Water-Energy-Food Nexus and water engineering projects in a water scarce region:

The Lower Jordan River basin as a case study

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Purposes of major water engineering projects

- Water supply
- Irrigation
- Industrial use
- Energy production, conversion and storage
- Inland navigation
- Fishing
- Recreation

(Lotti 1980)

After the mid 20th century, multipurpose of water engineering project have become common.

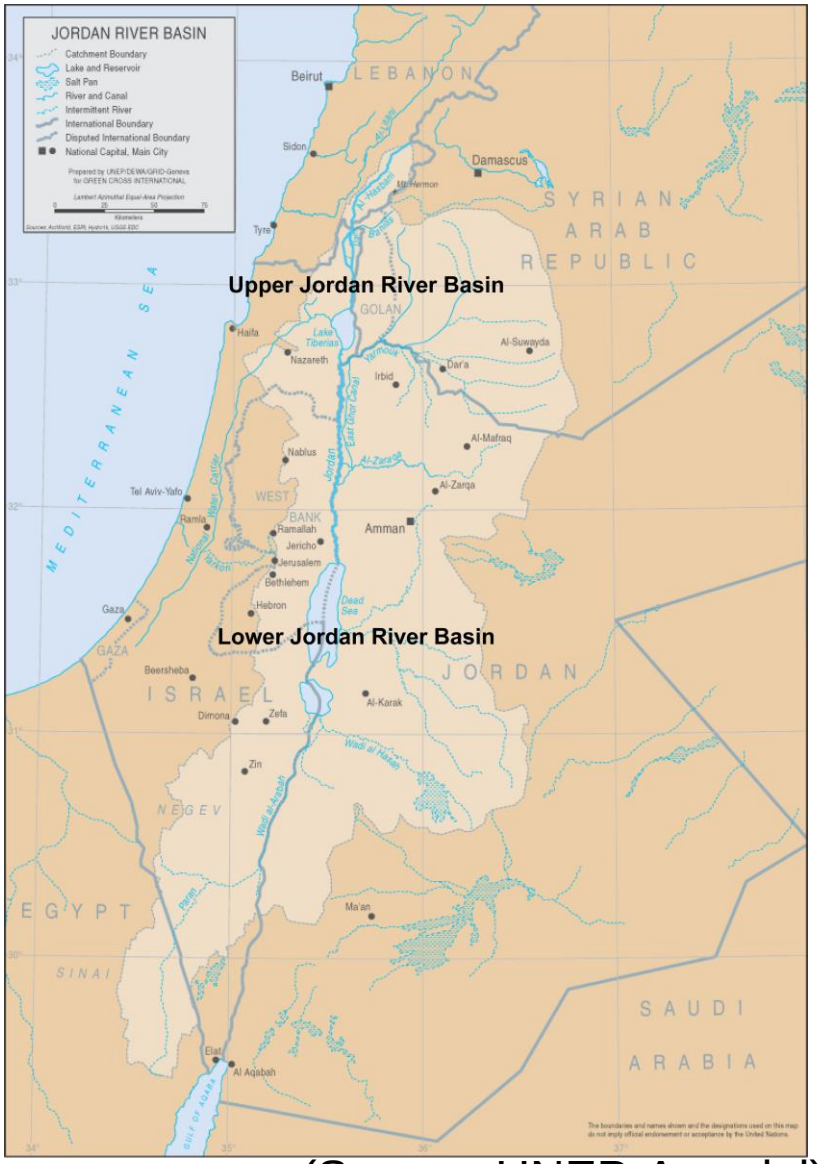
Major water engineering projects will continue to increase

- “Rising needs” for energy and food have led to some sort of “renaissance” of major water engineering projects (Huttel et.al. 2015)

- Technocratic solutions is inclined to favor supply-oriented options rather than solutions based on ethics of sustainable development and right-based distribution (Aggestam & Sundell 2014)

- New transnational actors – investors and multinational companies are gaining influence in the water sector, prioritizing economic interests. They are likely to have long-term consequences on the water-energy-food sustainability.

Lower Jordan River Basin



(Source: UNEP-Arendal)

It locates in one of the most politically unstable and conflict-driven region as well as heavily populated and water scarce regions in the world, placing region's freshwater resources under severe stress.

