SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Regional on-site training and study tour on “Drought Risk Management Mainstreaming” (REG-7 and ST-6)

Presented by:

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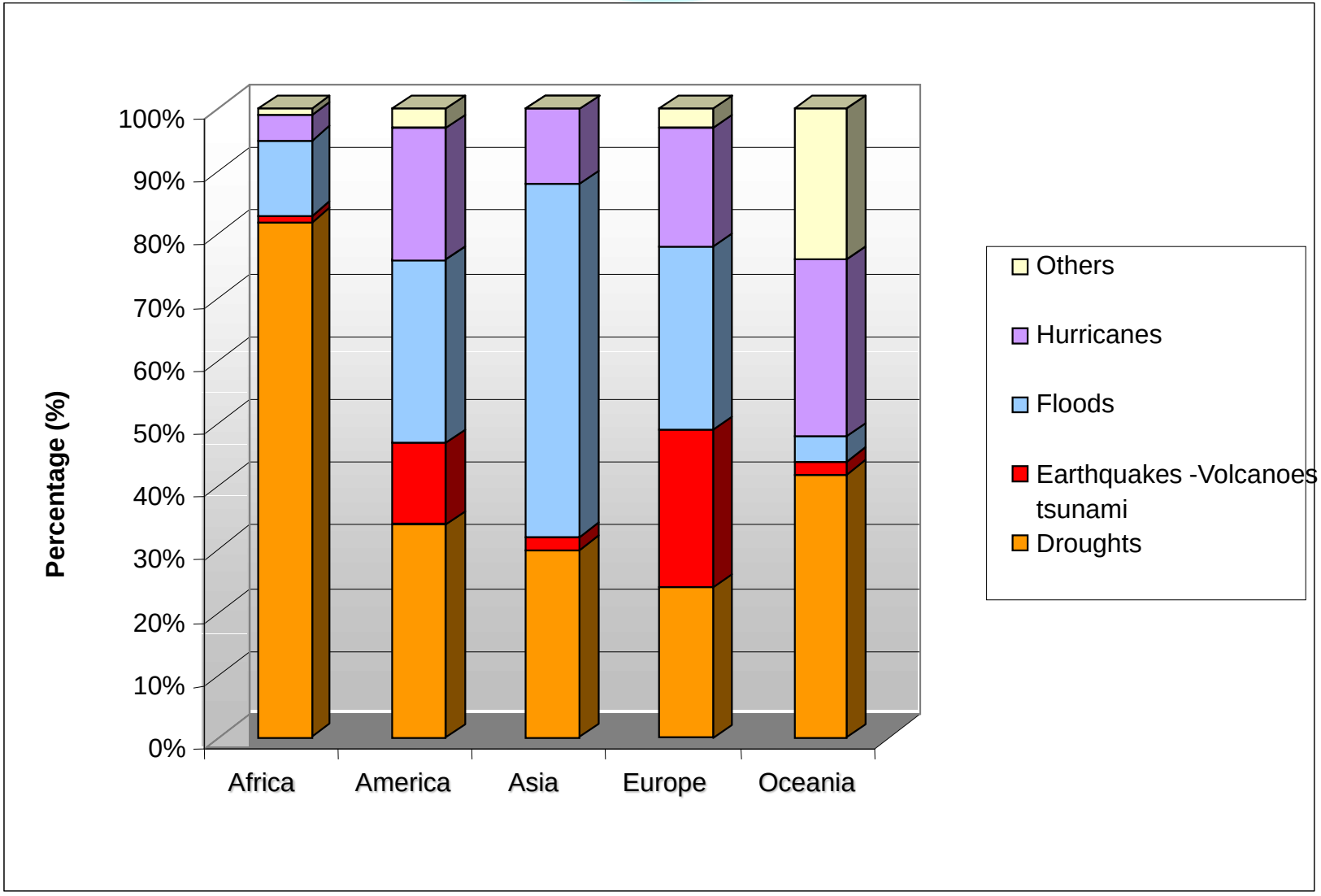
Natural Hazards



Droughts in Africa

Το πηγάδι αποτελεί τον συνδεσικό ιστό των διαφορετικών φύλων στην περιοχή Τούμπα, στο Φλεβ της Σενεγάλης, το 1978. Ανθρώποι με κάθε μέσο προσπαθούν να πάρουν λίγο νερό για τις οικογένειές τους.

Droughts as Natural Hazards

- affect most parts of the world
- more frequent and intense in the future
- do not occur abruptly

→ possible to devise management plans in advance

Outline of Presentation

OUTLINE:

- **clarification of related concepts**
- **drought severity assessment**
- **vulnerability-risk evaluation approach**
- **preparedness & contingency planning**

Concepts of Water Stress/Scarcity

Regime	Causes	
	Natural	Human Induced and Natural
Permanent	Aridity	Desertification
Temporary	Drought	Water Shortage

Water Stress

Aridity

natural imbalance of water availability characterising the climatic conditions of a region

Drought

natural but temporary imbalance of water availability caused mainly by low precipitation

Drought Characteristics

- Water availability falls below a critical threshold
- Considerable time period below this threshold
- Large area affected

