

COASTAR® in The Netherlands

COastal Aquifer STORAGE And Recovery

Use of subsurface solutions for a robust water supply and drought control by i) closing the water gap between water supply and demand in space and time and ii) prevent salinization of ground/surface water by using brackish groundwater for fresh water production

Interception and desalinization brackish groundwater below freshwater lenses - dunes Solleveld



Characteristics

- Important area for drinking water supply
- Sandy ridge between sea and hinterland
- Fresh groundwater lens in saline subsurface
- Robust existing system of river water infiltration and extraction fresh groundwater

Challenges

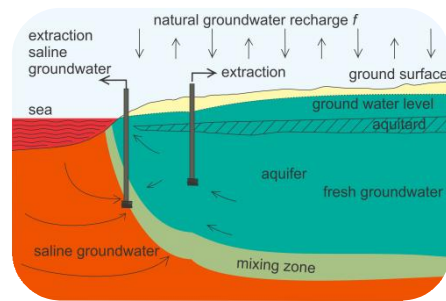
- Increasing drinking water demand and wish to enlarge water resources
- Sea level rise
- River water intake interruptions due to contamination

COASTAR solutions

- Extraction brackish groundwater (new source)
- Enlarging freshwater lens: larger bridging period in case of calamities
- Protection hinterland from future salinization
- Status: study phase

Similar areas

Small Developing Island States, Italy: Adriatic coastal zone, USA: East coast, Tunisia, Spain, Denmark, Belgium, Dar es Salaam (Tanzania)



Potential areas for COASTAR

- Dune areas
- Shallow brackish groundwater (<50m - mv)



Symbols

Water usage

- Domestic use
- Agricultural use

Water source

- Sewage effluent
- Rain/surface water surplus
- Brackish groundwater

Challenges

- Saltwater intrusion
- Drought
- Overexploitation
- Sea level rise



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Storage of rainwater in coastal aquifers – Westland-Eastland



Characteristics

- 4000 ha. greenhouse area Greenport, high value crops
- Brackish aquifer, desalinated groundwater used for irrigation
- Imbalance rainwater availability and irrigation water demand

Challenges

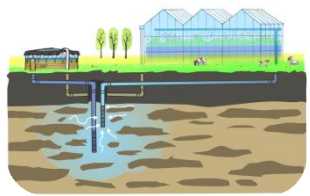
- Pluvial flooding
- Aquifer salinization due to extractions and deep polders inland, enforced by brackish water extractions including infiltration of membrane concentrate

COASTAR solutions

- Balance aquifer recharge and extraction by infiltrating precipitation surplus
- Aquifer management through water banking: (financially) promote infiltration, pay-per-use for groundwater extractions
- Status: in operation (ASR pilots) / study phase (water bank)

Similar areas

Aquifers that suffer from overexploitation, lowering of groundwater tables, and/or salinization. Arizona and California (USA), New Zealand



Effluent reuse - Dinteloord



Characteristics

- 200 ha. greenhouse area, high value crops for domestic and export markets
- Irrigation mainly from rain water

Challenge

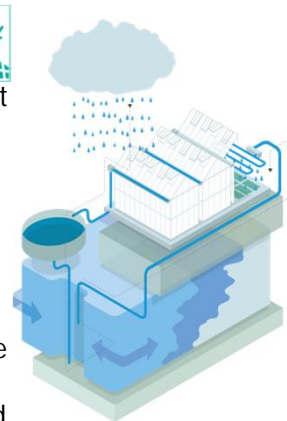
- Secure annual irrigation water supply
- Secure irrigation water availability during droughts

COASTAR Solution

- Reuse water from nearby food industry as additional water source (300.000 m³ per year)
- Aquifer storage and recovery to balance freshwater supply and demand
- Status: in operation

Similar areas

Coastal areas worldwide with time lag between water supply and demand.



Small scale agriculture - Zeeland



Characteristics

- Agriculture and tourism hotspot
- Large water demand in dry periods
- Saline groundwater and surface water: crop damage

Challenges

- Reduced groundwater recharge
- Sea level rise: increase seepage and salinization
- Large-scale uncontrolled extractions

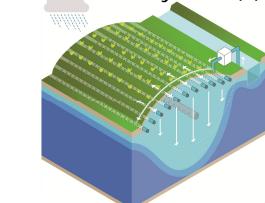
COASTAR solutions

- Aquifer Storage and Recovery in small sandy ridges: (1) and (2)
- Decrease salinity in root zone: (3)
- FRESHM: Large scale Helicopter EM survey for mapping fresh-salt groundwater distribution
- Upscaling local measures with successful field tests
- Large scale fresh groundwater mapping
- Website with opportunity tools and local ambassadors
- Status: in operation

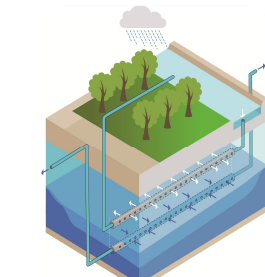
Similar areas

Small Islands Developing States, Spain: Seville and Valencia, Italy: Adriatic coast, Tunisia: East coast, Germany: North-east

