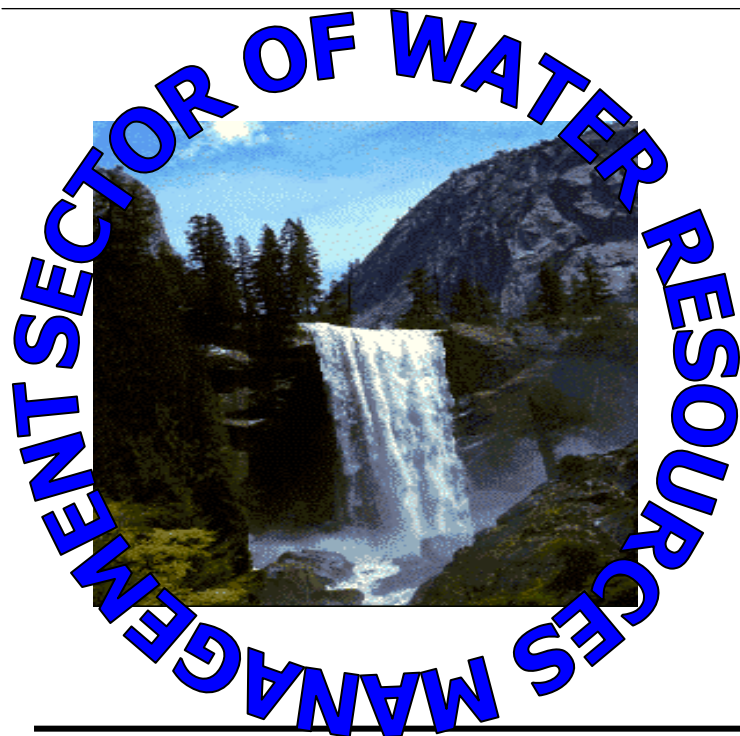
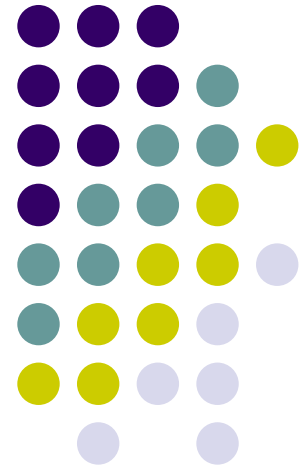


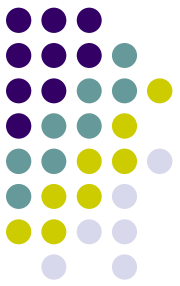
# TOWARDS THE DEVELOPMENT OF DROUGHT MASTER PLAN FOR GREECE



Christos A. Karavitis,  
Water Resources  
Management  
Agricultural  
University  
of Athens



# **TECHNICAL SUPPORT TO THE CENTRAL WATER AGENCY FOR THE DEVELOPMENT OF A DROUGHT MASTER FOR GREECE AND AN IMMEDIATE DROUGHT MITIGATION PLAN**



**Contract No. 10889/11/07 /2007**

**Ministry of Planning, Public Works and the Environment**

To Water Resources Management Sector,

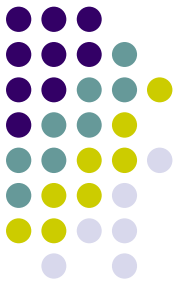
Department of Natural Resources and Agricultural  
Engineering,

**Agricultural University of Athens**

Co-ordinator Christos A. Karavitis

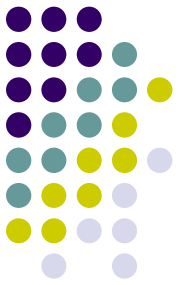
***Submitted on October 2008***

# PRINCIPLES



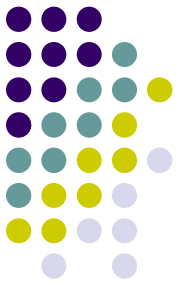
- **CONTINGENCY ORIENTED**
- **METHODOLOGICAL**
- **OPERATIONAL**
- **IMPLEMENTABLE TO A VARIETY OF LOCALES**

# STRUCTURE



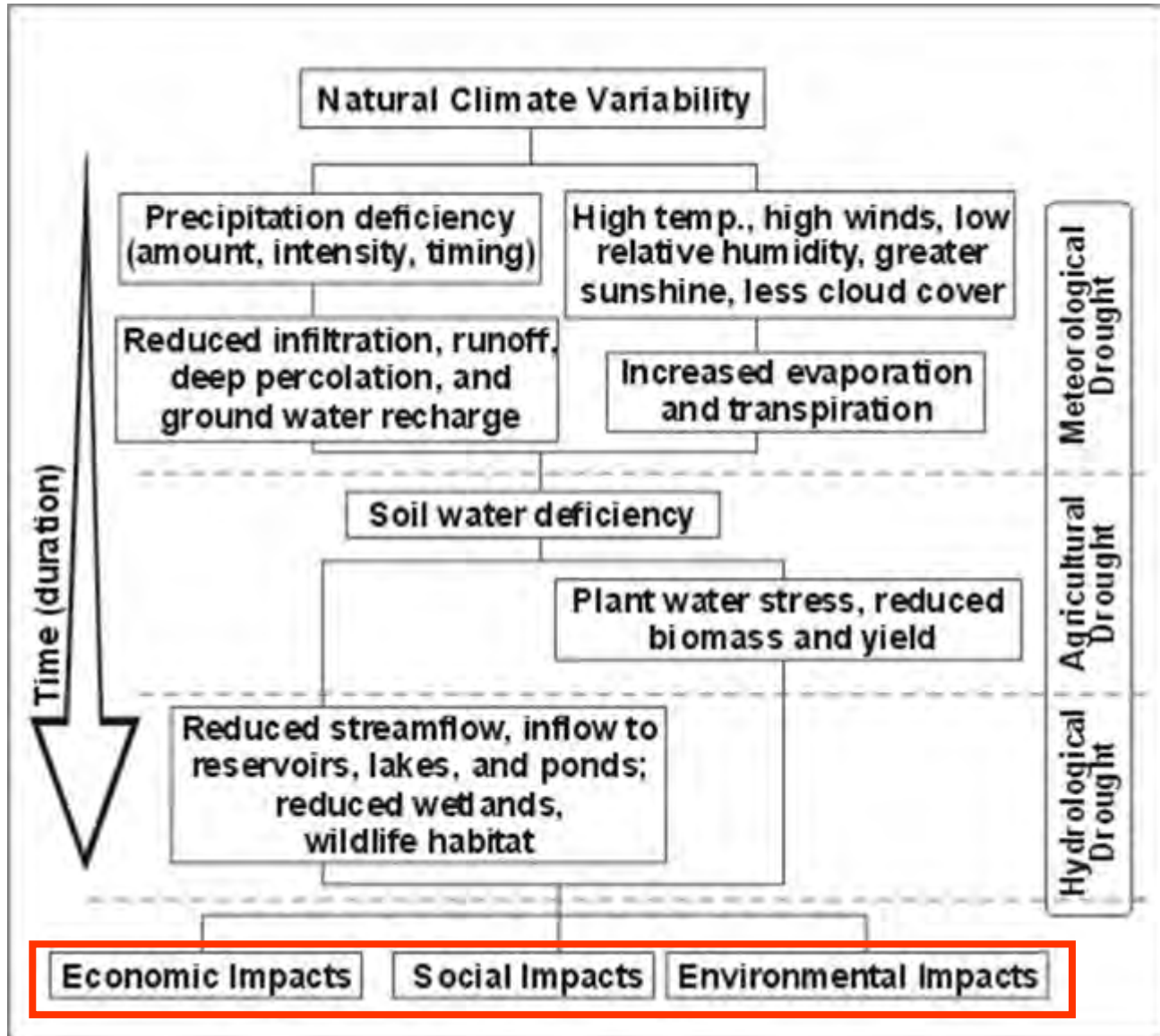
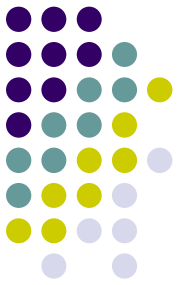
1. **Definition of Drought**
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# ***Definition of Drought***

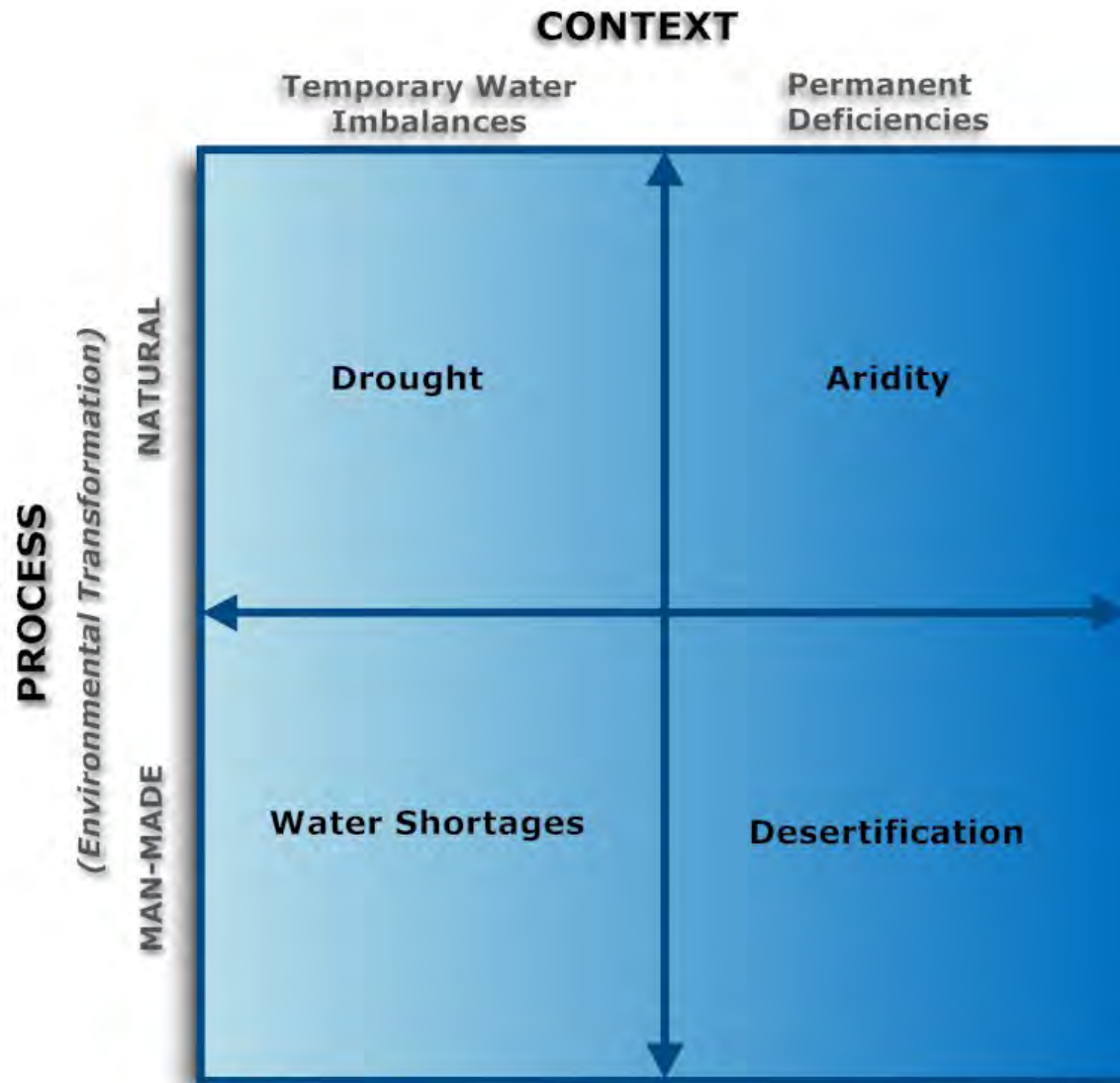


A creeping phenomenon, a “non-event”