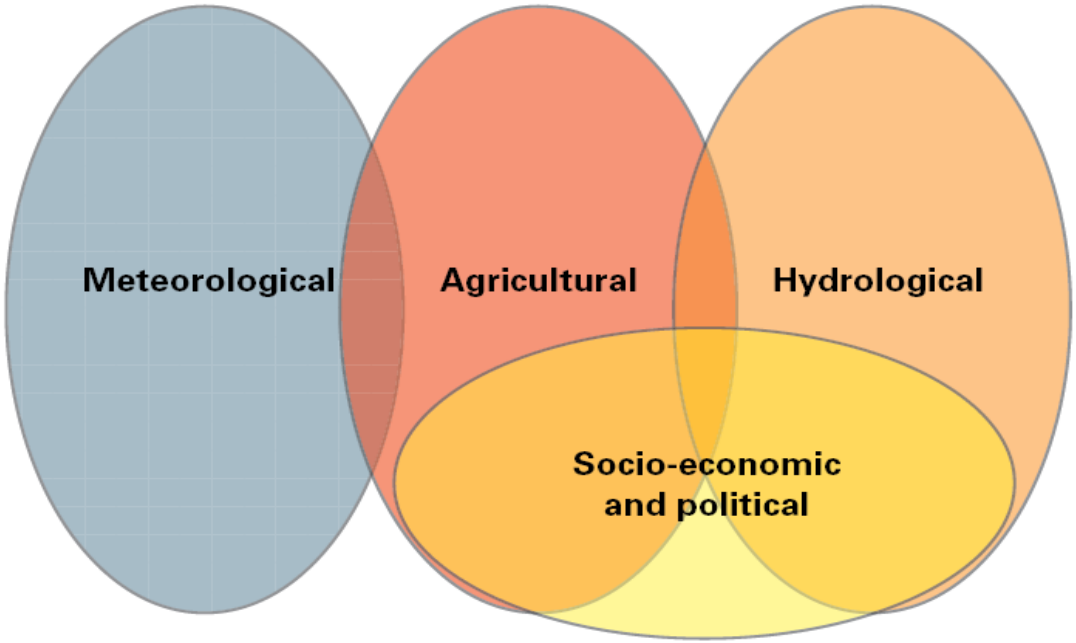
Characteristics: intensity,
total magnitude,
duration,
areal extent

Types of drought

Meteorological

Agricultural / Vegetation

Hydrological



Monitoring of Drought

Drought type	Water availability variable
Meteorological	precipitation, precipitation and evapotranspiration
Hydrological	streamflow, reservoir storage, aquifer storage
Agricultural/ Vegetation	soil moisture

Drought Indices

n	Drought Index	Abbreviation
1	Aggregate Drought Index (ADI)	ADI
2	Agricultural Drought Index	DTx
3	Anomaly of Normalized Difference Vegetation Index	NDVIA
4	Base Flow Index	BFI
5	Bhalme and Mooley Drought Index	BMDI
6	Colorado Palmer Drought Index	CPDI
7	Consecutive Dry Days	CDD
8	Corn Drought Index	CDI
9	Crop Moisture Index	CMI
10	Crop Specific Drought Index	CSDI
11	Cumulative Precipitation Anomaly	CPA
12	Cumulative Streamflow Anomaly	CSA
13	Deciles	DECILES
14	Drought Area Index	DAI
15	Drought Frequency Index	DFI
16	Drought Severity Index	DSI
17	Effective Drought Index	EDI
18	Evapotranspiration Deficit Index	ETDI
19	Foley Drought Index	FDI
20	Global Vegetation Water moisture Index	GVWI

Drought Indices

Soil Water Balance

PDSI - Palmer Drought Severity Index

Precipitation

SPI - Standardized Precipitation Index

Precipitation & Evapotranspiration

RDI - Reconnaissance Drought Index

SPEI - Standardized Precipitation and Evaporative Index

Reconnaissance Drought Index (RDI)

- Incorporates precipitation and potential evapotranspiration (PET)
- Suitable for use in climate change conditions
- Temperature methods for estimating PET are considered sufficient for the calculation of RDI, in several regions
- Appropriate for the assessment of meteorological and agricultural drought
- Potential use:
  - early estimation of drought impacts on crop yield
  - planning and taking supporting measures (e.g., timely arrangement of imports) against drought in the agricultural sector ensuring food security
  - supporting insurance companies and related organisations for covering the production losses of the affected farmers

Reconnaissance Drought Index (RDI)

Initial value of RDI (α)

$$\alpha_k^{(i)} = \frac{\sum_{j=1}^{k} P_{ij}}{\sum_{j=1}^{k} PET_{ij}} \quad , i=1(1)N \text{ and } j=1(1)k$$

Standardised RDI (RDI_{st})

Gamma distribution

$$RDI_{st}^{(i)} = \frac{y^{(i)} - \bar{\mu}}{\hat{\sigma}} \quad , \text{where } y^{(i)}=ln(RDI_n^{(i)})$$

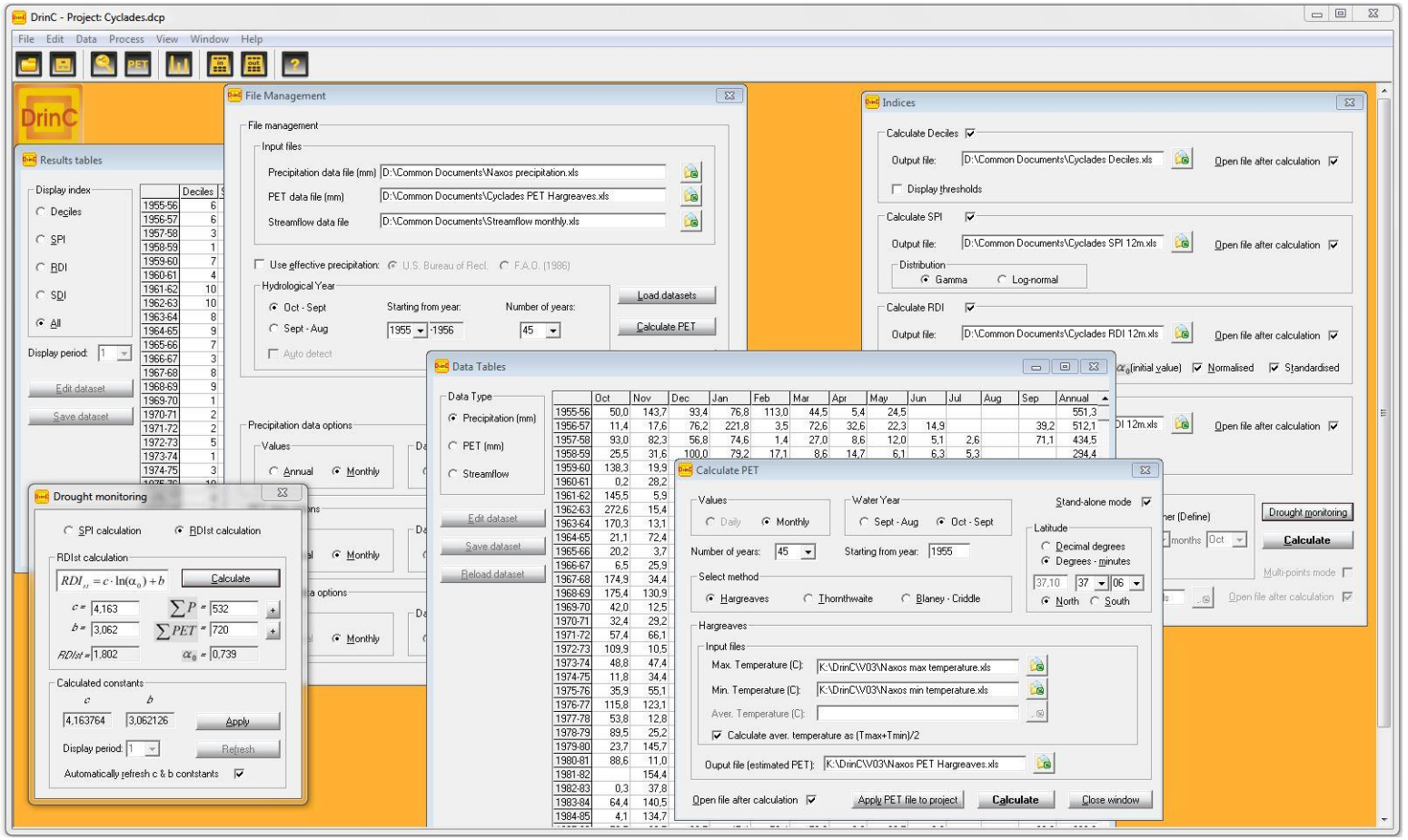
Composite cumulative distribution function:

$$H(x) = q + (1-q)G(x)$$

RDI_{st} value	Category
2.00 or more	Extremely wet
1.50 to 1.99	Severely wet
1.00 to 1.49	Moderately wet
0 to 0.99	Normal conditions - wet
0 to -0.99*	Normal conditions - dry
-1.00 to -1.49	Moderate drought
-1.50 to -1.99	Severe drought
-2 or less	Extreme drought

** values from -0.50 to -0.99 may be considered as a different category characterized as 'Mild drought'*

DrinC software



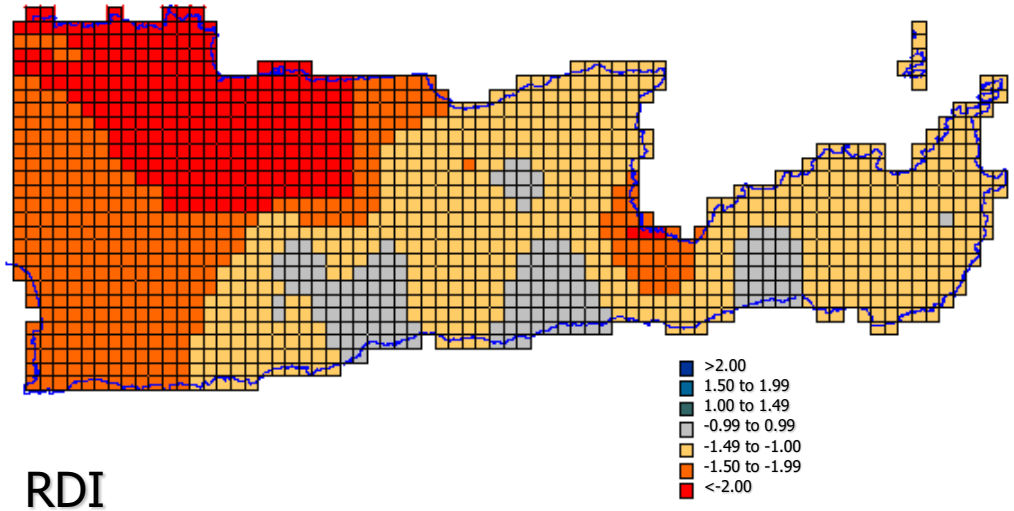
http://drinc.ewra.net

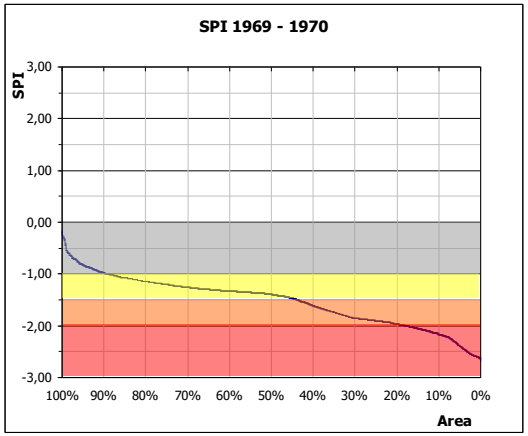
National Technical University of Athens

