The use of drought indices in Malta and hydrological monitoring needs

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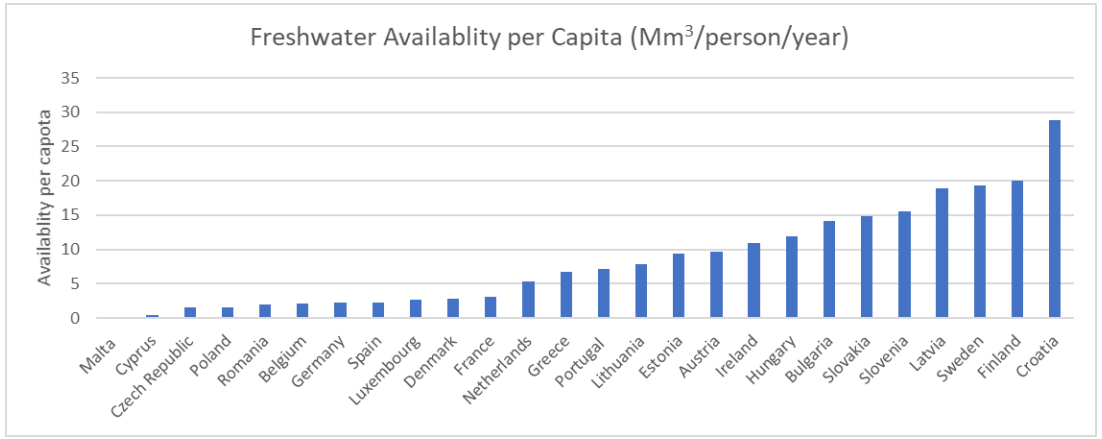
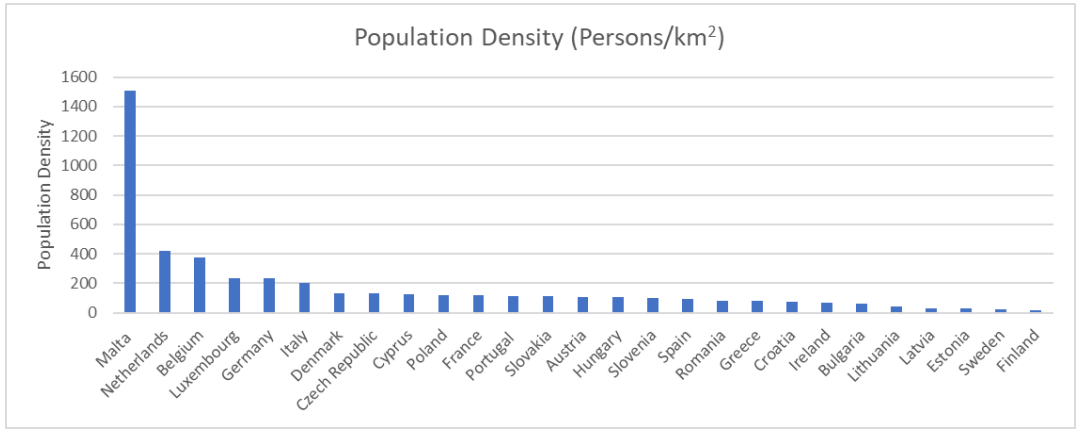
Context

- Climate: semi-arid with dry, hot summers and mild, wet winters.
- Geomorphology: small island, precludes the development of economically exploitable surface waters.
- Demography: the highest population density in the EU.

Low availability of Natural Water Resources, but high Specific Water Demand.