- Israel
- Jordan
- Occupied Palestine Territories

- Terminus: the Dead Sea

Lower Jordan River Basin (LJRB) has difficulties of water – energy– food security

Annual freshwater withdrawals (% of internal renewable resources)

- Israel - 2.0BCM – 261%
- Jordan - 0.9BCM – 134%
- Palestine - 0.4BCM - 49%
- Total 3.3BCM – 146%

(Source: FAO Aquastat)

Energy imports (% of total use)

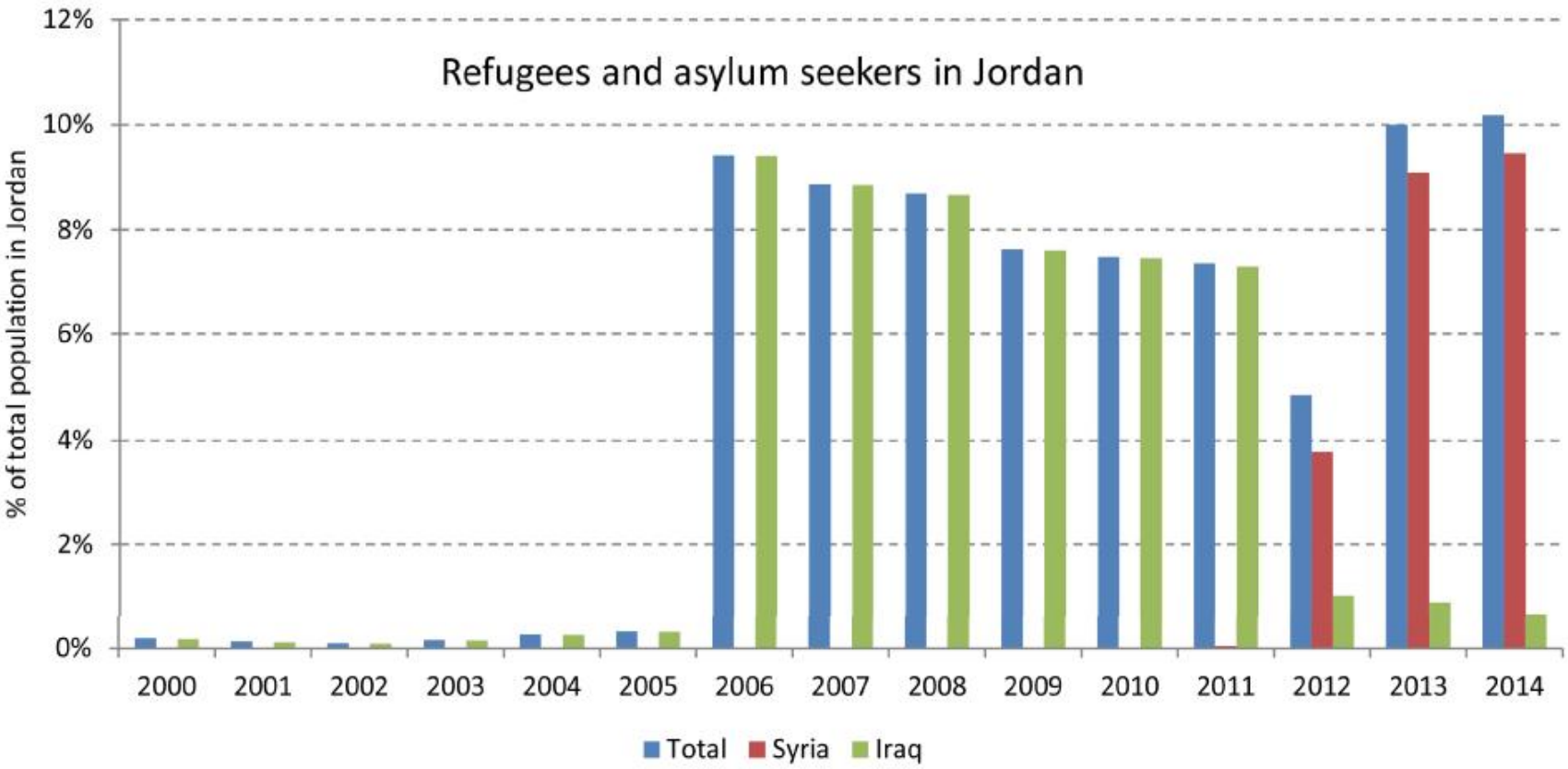
- Israel – 68
- Jordan – 97
- Palestine – 100

