The importance of the desalination process in an arid country: The Maltese Islands case study

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EUROSAI
Working Group on Environmental Auditing

Agenda

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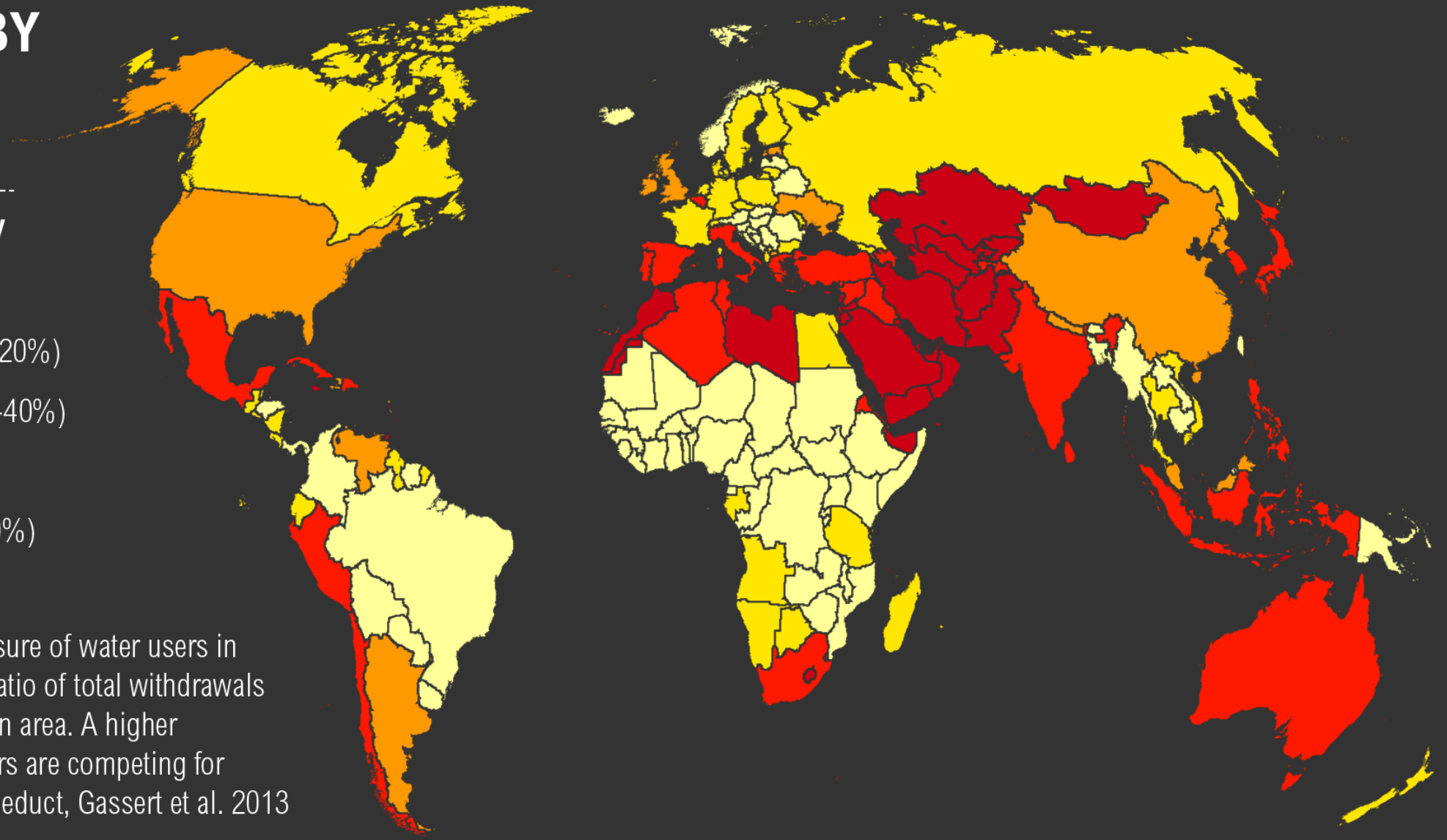
WATER STRESS BY COUNTRY

ratio of withdrawals to supply

- Low stress (< 10%)
- Low to medium stress (10-20%)
- Medium to high stress (20-40%)
- High stress (40-80%)
- Extremely high stress (> 80%)



This map shows the average exposure of water users in each country to water stress, the ratio of total withdrawals to total renewable supply in a given area. A higher percentage means more water users are competing for limited supplies. Source: WRI Aqueduct, Gassert et al. 2013