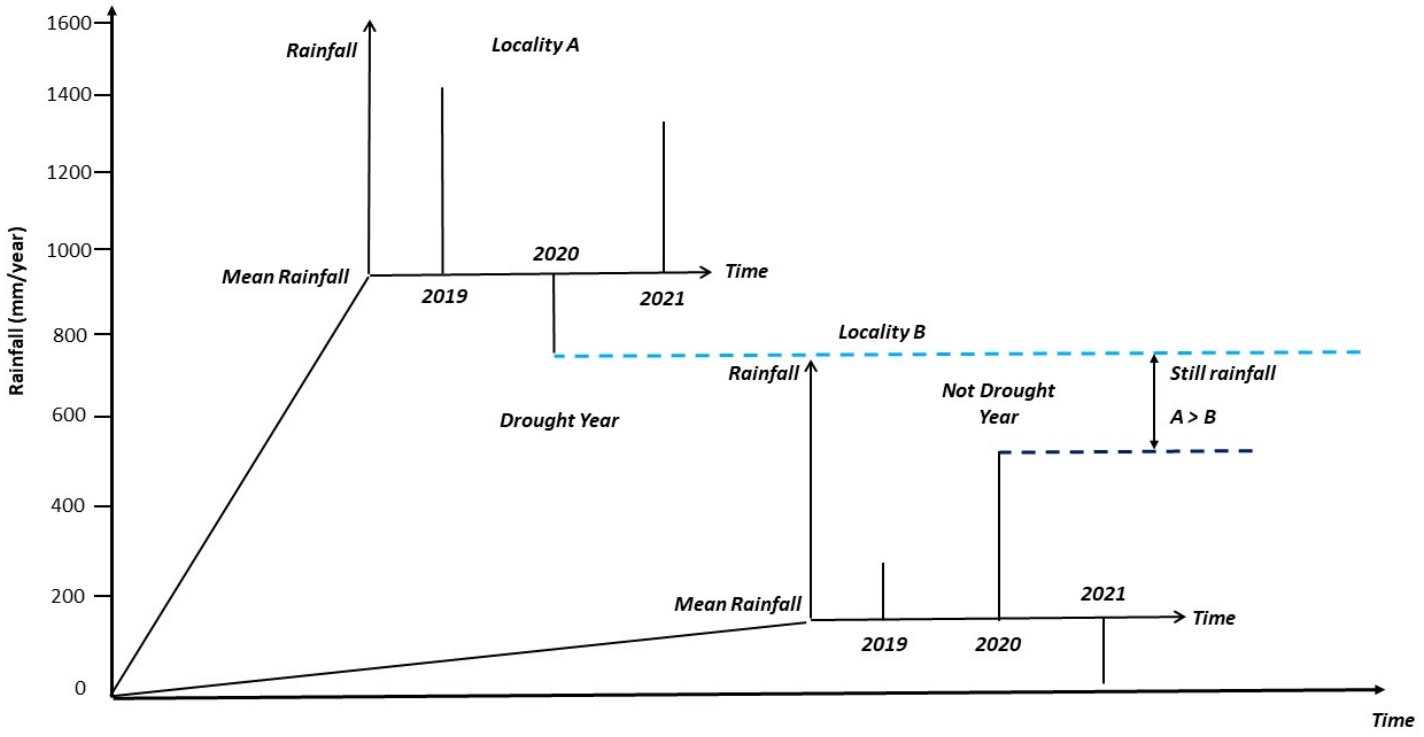


Defining Drought

Drought is defined as a negative variation from the mean annual rainfall.

But the mean annual rainfall is "relative" – and depends on the climatic conditions prevailing in different locations.

Therefore the "relativity of drought" should also be considered – extending the context of "drought" to "aridity" – chronic lack of water resources.



