Food and Agriculture Organization of the United Nations

World Soil Day

Halt soil salinization, boost soil productivity

5 DECEMBER 2021

Old issues and new challenges in soil salinity research

Tibor Tóth

International Union of Soil Sciences, Commission 3.6 Salt-affected soils

&

Institute for Soil Sciences, Centre for Agricultural Research

Budapest, Herman Ottó 15, Hungary 1022. Email: tibor@rissac.hu

World Soil Day 2021

GLOBAL SOIL PARTNERSHIP

Outline of the presentation

- More technical possibilities, less resilient environment
- Less resilient socio-economic and physical environment
- Soil “Ecosystem” Services
- Limitations of agricultural land area increase
- On/offsite effects of irrigation
- Response of society with examples
- How can managements be evaluated?
- Rated examples of management

More technical possibilities

- Faster, cheaper, more detailed spatial and temporal assessment → more suitable reclamation plans
- Improved dam construction technology
- More powerful water pumping
- More precise and cheaper precision/micro irrigation technology
- Evaporation control
- Improved drainage technology

Less resilient environment

- Inreased population → more land/water is needed → conflict between nature *versus* production, population *versus* farmer/regions/countries
- Global warming → increasing evaporation → increasing salt accumulation
  → sea level rise

Less resilient socio-economic and physical environment

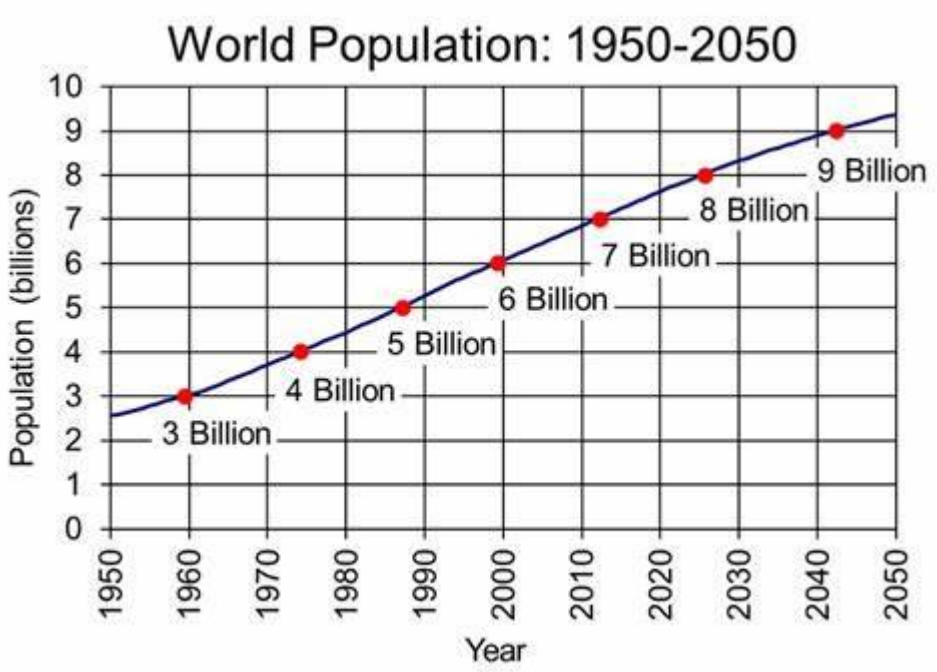
Agricultural management serves the rural economy; every decision is based on cost/benefit ratio.
It is the same for land/soil management.
Nowadays not only financial costs, but environmental, natural “costs” are also evaluated. Some of them are easy to be expressed quantitatively e.g. drainage of waterlogged area after faulty irrigation project.

