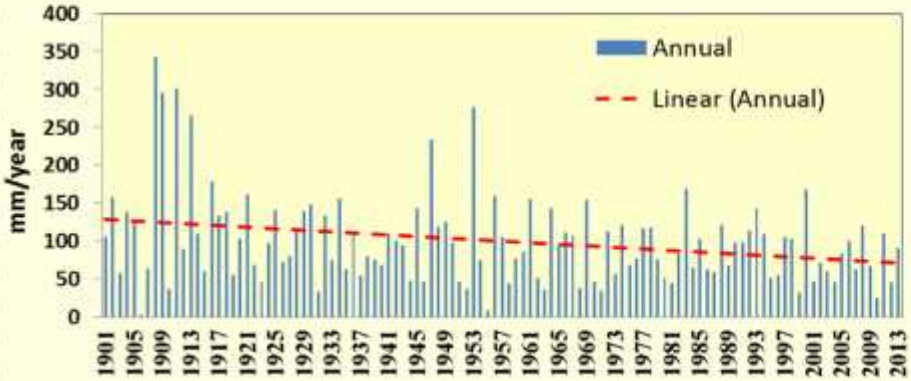
The Impact of Climate Change on Rainfall (In Historical Records)



Damietta (Delta North Coast)



Alexandria (North Coast)

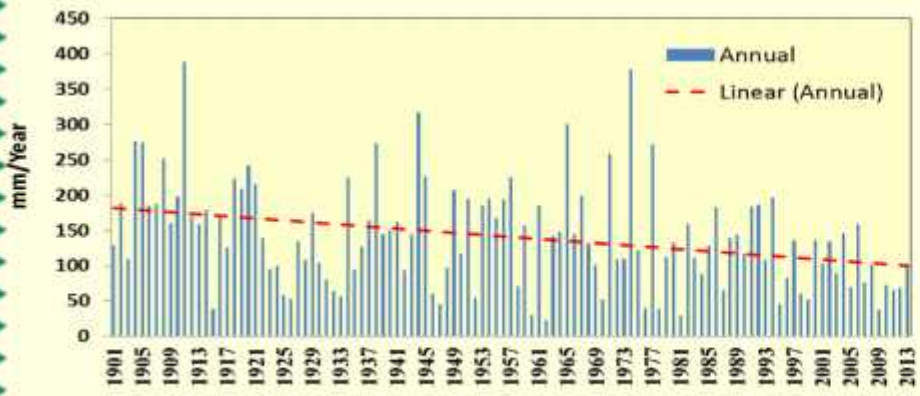


Salloum (West North Coast)

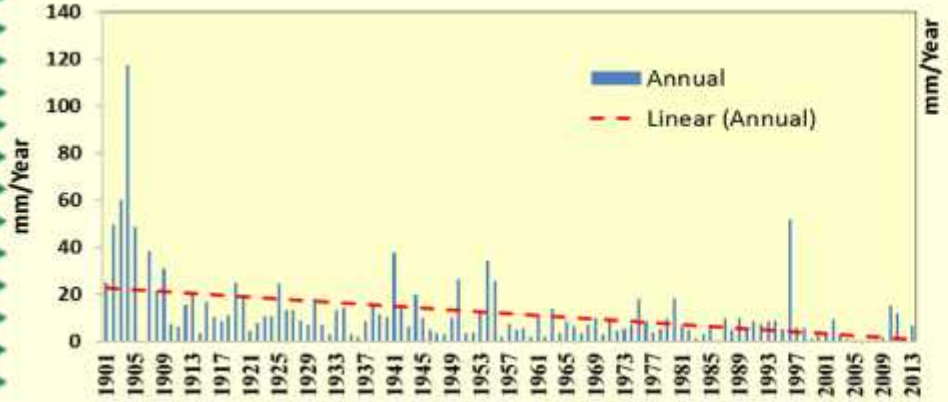
Data Source: GPCC (https://www.esrl.noaa.gov/psd/data/gridded/data.gpcc.html)

Water Resources Research Institute (WRRI). 2017

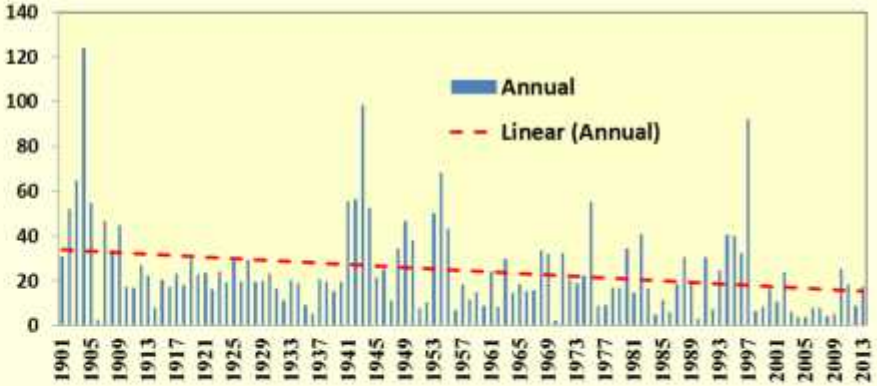
The Impact of Climate Change on Rainfall (In Historical Records)



Al Arish (North Sinai)



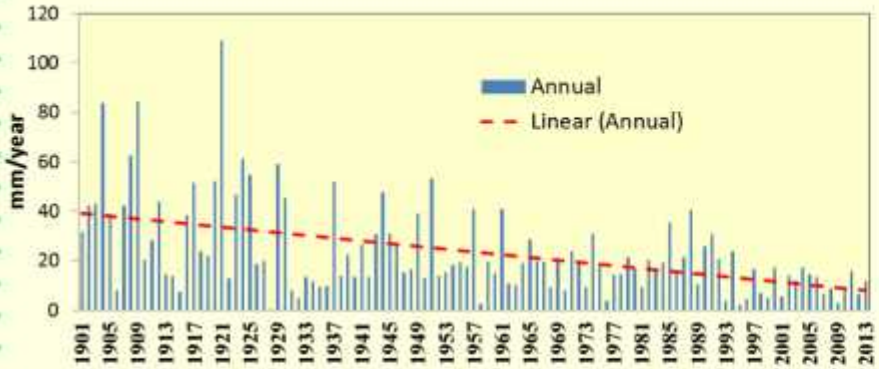
Sharm ElShaik (South Sinai)