Meteorological Data

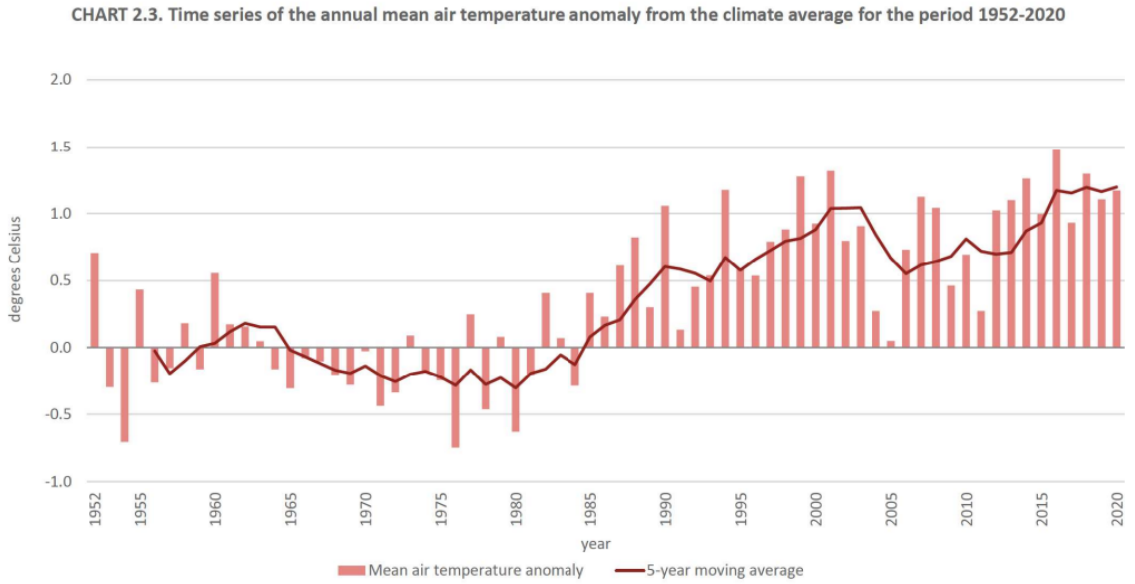
Long-term meteorological data for Malta shows:

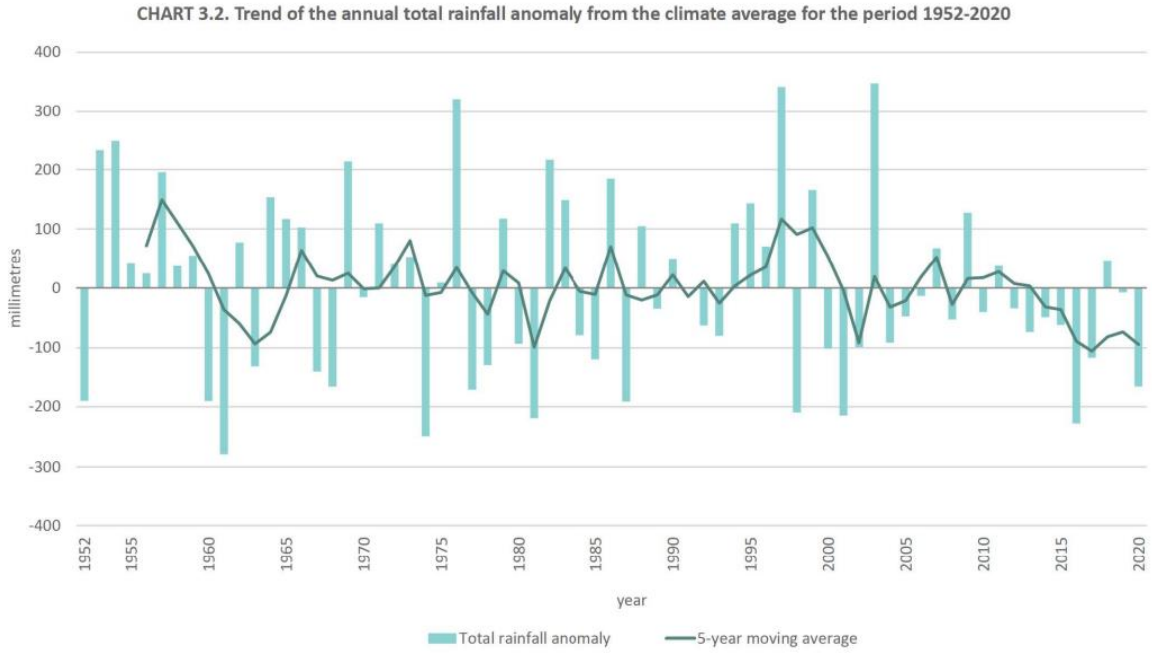
(i) Increasing temperatures, and

(ii) Decreasing annual rainfalls.