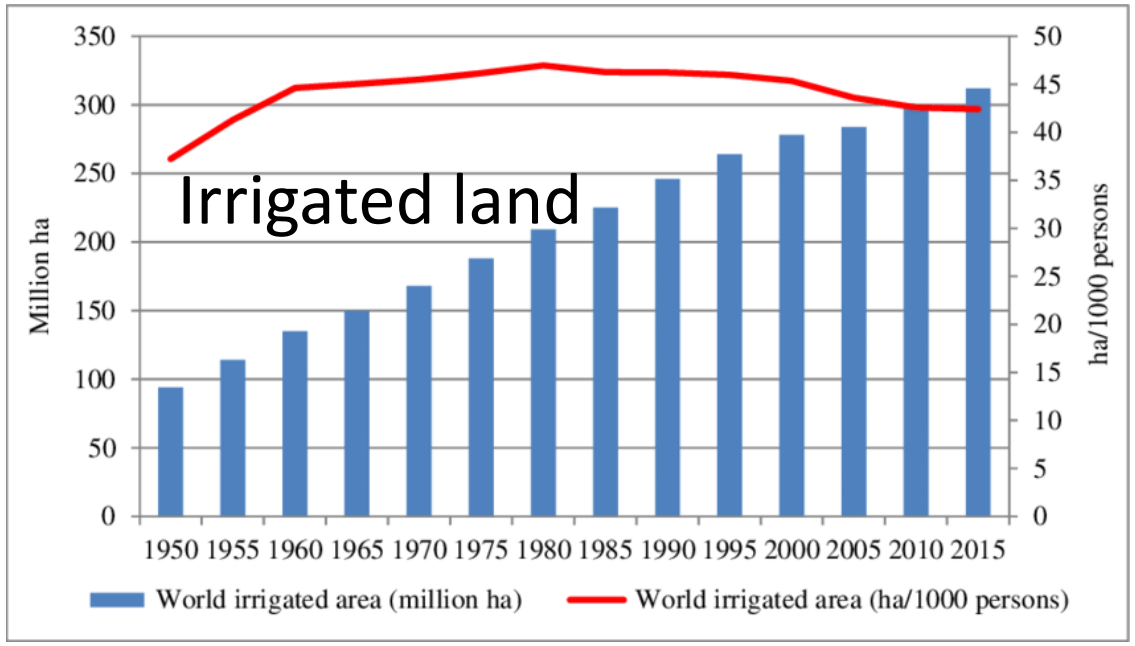
Different sectors of society consider different soil functions to be most important, conflicts are not easy to be solved.

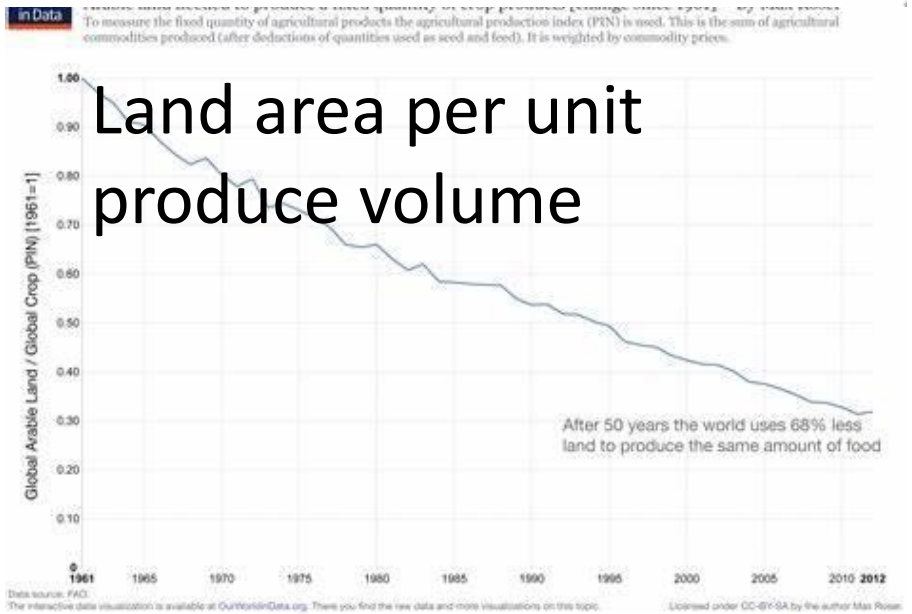
By considering the soil as a natural body that provides services, the following list of Soil "Ecosystem" Services was formulated. Most of these might be allocated financial costs

MAIN GROUP OF SERVICES	INDIVIDUAL SERVICES	INDICATORS
Regulating service	Climate regulation	Carbon sequestration
	Protection from erosion	Soil loss
	Pollination	Contribution of soil to the diversity of pollinators
	Capacity to retain and degrade pollutants	Nitrogen-retention capacity
Provisioning services	Suitable amount and quality of food and raw material	Annual yield
	Timber	Annual timber volume growth
	Fodder	Annual fodder yield or number of supported grazing animals
	Water	Infiltration
Habitat supporting services	Biodiversity	Contribution of the soil to vegetation diversity in case of grassland/wetland

Cropland area cannot be increased over a limit







Is there a price?
Earlier most optimal areas were used for cropping/irrigation.
As population increased more and more territory was covered by cropland, with less and less optimal conditions, thereby carrying risk of degradation.

