Facing Eco-Sustainability Challenges Through a Paradigm Change in National Water Resources Management

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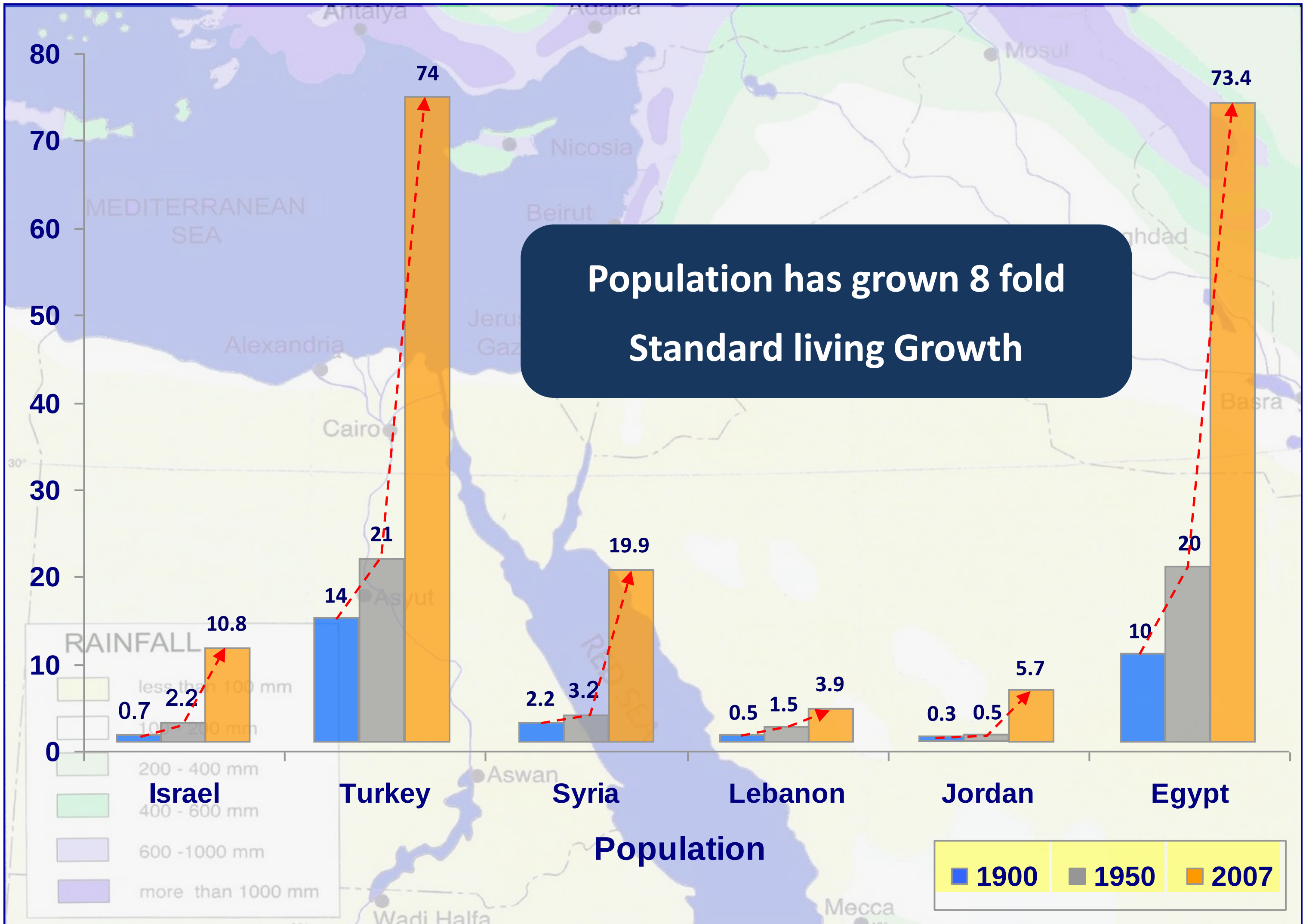
Population Growth in the Middle East in the Last 100 Years



