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, Spain: Seville and Valencia, Italy: Adriatic coastal zone, USA: East coast, Tunisia:
- Similar areas

**Potential areas for COASTAR**

- **Dune areas**
- **Shallow brackish groundwater** (>50m - 1m)

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**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)

**Status:** operation (ASR pilots) / study phase (water bank)

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

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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
- Brackish groundwater and surface water: crop damage

**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

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**Effluent reuse - Dinteloord**

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

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

**COASTAR solutions**
- Use water from nearby food industry as additional water source
- Secure annual irrigation water supply

**Status:** in operation

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

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**Desalinization brackish groundwater polders - Polder Noordplas**

**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)
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

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

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, Guajarat (India)

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
- Flooding 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)

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)

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)

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