List of on-site and off-site effects of irrigation

On-site

-Waterlogging
-Salinization/sodification

Off-site

Upstream

-Lack of water
-Dam issues
-Silting of reservoirs
-Seepage from conveyance system

Downstream

-Polluting drainage water

Response of society with examples

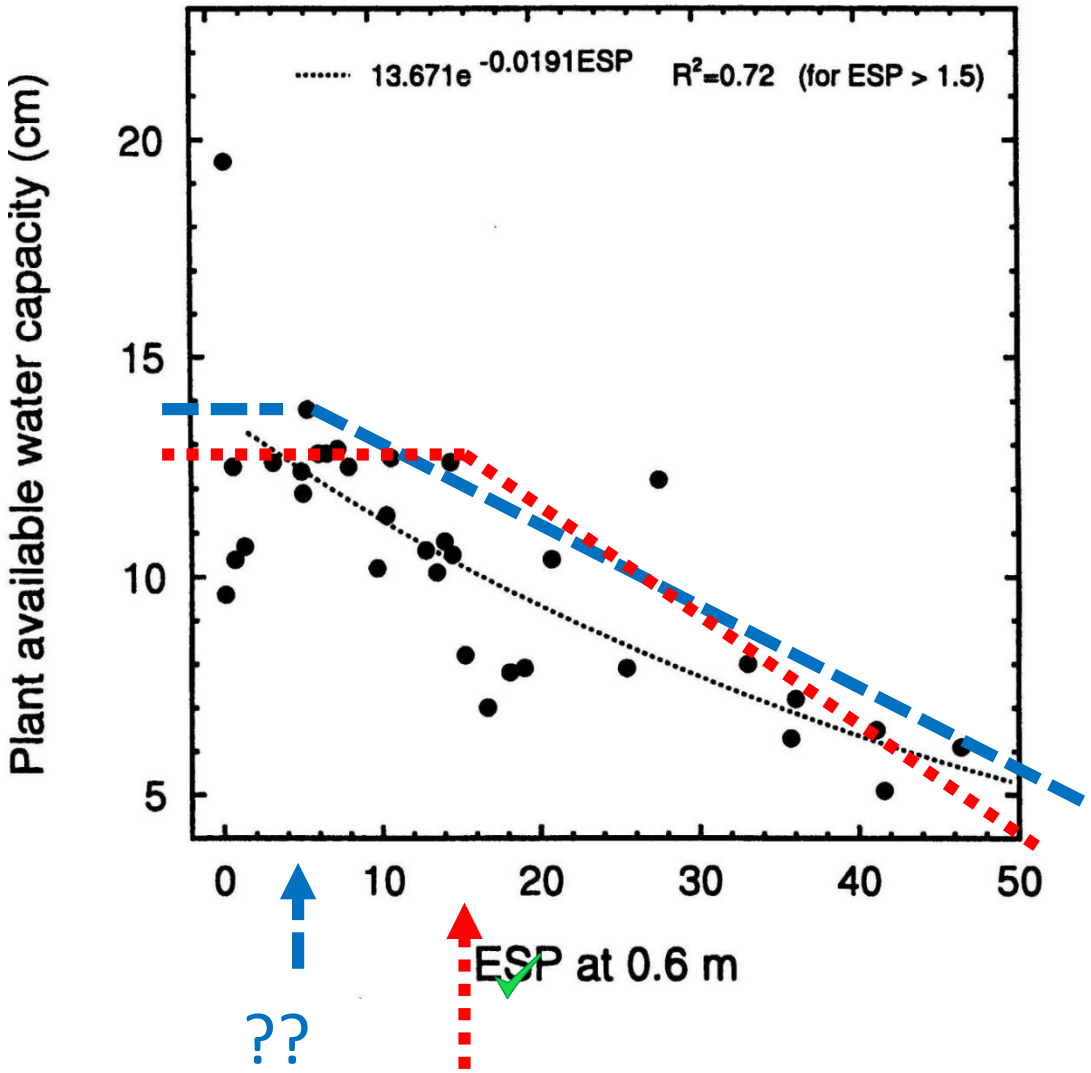
← Subsidy

← Regulation

Punishment →

Scheme for subsidy in Agricultural Areas with Natural Handicaps inside the European Union