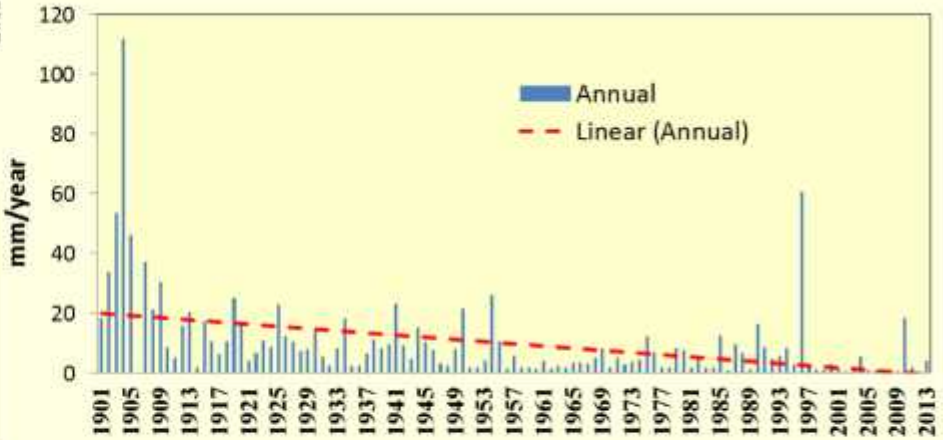
Sant. Katrina (Middle Sinai)

Data Source: GPCC (https://www.esrl.noaa.gov/psd/data/gridded/data.gpcc.html)

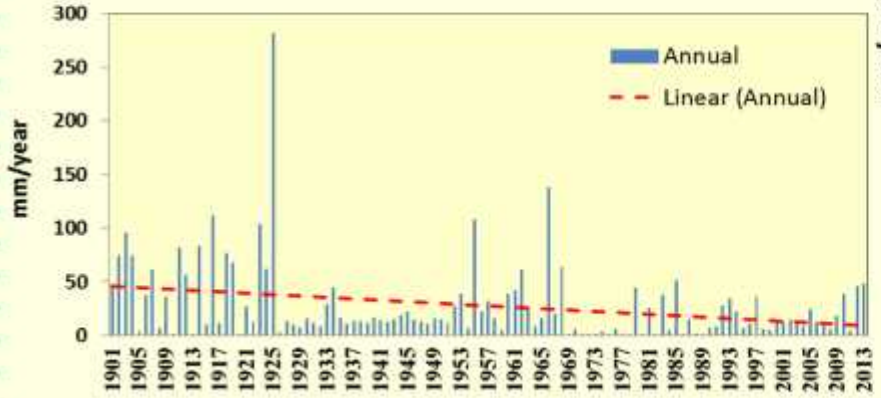
The Impact of Climate Change on Rainfall (In Historical Records)



Elsuez (North Red Sea)



Hurgada (Red Sea)



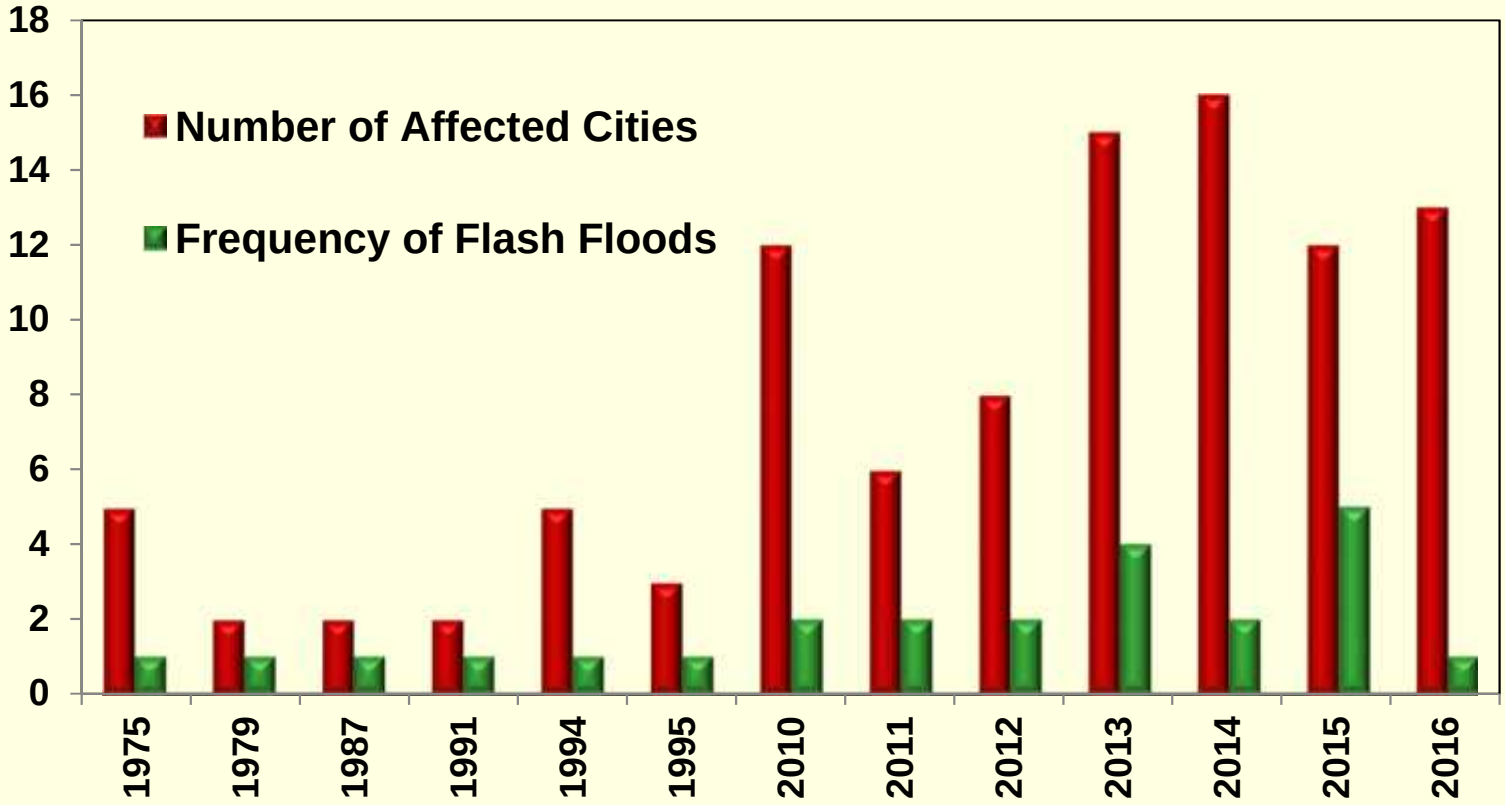
Shalateen (South Red Sea)