AQUEDUCT

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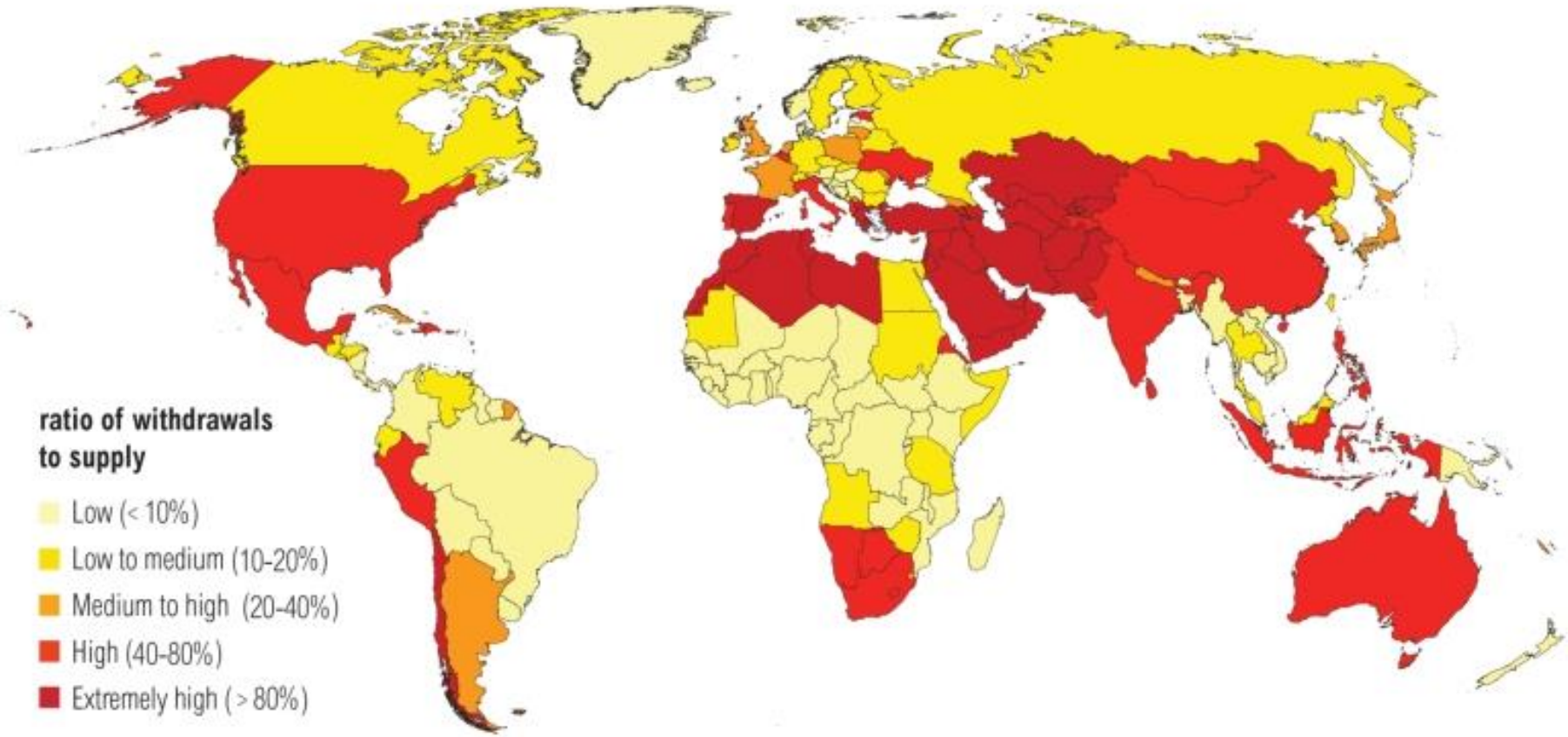
Water Stress by Country: 2040



NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

For more: ow.ly/RiWop

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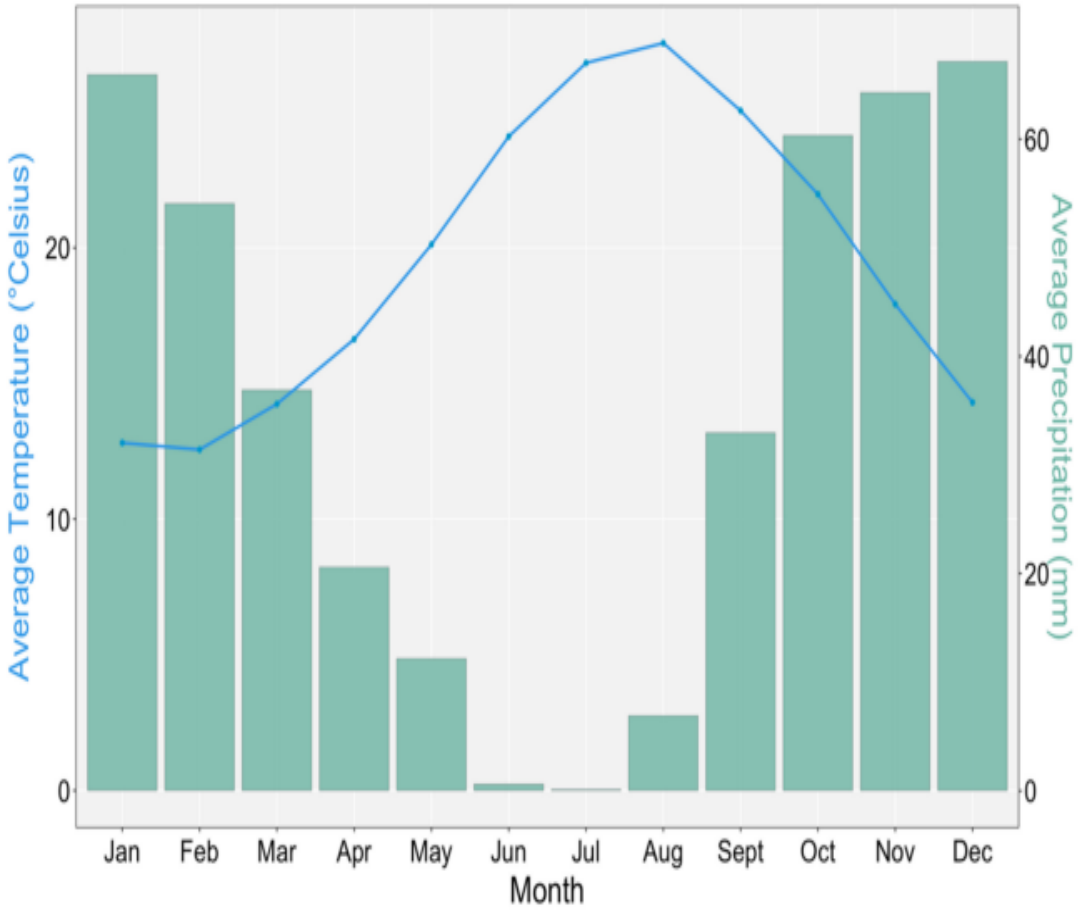


Malta:

- ranked as one of the most water-stressed countries in the world, with second highest population density (on a national scale) in the world, following Singapore (compounded by ca. 2.5 million annual tourists, pre-COVID era)
- semi-arid country, with an average annual rainfall of 520-550mm and an average of 60 rainy days during a year
- significant fluctuation in annual precipitation total, with the mean annual total only being reached in 4 of the last 5 years
- considerable volume of precipitation lost to the sea through runoff (low degree of retention) as a result of soil sealing
- no permanent water bodies

Malta – anatomy of a ‘thirsty’ maritime republic

- Malta’s pre-COVID era tourism flows equivalent to a resident population of 40,000
- The non-Maltese resident worker population (50,000) has also to be factored in
- Average Maltese daily freshwater consumption = 110litres (below European average), whilst visiting tourists are accustomed to using in excess of a daily 250 litres
- In Malta, the price for domestic residential users is already on the high side: users pay EUR 1.39 per cubic metre for the first 33 cubic metres per year. When that quantity is exceeded, the price increases to EUR 5.14 per cubic metre. So this rising block tariff mechanism is an incentive in itself to limit water consumption.