Inter-annual variability (dry years following by wet years) is being lost – and replaced by a long-succession of dry years.

Source – Galdies, C. The State of the Climate (2022)





Aridity Index – UNEP (1992)

Defined as the long-term average of annual precipitation to annual potential evapotranspiration ratio.

$$AI = \frac{P}{PET}$$

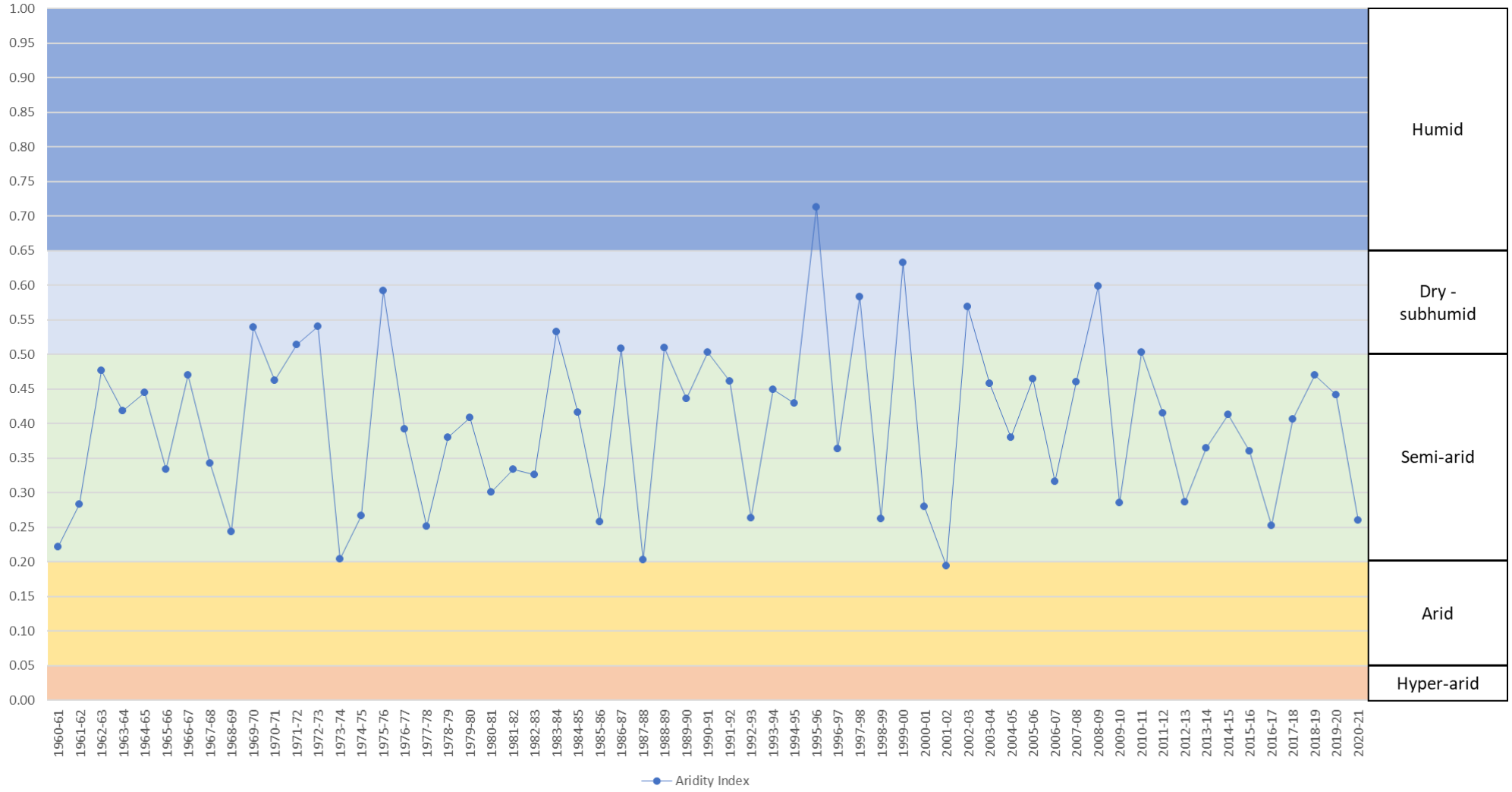
where:

PET is the potential evapotranspiration, and

P is the average annual precipitation.

State	Criterion
Humid	AI ≥ 0.65
Dry - subhumid	0.50 ≤ AI < 0.65
Semi-arid	0.20 ≤ AI < 0.50
Arid	0.05 ≤ AI < 0.20
Hyper-arid	AI < 0.05

Malta – Annual Aridity Index 1960 - 2021



Standardized Precipitation Index (SPI)

The SPI is a drought index representing the probability of occurrence of an observed rainfall amount when compared with the rainfall climatology at a certain geographical location over a long-term reference period.

Negative SPI values represent rainfall deficit. Intensity of drought events can be classified according to the magnitude of negative SPI values.

Drought conditions usually are associated with SPI values of less than –1.0 or less.

State	Criterion
Extremely Wet	SPI ≥ 2.0
Very Wet	1.5 ≤ SPI < 2.0
Moderately Wet	1.0 ≤ SPI < 1.5
Near Normal	-1.0 ≤ SPI < 1.0
Moderately Dry	-1.5 ≤ SPI < -1.0
Severely Dry	-2.0 ≤ SPI < -1.5
Extremely Dry	SPI < -2.0

Reconnaissance Drought Index (RDI)

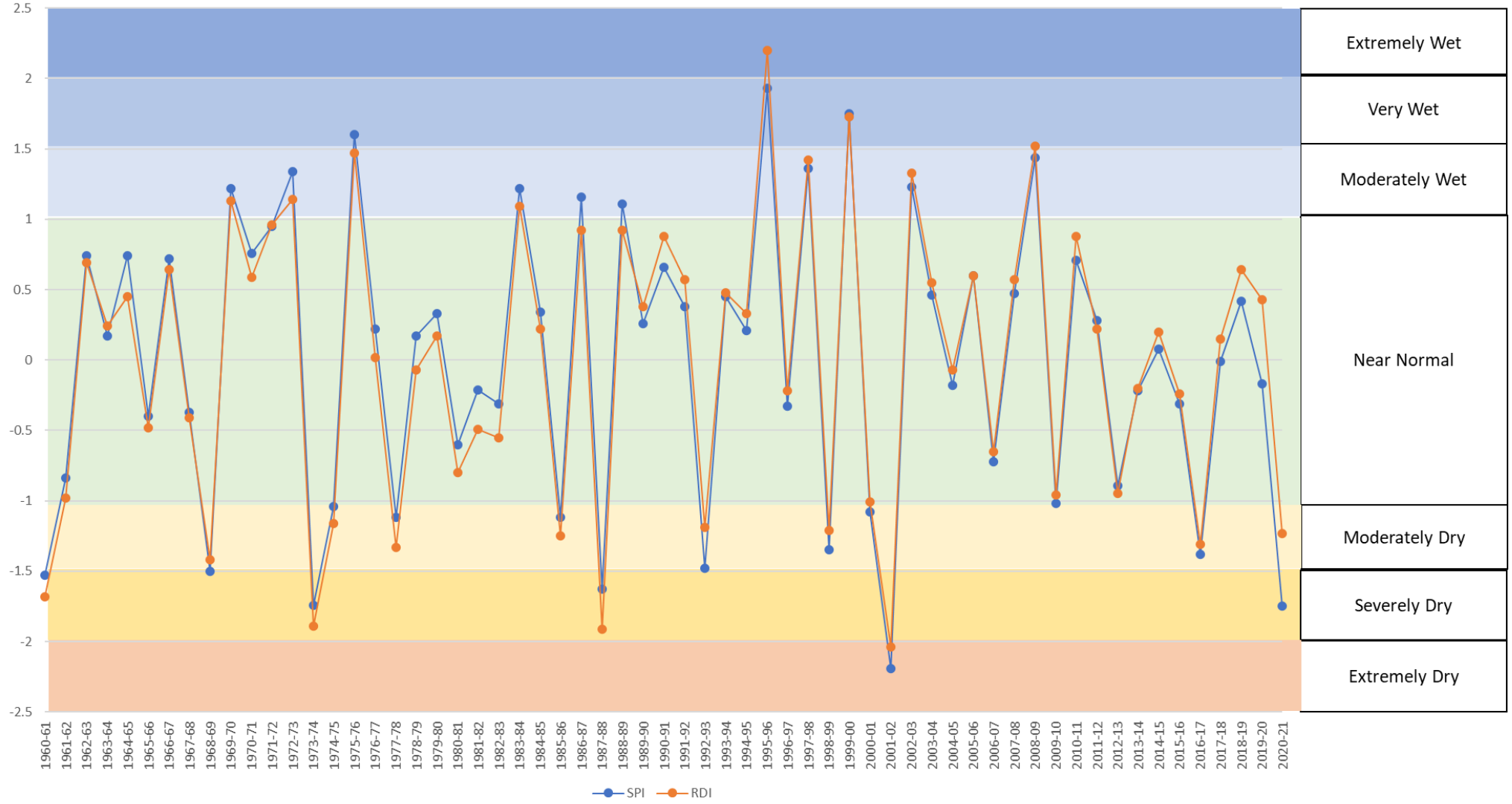
The RDI works on a simplified water balance equation considering precipitation and potential evapotranspiration (PET) on a reference time scale.

The RDI is considered as more representative than the SPI, as it also considers a more comprehensive water balance rather than just precipitation.

Similar to SPI, the RDI index can be utilised to categorise the drought status of a particular region. Negative RDI values of -1.0 or greater usually indicate dry periods.

State	Criterion
Extremely Wet	RDI ≥ 2.0
Very Wet	1.5 ≤ RDI < 2.0
Moderately Wet	1.0 ≤ RDI < 1.5
Near Normal	-1.0 ≤ RDI < 1.0
Moderately Dry	-1.5 ≤ RDI < -1.0
Severely Dry	-2.0 ≤ RDI < -1.5
Extremely Dry	RDI < -2.0