- Operational definitions attempt to demarcate the severity, onset and termination point of droughts
- Conceptual definitions attempt to identify the boundaries of the drought event

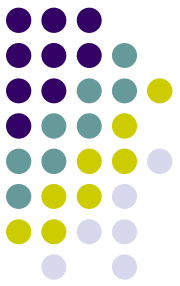


# Water Deficiencies



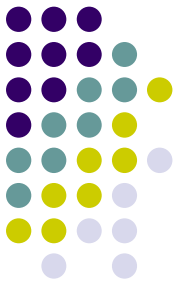
VLACHOS  
(1983)

# Drought



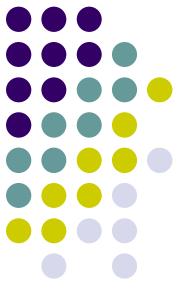
- a usually unexpected and unpredicted time period of abnormal dryness which affects water supply" (Grigg, N.S., 1988).
- The state of adverse and wide spread hydrological, environmental, social and economic impacts due to less than generally anticipated water quantities (Karavitis, 1992)

# Social and Economic Drought / Water resources Engineering



- Gap between supply and demand of economic goods such as
  - water,
  - food,
  - raw materials,
  - hydroelectric power,
  - transportation
- depends on the time and space processes of supply and demand
- Social Stresses – Economic impacts

# STRUCTURE

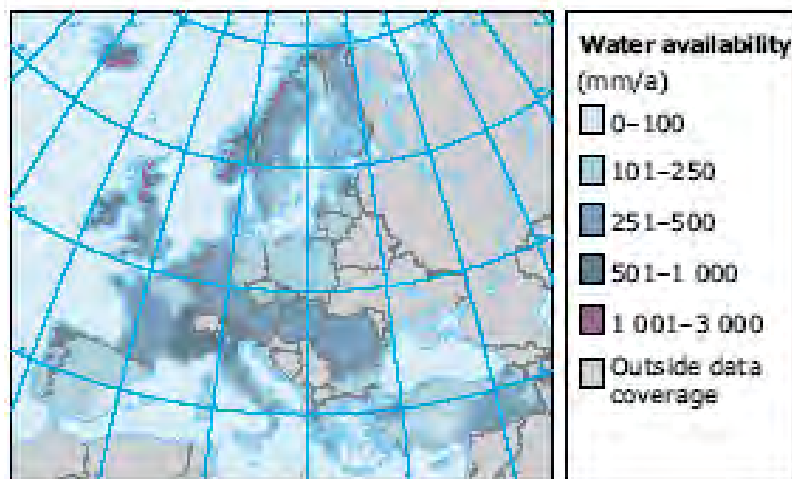


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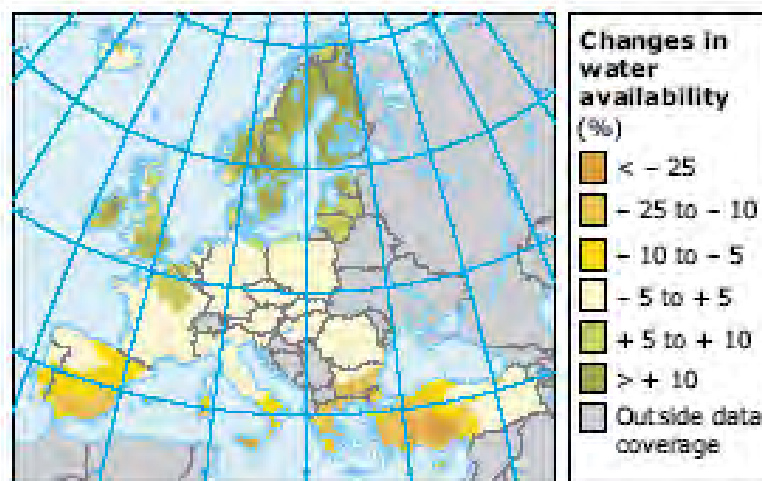


## Map 5.1 Current water availability and changes expected by 2030

Current water availability in European river basins

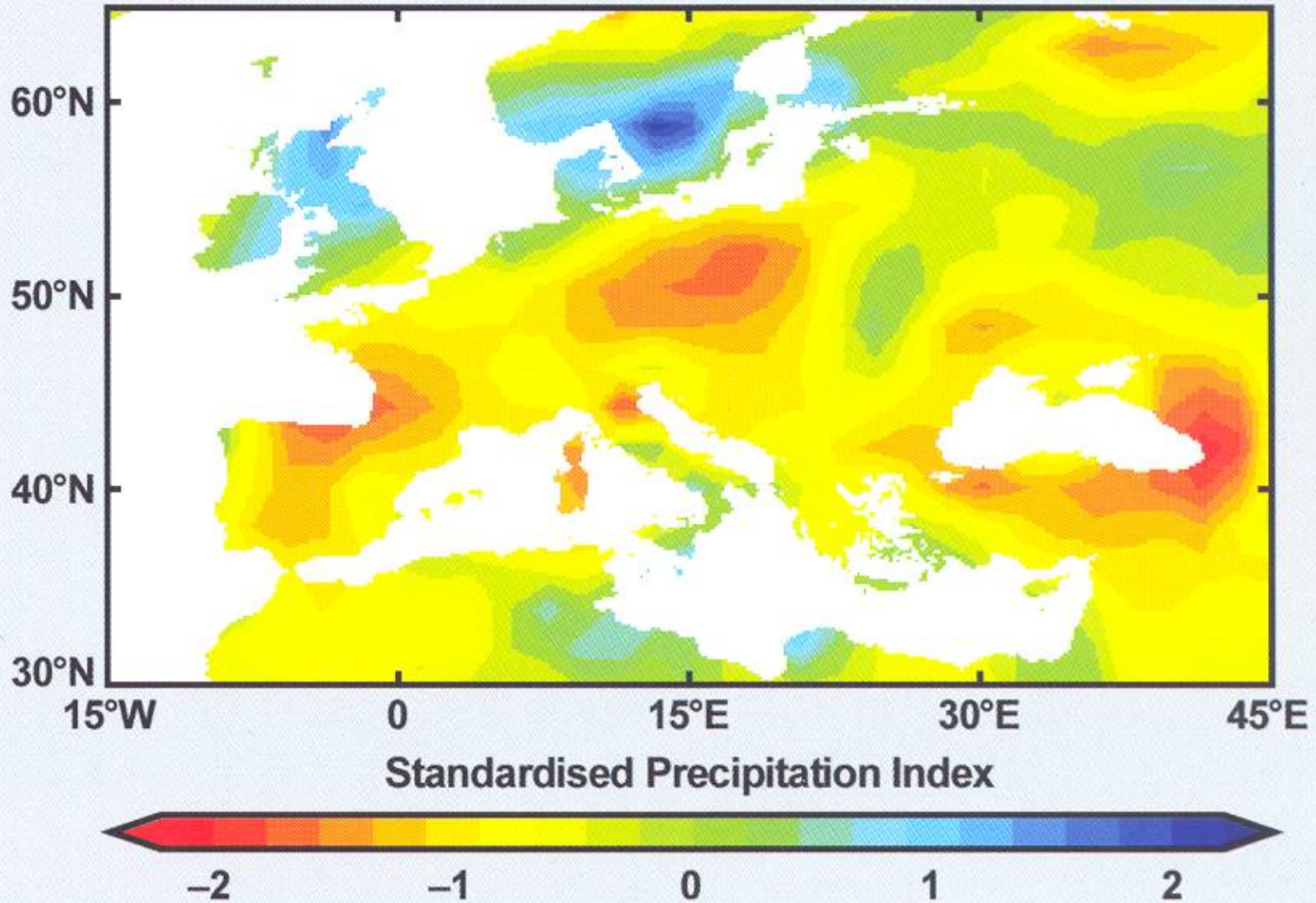
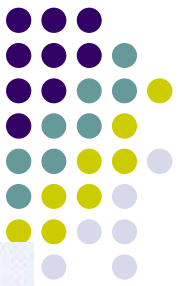


Changes in average annual water availability under the LREM-E scenario by 2030



Source: EEA, 2005.