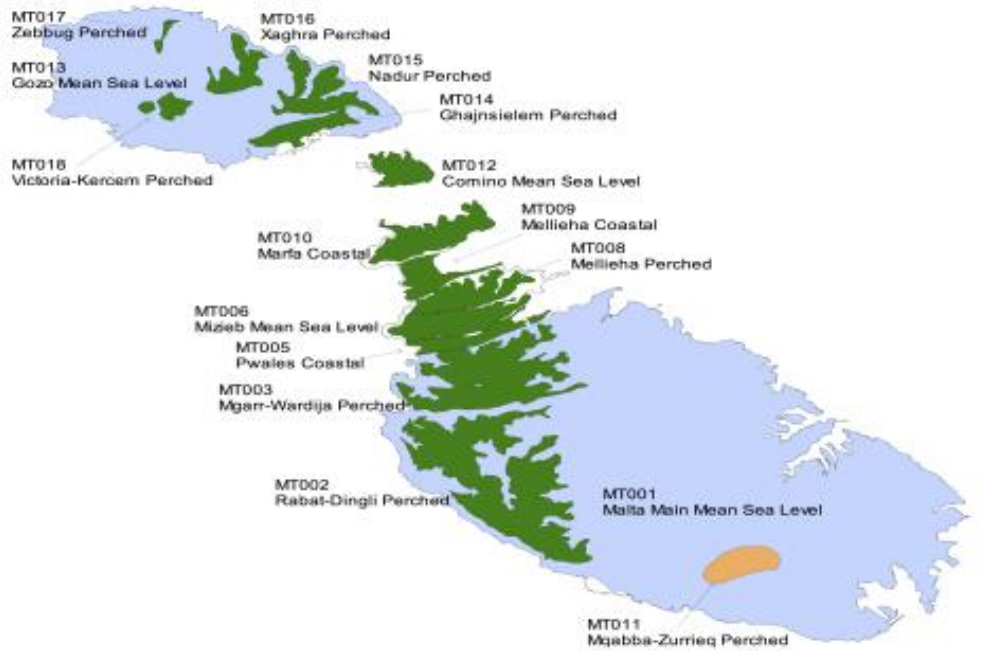
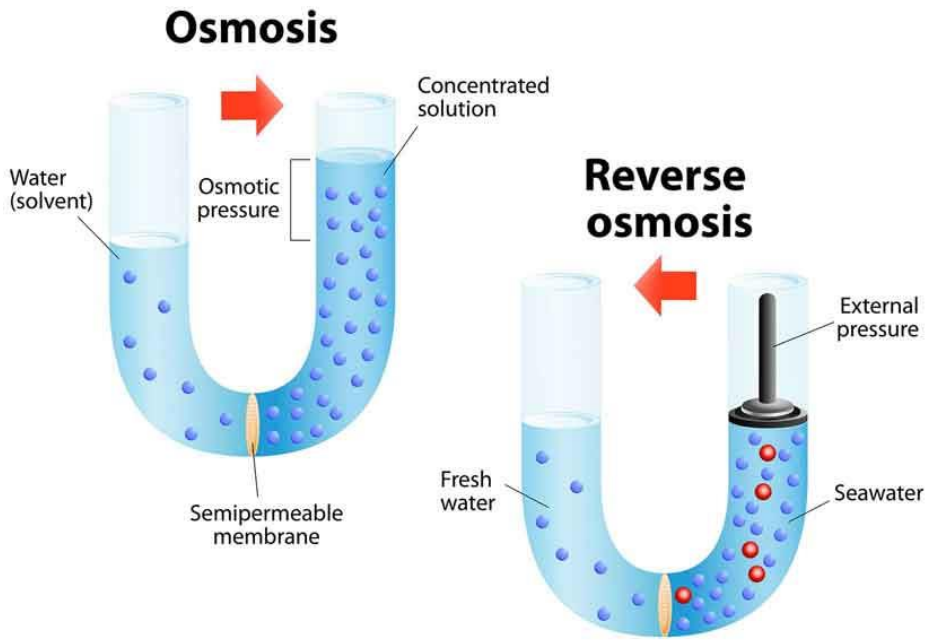
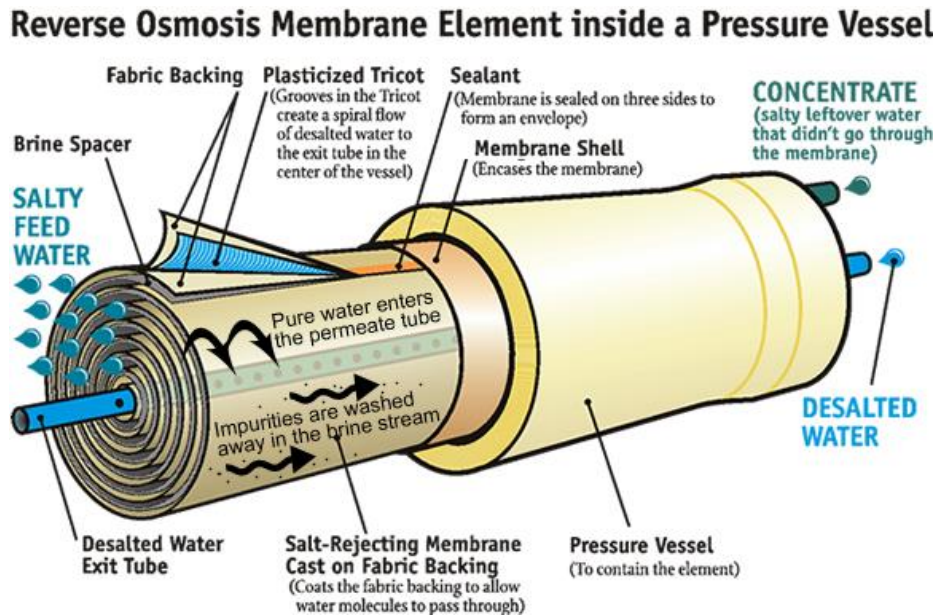