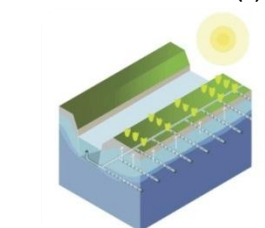
Creekridge Infiltration System (1)



Freshmaker (2)



Drains2Buffer (3)



Desalination brackish groundwater polders - Polder Noordplasp



Characteristics

- Polder below sea level
- Shallow brackish groundwater (incl. nutrients) reaches surface water
- Salt-sensitive agricultural crops

Challenges

- Autonomous salinization
- Increasing salt damage agricultural crops
- Increase freshwater shortages in dry periods
- Increasing drinking water demand

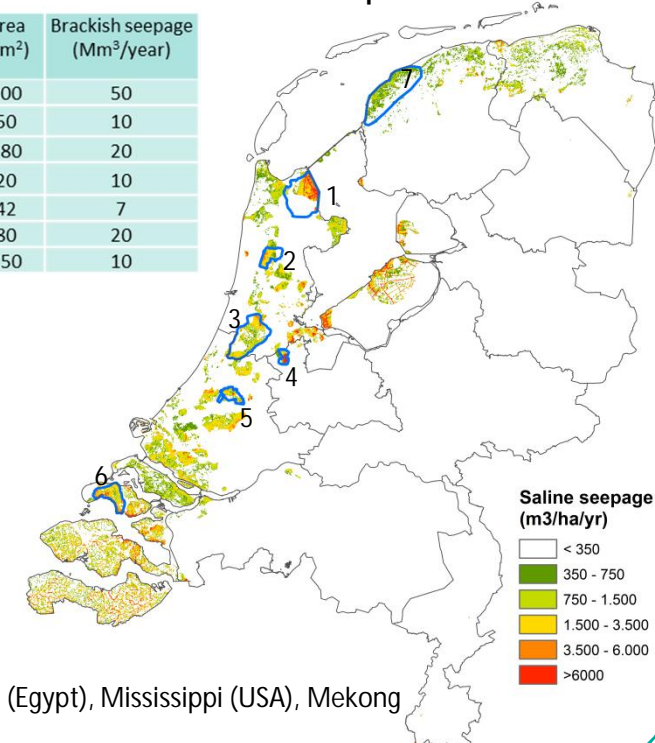
COASTAR solutions

- Brackish groundwater as source for drinking water
- Reverse osmosis on brackish groundwater
- Decrease seepage, salt load and eutrophication
- Decrease salt damage crops polder and its environment
- Status: study phase

Similar areas

Netherlands: polders (map), Deltas: Yellow river (China), Nile (Egypt), Mississippi (USA), Mekong (Vietnam), Po (Italy), Ganges-Brahmaputra (Bangladesh)

Polder	Area (km ²)	Brackish seepage (Mm ³ /year)
1. Wieringermeer	200	50
2. Schermer	50	10
3. Haarlemmermeer	180	20
4. Groot Mijdrecht	20	10
5. Noordplasp	42	7
6. Schouwen	80	20
7. Northwest Friesland	250	10



Where can COASTAR® be applied?

COASTAR aims for large-scale use of the subsurface to store freshwater for industrial, domestic and agricultural use, including using brackish water for freshwater production.

Benefits can be achieved by combining water supply with other functions, such as preventing land subsidence and flooding or strengthening coastal defences.

Reuse of municipal wastewater

Mexico



Characteristics

- Coastal alluvial plain
- Over-exploitation of coastal aquifer
- Production of high value crops for export market

Challenges

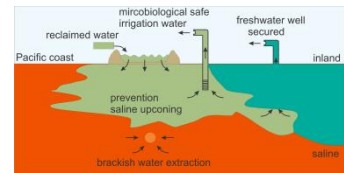
- Seawater intrusion
- Lack of fresh irrigation water
- 1000 hectares taken out of production
- Reduced crop production, economic losses, jobs at stake

COASTAR solutions

- Treated municipal wastewater as additional water source
- Soil aquifer treatment for microbiologically safe irrigation water
- Underground storage to enable large-scale reuse of wastewater

Similar areas

Baja California (Mexico), California (USA), Chile, Australia



Symbols

Water usage

Domestic use

Agricultural use

Industrial use

Water source

Sewage effluent

Rain/surface water surplus

Island groundwater (incl. reclaimed islands)

Brackish groundwater

Challenges

Flooding

Saltwater intrusion

Drought

Overexploitation

Sea level rise

Land subsidence



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Land reclamation and industrial areas

Singapore



Characteristics

- Industrial area
- Lack of space for above ground storage of freshwater
- Reclaimed land with freshwater infiltration; potential for industries to become self-sufficient in terms of supply

Challenges

- Reduction in groundwater replenishment due to built-up areas on the reclaimed land

COASTAR solutions

- Use of existing infrastructure to infiltrate water
- Water resources management system for operational use