Data Source: GPCC (https://www.esrl.noaa.gov/psd/data/gridded/data.gpcc.html)

Water Resources Research Institute (WRRI). 2017

The Impact of Climate Change on Rainfall

Frequent of the Storms



Cases of damages

Alexandria. 2015

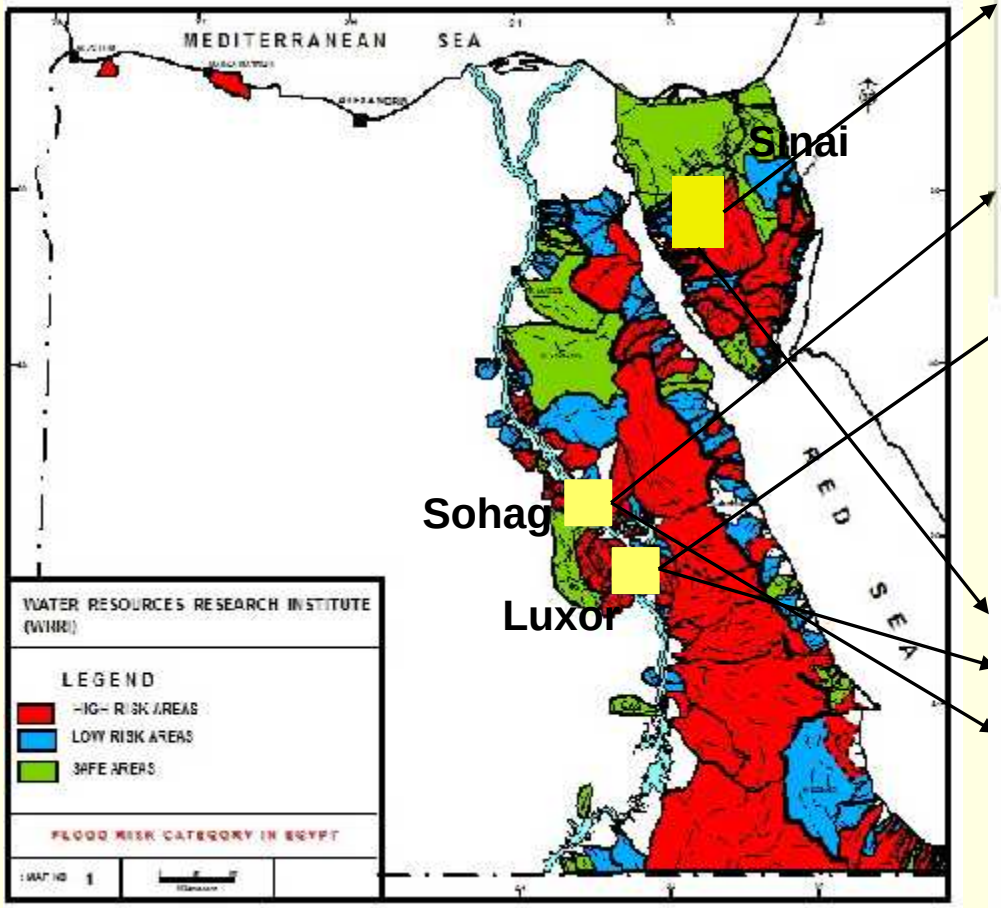
Taba. 2014

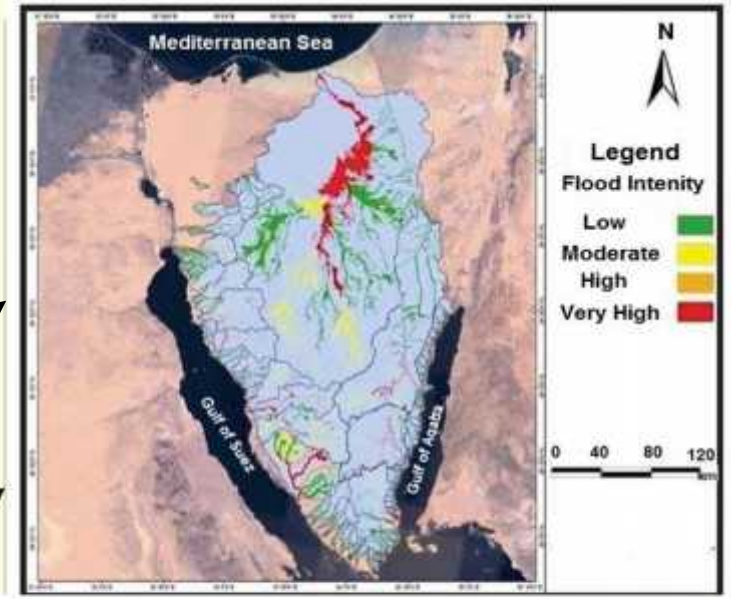
Al - Arish. 2010

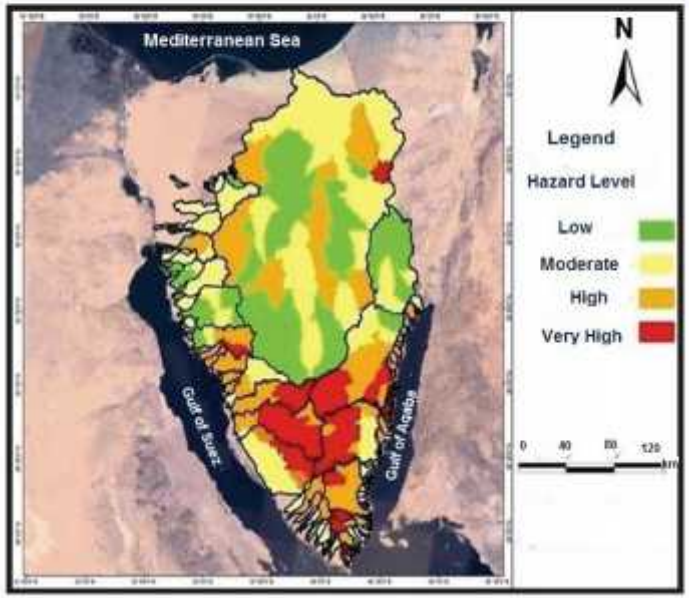
RasGhareb. 2016