Malta – Annual SPI &RDI 1960 - 2020

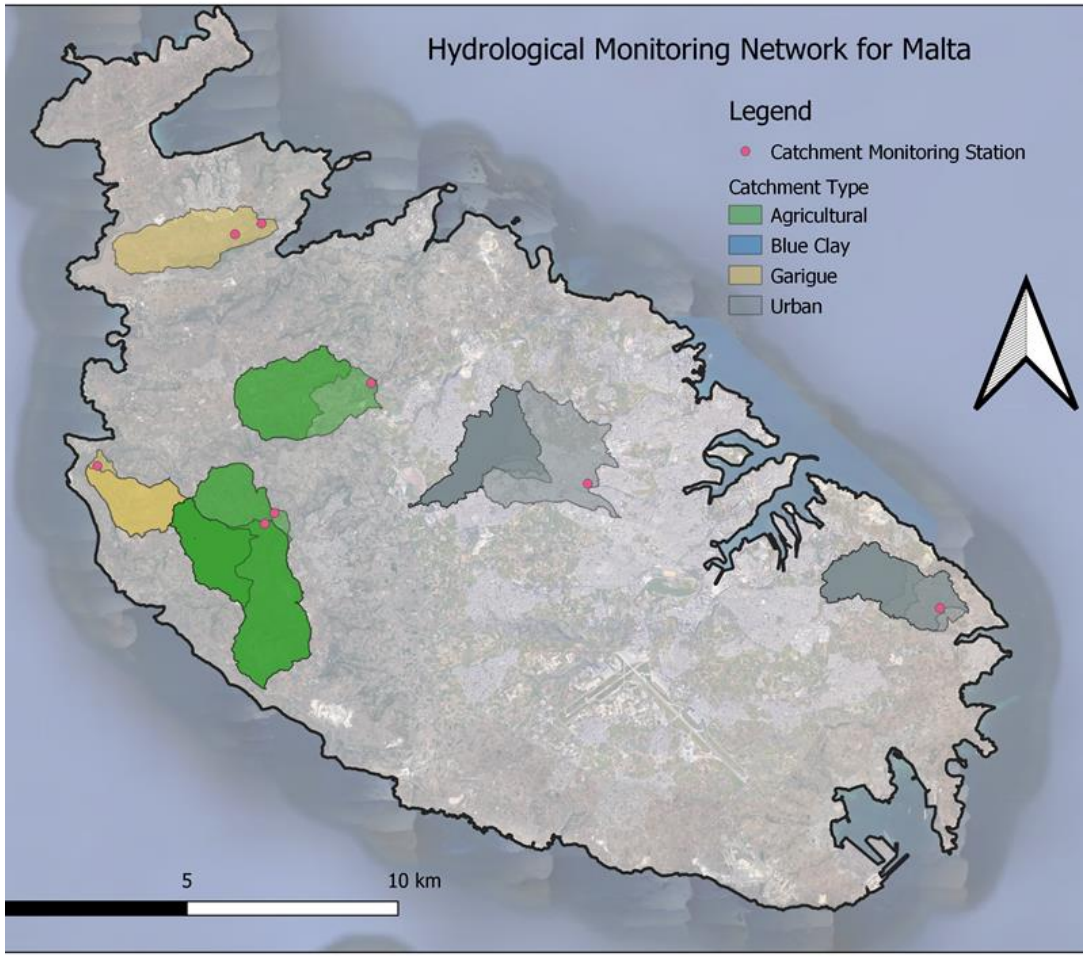


Additional Monitoring

Development of a catchment-based monitoring network at 6 representative catchments.

The objective of this network is to provide measured information on rainfall, runoff, windspeed, solar radiation and evaporation within each catchment.