* In Millions of people

Israel: Average Annual Replenishment of Natural Water Resources

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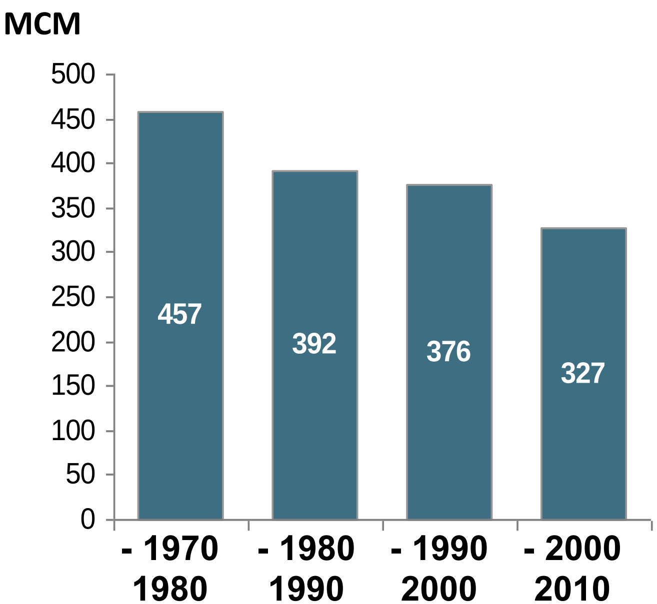
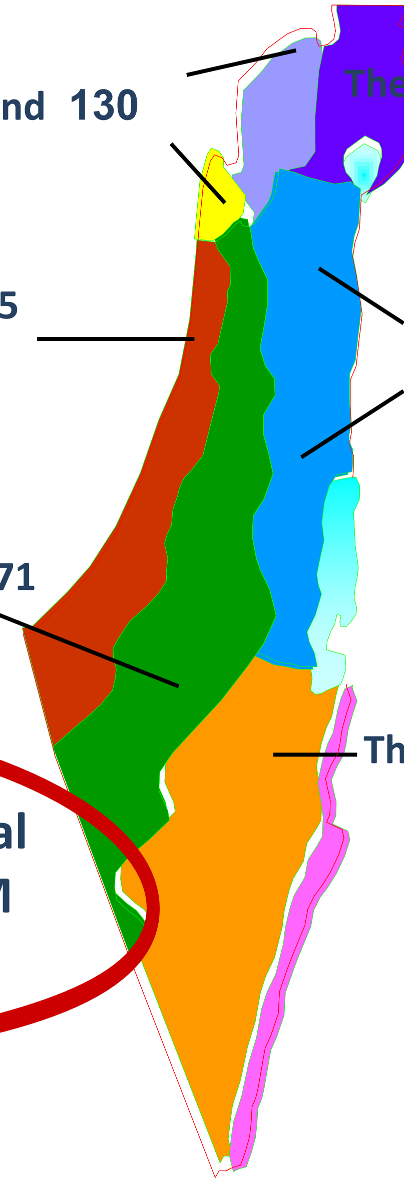
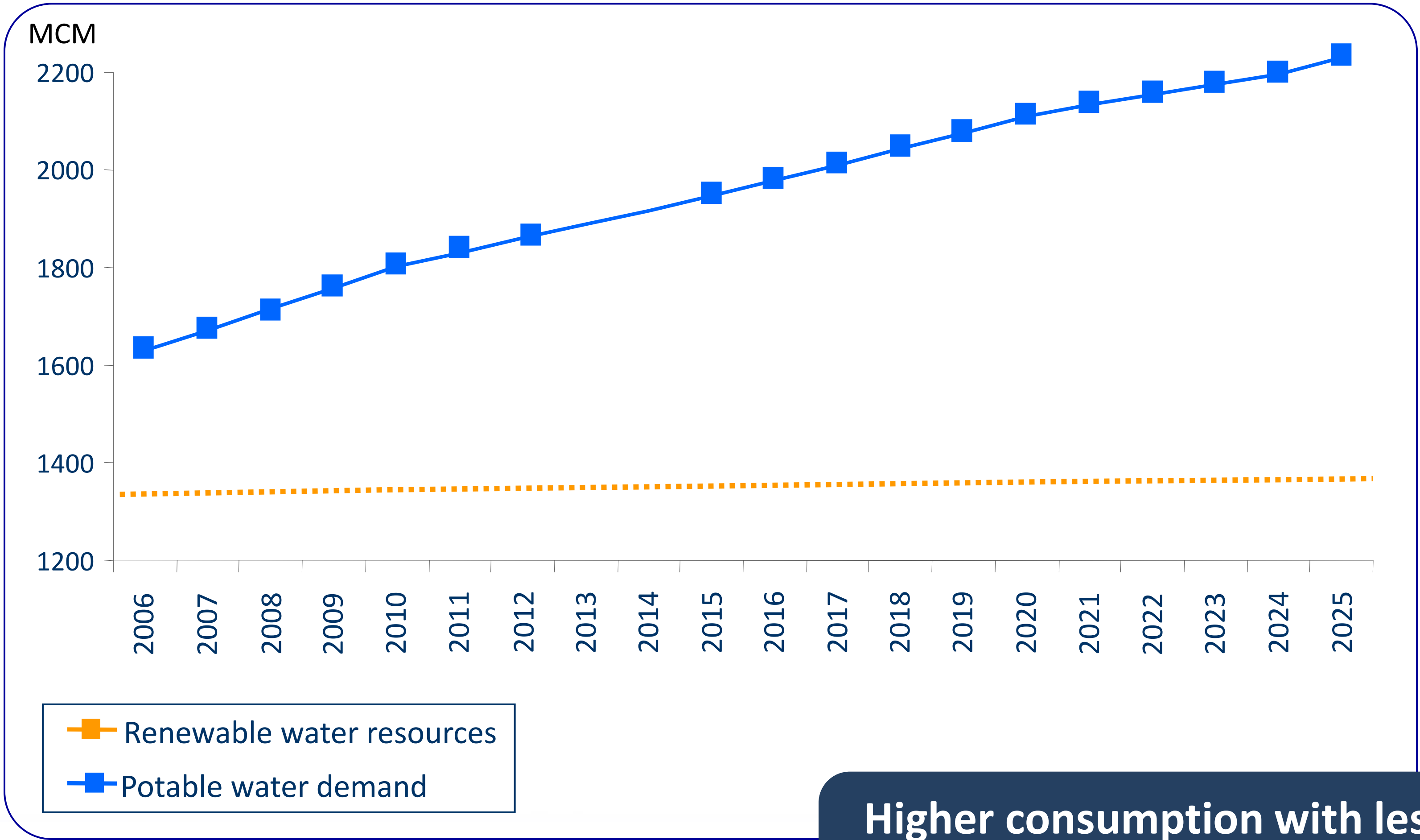
Average net inflows in to the Sea of Galilee in the last decades