# The 2003 Drought in Europe

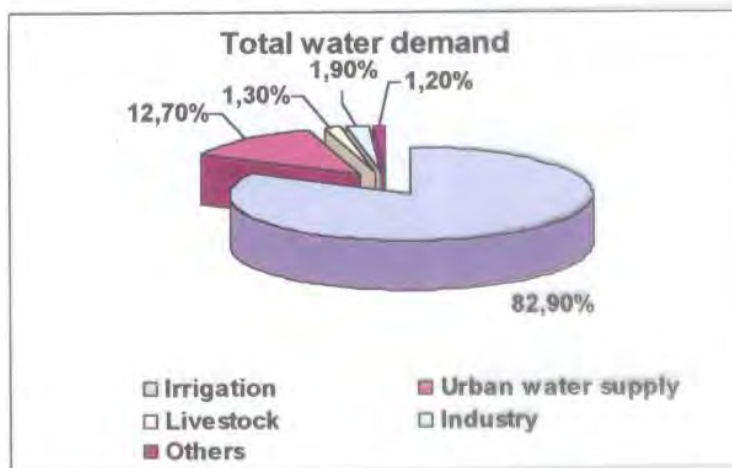


## WATER DEMAND

**Table 4. Annual water demand per sector and water district.**

Water district	Irrigation	Livestock	Urban water supply	Industry	Others	Total
1. W. Peloponnesus	201,0	5,0	23,0	3,0	20,0	252,0
2. N. Peloponnesus	401,5	6,6	41,7	3,0	-	452,8
3. E. Peloponnesus	324,9	4,7	22,1	-	-	351,7
4. W. Central Greece	366,5	9,0	22,4	-	-	397,9
5. Epirus	127,4	9,9	33,9	1,0	-	172,2
6. Attica	99,0	2,5	400,0	17,5	-	519,0
7. E. Central Greece	773,7	9,9	165,9*	12,6	-	962,1
8. Thessaly	1550,0	12,0	54,0	-	-	1616,0
9. W. Macedonia	609,4	7,9	43,7	30,0	80,0	771,0
10. Central Macedonia	527,6	8,0	99,8	80,0	-	715,4
11. E. Macedonia	627,0	5,8	32,0	-	-	664,8
12. Thrace	825,2	7,1	27,9	11,0	-	871,2
13. Crete	320,0	10,2	42,3	-	-	372,5
14. Aegean Islands	80,2	6,8	37,2	-	-	124,2
<b>Total</b>	<b>6833,4</b>	<b>105,4</b>	<b>1045,0</b>	<b>158,1</b>	<b>100,0</b>	<b>8242,8</b>

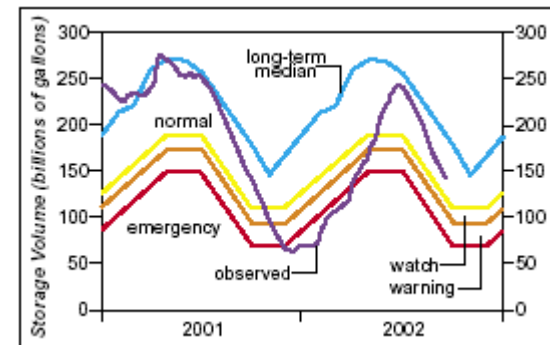
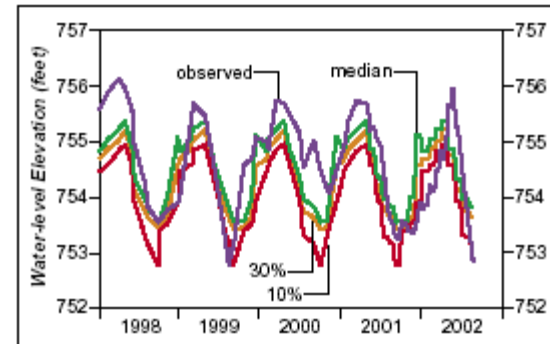
\* From these, 41,6 are being used for the water supply of water district and the 124,3 for the water supply of Athens.

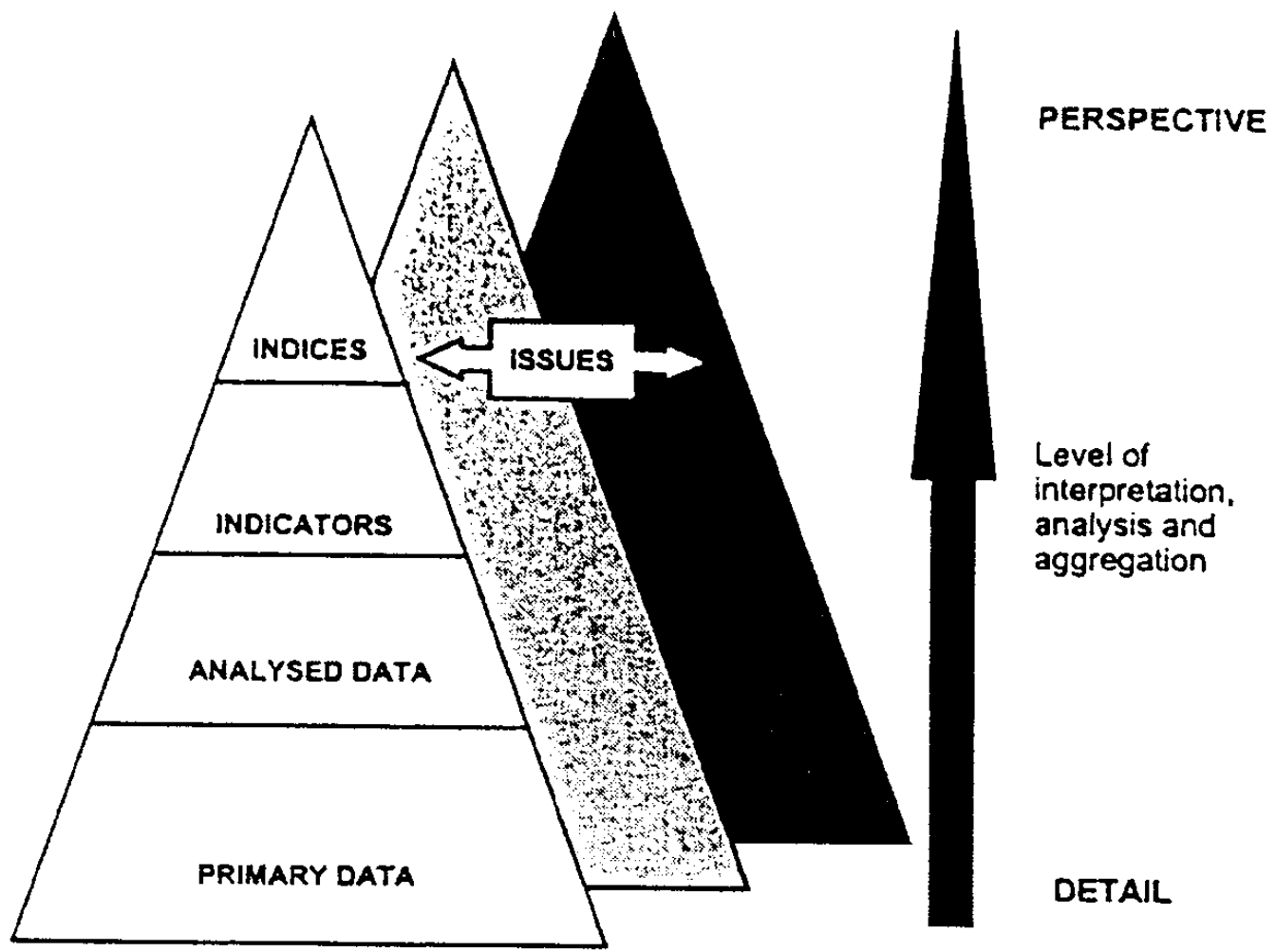
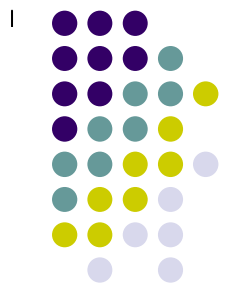


# A plethora of Meteorological, Agricultural or Hydrological Drought Indices



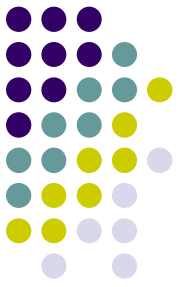
- Percent of Normal
- Deciles
- Palmer Drought Index
  - PDSI, PHDI, CMI
- Surface Water Supply Index
- Standardized Precipitation Index (SPI)
- Vegetation indices (NDVI, VCI, SVI)
- U.S. Drought Monitor
  - Composite index approach





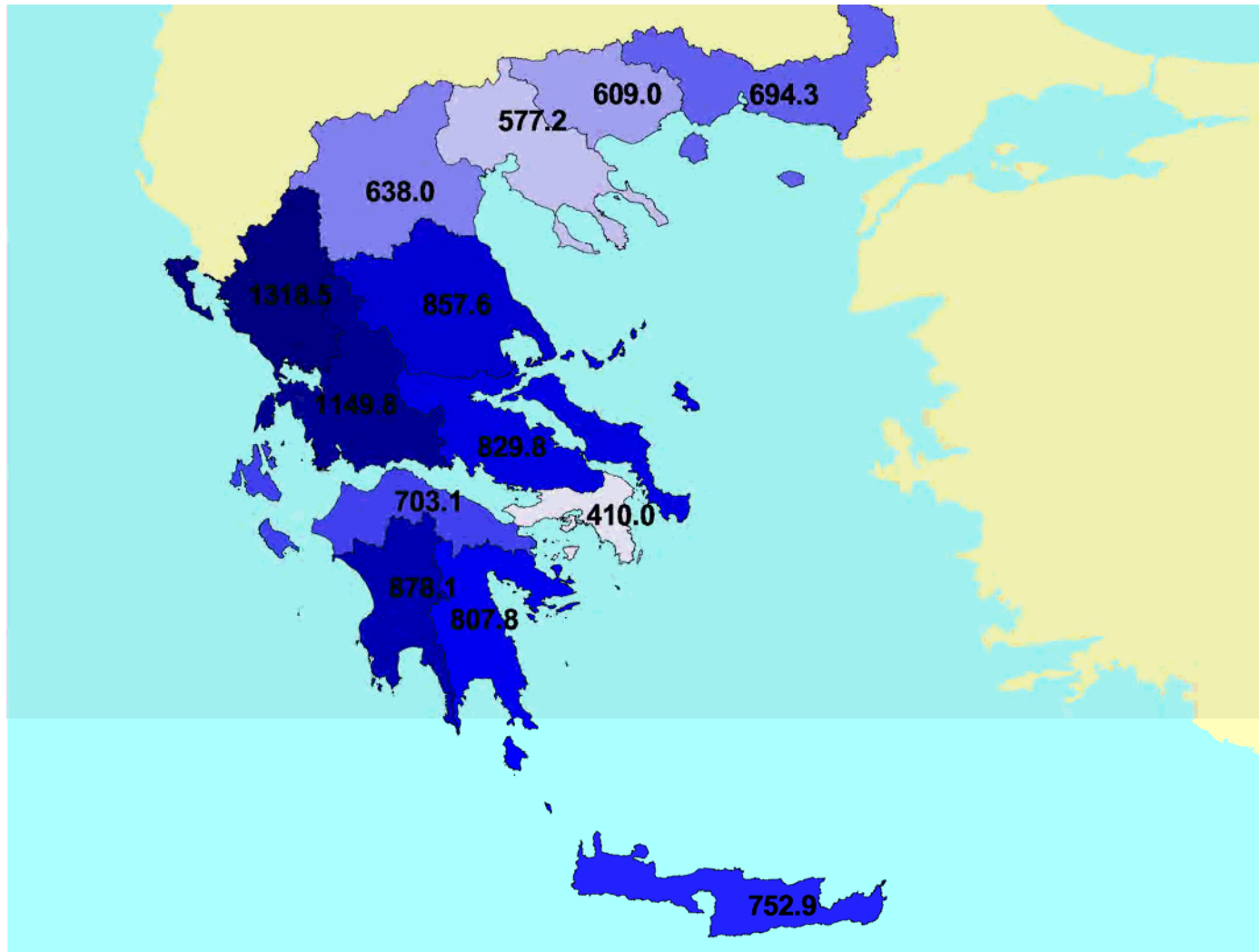
Information pyramid (adapted from Walmsley and Pretorius 1996).