Threshold value of sodicity (Shaw et al. 1994)



Areas with Natural Constraints

	Criteria	Threshold
SOIL	Limited soil drainage	Wet 80 cm > 6 months, or 40 cm > 11 months OR Poorly or very poorly drained OR Gleyic color pattern within 40 cm
	Unfavourable texture and stoniness	≥ 15% of topsoil volume is coarse material, rock outcrop, boulder
		Texture class in half or more (cumulatively) of the 100 cm soil surface is sand, loamy sand
		Topsoil texture class is heavy clay (≥ 60% clay)
		Organic soil (organic matter ≥ 30%) of at least 40 cm
		Topsoil contains 30% or more clay AND there are vertic properties within 100cm of the soil surface
	Shallow rooting depth	Rooting depth ≤ 30 cm
	Poor chemical properties	Salinity (electrical conductivity) ≥ 4 dS/m in topsoil
		Sodicity ≥ 6 ESP in half or more of the 100 cm surface layer
		Soil acidity topsoil pH (H_20) ≤ 5

Criterion 6.1: Chemical Properties – Salinity

Threshold

- Salinity tolerance is influenced by plant physiology, soil and environmental factors and their interrelationships. Although crop response to soil salinity is crop specific, overall there are good arguments to accept that:
- Levels over 4 dS/m severely affect many plants.
- In case of negative synergy, the sub-severe threshold is 3.2 dS/m.

Assessment

- Soil salinity is determined by measuring the electrical conductivity of a solution extracted from a water-saturated soil paste.
- Soil names in the WRB that can be used for indicating severe salinity constraints of natural saline soils are Solonchaks and *salic* and *petrosalic* soils.

Criterion 6.2: Chemical Properties - Sodicity

Threshold

- The effect of Exchangeable Sodium Percentage (ESP) on the yield, chemical composition, protein and oil content and uptake of nutrients is severe when soil sodicity is at ESP > 6
- In case of negative synergy, the sub-severe threshold is ESP >4.8

Assessment

- Sodicity is determined by measuring the exchangeable sodium proportion of the cation exchange capacity or by comparing the soluble Calcium and Magnesium in a soil solution (SAR – Sodium Adsorption Ratio). According to WRB classification soils having a high content of exchangeable Na are Solonetz, *natric* soils, or *sodic* soils, which can be used for indicating a severe sodicity constraints.

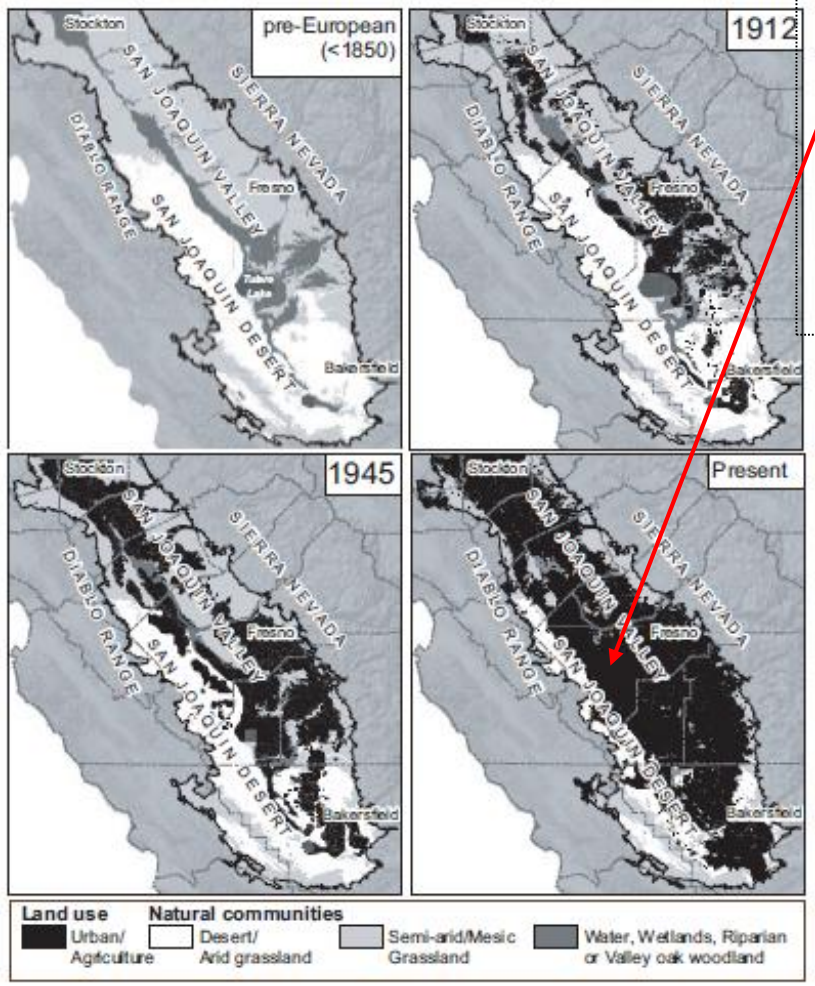
Irrigation, water demand, salinity and sustainability in the San Joaquín Valley, CA, USA