Total Available Annual Quantity: 1355 MCM

A Growing Shortfall: Israel's Water Supply vs. Demand



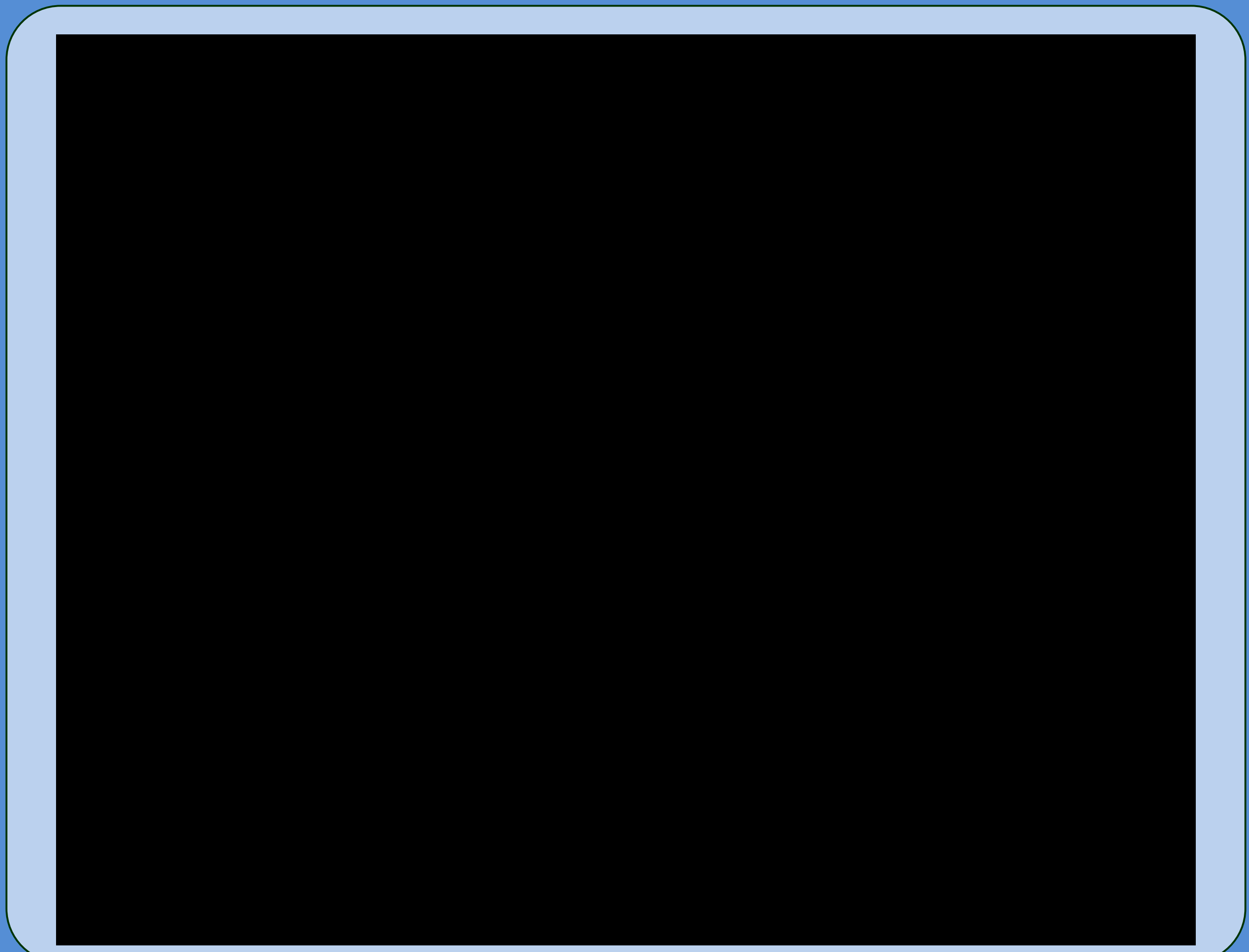
Higher consumption with less available water…

A Solution to Water Shortage: Seawater Desalination

Main water resources 2013 (MCM)

Main water resources 2008 (MCM)

Israel Water Revolution



Changing regional surplus/deficit landscape

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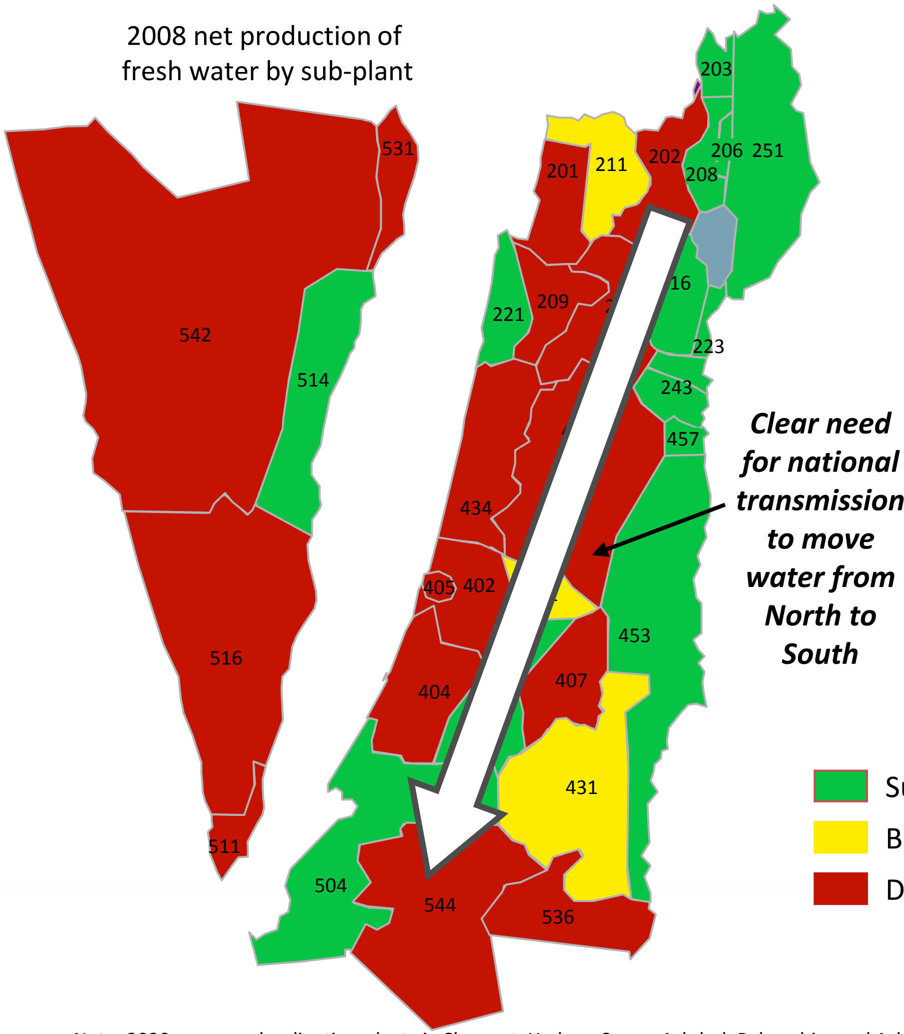
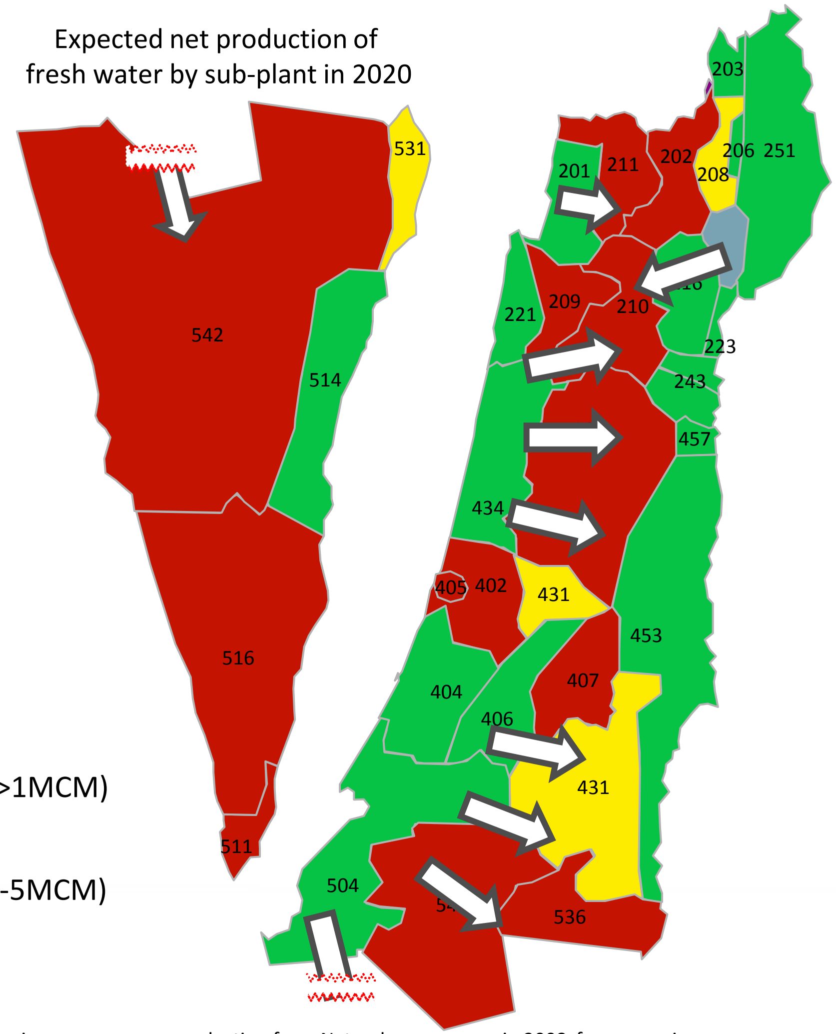
In 2008, deficit exists across most of Israel