# Primary Data for Meteorological, Agricultural or Hydrological Drought Indicators

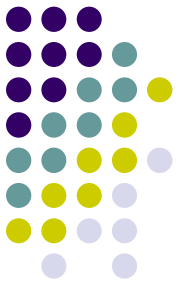


- Climate variables (e.g., precip., temp.)
- Reservoir and lake levels
- Soil moisture
- Ground water
- Snow pack
- Stream flow
- Vegetation

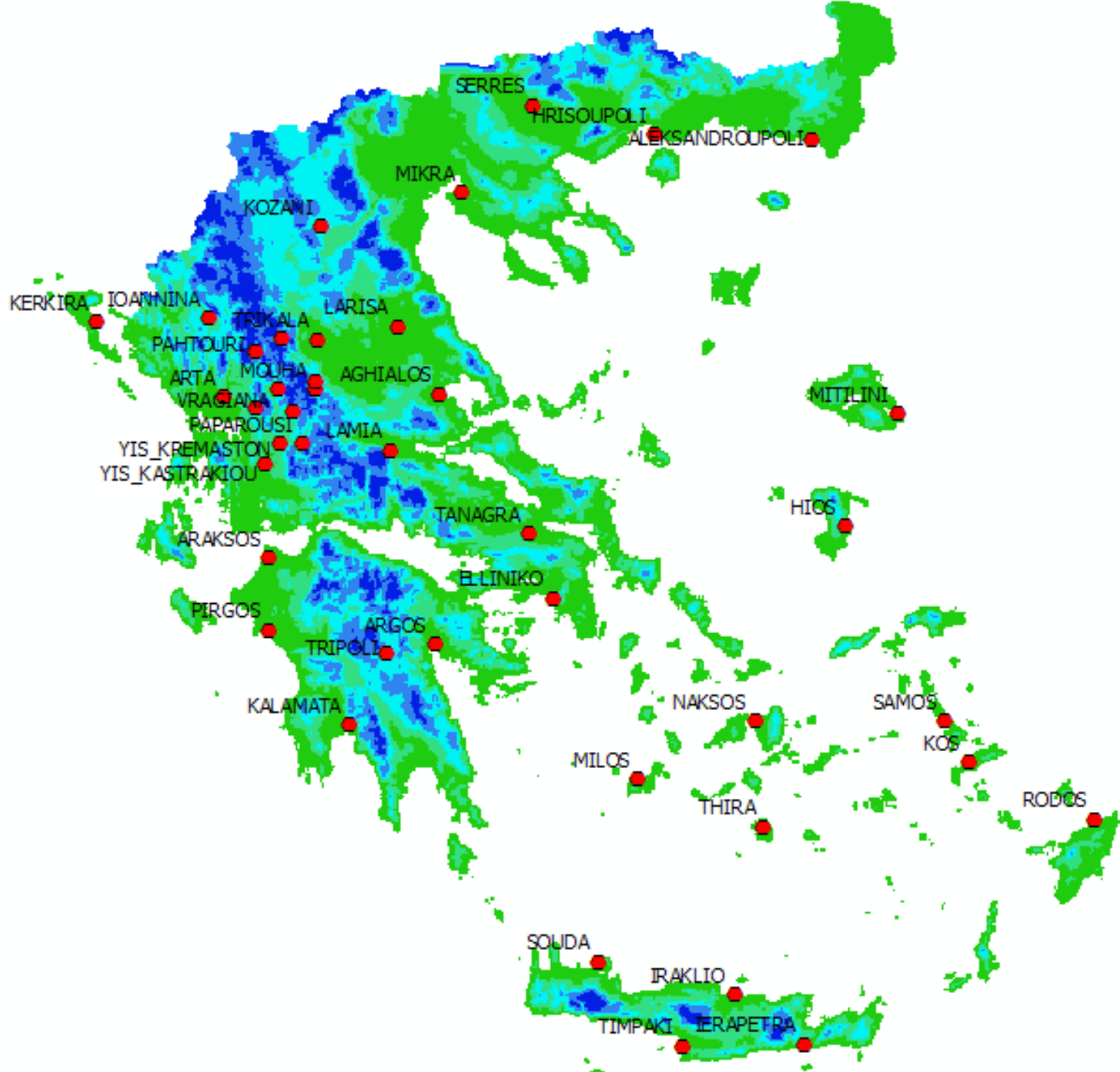
# AVERAGE ANNUAL PRECIPITATION in mm (MCPPE 2007)



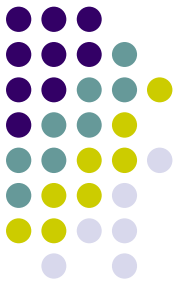
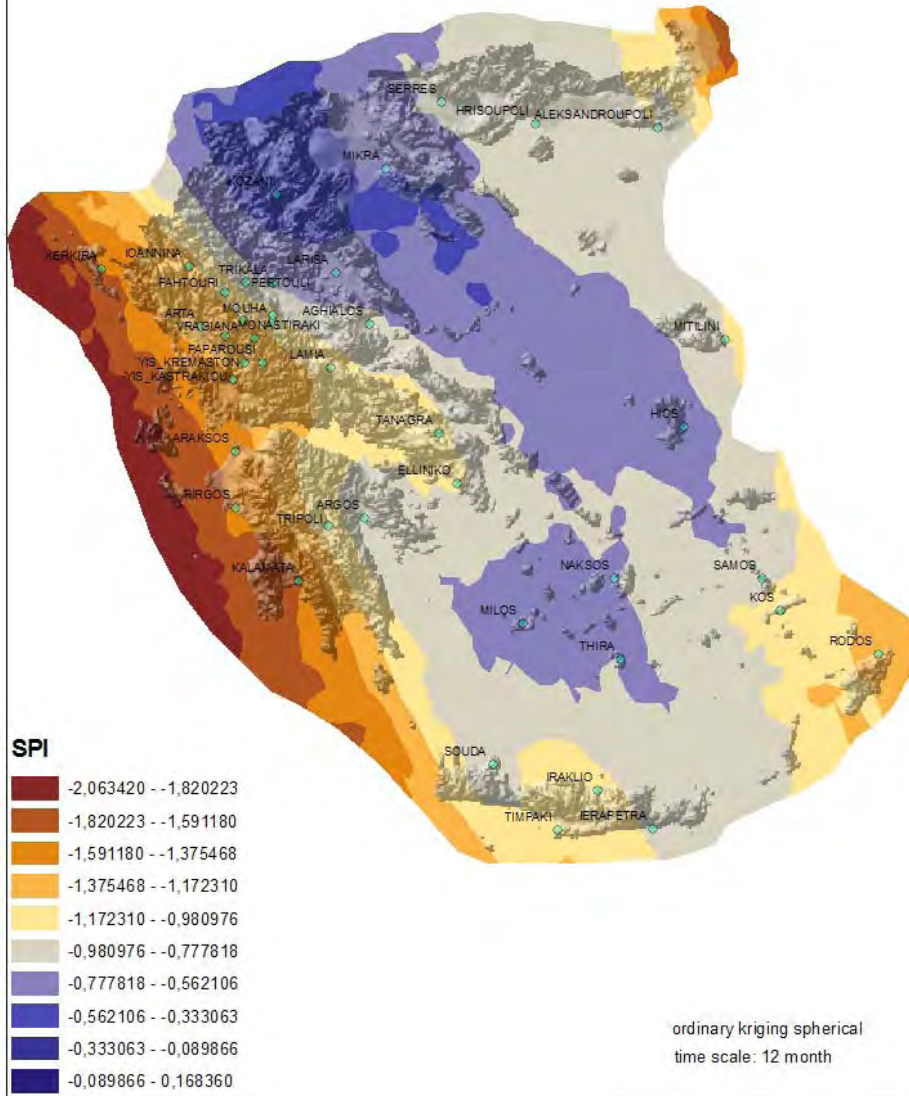
# SPI Application



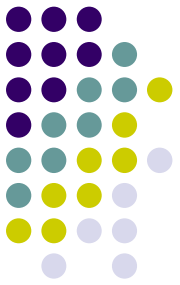
precipitation data from 41 meteorological stations, covering the periods 1959- 2001 were used



# SPI 1992

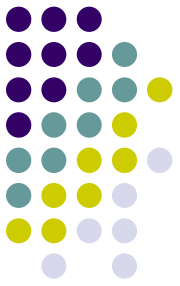


# STRUCTURE



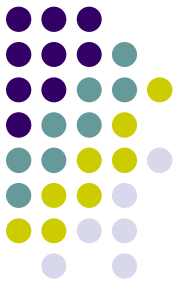
1. Definition of Drought
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# Drought Research Methods

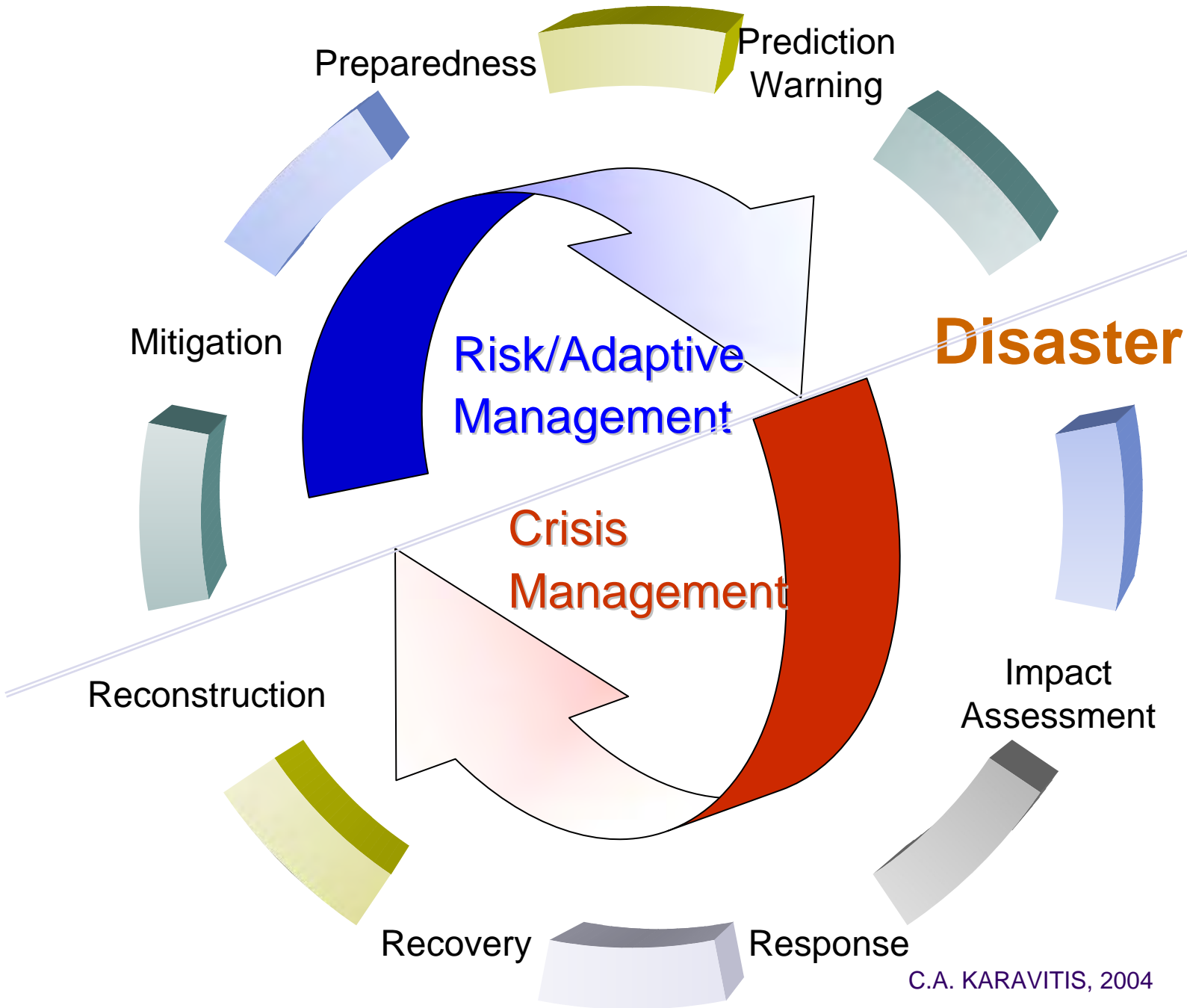
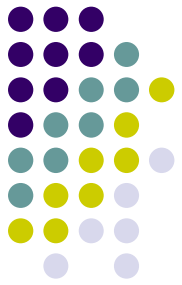