Intensive irrigated agriculture → At some places rising watertable → Salinization → Dust pollution → Health concerns

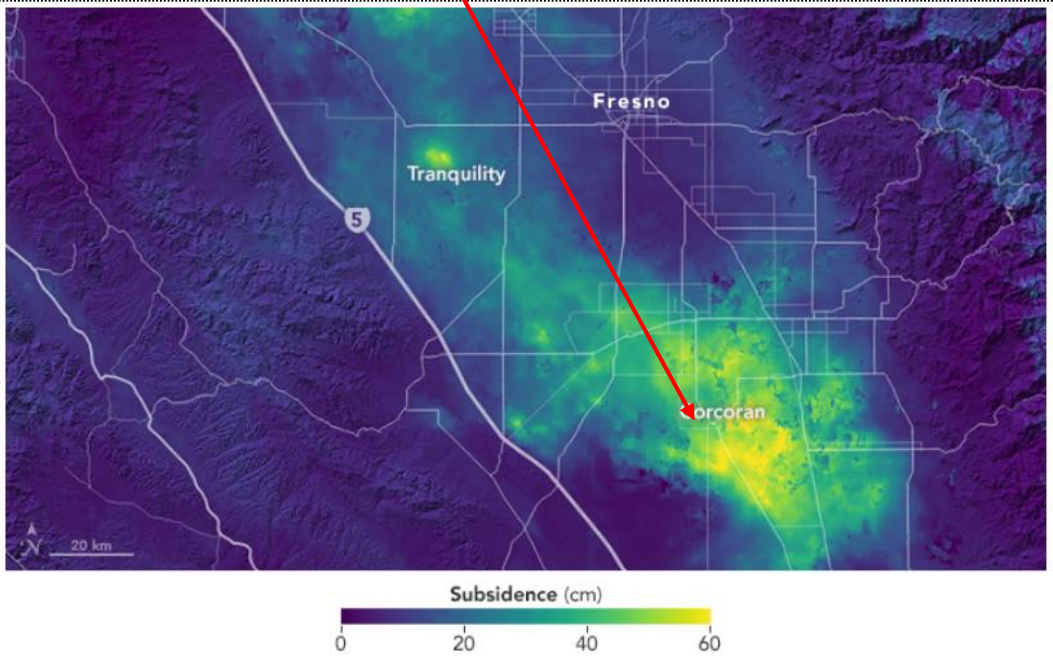
→ At other places increasing groundwater use → Land subsidence → Damages to infrastructure