Extreme Events due to Climate change

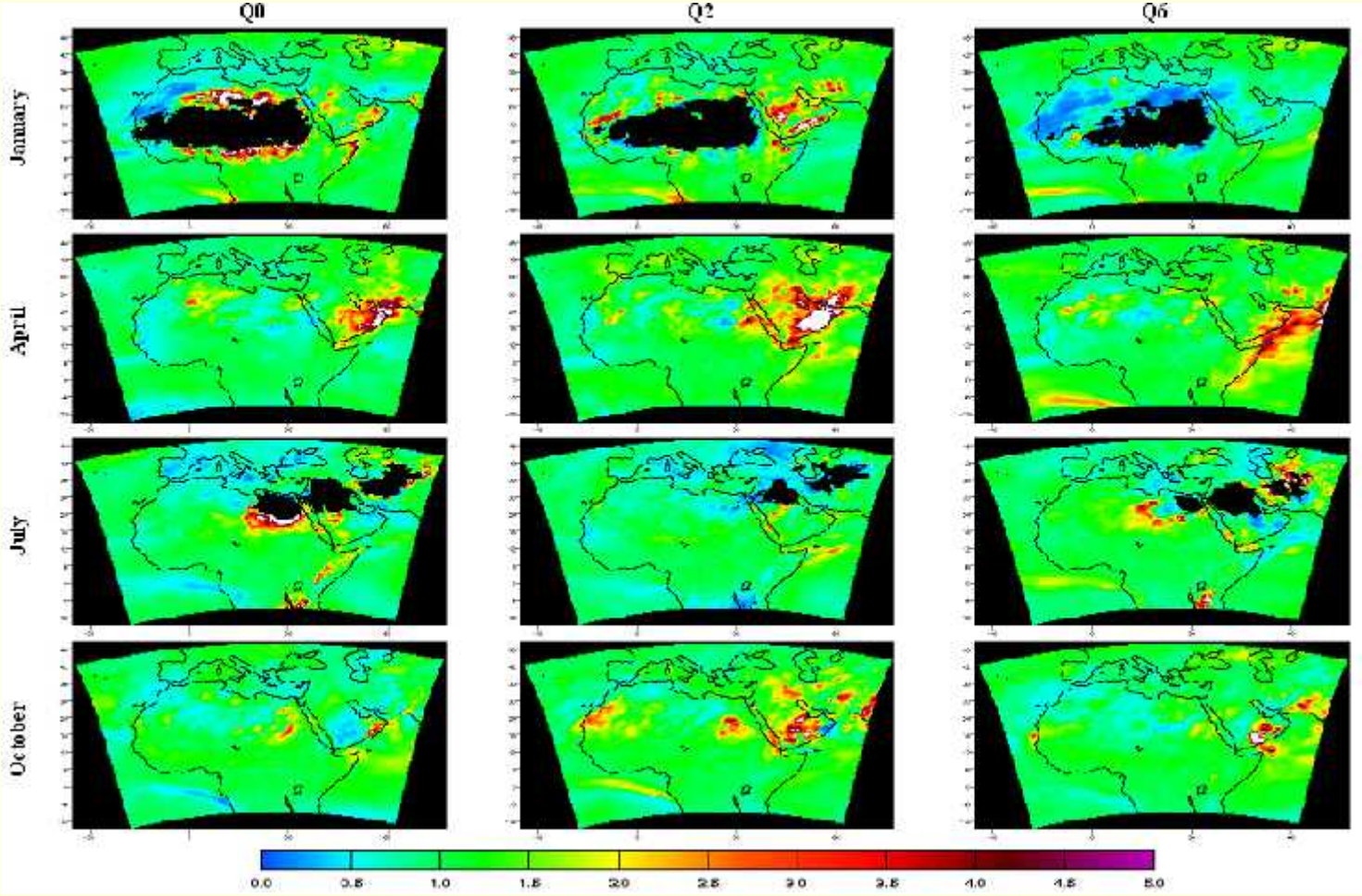
Areas vulnerable to flash floods in Egypt







The Impact of Climate Change on Rainfall (Future Projection)

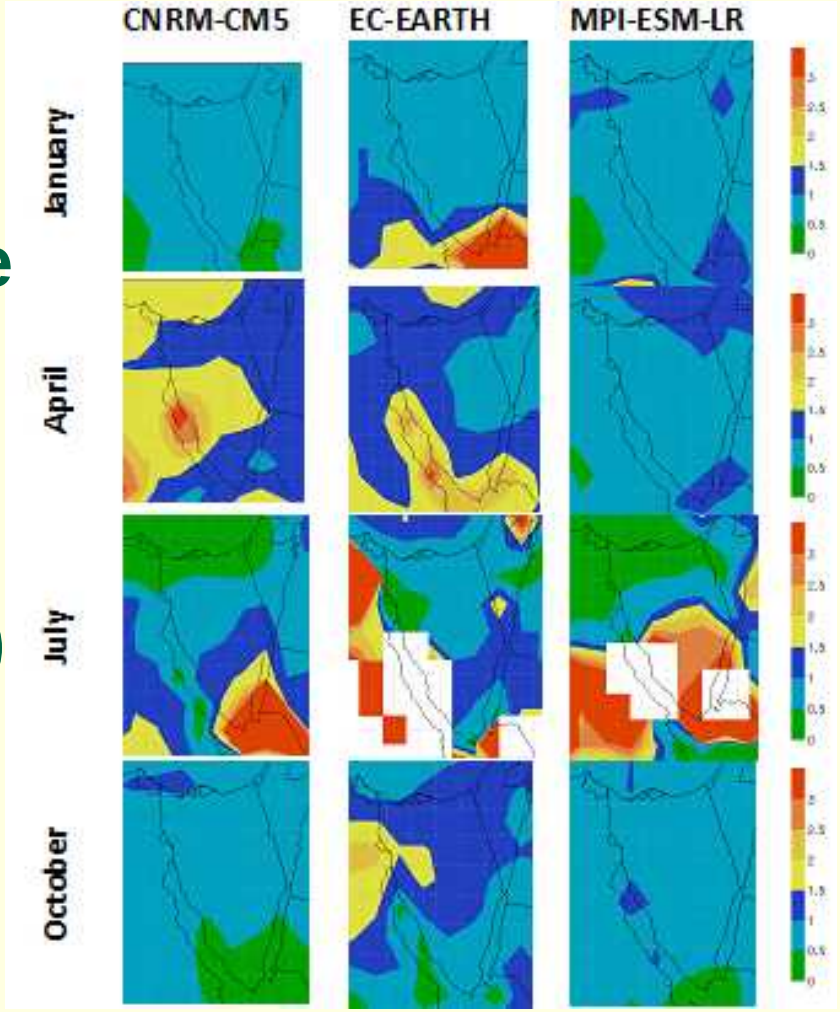


Delta Change Factors for Precipitation (Ratios) for Selected Scenarios and Months

(DCF is not calculated for Black Areas, White Areas are off Scale), MWRI, 2012.