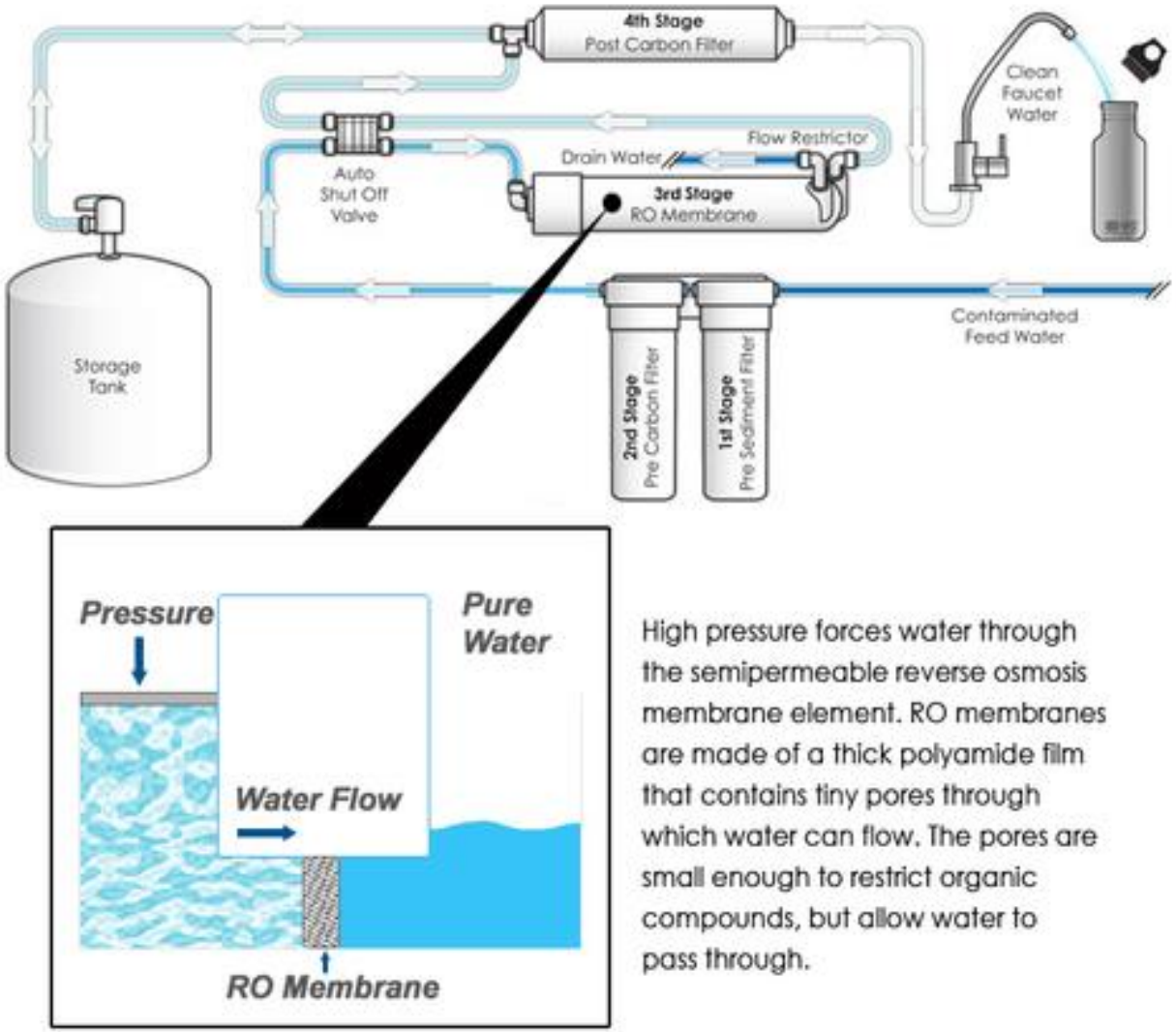
Figure 1: Groundwater bodies found in the Maltese Islands (Copyright ©2014 Malta Resources Authority; reproduced with permission).

Studies estimate that the maximum sustainable annual extraction total for groundwater in Malta stands at 23 million cubic metres (private borehole extraction is an issue), but current extraction estimated to be in excess of 34 million cubic metres.

Reverse osmosis in the spotlight







High pressure forces water through the semipermeable reverse osmosis membrane element. RO membranes are made of a thick polyamide film that contains tiny pores through which water can flow. The pores are small enough to restrict organic compounds, but allow water to pass through.