(Source: IEA statistics)

Population growth rate

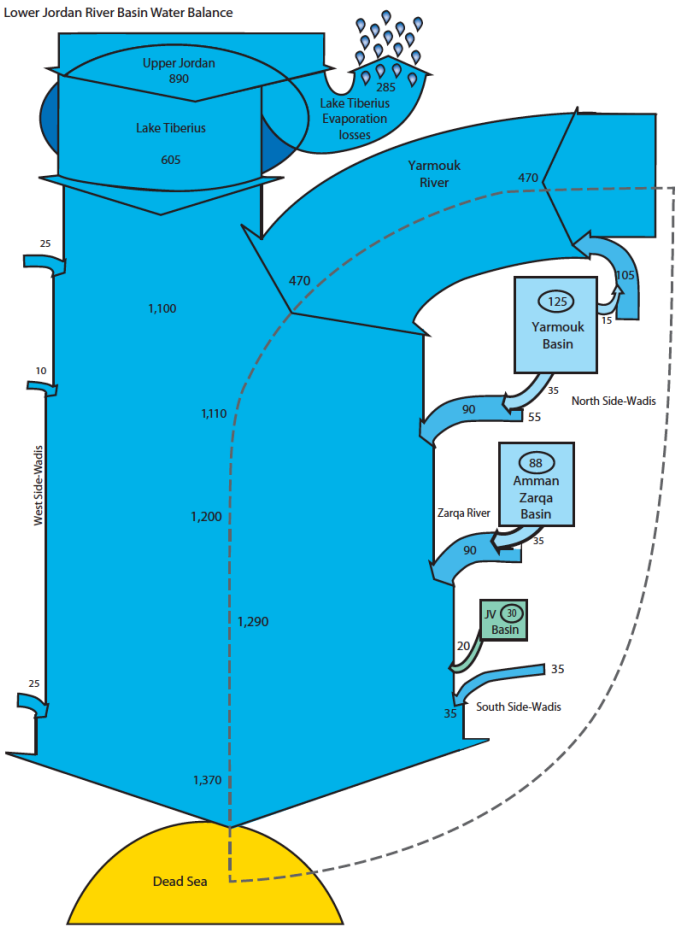
- Israel - 1.9%
- Jordan - 2.3%
- Palestine - 3.0%

(Source: World Bank)



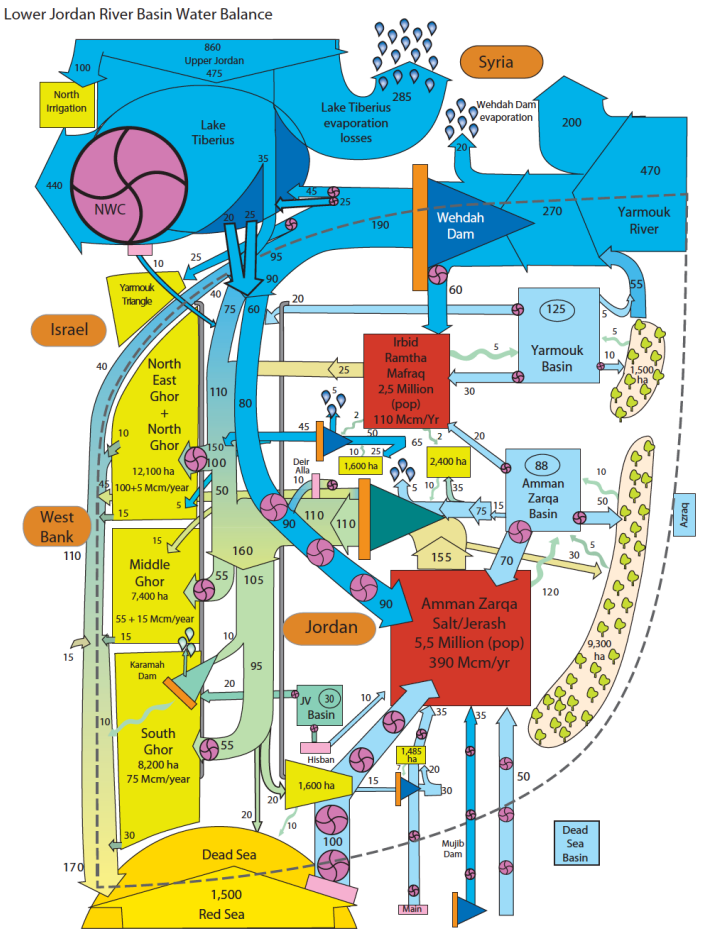
Description	2013	2014 expected
Syrian refugees	>600,000	>800,000
Total no. of Syrians living in Jordan	1,200,000	1,400,000
Daily water consumption @ 70 l/cd	84,000 m^3/d	98,000 m^3/d
Annual water consumption	30.7 MCM/a	35.8 MCM/a