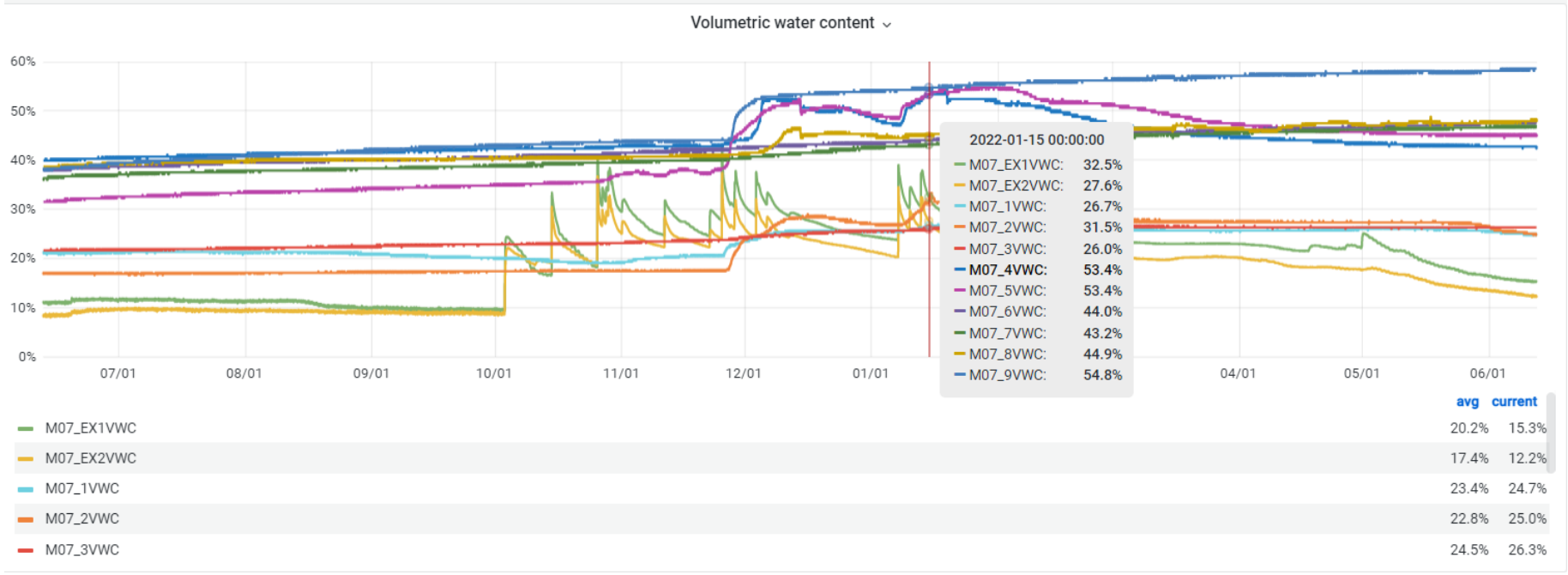
This will allow for a reliable assessment of the relationship between rainfall, runoff, evapotranspiration, and recharge



Additional Monitoring

Catchment monitoring will be complemented by an “Unsaturated Zone Monitoring Network” measuring water flux in the unsaturated zone.

Supplementary monitoring to monitor recharge, and of particular importance given the changing rainfall patterns towards a prevalence of high intensity rain events.



Additional Indicators – WEI+

Limitations of WEI+ as an indicator:

- Lack of consideration of NCWR (make up app. 50% of Malta's water resource base), and
- other technical issues, such as consideration to groundwater coastal discharge in coastal areas.

$$WEI^{+} = \frac{\text{abstraction} - \text{returns}}{\text{renewable water resources} - \text{environmental flow}}$$

Further limitations arise when applied at a seasonal level. Semi-arid climates have extremely dry summers, with no water inflows (precipitation). WEI+ should have an "infinite" value.

The 40% EEA threshold is simply not attainable under these conditions.

Parameter	LTAA	2019
Precipitation (hm^3)	174	170
Actual Evapotranspiration (hm^3)	109	107
Renewable Water Resources (hm^3)	65	63
Natural Subsurface Discharge (hm^3)	24	24
Unrecoverable Surface Runoff (hm^3)	4	4
Actual available Water Resources (hm^3)	37	35
Total Abstraction / Utilisation (hm^3)	38	41
Returned Water (hm^3)	12	11
WEI+	78%	89%

Conclusion

Looking forward to a discussion within EDORA which goes beyond “droughts” and addresses “water scarcity” from the perspective of chronic, long-term unavailability of water resources.

Discussion should explore options for including considerations to “arid” and “semi-arid” climates in water management frameworks in the EU – and hence go beyond “prolonged drougths”.

Therefore we need an analytic framework which enables a broad consideration of “water scarcity” ranging from lowering water levels in rivers to the prolonged and even permanent unavailability of water resources.