2008 net production of fresh water by sub-plant



..most disappear by 2020

Expected net production of fresh water by sub-plant in 2020



Surplus (>1MCM)
Balanced
Deficit (<-5MCM)

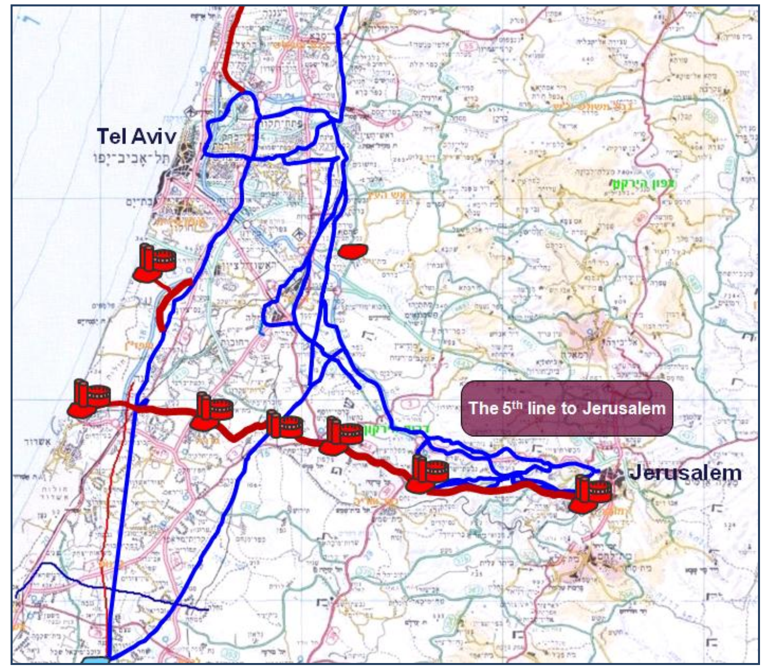
Note: 2020 assumes desalination plants in Shomrat, Hadera, Soreq, Ashdod, Palmachim and Ashkelon; Scenario assumes same production from Natural resources as in 2008, for comparison
Source: Mekorot and water Authority 2008 actual production and consumption; Mekorot's initial 2020 fresh water demand forecast

Seawater desalination: Infrastructure requirements

Seawater desalination plants require additions to existing water supply system:

- operational reservoirs
- pumping stations
- pipes
- water quality monitoring facilities

Connection of the Hadera seawater desalination plant (2009)



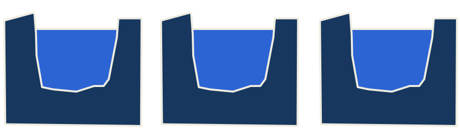
New facilities enable efficient transfer of water from the Coastal area to the Eastern part of the country