Water resources development in the Jordan River Basin



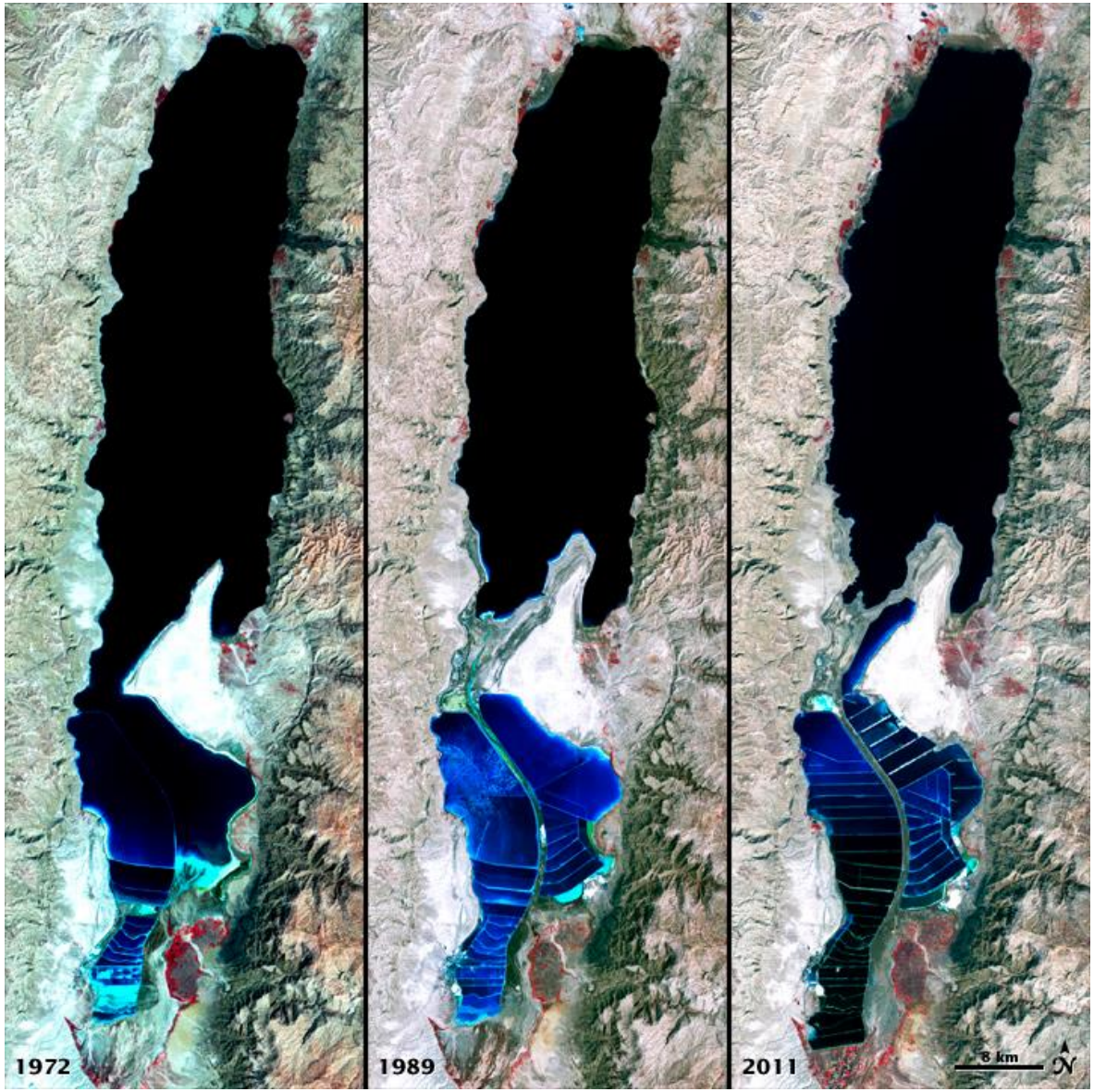
(Courcier et.al., 2005)