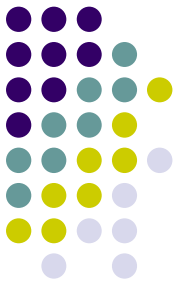
- according to the field of study (i.e., meteorology, agriculture, hydrology, economics, biology, sociology, etc.).
- centering on a specific drought physical variable (i.e., soil moisture, precipitation, evapotranspiration, streamflow, groundwater level, etc.)

# Why are Drought Contingency Policies Needed?



- Prevailing crisis management attitude
- Natural Hazards Emergency Response Procedures
- Protocols for Processes and Procedures
- Create a wider menu of options and alternatives

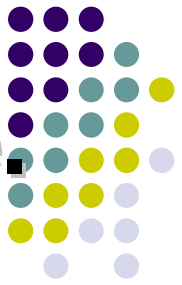




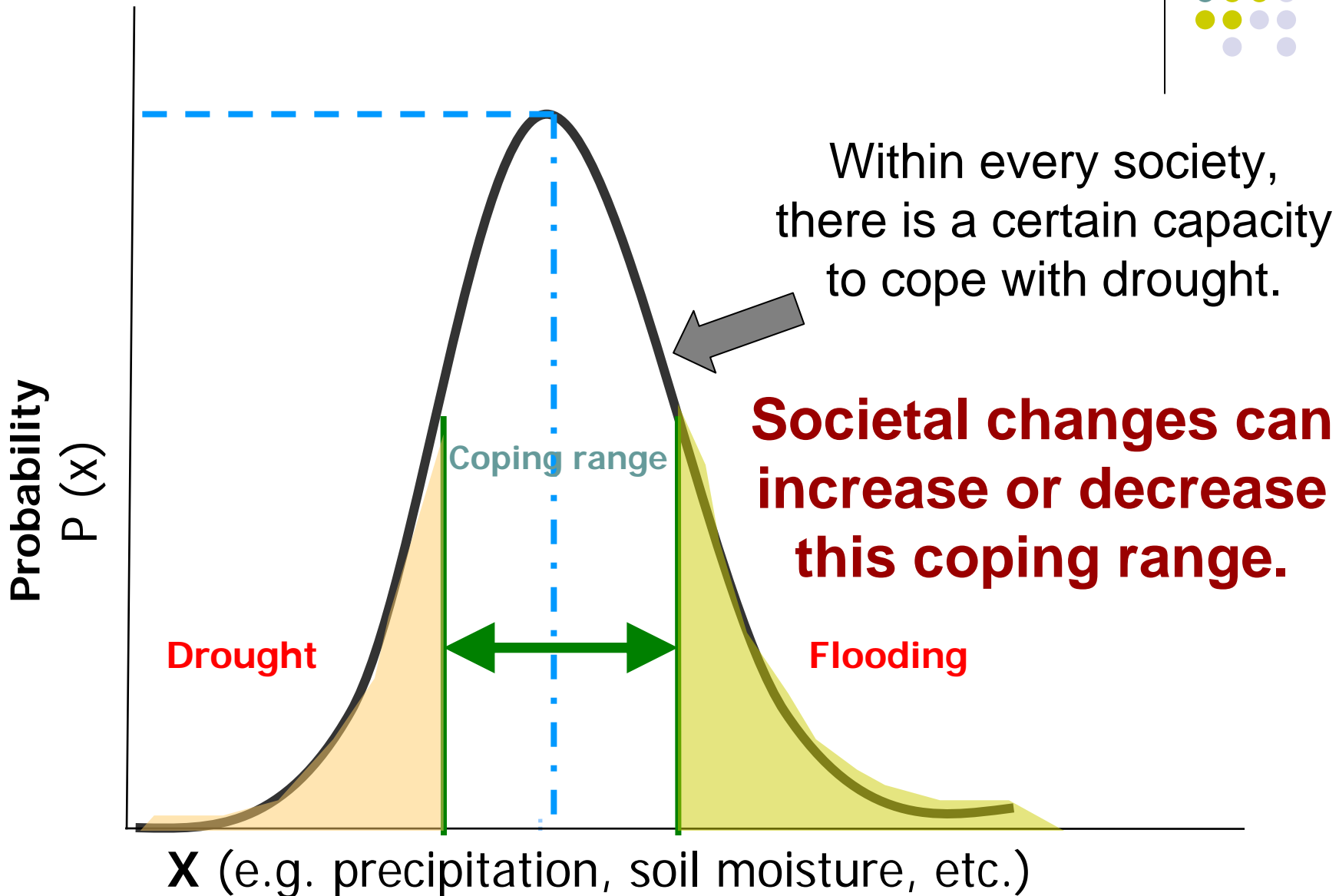
# Aggregation in Space and Time

- **Frequencies (risks, reliabilities)**
- **Durations**
- **Spatial Extent**

As impacts differ within and between spatial scales, risk indicators should reflect who and what is at risk and why.



# Drought vulnerability is a variable.

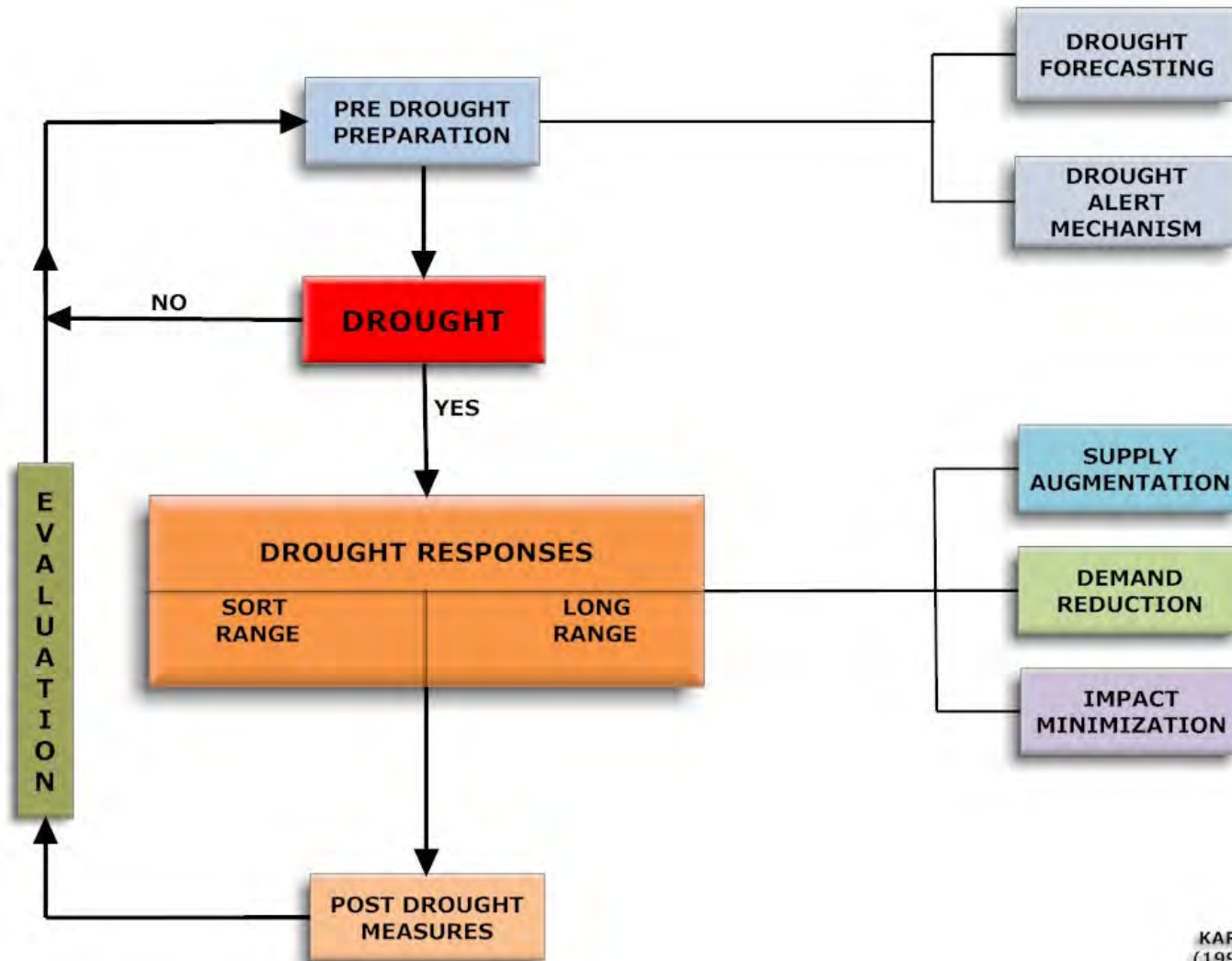
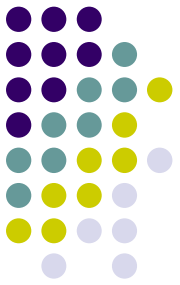