Increasing water demand + Drought → Conflicts between population and farmers

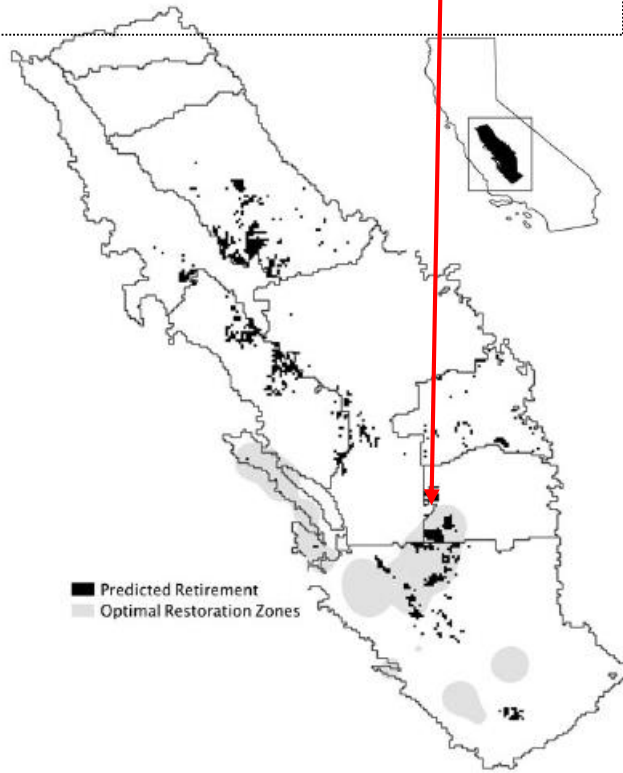
Societal response → Legal limitation of water use/irrigated land area → Land retirement → Rewilding former agricultural land



Land use change due to agricultural expansion and urbanization in the San Joaquin Valley over the past 150 years.

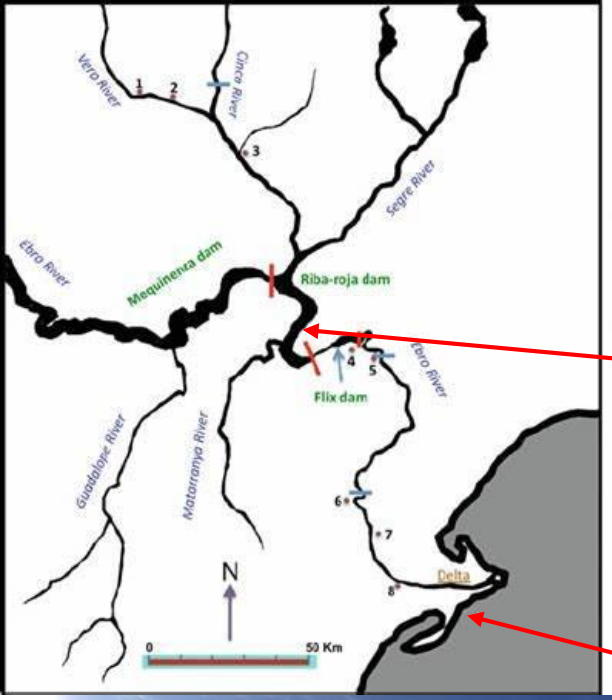


Extent of land subsidence due to groundwater extraction



Planned land retirement

Cropland occupied by seawater on Mediterranean coast, Spain



Cities/Towns

1.- Castillazuelc
2.- Barbastro
3.- Monzón
4.- Flix
5.- Ascó
6.- Xerta
7.- Tortosa
8.- Amposta

Nothing can be done?

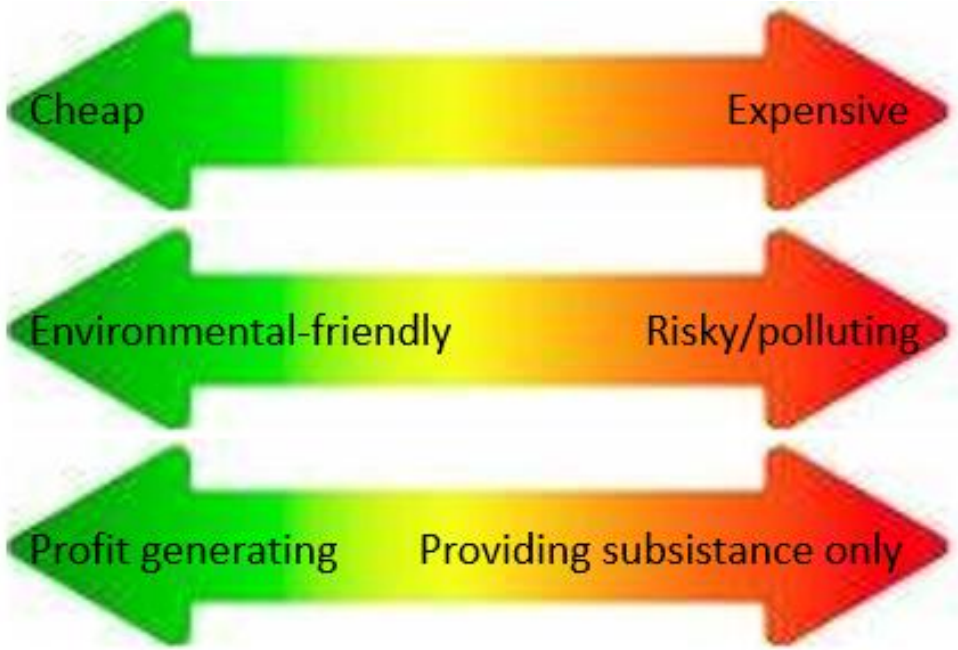
As the consequence of silting of reservoirs built for irrigation/electric energy
Ebro river sediments do not reach the sea, the waves destroy the coast+sea level rise.