Water resources development in the Jordan River Basin



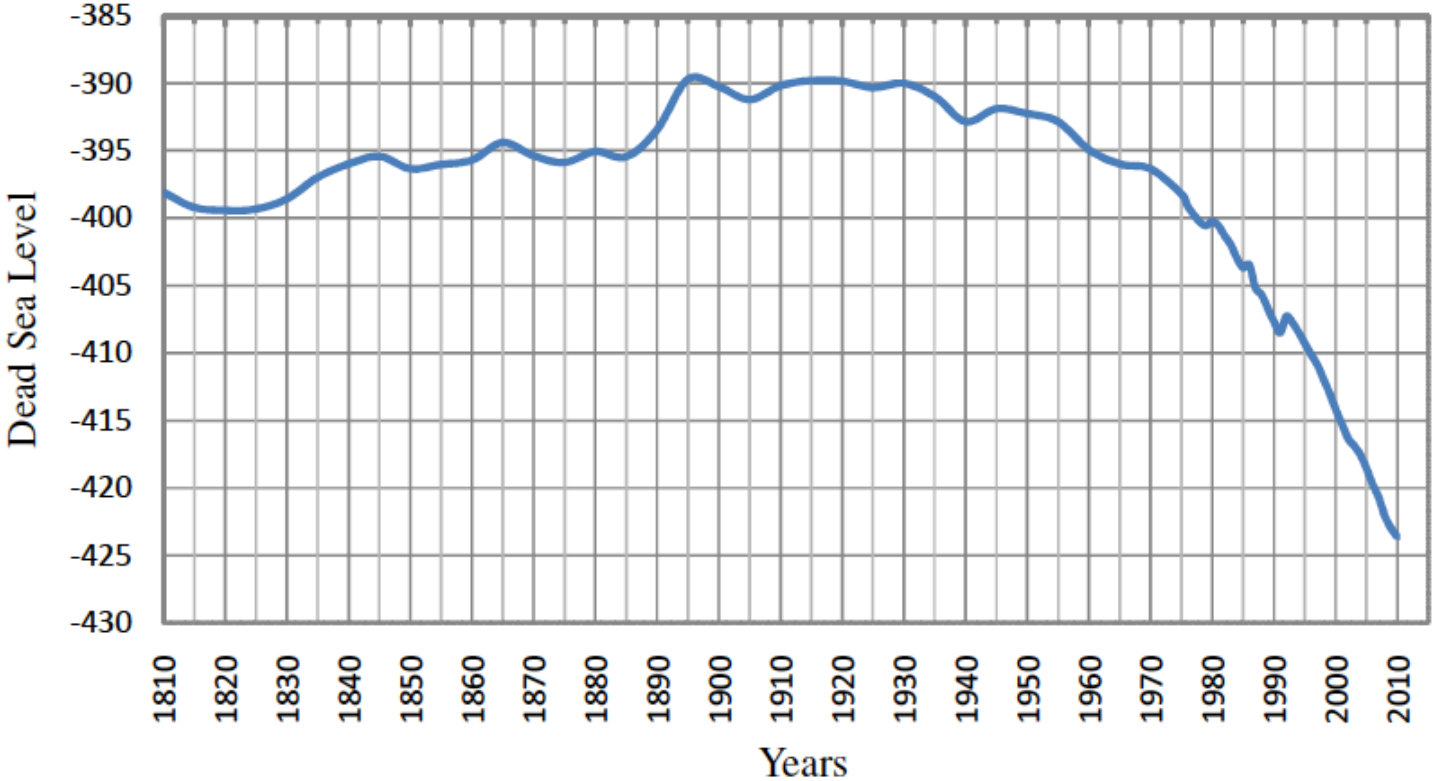
(Courcier et.al., 2005)

Dead Sea is drying up

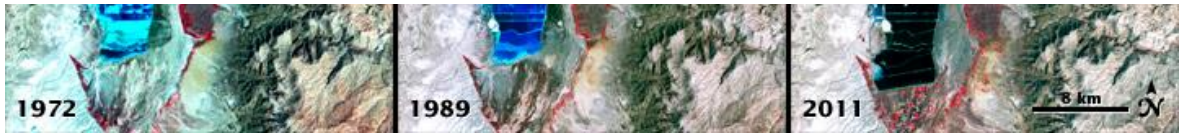


1972 1989 2011 (Source: NASA)