The Impact of Climate Change on Rainfall (Future Projection)

- The DCFs for the CORDEX output for three GCMs
- One emission scenario RCP4.5
- For base line (1971-2000)
- The future period (2041-2070)

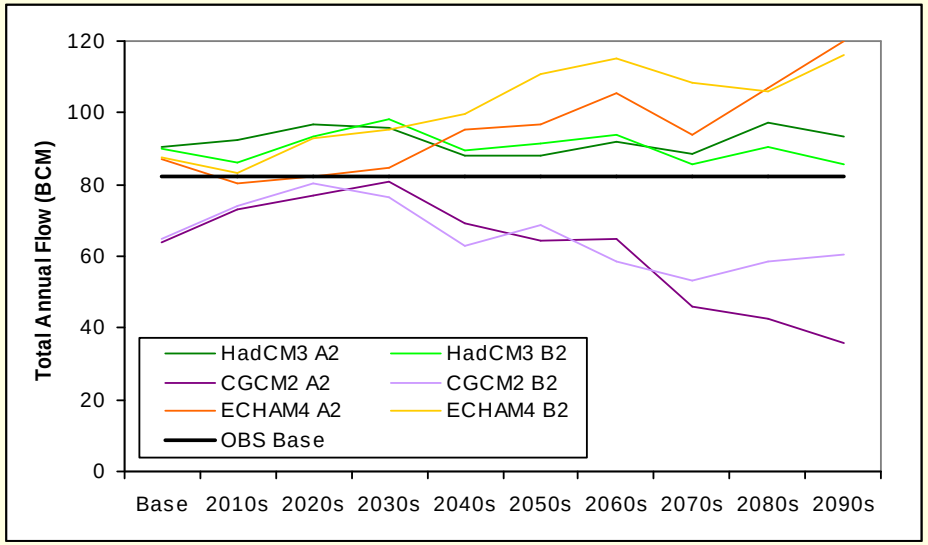


Water Resources Research Institute (WRRI). 2017

The Impact of Climate Change on the Nile Flow Using (SRES), Statistical D.S.

Lake Nasser Flood & Drought Control Project (2008)

- 6 Transient scenarios (3 GCMs x 2 Emission Scenarios)
- Statistically downscaled using a spatio-temporal weather generator
- Changes at Dongola from 2010-2100

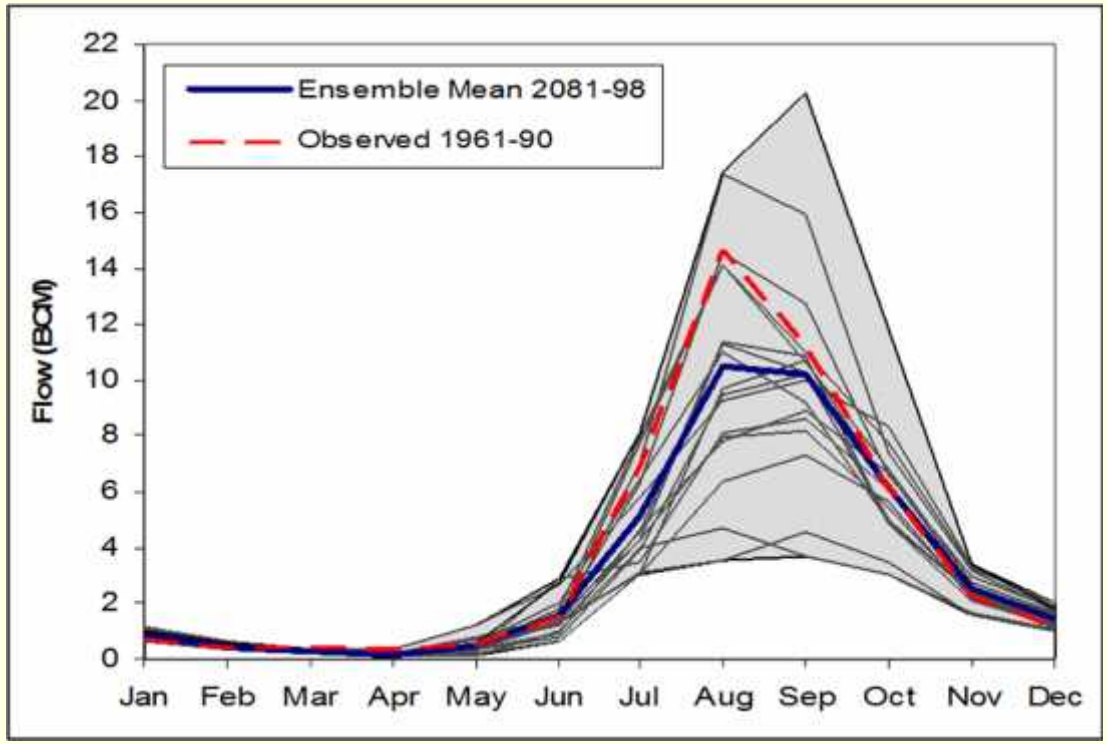


Ministry of Water Resources and Irrigation (MWRI). 2008

The Impact of Climate Change on the Nile Flow Using (SRES), Statistical D.S.