Centre for the Assessment of Natural Hazards and Proactive Planning

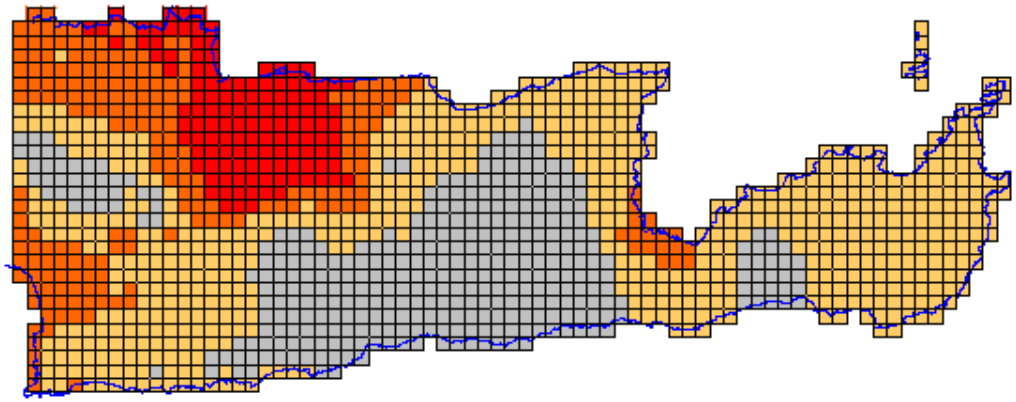
Monitoring Drought

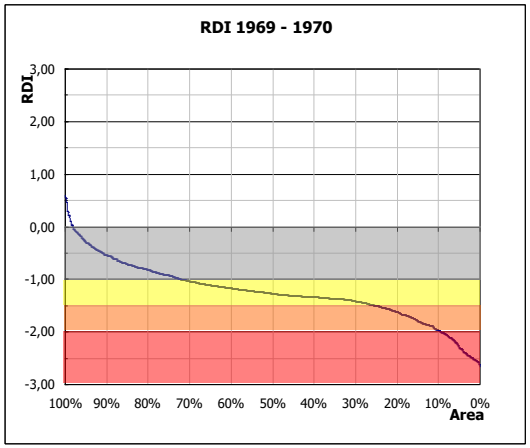
SPI





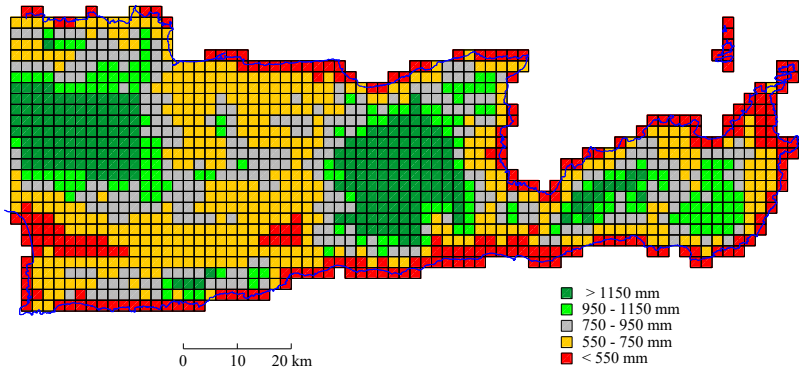
RDI



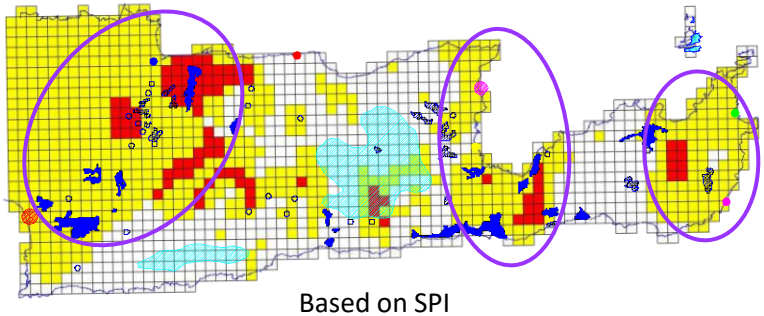


Drought Prone Areas

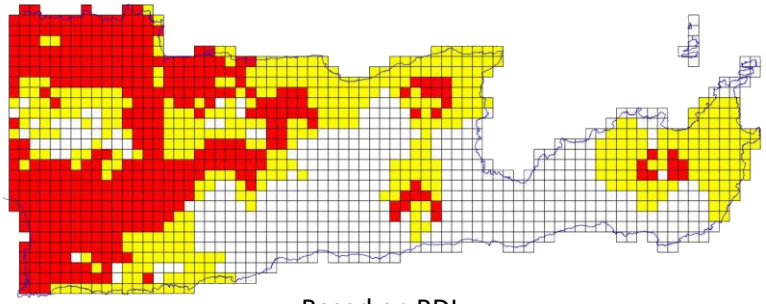
Distribution of Mean Annual Precipitation



Drought Prone Areas



Based on SPI



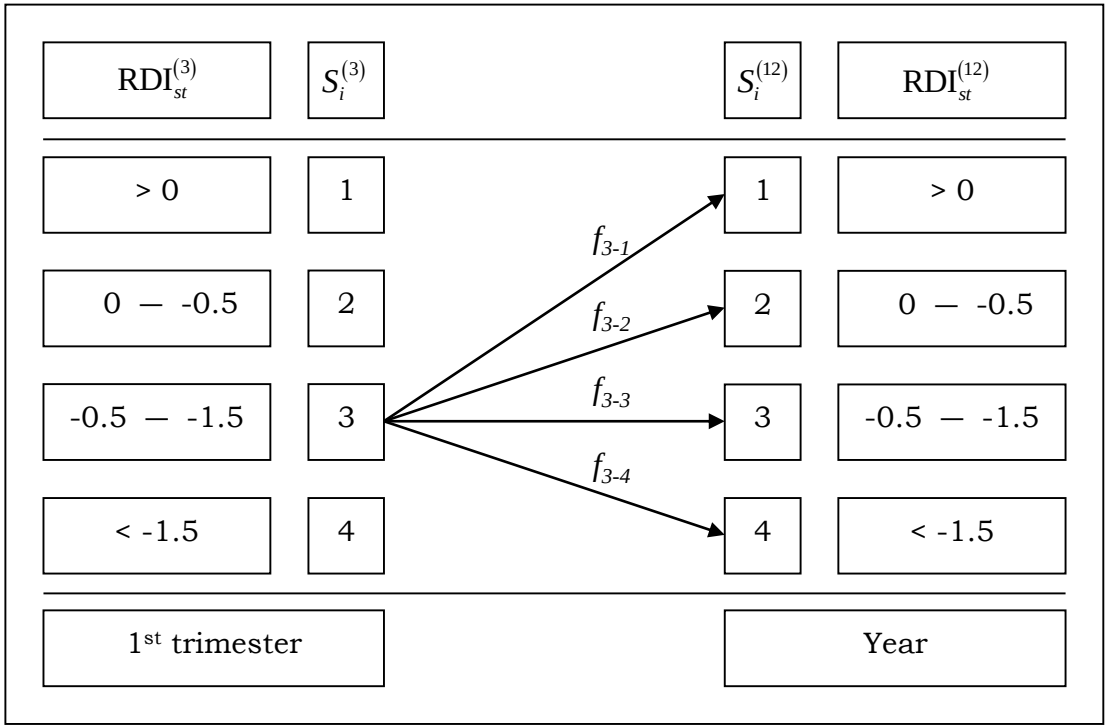
Based on RDI

Forecasting System

$$S_i^{(3)} = \left\{ \text{class of } \mathrm{RDI}_{\mathrm{st}}^{(3)}(i) \right\} \qquad i = 1(1)4$$