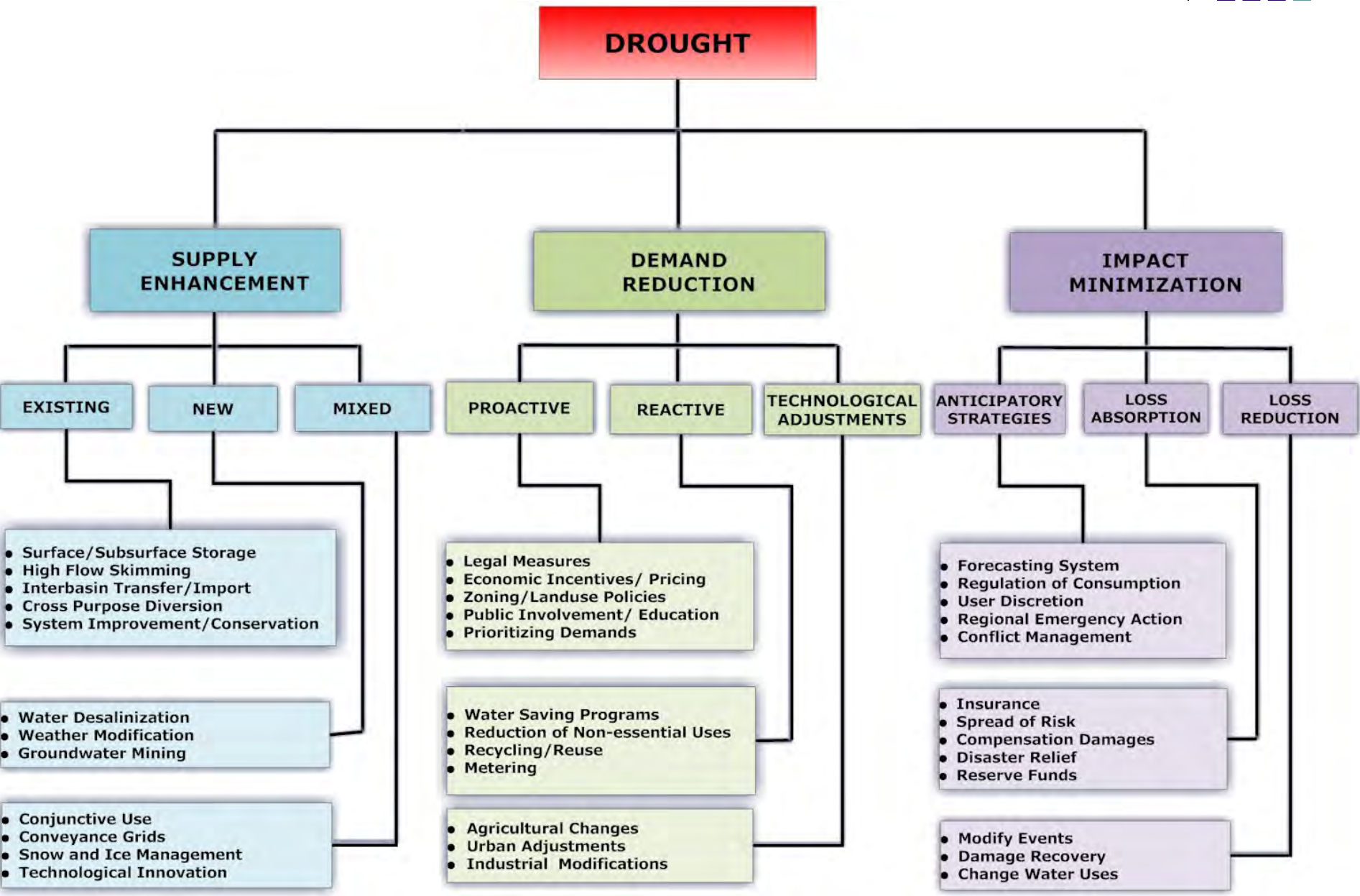
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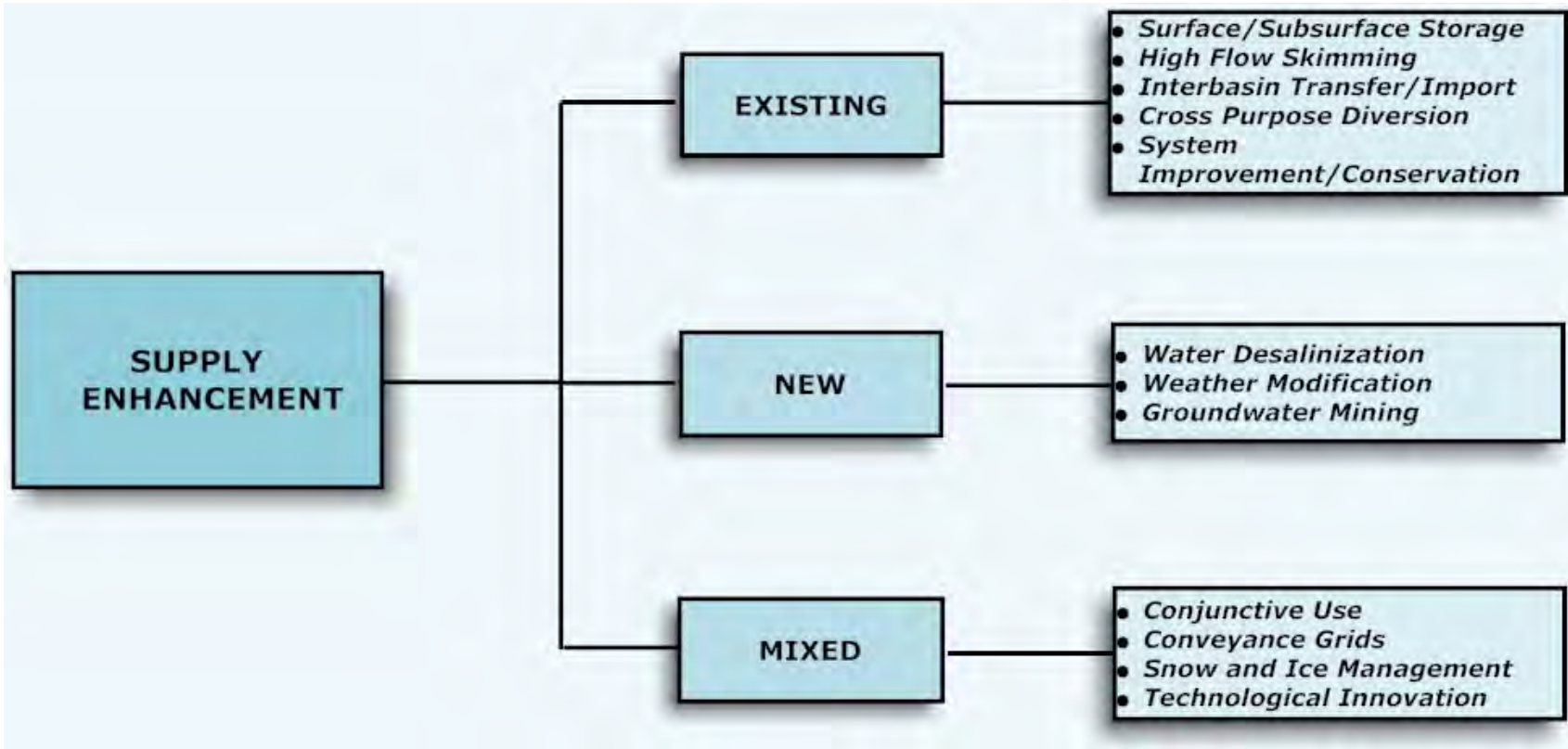
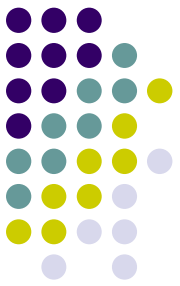
# Drought contingency Plan



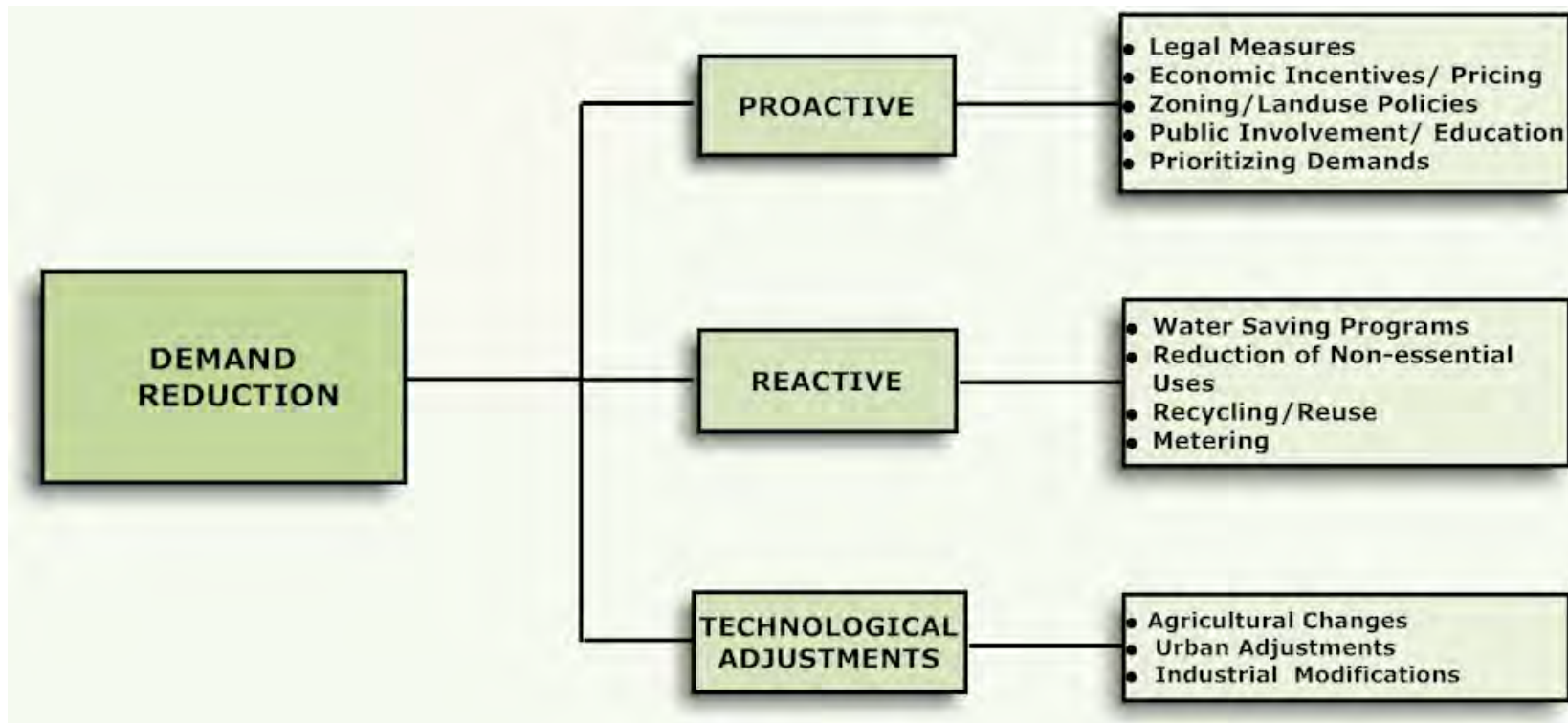
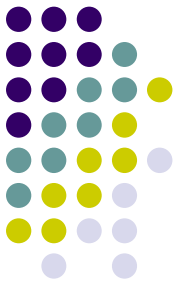