Elshamy et al. (2009)

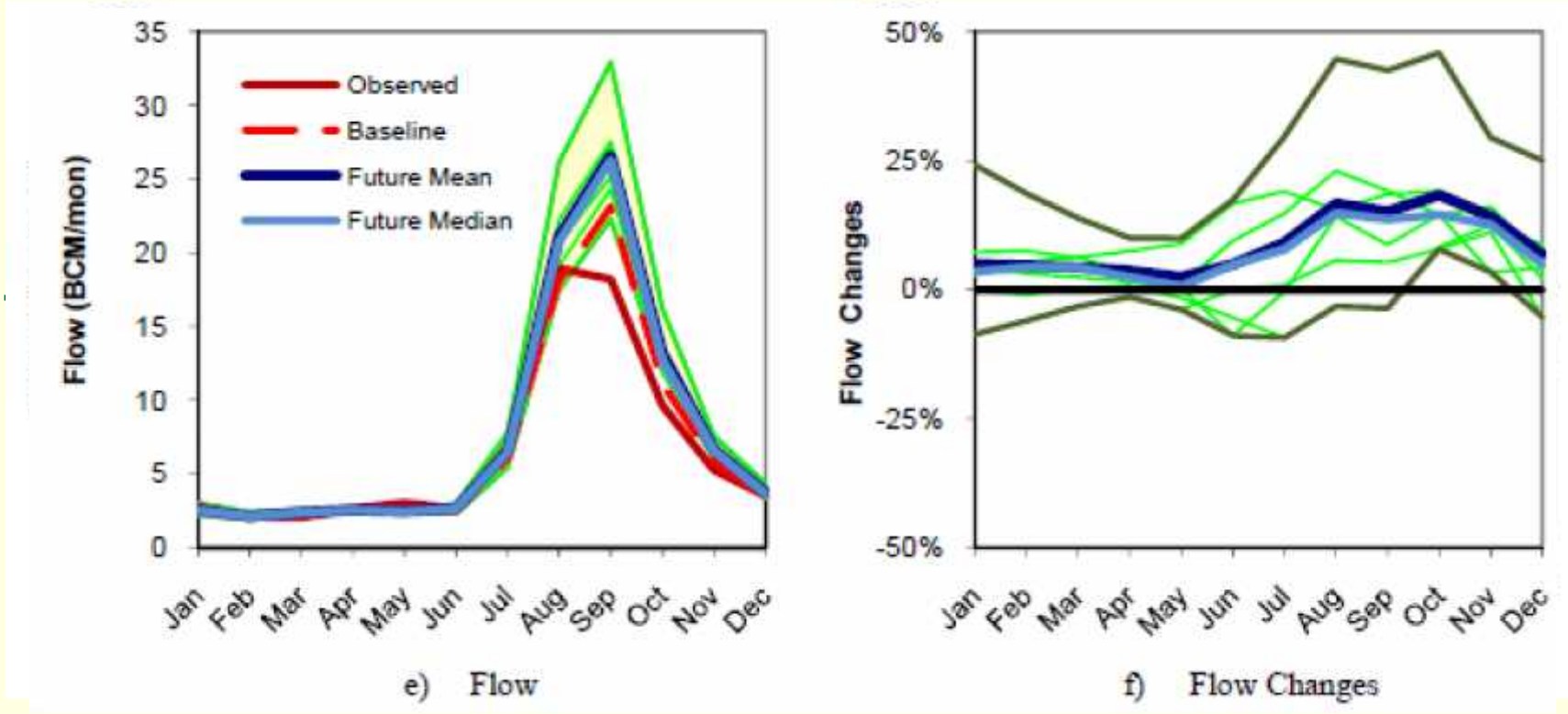
- **17 GCMs x A1B scenario**
- **Statistically downscaled using Bias Correction Method**
- **Blue Nile Flow Changes: -60% to +45%**



Elshamy et al, 2009b

The Impact of Climate Change on the Nile Flow Using (SRES), Dynamical D.S.

Climate change Risk Management Project (CCRMP), 2012



Dongala Station at the Main Nile

Ministry of Water Resources and Irrigation (MWRI). 2012

The Impact of Climate Change on the Nile Flow Using (SRES), Dynamical D.S.

Climate change Risk Management Project (CCRMP), 2012

Sub-basin (outlet)	Rainfall Changes (%)		PET Changes (%)		Flow Changes (%)	
	Range	Mean	Range	Mean	Range	Mean
L. Victoria (Jinja)	-5.2 – -0.6	-2.5	+3.5 - +8.2	+5.6	-24.9 – -6.8	-18.0
White Nile (Malakal)	-3.5 – +3.8	+1.0	+0.8 – +5.9	+3.7	-11.7 – +9.6	-2.5
Upper Blue Nile (Diem)	+2.5 – +8.0	+5.5	+0.3 – +5.3	+2.5	-5.7 – +29.0	+9.2
Blue Nile (Khartoum)	+4.3 – +9.8	+6.8	-0.4 – +4.9	+2.2	-5.6 – +39.2	+13.2
Atbara (mouth)	+3.5 – +21.2	+13.9	-1.7 – +3.3	+1.9	+2.3 – +83.3	+38.3
Main Nile (Dongola)	**-0.9 – +6.1**	**+0.9**	**+0.3 – +5.1**	**+2.9**	**-0.5 – +36.2**	**+13.1**

Ministry of Water Resources and Irrigation (MWRI). 2012

The Impact of Climate Change on the Nile Flow Using (RCPs)

Keith et al. (2014)

- 33 GCMs X 2 emission Scenarios (RCP4.5, RCP8.5)
- The study was applied on the Upper Blue Nile for two future periods (2010-2039), (2040-2069), (2070-2099)
- The results conclude to:
    1. Increasing in flow in Ethiopia
    2. Stability flow in Sudan
    3. Decreasing flow in Egypt

The Impact of Climate Change on the Nile Flow Using (RCPs)

Ayele, et al., 2016

Time Windows	Scenarios (RCPs)	Dry-Season				Wet-Season			
		P		ET		P		ET	
		(+), 2	(−), 5	(+), 2	(−), 5	(+), 6	(−), 1	(+), 7	(−), 0
2021–2040	RCP 8.5	10%	13%	9%	17%	10%	10%	12%	0
	RCP 4.5	7%	9%	6%	13%	7%	7%	9%	0
2081–2100	RCP 8.5	20%	15%	17%	20%	15%	13%	16%	0
	RCP 4.5	14%	10%	10%	13%	10%	9%	11%	0

Notes: P stands for precipitation and ET stands for Evapotranspiration; (+) and (−) shows sign of increment and decrement; and the adjacent number shows the number of GCMs shown projected increment or decrement change with respect to the baseline.