Transition probabilities

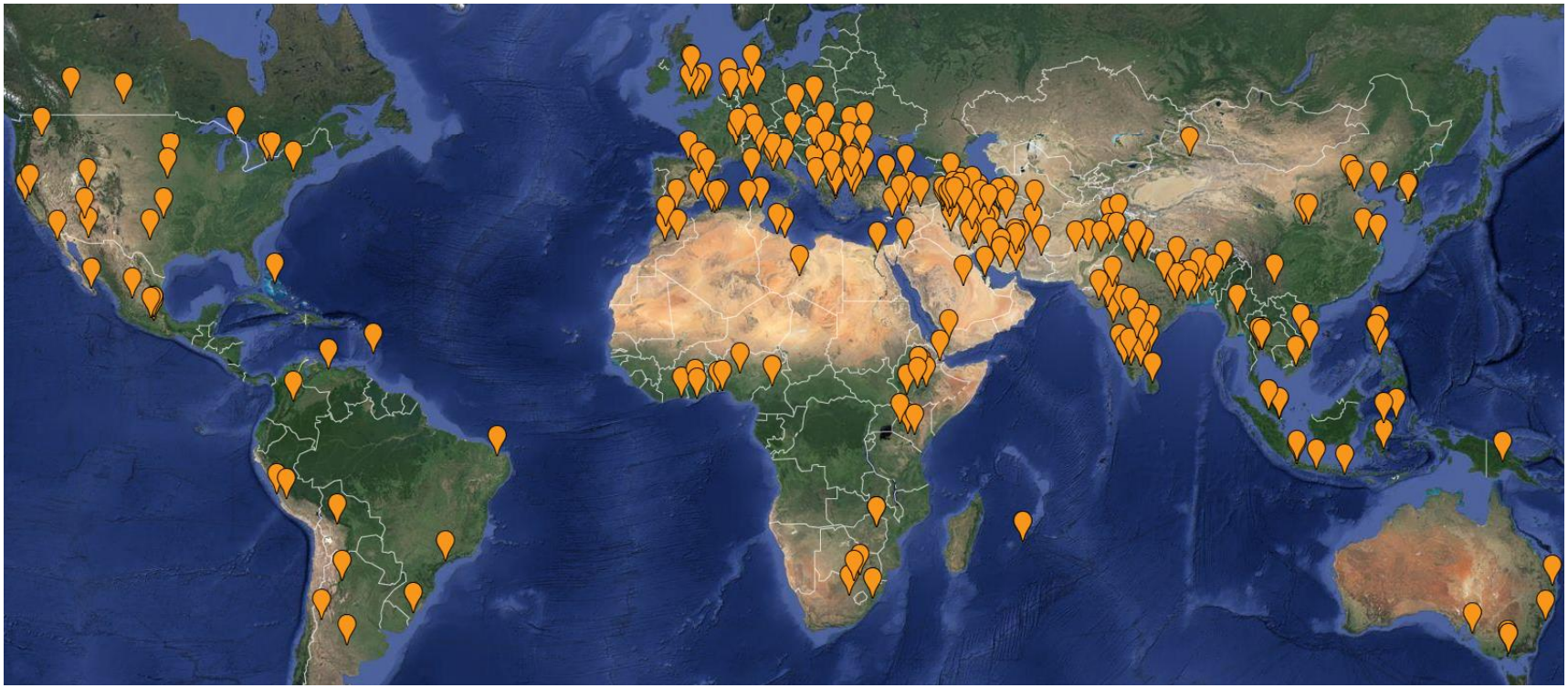
$$\begin{matrix} f_{1-1} & f_{1-2} & f_{1-3} & f_{1-4} \\ f_{2-1} & f_{2-2} & f_{2-3} & f_{2-4} \\ f_{3-1} & f_{3-2} & f_{3-3} & f_{3-4} \\ f_{4-1} & f_{4-2} & f_{4-3} & f_{4-4} \end{matrix}$$



$$\sum_{i=1}^{4} f_{1-i} = \sum_{i=1}^{4} f_{2-i} = \sum_{i=1}^{4} f_{3-i} = \sum_{i=1}^{4} f_{4-i} = 1$$

Assessing Drought Severity

DrinC (PDSI, Deciles, SPI, RDI, - eRDI)



Impacts of Droughts

Drought hazard

Vulnerability of affected system

System drought risk

Impacts → Economic; Environmental; Social

Impacts → Direct or indirect; Immediate or delayed; Tangible or intangible

Principal methodologies

The DPSIR framework

The Risk approach

DPSIR framework

Driver:

activity which may have an environmental impact (e.g., industry)

Pressure:

direct effect of the driver (e.g., pollution of the system)

State:

physical, chemical and biological status of the system

Impact:

effect of the pressure (e.g., fish deaths)

Response:

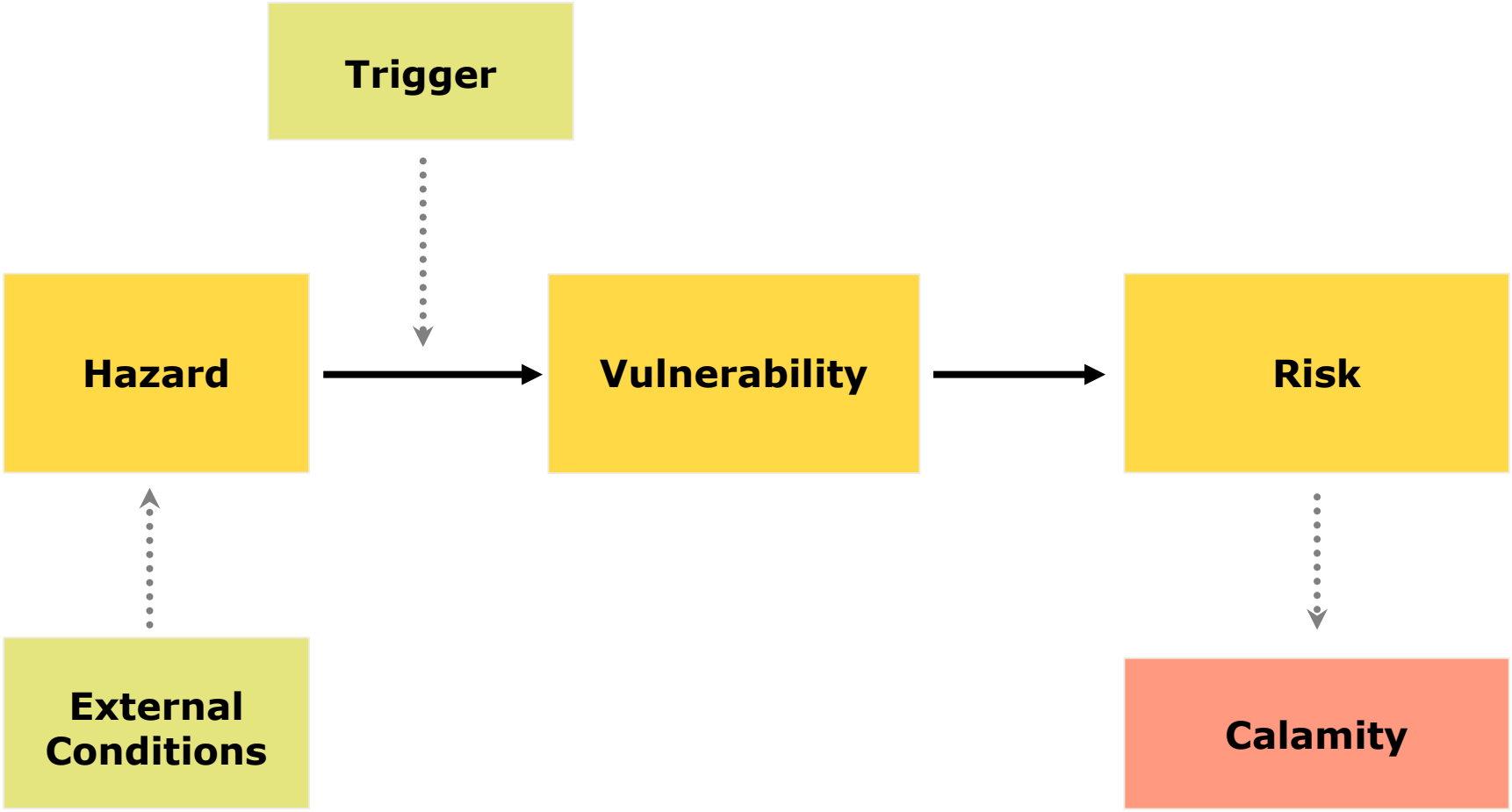
measures taken to improve the state of the system

DPSIR in Droughts

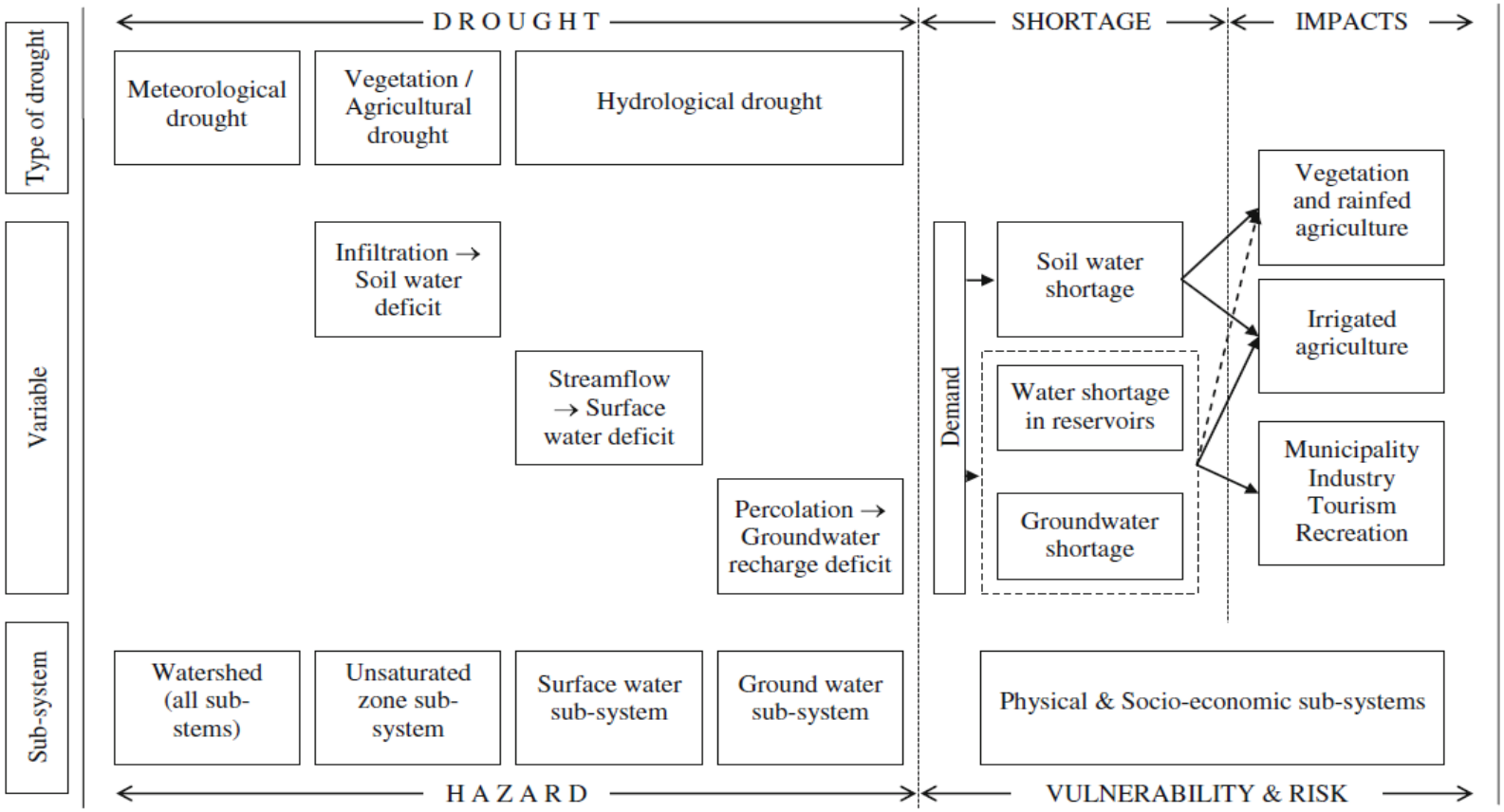
Driver – Pressure – State – Impacts – Response