Similar areas

Hong Kong, Macau, Taipei, Maasvlakte (the Netherlands), UAE, Qatar, Gujarat (India)



Agricultural areas

Vietnam



Characteristics

- Small-scale agriculture, including shrimp farming
- Intense shallow groundwater abstractions
- Surface water and groundwater are mainly salty
- Large precipitation surplus in the rainy season
- Thick shallow clay layer prevents infiltration

Challenges

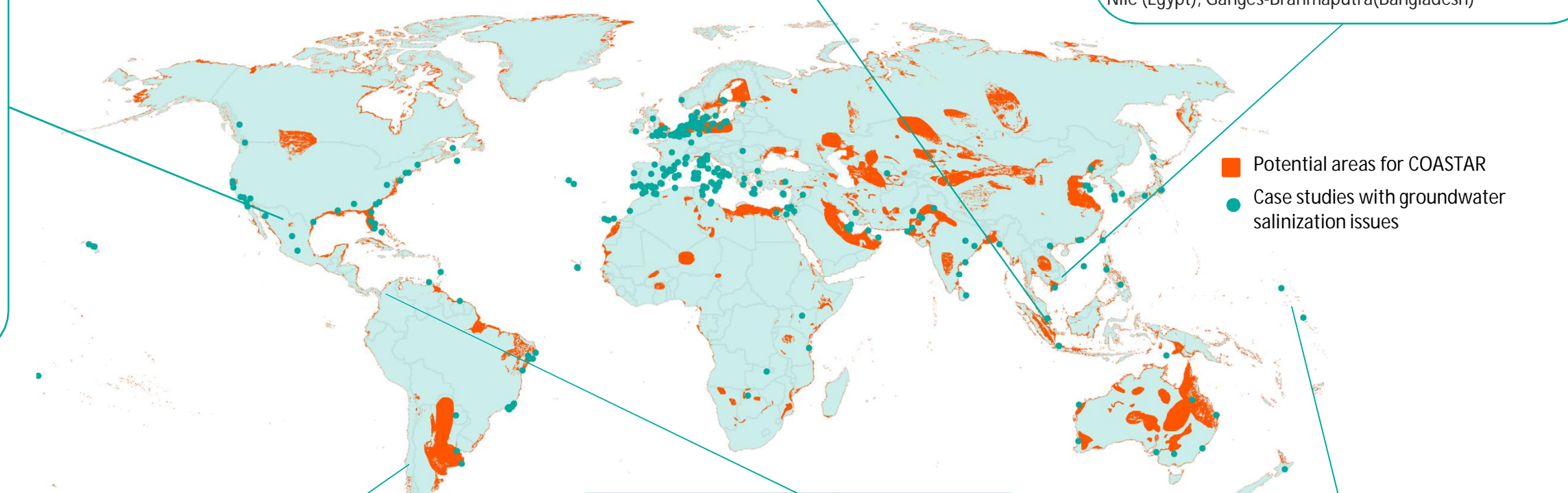
- Increasing water demand
- Land subsidence
- Lowering of water table due to abstractions

COASTAR solutions

- Aquifer storage and recovery: precipitation surplus injected into the brackish/saline aquifers

Similar areas

Mississippi (USA), Myanmar, Mozambique, Deltas: Po (Italy), Nile (Egypt), Ganges-Brahmaputra (Bangladesh)



Potential areas for COASTAR
 Case studies with groundwater salinization issues

Water scarce areas

Chile



Characteristics

- Water is used for domestic, irrigation, and mining uses
- Precipitation surplus in the rainy season
- Severe droughts and water scarcity; brackish groundwater

Challenges

- Shortage of freshwater for irrigation and domestic use

COASTAR solutions

- Infiltration of precipitation surplus
- Extraction and use of brackish groundwater

Similar areas

South Africa, Colombia, USA: East coast, Florida, California



Large cities in coastal areas

Colombia



Characteristics

- Large urban coastal areas
- Shallow fresh-salt groundwater interface
- Precipitation surplus in the rainy season causes flooding
- Frequent and severe droughts affect water supply

Challenges

- Sea level rise and saltwater intrusion
- Floods in the rainy season, water scarcity in dry season
- Increasing water demand

COASTAR solutions

- Infiltration of precipitation surplus
- Extraction and use of brackish groundwater
- Prevention of flooding

Similar areas

Jakarta (Indonesia), São Paulo (Brazil), Buenos Aires (Argentina), Miami (USA)



Small Islands



Characteristics

- High population density and isolated from large land masses
- Self-sufficient freshwater supply is necessary: rely on rainwater harvesting and on groundwater

Challenges

- Sea level rise and increased saltwater intrusion
- Increasing water demand
- More extreme droughts

COASTAR solutions

- Combination of coastal defence and water supply
- Underground water storage in combination with desalinization of brackish groundwater (SeepCap)

Similar areas

Small Island Developing States (e.g. São Tomé and Príncipe, Maldives), San Andrés (Colombia), Wadden Islands (the Netherlands, Germany)