Climate Change Projection on Water Sector (supply & demand)

Projections for Nile Water Availability, Population and in Evapo-Transpiration

Year		2010	2015	2025	2050	2075	2100
Reduced Flows due to Upstream abstraction	(Billion m3)	0.0	-3.0	-5.0	-8.0	-10.5	-13.0
Estimated Population in Egypt	(million)	80	86	104	146	191	237
% Decrease of Nile Flows at Aswan due to climate change		-	-	-6 %	-15 %	-20%	-31 %
% Increase of Nile Flows at Aswan due to climate change		-	-	10 %	21%	24%	27 %
% Change in Evapo-Transpiration			1.1%	2%	4.5%	8 %	12%

Projected Averaged direct & indirect impacts of climate change on water demands

year		2010	2025	2050	2075	2100
Population	(million)	79	104	146	191	237
Mean air Temperature increase	(°C)		1.0	1.7	2.5	3.5
ETo and Irrigation Water Requirements	%	--	2%	4.5%	8 %	12%
Municipal Water	(million m3/yr)	9.0	9.6	12.55	14.75	17.2
Industrial Water	(million m3/yr)	2.0	2.20	3.4	4.0	4.9

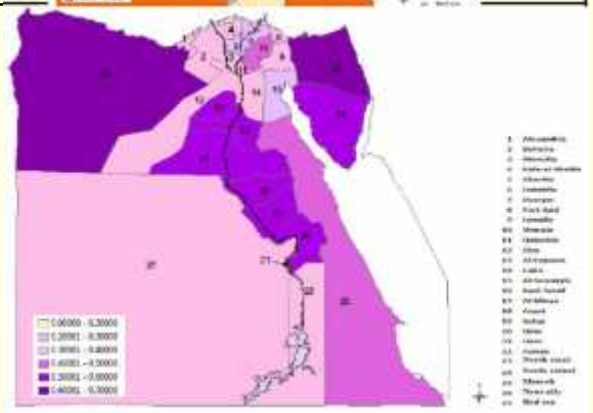
Proposed CLIMATE CHANGE ADAPTATION STRATEGY for the Ministry of Water Resources & Irrigation EGYPT

Nour El-Din, 2013

International Conference on Mitigating the Impact of Natural Risks in Africa Lessons from 1992 Cairo Earthquake

NRIAG - African Union- African Seismological Commission – UNESCO, 23-26 October 2017

Projection of vulnerability components for Egypt governorates

Vulnerability components	Resources	Indicators	Results
Exposure	Extreme Events	No of flash Floods	
	Change in Climate Variables	Max. Temperature	
		Min. Temperature	
Sensitivity	Human	Population density	
		Rural area	
		Distance from sea	
	Ecology	Protected area	
	Water	Water poverty index	
	Energy	Available energy for consumption	
	Agriculture	evapotranspiration	
		Area under major crop	
Capacity adaptation	Socio-economic	Human development index	
		Gender development index	
		GDP	
		Share of Agriculture GDP	
	Infrastructures	Drainage covered area/total cultivated area	
		Paved roads (% of total roads)	
		% of households with access to sanitation	
		% of households with access to piped water	
	Technology	Per capita consumption of Electricity	

Source, Inas El Gafy and Neil Grigg, 2016, Journal of American Science 2016;12(8)

Conclusions and Recommendations

- Most of Egypt sectors are vulnerable to climate change
- Although rainfall is declining, the events of Flash Flood (storms) are changed in their frequency, intensity and distribution
- Most of the CC studies confirm the two direction of increasing and decreasing of the Nile Flow.
- Public awareness of climate change and the adaptation measures should be given high priorities.

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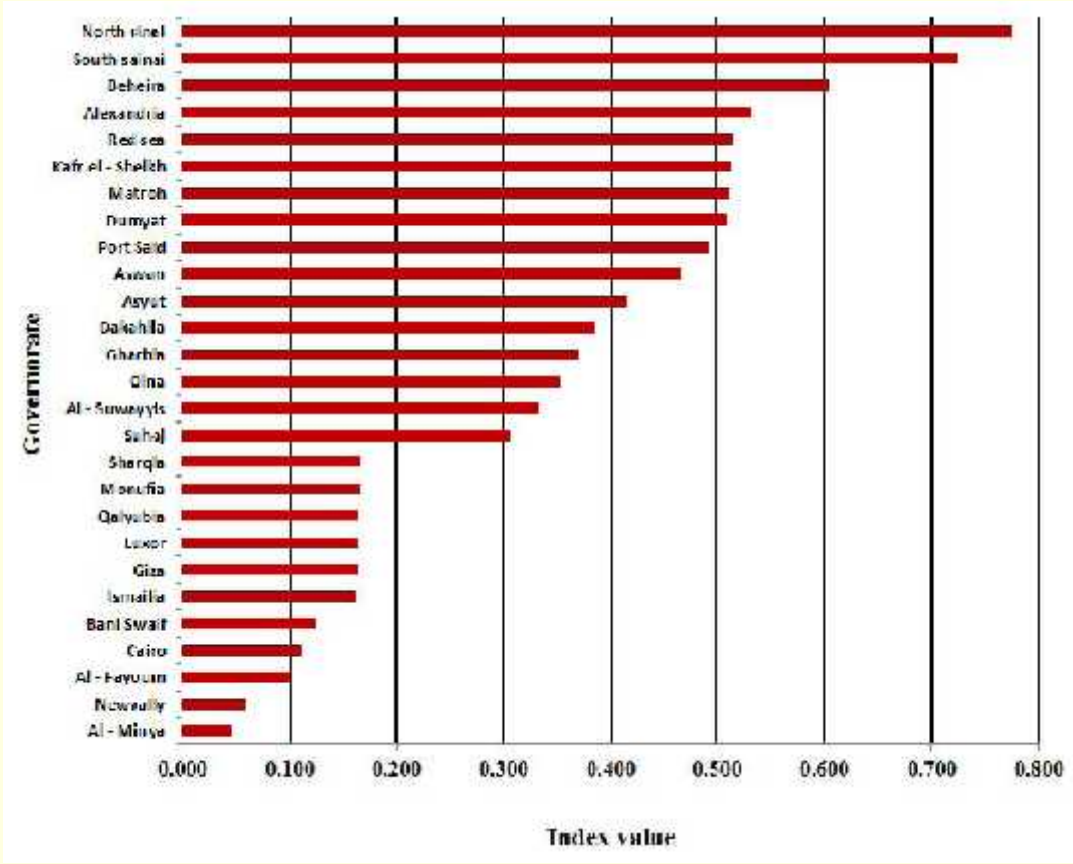
High Exposure:
North Sinai