Seawater Desalination: Operational Complexity in Water Supply System Operation

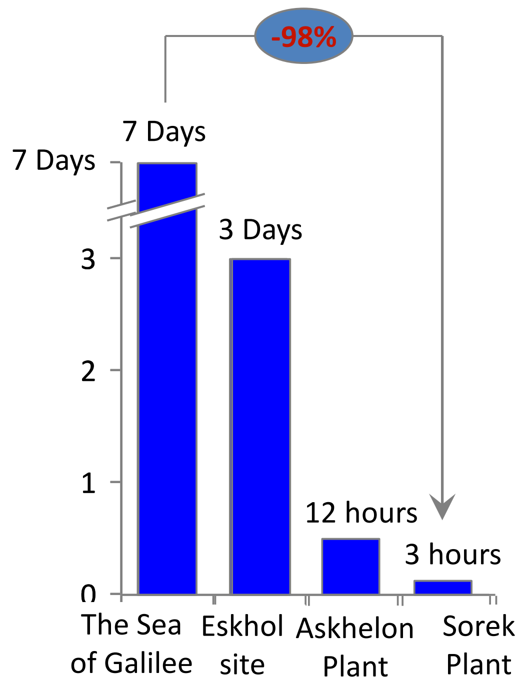
Insufficient operational Storage

The Eshcol reservoir: 5-day storage cycle

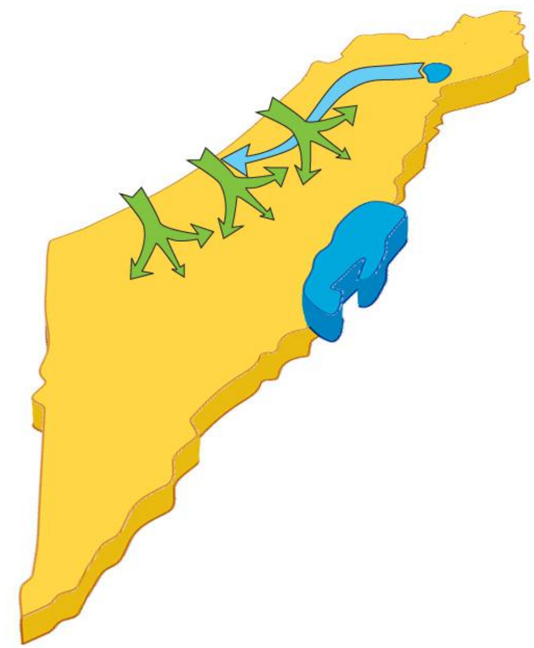
Desalination plants: 6 hours storage cycle



Shorter response time



Multiple water inputs : changes in flow direction



Due to insufficient operational storage, reservoir cycle is 20 times shorter (Tel-Aviv region)

Shorter response time requires advanced real-time water supply system operation

Abrupt changes in direction of flow in the WSS and higher pressures in the Coastal lines

Source: Mekorot

Other changes in operational conditions and constraints

- **“take or pay”** arrangement: Mekorot is obliged to take desalinated water supplied at constant hourly flows, every day, throughout the year;

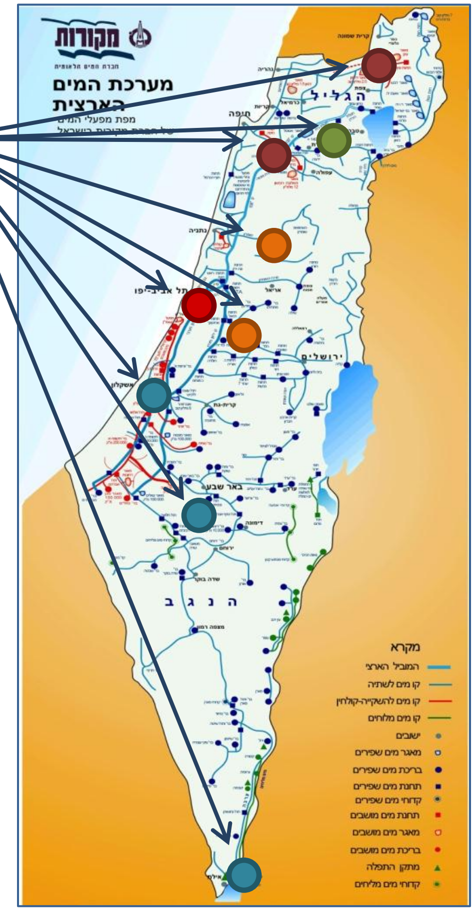
- **energy costs:** available operational storage is small relatively to inflows so that variable tariffs of energy cannot be completely utilized;

- **coordination:** a greater need for **frequent inter-regional water transfer** and for an **“integrated” approach to operation** of the water supply system;

- Mekorot’s responsibility to supply water in case of desalination failure implies **high maintenance costs** for facilities that will be rarely used at full capacity.

Water Supply Operation and Control

- 8 control rooms supervised by the Central Coordination Room from the headquarters.



- Optimal planning of the WSS operation by simulation of various operating scenarios.
- Real-time optimization: large amounts of real-time data (hydraulic & water quality parameters) used as input to on-line optimization models.

Decision Support Systems (DSS) for the Optimal Operation of the WSS

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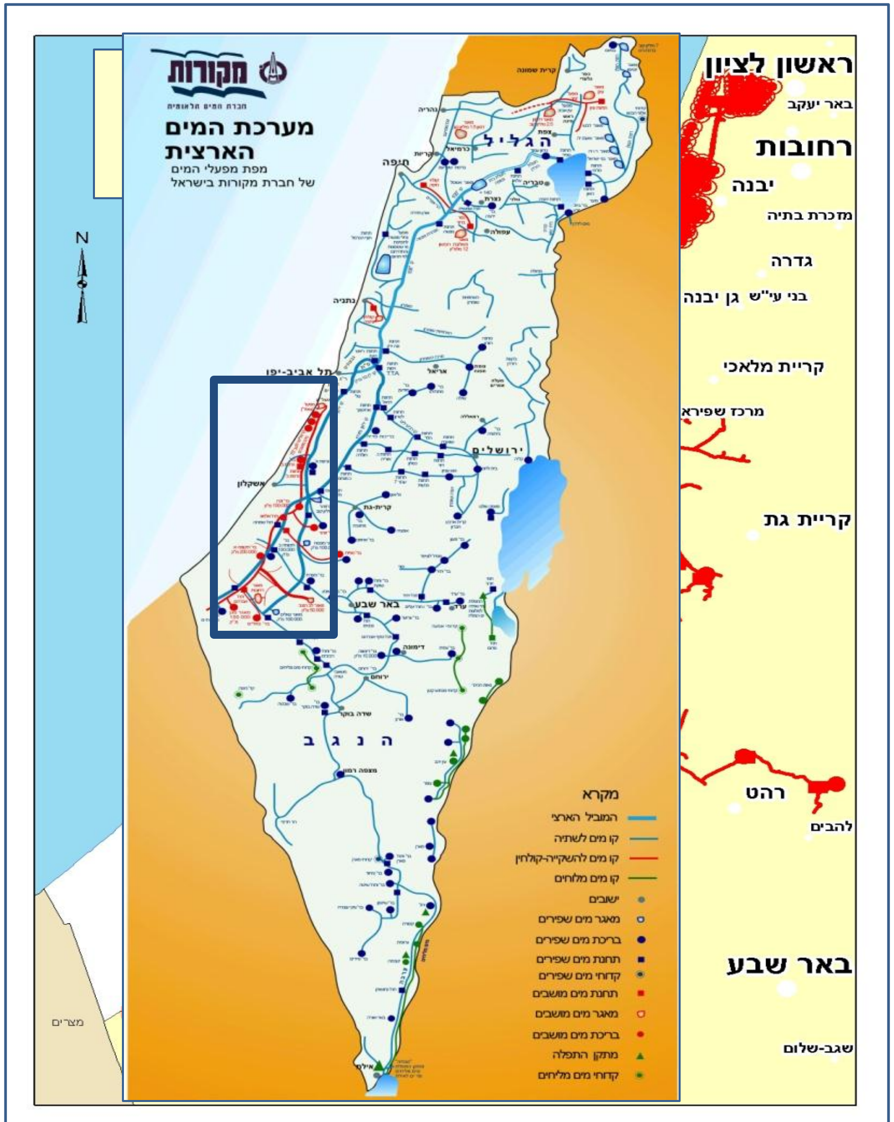
In the following…