Replicated within domestic RO systems

Reverse osmosis in the spotlight

sustainability

MDPI

Review

Malta's Water Scarcity Challenges: Past, Present, and Future Mitigation Strategies for Sustainable Water Supplies

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The three main Reverse Osmosis plants in operation in Malta are located in Ghar Lapsi, Cirkewwa, and Pembroke, which have been strategically located so that in the event of an oil spill, only one would need to be closed down.

These were designed with capacities of 20,000, 18,600, and 54,000 m3 /day, respectively, and were installed from 1981 to 1994. These plants had recovery rates (the amount of water that goes to be used versus discharged as brine) of 33%, 42%, and 45%, respectively, as of 2004.

Latest RO plant (south-east Gozo) was reactivated in 2021 (daily capacity of 9000m^3) to decrease Gozo's water dependence on groundwater and a submarine supply from Malta

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Reverse osmosis in the spotlight

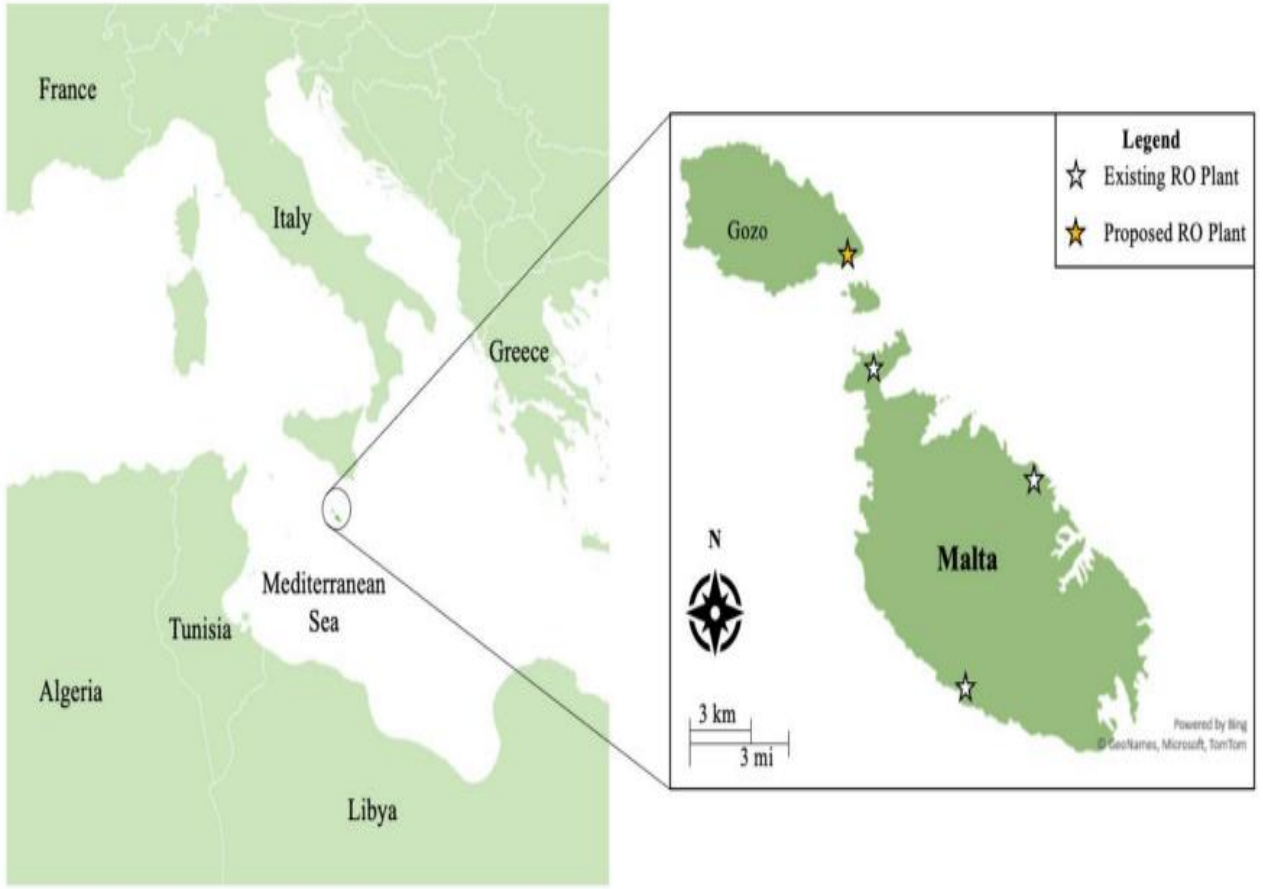
- Water production in Malta in 2015:
- Total = 31.2 million cubic metres, of which:

- 18 million cubic metres (57.5% of total) – through RO plants
- 13.2 million cubic metres (42.5% of total) – from groundwater sources

- Deteriorating quality of groundwater (nitrates from agriculture, salinization from over-extraction) has meant a greater reliance on RO for water production

- Around 4% of electrical energy generated on the islands is used to power four coastal RO plants

- High-grade RO water blended with groundwater (‘polishing’) and stored in 24 large reservoirs around the islands prior to distribution



Reverse osmosis in the spotlight

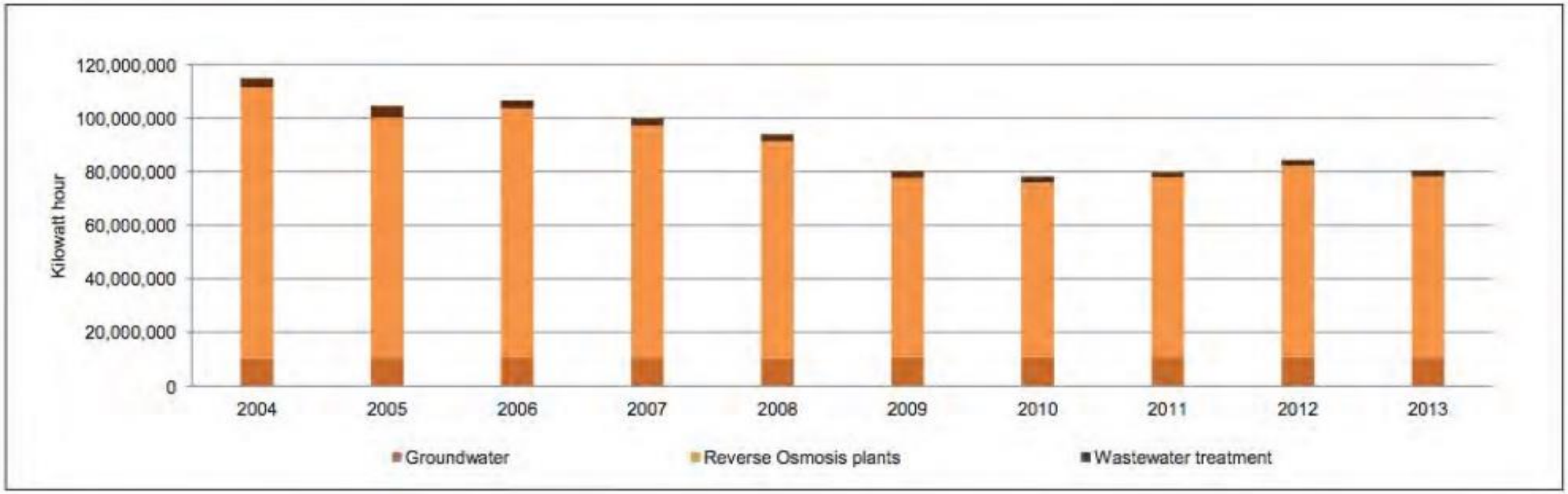


Figure 2: Electricity consumption of water production sources (Copyright ©2014 National Statistics Office, Malta (NSO); reproduced with permission).

RO = an **energy-intensive process** (as high as 7.0kWh/m^3 water in the mid-90s; in 2015, this stood at 4.6kWh/1m^3 of water and was reduced in 2018 to 2.8kWh/1m^3 of water); conversion of treated sewage into second-class water consumes ca. 1.5kWh/m^3 of water whilst extraction of groundwater consumes <1.0kWh/m^3 of water)