Driver	Pressure	State	Impacts
Meteorological Drought	Hydrological drought	Low storage in water supply systems	Hardship (municipalities) Less revenue (Industry-Tourism Irrigated agriculture)
	Agricultural drought	Low soil moisture in the root zone of the crops	Less production Less revenue (Rainfed agriculture)

Risk Approach



Drought and Water Shortage Risk Analysis



Annualised Risk Assessment

annualised risk

$$R(D) = \int_0^T x \cdot V(x) \cdot f_D(x) dx$$

in which V(x) is a 1-1 function between 1 and 0
x is the potential consequence
f(x) is the relative frequency of occurrence

Tasks & Options to Combat Drought

- **Severity Assessment – Transparency**
- **Demand Reduction Measures**
- **System Improvements**
- **Emergency Water Supplies**
- **Prioritisation of Water Demands**

A. Severity Assessment- Transparency

a. Frequent information of water shortage severity
b. Meetings and public discussions
c. Task force establishment
d. Analysis of demand and efficiency
e. Preparation of options and responsibilities
f. Targets in various uses
g. Official request to central government and/or EU
h. Planning of employees' vacations

B. Demand Reduction Measures (1)

a. Public learning campaign appeals for voluntary conservation from

i. Farmers

Industrialists

Touristic agents

Public

ii. Bounces and incentives

b. Free distribution/ installation of particular water saving devices

i. Extensive installation of water meters (in all types of systems)

ii. Low-flow showerheads

iii. Shower flow restrictions

iv. Toilet dams

v. Displacement devices

vi. Pressure-reducing valves

B. Demand Reduction Measures (2)

c. Restrictions on non essential uses:

i. Street flushing
ii. Pavement hosing
iii. Car washing
iv. Lawn sprinkling
v. Filling of swimming pools
vi. Water cooled air conditioning without re-circulation
vii. Public fountains
viii. Park irrigation
ix. Irrigation of golf courses
x. Irrigation of perennial and drought resistant crops

d. Prohibition of selected commercial and institutional uses:

i. Car washes
ii. School showers
iii. Irrigation of non important plants

B. Demand Reduction Measures (3)

e. Drought emergency pricing:

i. Irrigation water charge per volume
ii. Drought rate (special extra charge for irrigation)
iii. Drought surcharge on total water bills
iv. Summer use charge

f. Rationing programmes

i. Per area and crop allocation of irrigation water
ii. Per capita allocation of residential use
iii. Per household allocation of residential use
iv. Prior use allocation of residential use
v. Percent reduction of commercial and institutional use
vi. Percent reduction of industrial use
vii. Complete closedown of industries and commercial establishments with heavy use of water