Dead Sea is drying up



(Allan, Malkawi and Tsur 2010)



1972 1989 2011 (Source: NASA)

Red Sea-Dead Sea Conveyance Project (RSDSC)

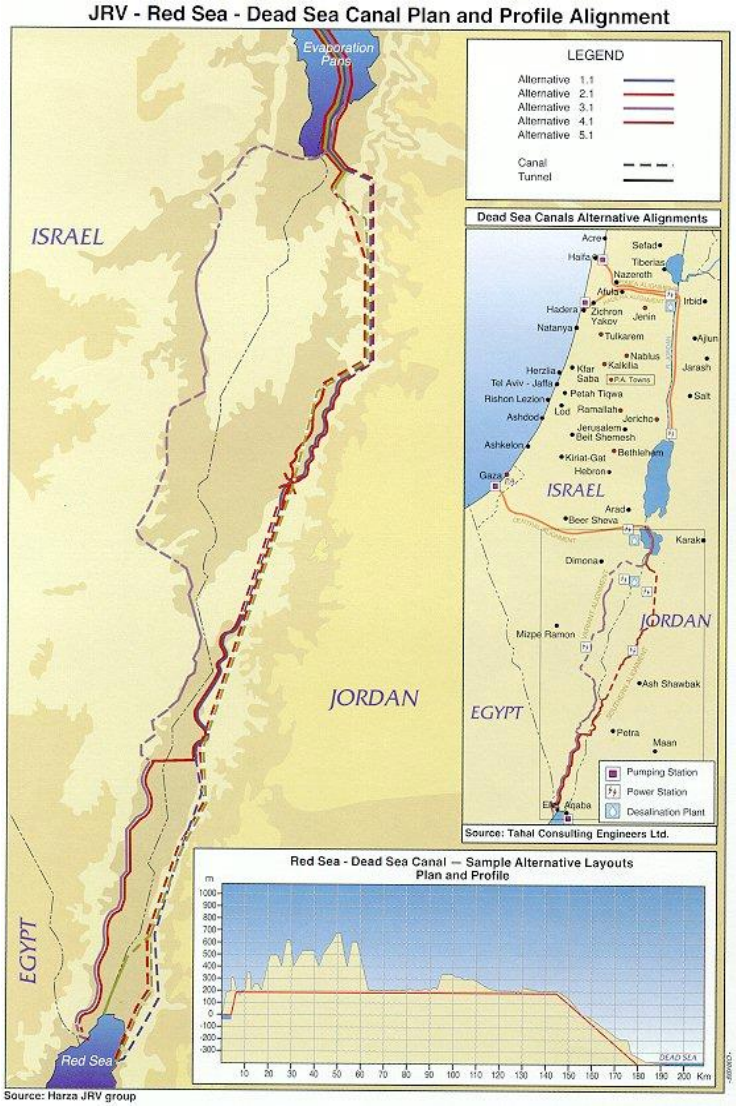
Project goals

(1) Save the Dead Sea from environmental degradation.

(2) Desalinate water/generate energy at affordable prices for Jordan, Israel, and the Palestinian Authority.

(3) Build a symbol of peace and cooperation in the Middle East.

These were declared in the project proposal by three parties, submitted to the World Bank.



(Source: Harza JRV Group)

Red Sea-Dead Sea Conveyance Project (RSDSC)

WB feasibility study estimates 11.1 to 11.3 billion U.S. dollars for the construction.