Environmental impacts of desalination

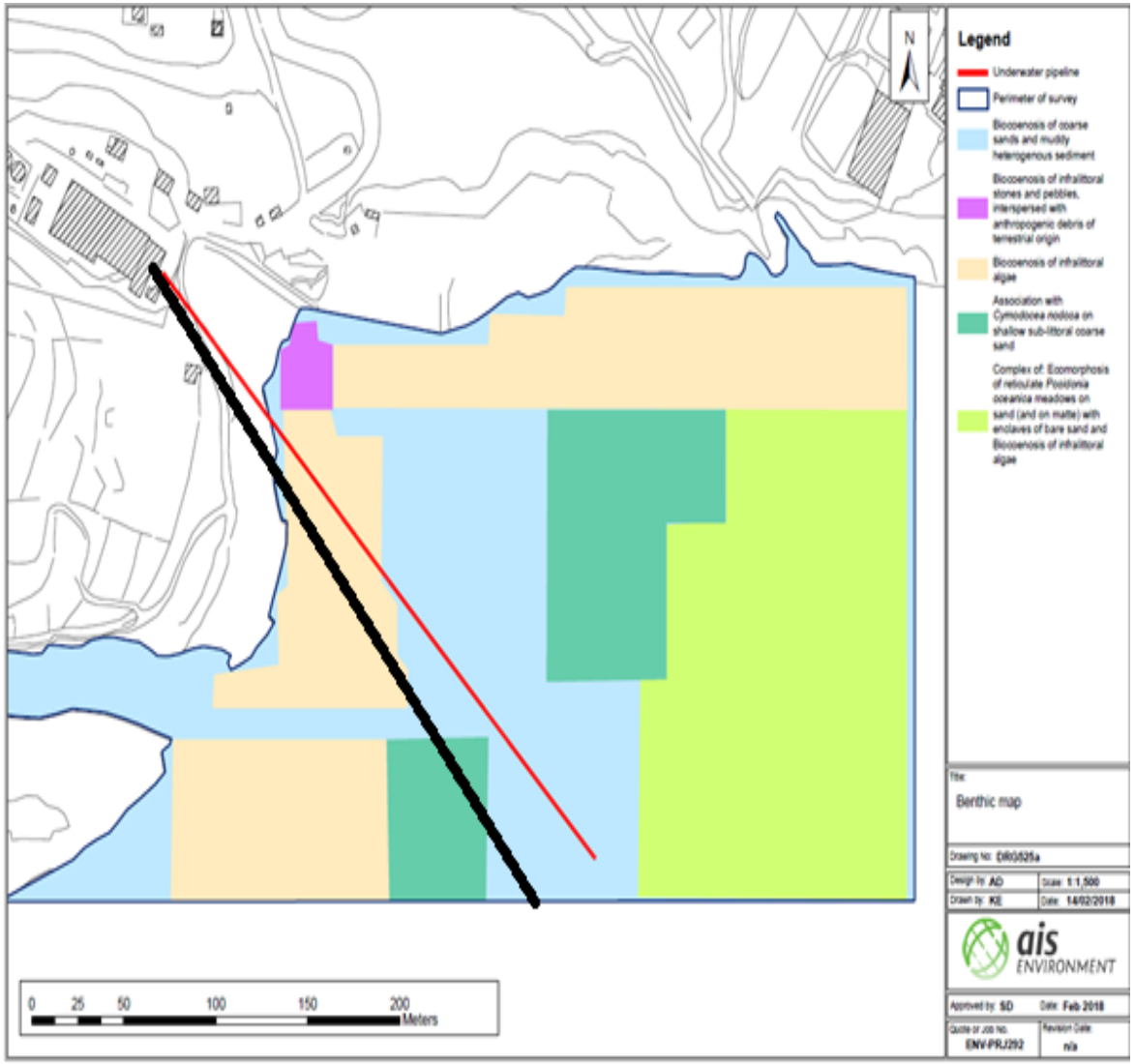
Environmental impacts are limited (especially when compared to other less strategically-important activities) and include:

- During desalination plant construction phase – ecological impact on coastal natural communities through the footprint of the RO plant infrastructure;
- During operational phase – discharge of hypersaline brine into the surrounding marine environment.
- During operational phase – release of a number of contaminants, including:

1. anti-scalants used to clean desalination plant membranes
2. anti-fouling compounds used to reduce fouling of discharge piping and
3. copper as a result of the use of copper-nickel alloys in plant condensers

Mitigating the impacts……

- Placing/siting RO plant bring discharge point within a well-flushed location (strong hydrodynamism/currents – e.g. within a channel)
- Opting for a shallow (30-45 degrees) brine discharge angle with multiple diffusers, to facilitate diffusion of the brine
- Extending submarine discharge pipeline length to avoid sensitive benthic habitats



Other points to ponder….

- Focus on cutting down domestic leakages (through free provision of tap-associated devices) and leakages through the distribution network – very effective. For example, the leakages have been reduced from an estimated 2692 m3 hr−1 in 1995 to 650 m3 hr−1 in 2007, representing a great deal of progress, with an estimated 300 m3 hr−1 of unavoidable leakages. These leakages have been further reduced to 395 m3 hr−1 as of 2015. **The current domestic demand is about 60% of what it was in 1992,** primarily as a result of the reduction in leakages and partially from the improved efficiency of various water using appliances, toilets, showers, faucets, etc.

- Focus on agricultural sector needs (estimated to be in region of 20million cubic metres, annually, one-third of which can be provided through second-class water provided by the treatment of sewage – ultrafiltration, RO and advanced oxidation). Irrigated agriculture uses 75% of all extracted groundwater but only takes up 15% of the land.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