From V. Yevyevich and E. Vlachos, 1983; C. A. Karavitis and N.S. Grigg, 1992, 1999

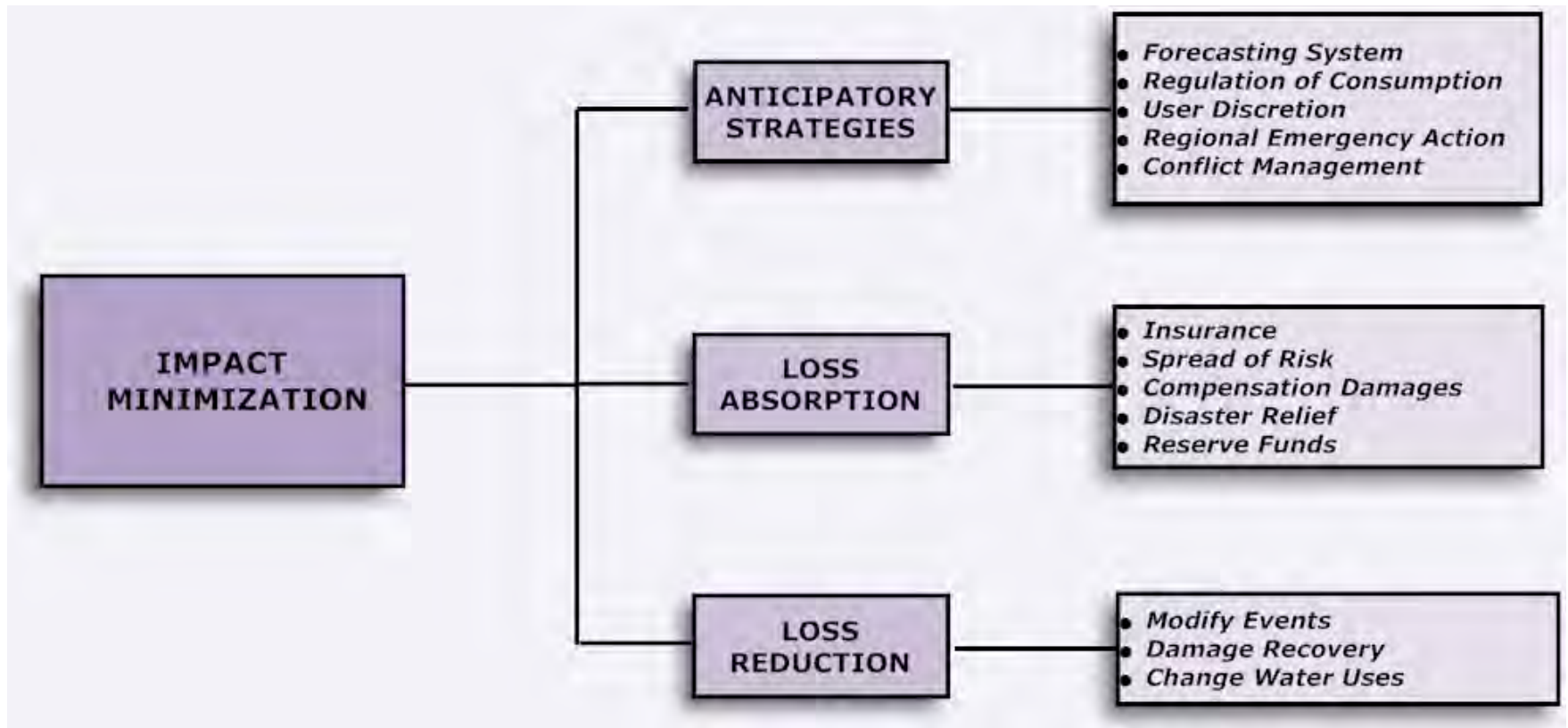
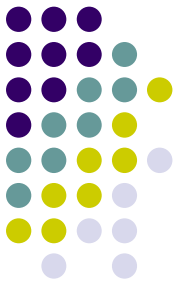
# TOOLBOX FOR SUPPLY MANAGEMENT



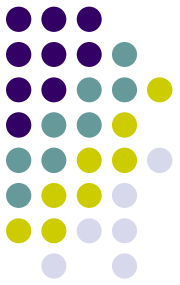
# TOOLBOX FOR DEMAND MANAGEMENT



# TOOLBOX FOR IMPACT MINIMIZATION

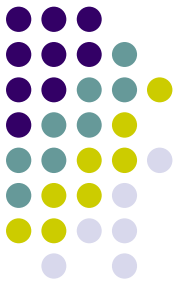


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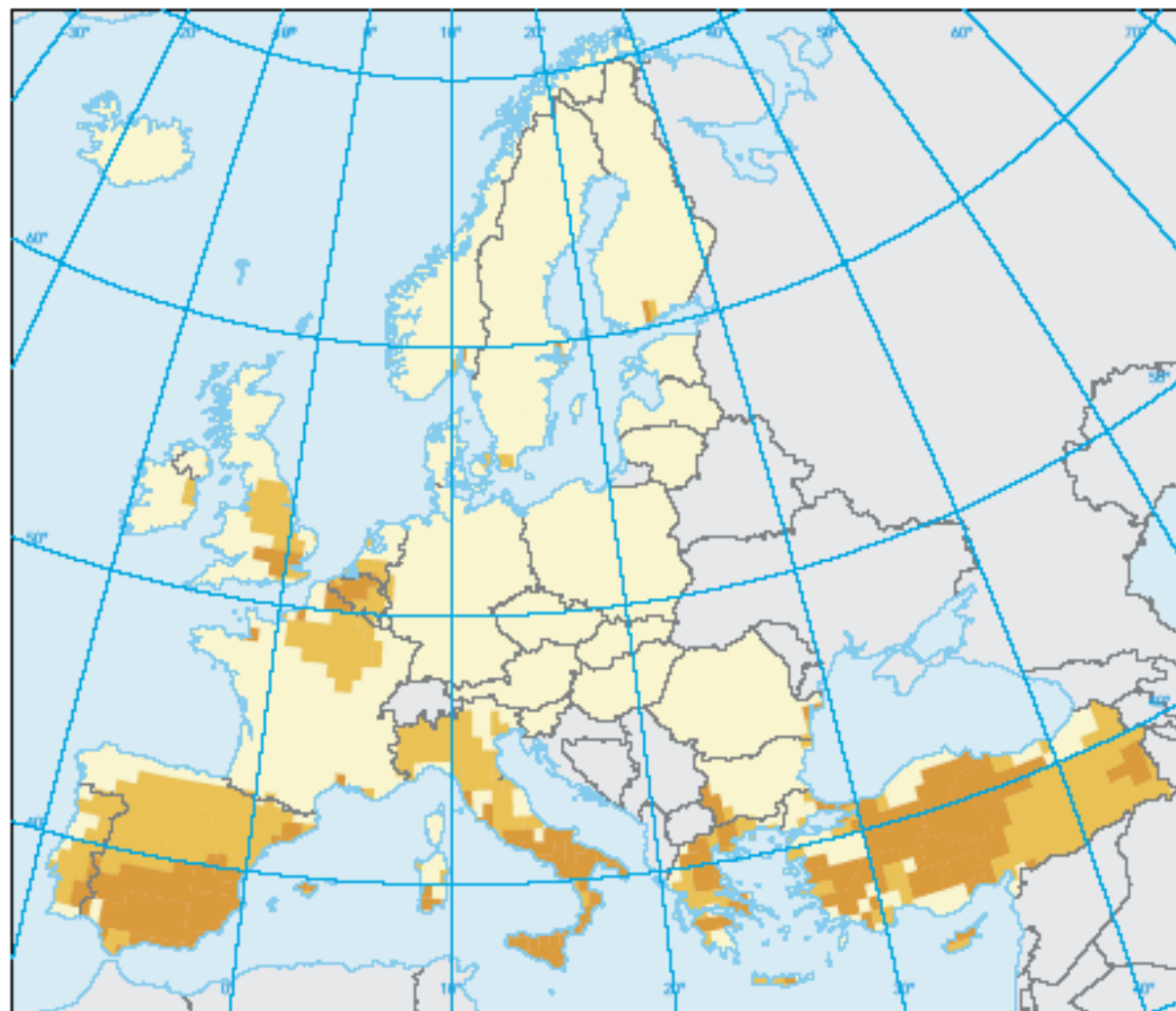
# DROUGHT FORECASTING



- Statistical predictions: based on lagged relationships between regional meteorological patterns (i.e. rainfall) and actual data.
- Probabilistic predictions: by trying to estimate the mathematical probability of a given phenomenon in a certain time frame based usually on analysis of time series data.
- Deterministic predictions: which attempt to model important features of the existing system and provide a basis for contingency analysis through simulation

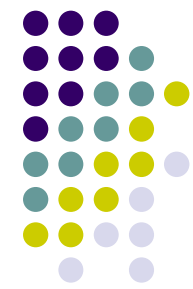
Map 5.3

Water stress in 2030

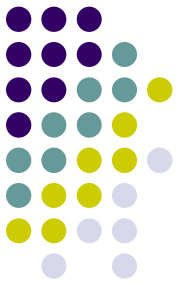


Water exploitation index (%) around year 2030

- 0–20 (low water stress)
- 20–40 (medium water stress)
- > 40 (severe water stress)
- Outside data coverage



Source: EEA, 2005.