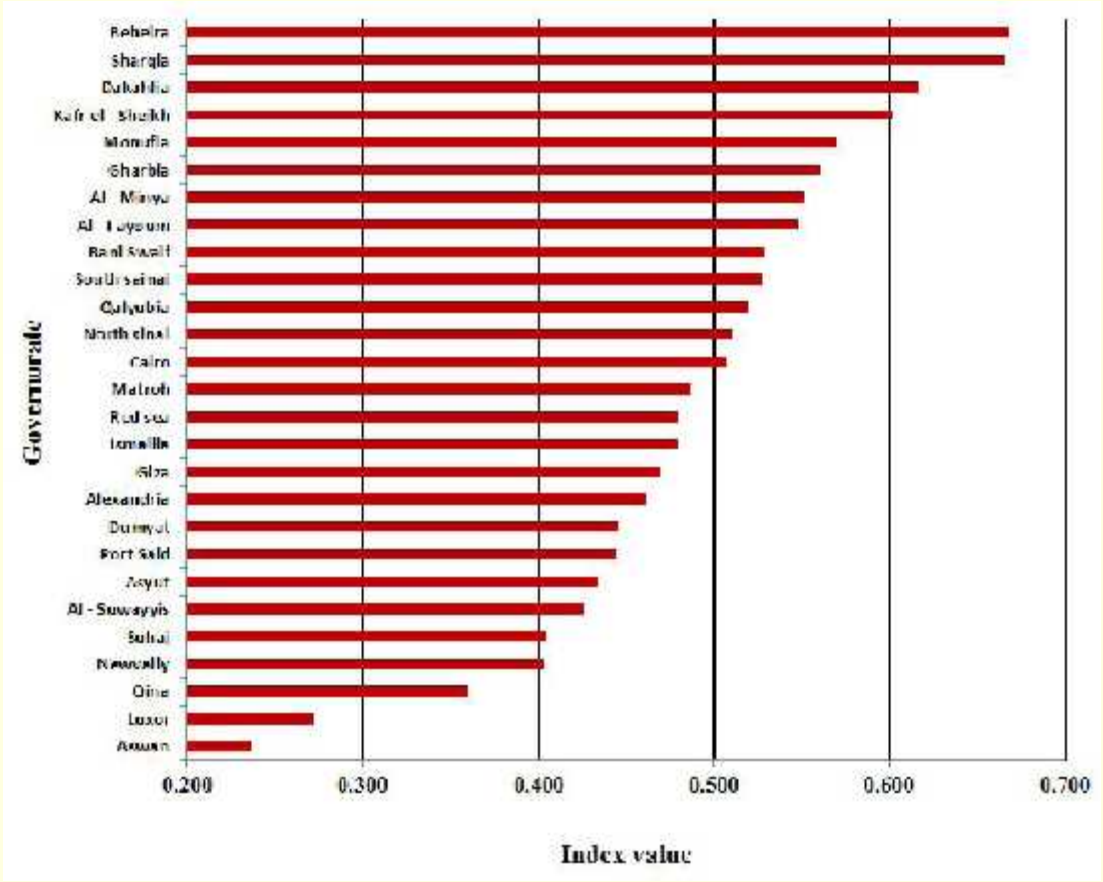
Low Exposure:
Al-Minya



Exposure index of the Egyptian governorates

High Sensitive:
Beheira

Low Sensitive:
Aswan



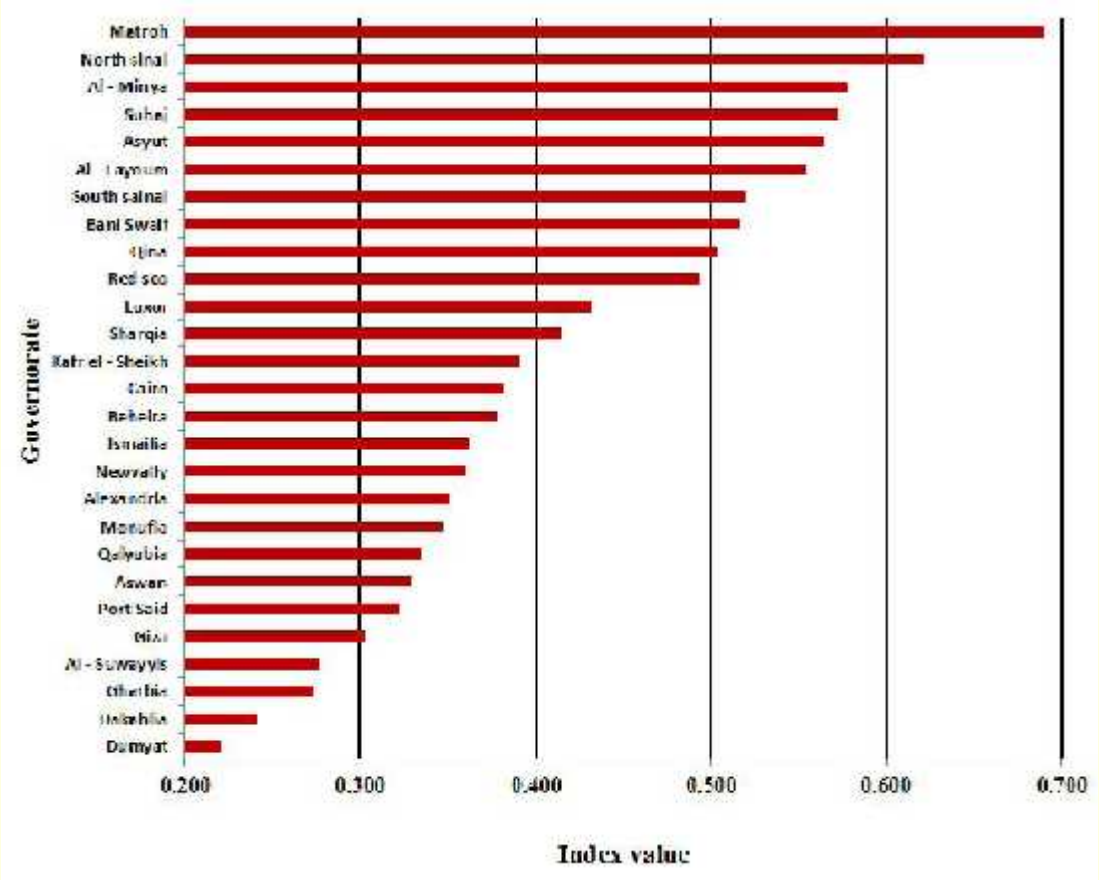
Sensitivity index of the Egyptian governorates

High Adaptation Capacity:

Matrouh

Low Adaptation Capacity:

Dumyate



Adaptation capacity index of the Egyptian governorates