1. An integrated approach to operation of the Water Supply System – an example

2. A simulation-optimization model of the Israel National Water Carrier aimed at:
   - Evaluation of infrastructure development scenarios
   - Optimal planning of daily operation of the NWC

An Integrative Approach to Optimal Operation of “The 3rd line to Negev”



“The 3rd line to Negev”:
Supply of reclaimed water for the use in agriculture.

The wastewater from the central part of Israel is collected and treated by activated sludge and by infiltration into the sandy Coastal Aquifer.

Treated water is pumped by a system of 150 production wells and supplied to the South of Israel (Negev).

General data:

- annual supply– 170 mcm
- annual energy consumption – 190 Mkwh
- annual energy costs - ~20 mill.$
- “on-line” operation from 4 control rooms

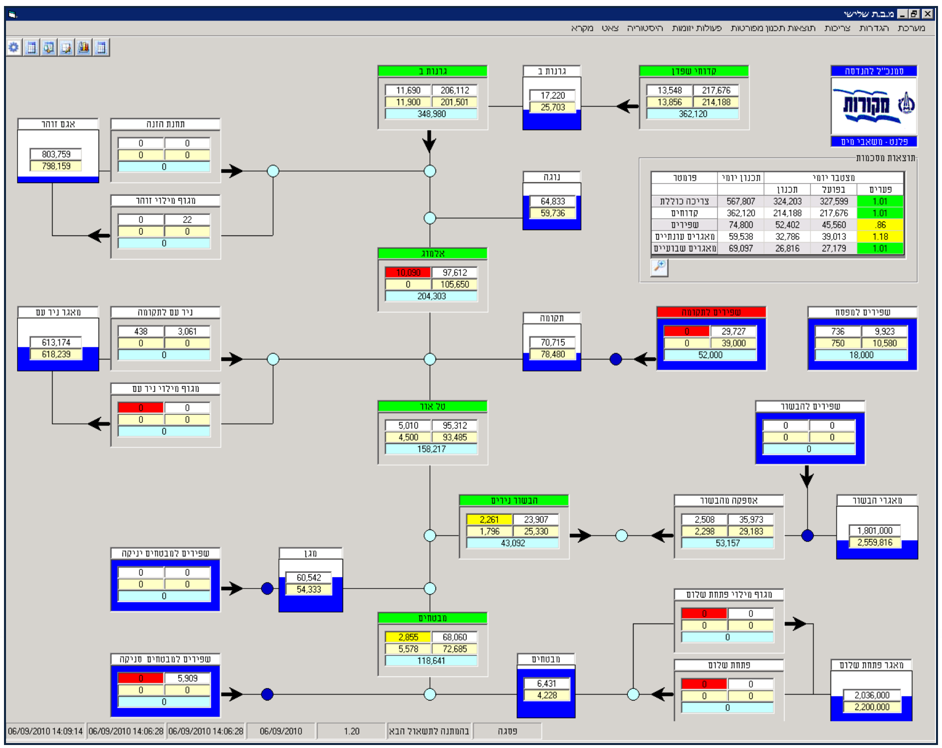
A DSS for the Optimal Operation of the “3rd line to Negev”: Objectives

Operating the water supply system in best efficiency:

- Minimizing the energy cost
- Optimizing the extraction from the production wells (subject to hydrological and water quality constraints)
- Optimizing supply reliability (by demand forecast)
- Minimizing supply from the potable water system

DSS: The operating concept

- The water supply system should be considered as an integrated system;
- System operation is based on yearly, monthly, daily and hourly planning;

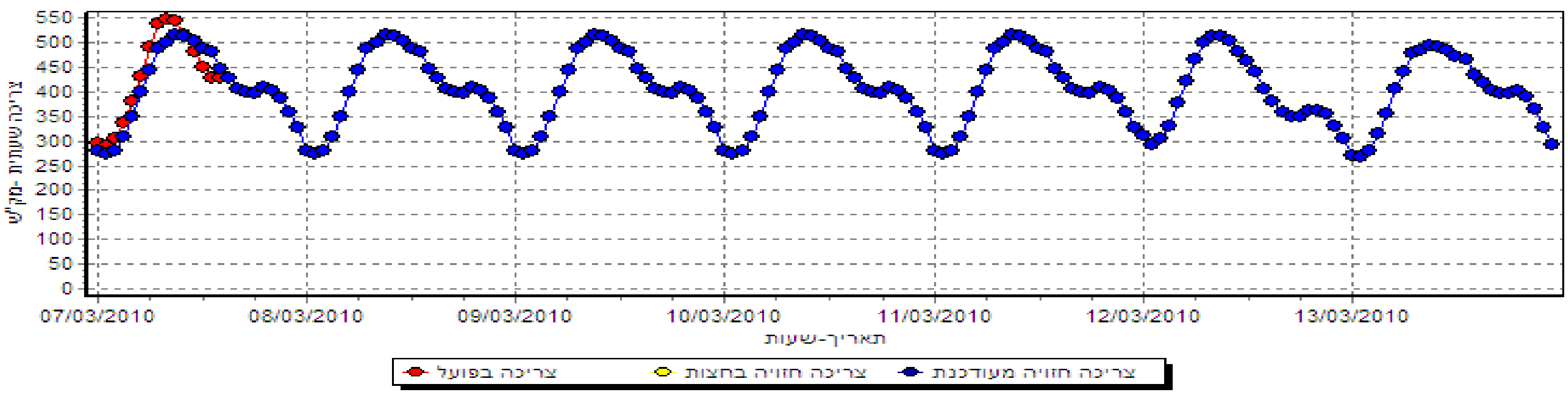


- Accessibility and transparency of operational data and decisions;
- Operational decisions reflect changes in operational conditions;
- Overall coordination by a “main user”.