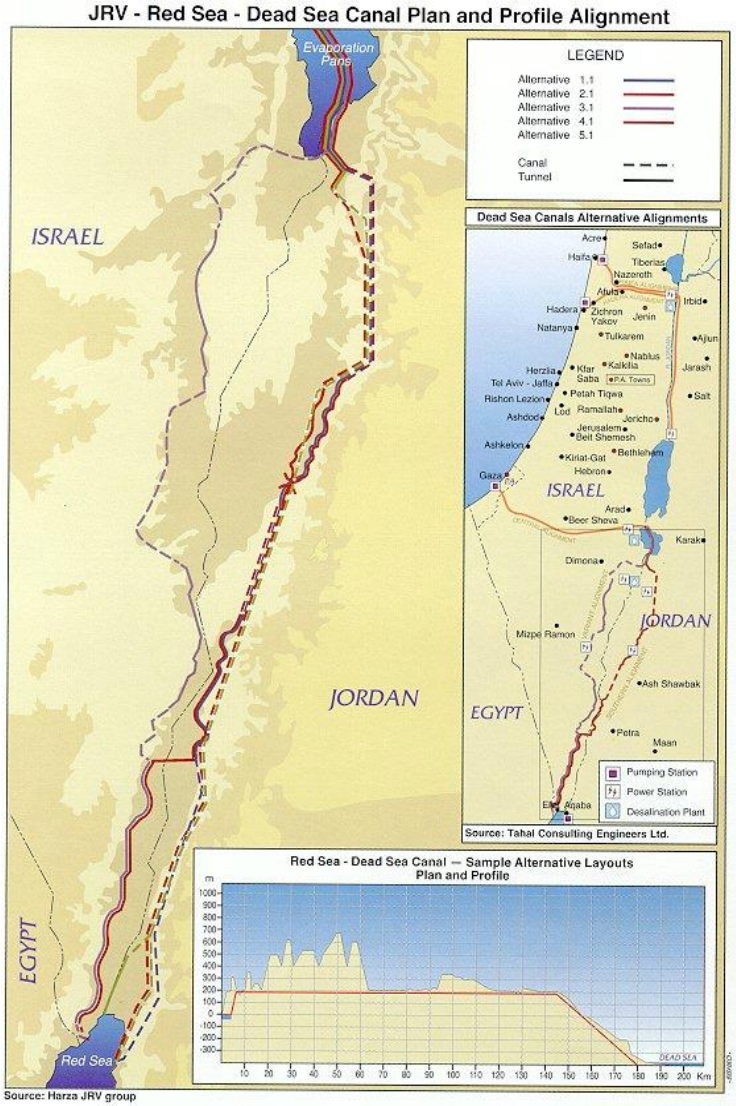
400 million U.S. dollars per year for maintenance and operation

- Total water = 2000 MCM

- Desalinated fresh water = 850 MCM
  550 MCM to Jordan
  300 MCM to West Bank

- 2 Hydropower plants: 250 MW

- Brine water = 1100 MCM to be discharged to stabilize the Dead Sea level at



(Source: Harza JRV Group)

Optimistic vs Pessimistic views

- Increasing water demand in Jordan – municipal and agricultural water demand - would be balanced through the project. Treated wastewater will be increased to meet the irrigation water demand.

- The energy produced in the hydropower plant is neither sufficient for the operation of the desalination plant nor for the pumps that transport the drinking water to the cities.
- According to the World Bank study the net energy balance will be -2,530 GWh/year in 2020.

Most of both views neither pay attention to possible trade-offs of the nexus nor lack the basin-wide perspective.

Virtual water export from LJRB

- Jordan exports fruits and vegetables with the virtual water content thus estimated at roughly 206 MCM (Talozi et.al. 2015). Also Palestine exports vegetables and fruits with 60 MCM and Israel exports with 800 MCM of virtual water contents.

- Three countries are net importers of food with virtual water, in particular, grain (wheat, corn, rice…) while they imports far fewer of fruits and vegetables than it exported. It is the opposite of what one would logically expect water-scarce countries to do.

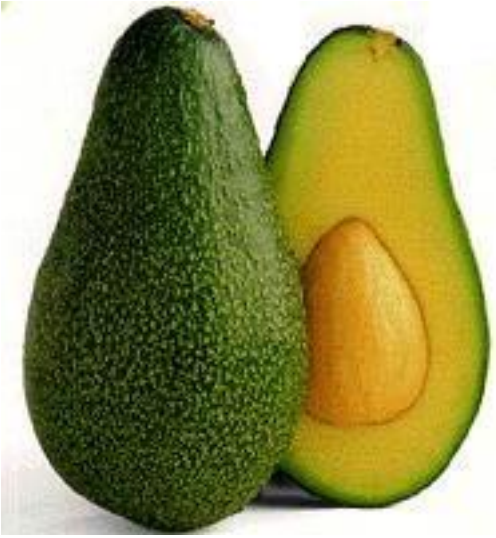
Recommendations based on water footprint assessment on Jordan