How can managements be evaluated?

Financial costs of production

Environmental damages caused by the production

Does it generate profit?



Investment /Cost ↔ Naturalness of original ecosystem

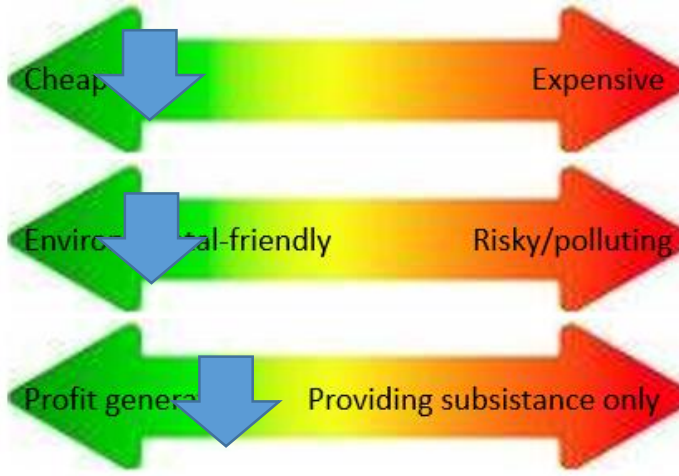
Extremes of this case

Maximum cost/Minimum naturalness		Minimum cost/Maximum naturalness
Rice cultivation in desert	↔	Grazing in sodic grassland

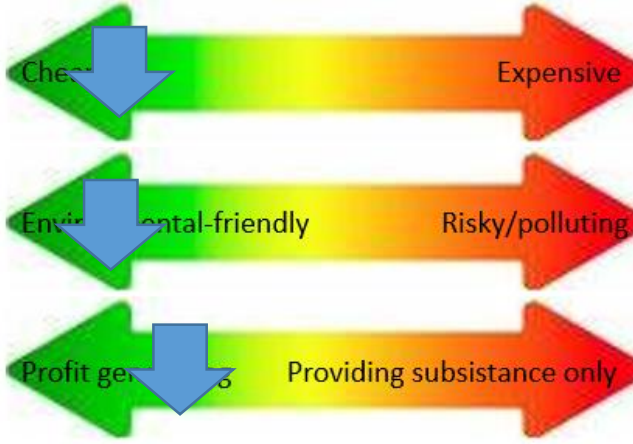
"Improving soil in one place degrades soil and water resources somewhere else." Oster and Jayawardane, 1998, p146