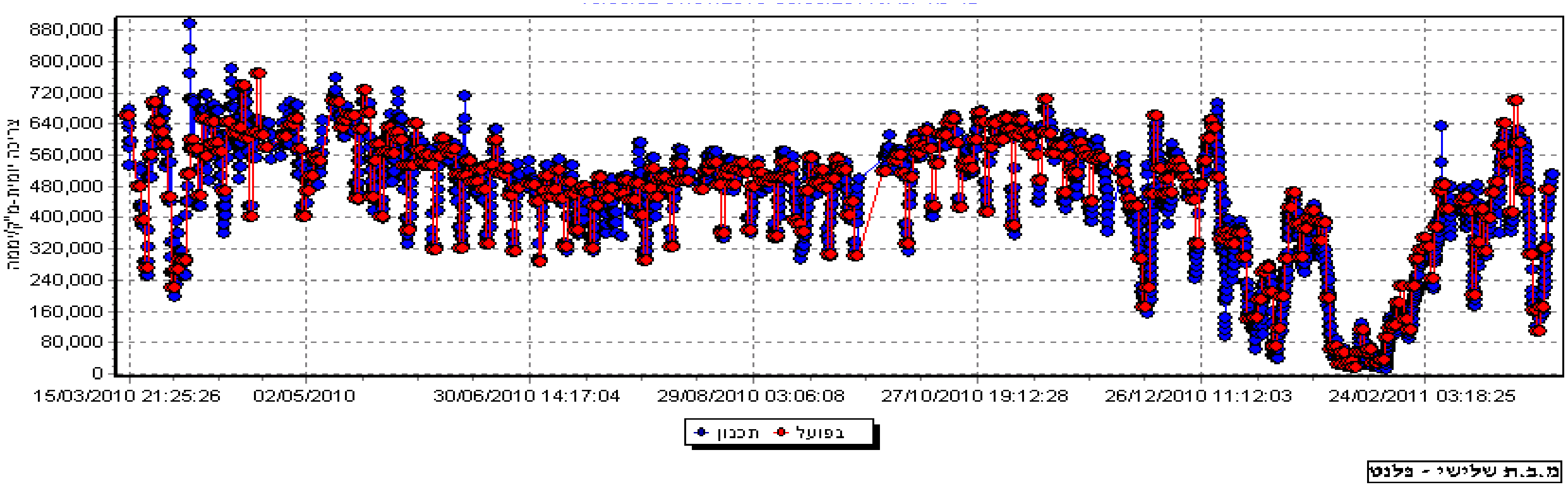
DSS Controller

Display of water demand forecast

Short term forecast



Long term forecast



The 3rd Line To Negev: 2010 Application Results

- Savings in annual energy costs: ~ 20%
  - Energy-efficient use of pumping facilities (specific energy values lower for 7 to 25 % per facility)
  - Efficient utilization of the available storage and of the variable energy tariffs
- Hydrologically optimal pumping from the Aquifer
- Optimal integration of valuable fresh water
- **Better Service**

National Water Carrier (NWC) Operational Optimization

• National Water Carrier (NWC) connects most of the water projects in Israel (including desalination plants);
• Length: 130 kilometers;
• Max. flow: 72,000 mcm/hour; 1.7 mcm/day.

Simulation/optimization objectives:

- Preparation for the water desalination era
  - Scenario simulation by optimization
    - Operation with frequent shift in water resources
    - Winter Vs. summer operating scenarios
    - Examination of planning alternatives
- Planning of daily operation
  - Operational cost minimization
  - Operational problem prediction