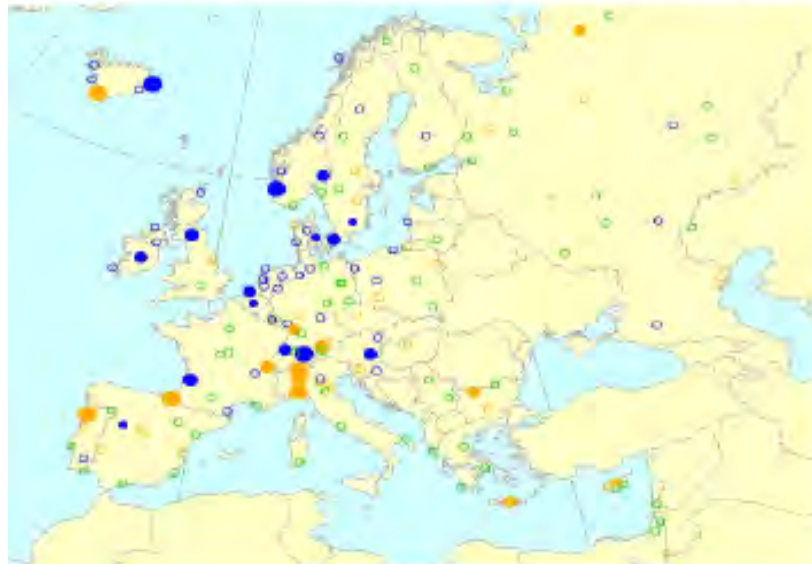


# Precipitation extremes

1976–1999:

- Southern Europe: decrease
- Mid and northern Europe: increase

past trends



annualdays/decade

- > 3
- 2 - 3
- 1 - 2
- 0 - 1
- pos. but n.s. at 5%
- n.s. at 25%
- neg. but n.s. at 5%
- -1 - 0
- -2 - -1
- -3 - -2
- < -3

Very heavy precipitation days ( $p \geq 20\text{mm}$ )  
Changes in 1976–1999

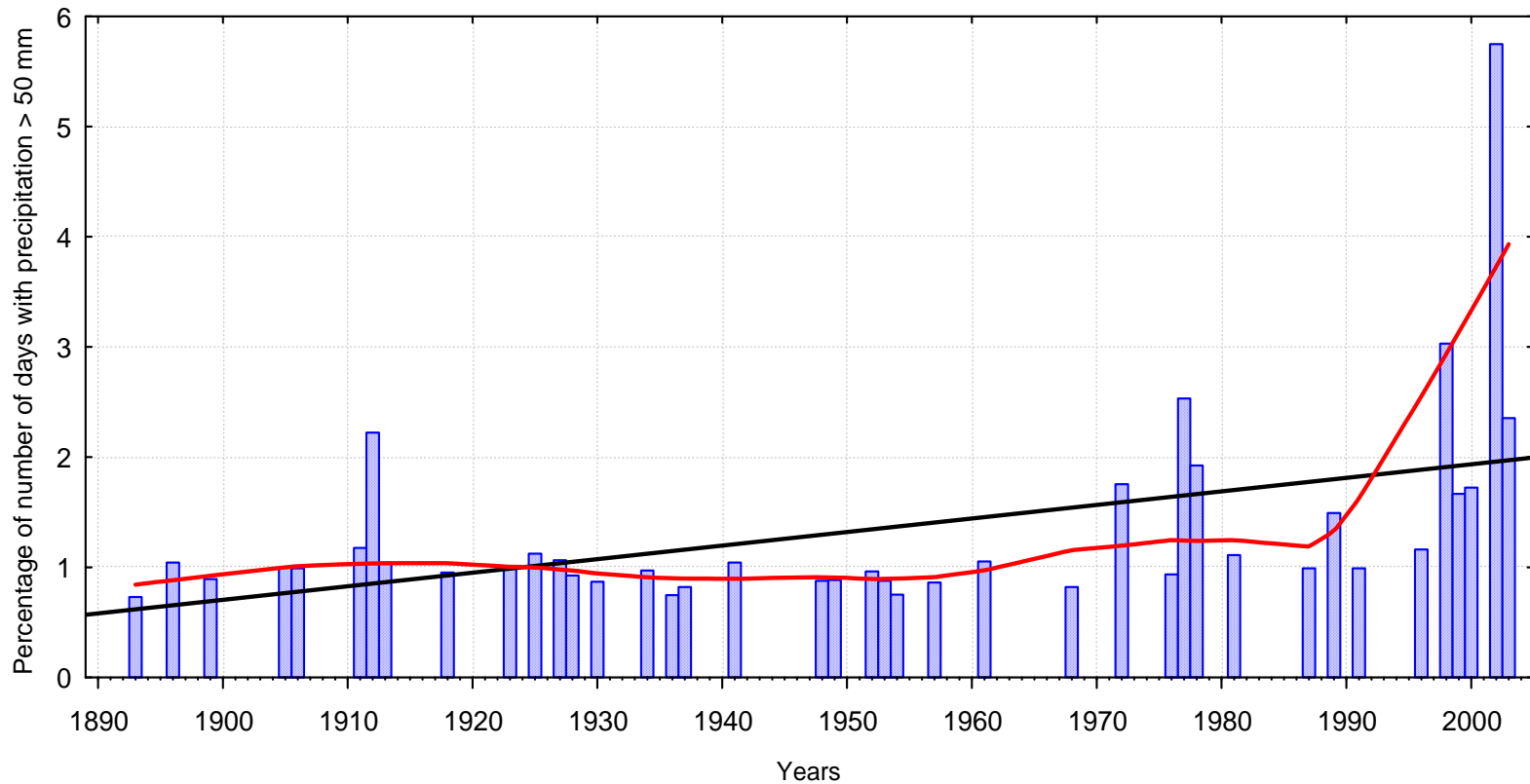
*Projections:*

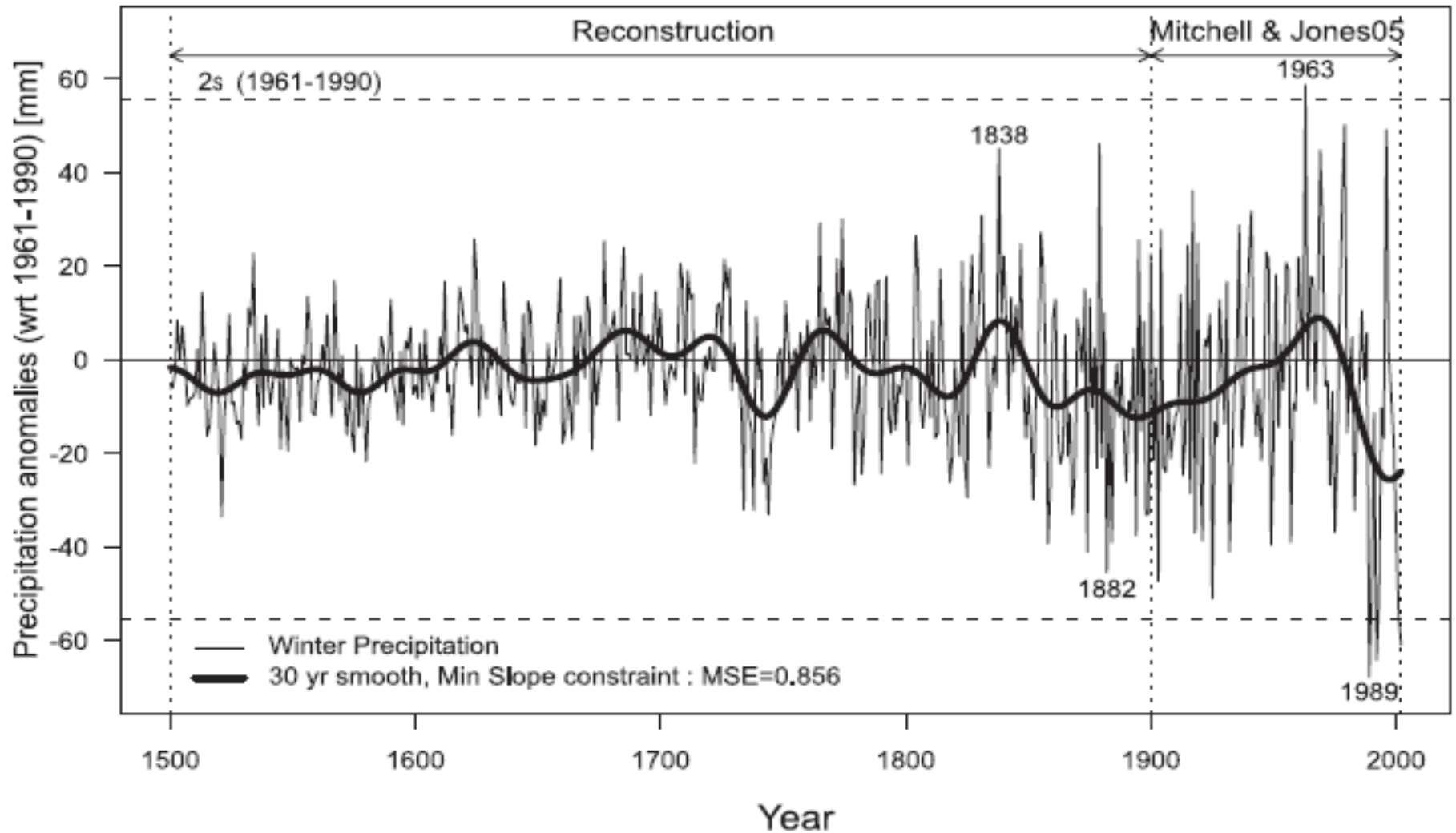
- Likely more frequent droughts and intense precipitation events

future projection

Data-source: ECA, IPCC, ACACIA, ...

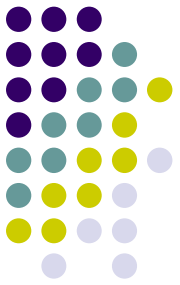
# Percentage of rain days with rain more than 50 mm from 1891 to 2004 over Athens (NOA)





Winter (DJF) averaged-mean Mediterranean precipitation anomalies (with respect to 1961-1990) from 1500 to 2002, defined as the average over the land area 10°W to 40°E and 35°N to 47°N (thin black line). The values for the period 1500 to 1900 are reconstructions (Pauling *et al.*, 2005); data from 1901 to 2002 are derived from Mitchell *et al.* (2004) and Mitchell and Jones (2005). The thick black line is a 30-year smooth 'minimum slope' constraint (mean squared error, MSE=0.856) calculated according to Mann (2004). The dashed horizontal lines are the 2 standard deviations of the period 1961-1990. The driest and the wettest Mediterranean winters for the reconstruction and the full period are denoted.

# THE EL NINNY EFFECT



NORMALLY THE GOVERNMENT DRIFTS  
ALONG AT ABOUT 8,000 METRES...



EVERY FEW YEARS, THERE'S A  
DROUGHT. WHEN IT GETS REALLY BAD,  
IT SUDDENLY RAINS POLITICIANS, EXPERTS AND MEDIA.



THEY FORM POOLS OF EXPERTISE AND  
FUNDING TO COPE WITH THE DROUGHT CYCLE...



AS SOON AS THE GOOD YEARS RETURN,  
THEY EVAPORATE BACK TO 8,000 METRES.

*Nicholson*  
5 OCT '02

# Questions ?