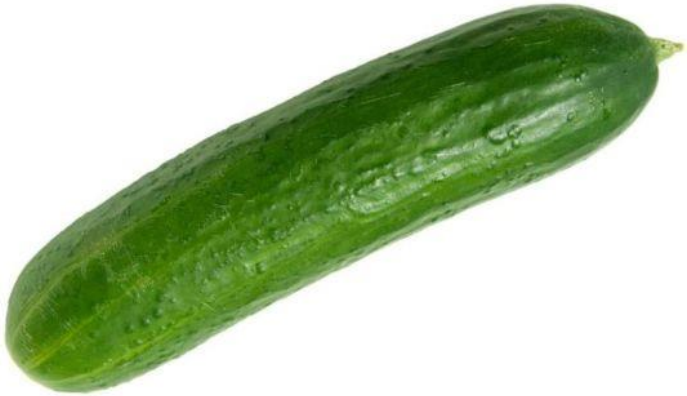
- Increase allocation efficiency by making sure domestic water demand is met and using the remaining available water below the maximum sustainable level for the production of high value-added products and crops with relatively low WFs for export.

- Use the revenue obtained by export to finance the inevitable imports of water-intensive products and commodities from a diverse number of countries that are under a significantly lower degree of water scarcity than Jordan.

(Schyns et.al., 2015)

Virtual water exports in LJRB





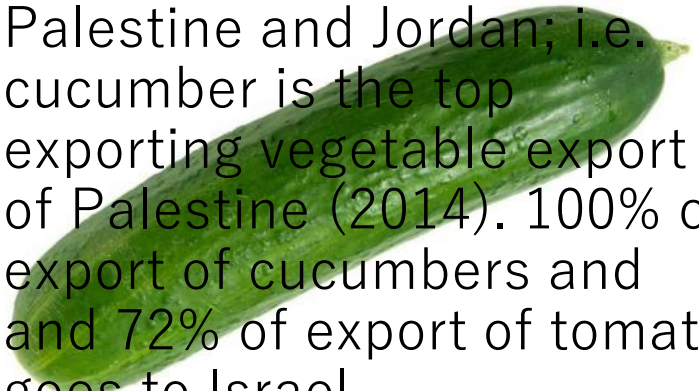
Virtual water exports in LJRB

- Israel has been increasing the export of the high-valued vegetable and fruits products such as avocado, date, mango, citrus to mainly EU countries and worldwide while decreasing the cultivation areas of low-valued cucumber and tomatoes.

- Average price is 2-3 USD/kg for tropical fruits.

6 USD/cum of virtual blue water for avocado.

- Israel's domestic consumption of cucumbers and tomatoes are partly covered by imports from Palestine and Jordan; i.e. cucumber is the top exporting vegetable export of Palestine (2014). 100% of export of cucumbers and and 72% of export of tomato goes to Israel.



- Export values from Palestine to Israel is 1 USD/kg for cucumber.

More than 20 USD/cum of Virtual blue water for cucumber

Israeli agricultural policy pressuring on the local water resources?

- Based on analysis on global virtual blue water trade, Biewald et.al. (2014) conclude that countries in the Middle East profit from trade by importing water intensive crops while countries in Southern Europe export water intensive agricultural goods from water scarce sites, deteriorating local water scarcity.

- Cucumbers and tomatoes are heavily subsidized in comparison to other crops. Cucumbers are characterized by high social losses in Israel and indicate the potential for imports from the Palestinian authority and Jordan (Finkelshtain, Kachel and Rubin 2011).

Concluding remarks

- If the Red Sea - Dead Sea water conveyance project aims at fostering the regional cooperation and peace, all parties will have to enjoy potential benefits of the implementation in a equitable way.

- Due to the the increase of complexity of the water system, the nexus analysis may need system-thinking tools such as system dynamics modeling. Conventional static scenario analysis may not suffice to assess the intertwined nexus.

- For assessing possible tradeoffs of the water engineering project, the water usage should be looked into at the micro level, particularly in agriculture. Already existing unfairness of water use should be addressed as a prerequisite to achieve the project goals.

Next steps….

- For the Jordan river basin: virtual water trade within the basin and with the outside of the basin to be analyzed to maximize water-food-energy security among countries, taking social and political contexts into consideration.

- For water engineering projects: need to consider an appropriate framework to assess both positive and negative impacts of projects in terms of the water-energy-food nexus. Such projects are inherently supply-augmentation-oriented, and demerits of trade-offs could be larger than expected.

- Each case has economically, socially, politically and environmentally different settings so as to require both macro- and micro- level assessments.