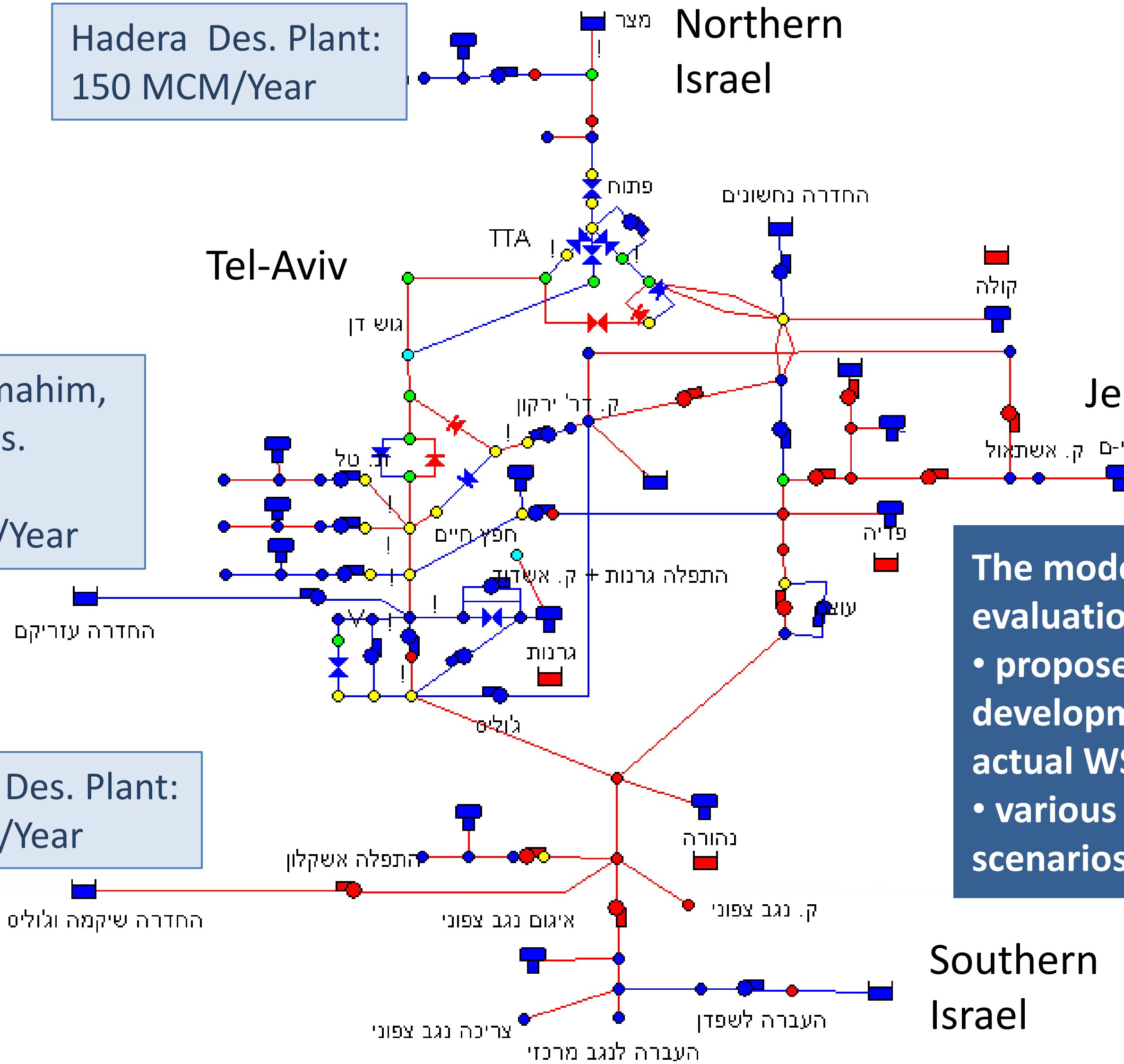
System Aggregation and Simplification

Simplified Hydraulic model

Hadera Des. Plant: 150 MCM/Year

Sorek, Palmahim, Ashdod Des. Plants:
340 MCM/Year

Ashkelon Des. Plant: 130 MCM/Year



The model enables evaluation of :
- **proposed changes and developments in the actual WSS**
- **various operating scenarios**

Challenges in Operation of the Israel National Water Supply System : Summary

By year 2020, Israel will supply 750 mcm of desalinated seawater. Introduction of large quantities of the water from a new source imposes two major requirements:

- large investments in additions to existing water supply system
- adaptive and flexible operational rules that can assure:
  - high water supply reliability for various operational conditions
  - minimum operational costs
  - sustainable use of natural water resources

Simulation and optimization models and Decision Support Systems enable:
- **evaluation of various proposed infrastructure development projects**
- **optimal real-time operation of complex water supply systems**

Integrated Approach to WSS Operation: A Paradigm Shift

Complex water supply systems should be operated while balancing the requirements of the system as a whole with the local operating conditions:

- Data transparency and accessibility to all involved operating teams
- Efficient coordination of several control rooms by a single "system operator"
- Application of simulation and optimization models as Decision Support Systems

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THE REAL CHALLENGE = PEOPLE

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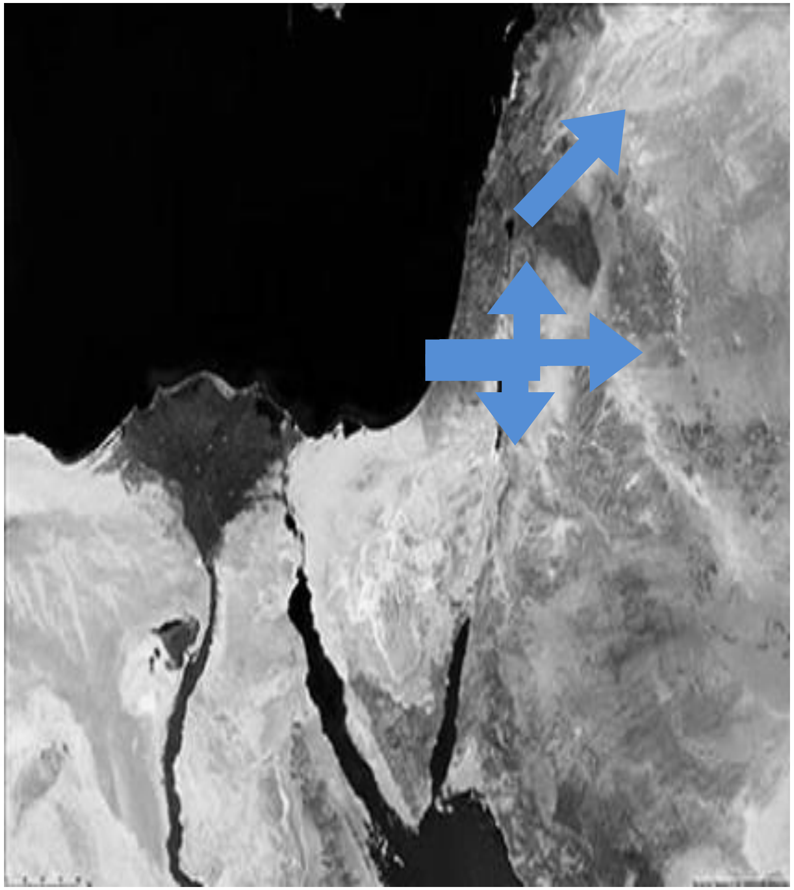
<u>Human factor Elements</u>:

- Resistance to changes in the organization
- Resistance to more transparency and control
- Increase “human operators” willingness and trust in (proven) mathematical models (education and re-definition of job requirements)
- Adjust performance measures to the overall-system objectives

A Vision…

Sea-water desalination, as a solution to water scarcity, provides opportunities for regional cooperation:

- Access to the Sea and technological capabilities enable water-transfer between Israel and its neighbors.
- International community funds the *Red Sea-Dead Sea* water project which implies high energy costs and is not likely to be finished in the near future.
- Higher water availability is likely to invoke more determination in preserving natural water resources .



1. Including National Carrier and 5.4Bn NIS invested in the central region to receive the desalinated water
Source: Mekorot 10-years investment plan, GWI 2010

Thank you