C. System Improvements

a. **Raw water sources**

b. **Water treatment plant**

c. **Distribution system:**

   i. Reduction of system pressure to minimum possible levels

   ii. Implementation of a leak detection and repair programme

   iii. Discontinuing hydrant and main flushing

d. **Selection of individual household inspection for repairs**

D. Emergency Water Supplies (1)

a. Inter-use transfers

i. Purchase of water rights of farmers

ii. Planned reallocation of irrigation to municipal use

iii. Water trade - water banks

b. Inter-district transfers

i. Emergency interconnections

ii. Importation of water by trucks

iii. Importation of water by railroad cars

D. Emergency Water Supplies (2)

c. Cross-purpose diversions

i. Reduction of reservoir releases for hydropower production

ii. Reduction of reservoir releases for flood control

iii. Diversion of water from recreation water bodies

iv. Relaxation of minimum streamflow requirements

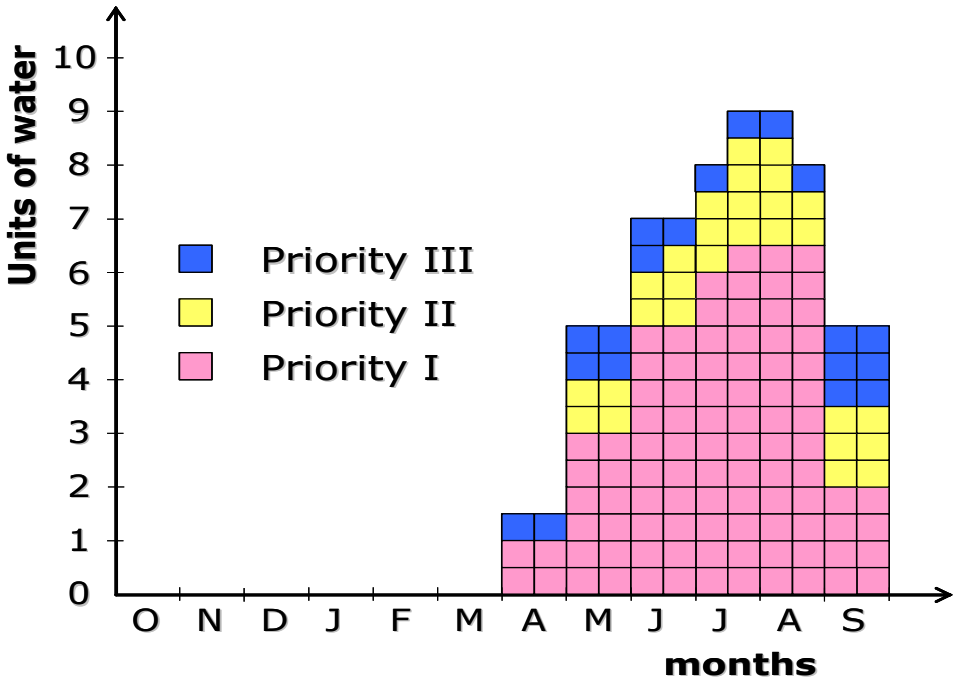
d. Auxiliary emergency sources

i. Utilization of untapped creeks, ponds and quarries

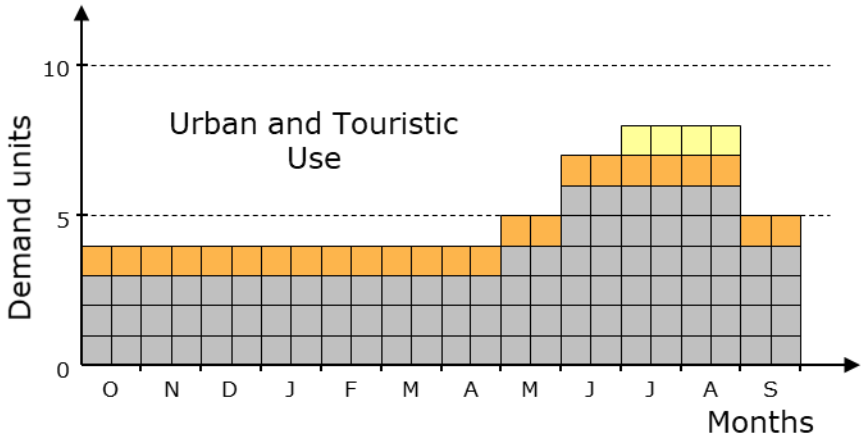
ii. Utilization of dead reservoir storage

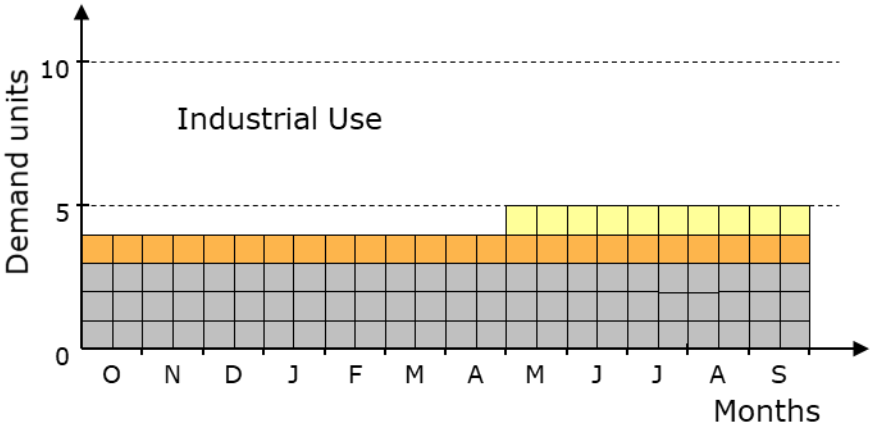
iii. Construction of a temporary pipeline to an abundant source of water (major river)

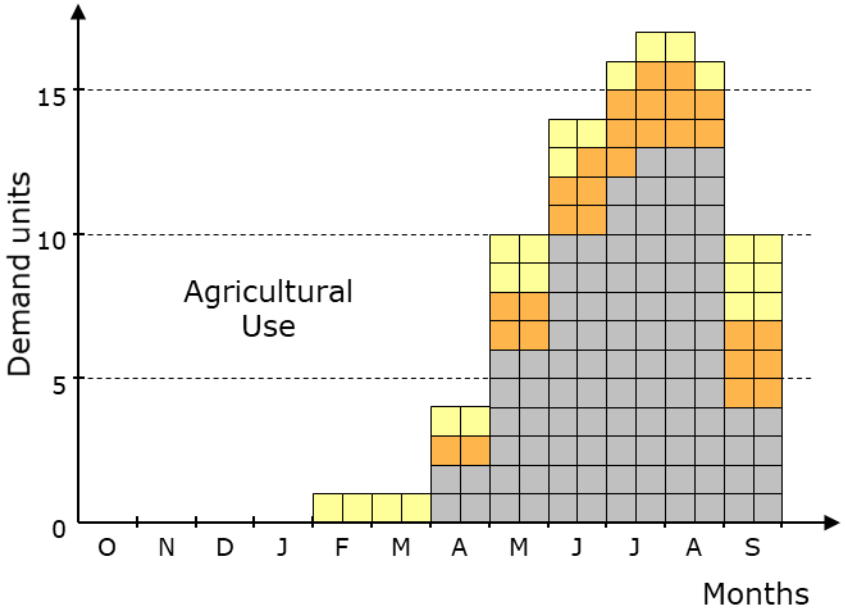
E. Prioritisation of Water Demand



Prioritisation of Water Demand







Institutional Issues

Technocratic dimension

Institutional context

Implementation process

RBOs → Special Task Force

Organisational Process

- Decentralised decisions
- Commitment of governments
- Acceptance of shared responsibilities
- Active participation of stakeholders

Concluding Remarks

- Proactive approach for combating droughts
- Comprehensive methodology:

  drought severity – system vulnerability & risk
- Tools:

  drought indices, DPSIR, annualised risk
- Organisational aspects:

  preparedness and contingency plans

  decentralised structure

  participation of stakeholders
- More systematic efforts needed in WFD implementation (2016-2021)

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Thank you for your attention.

This Project is funded by the European Union