Rated examples of management

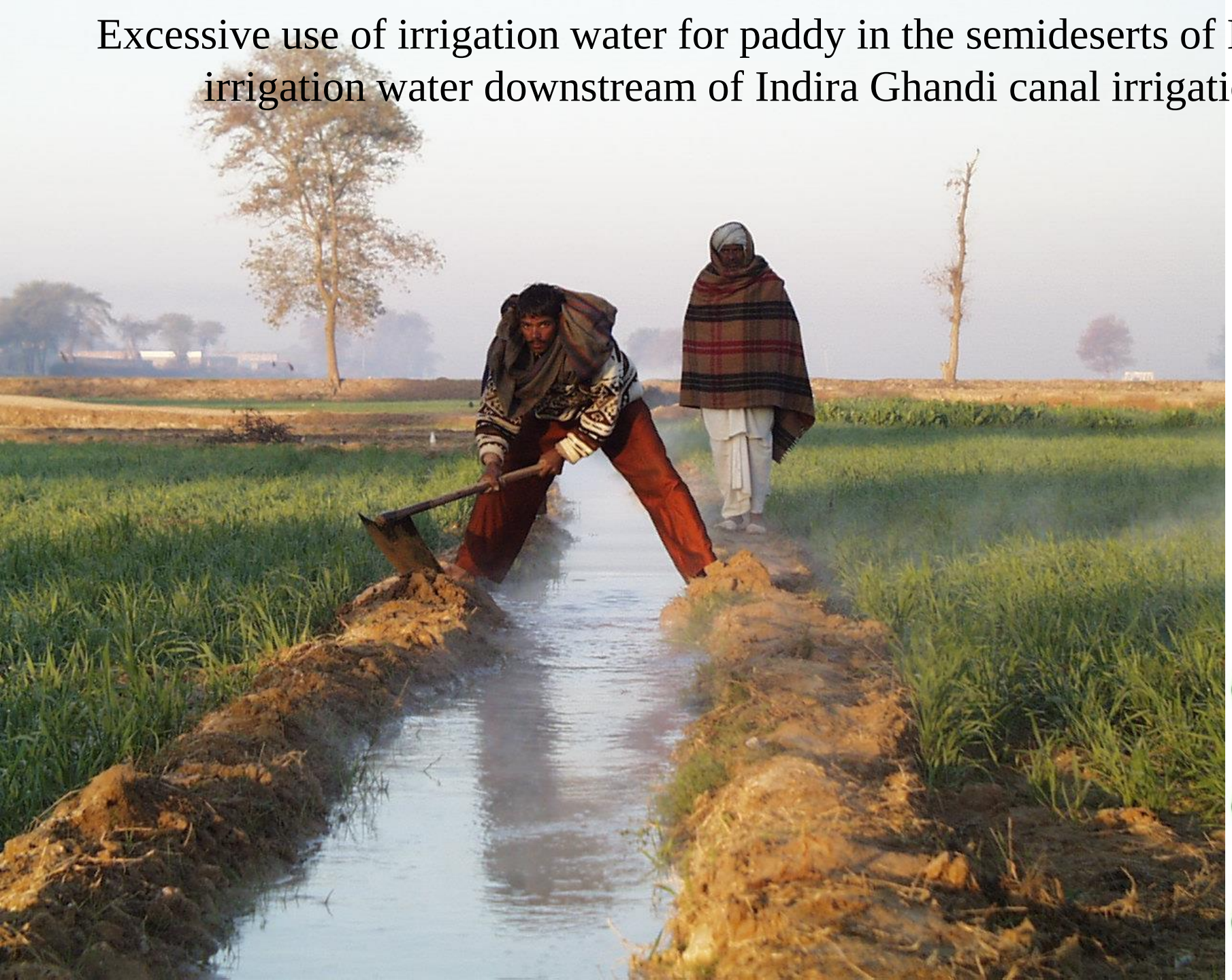
Grazing in a sodic grassland in Hungary

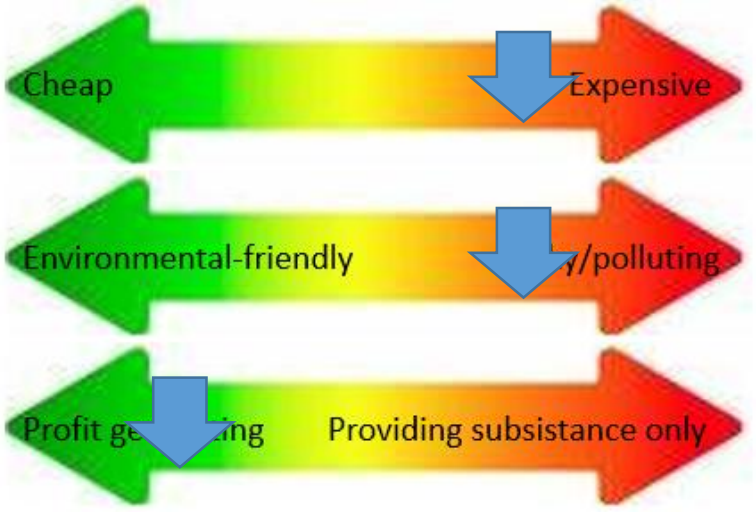


Old environmental friendly adaptation with pokkali rice cultivation in South Indian Coast



Excessive use of irrigation water for paddy in the semideserts of India causes shortage of irrigation water downstream of Indira Ghandi canal irrigation command area





25 cm/year groundwater level rise

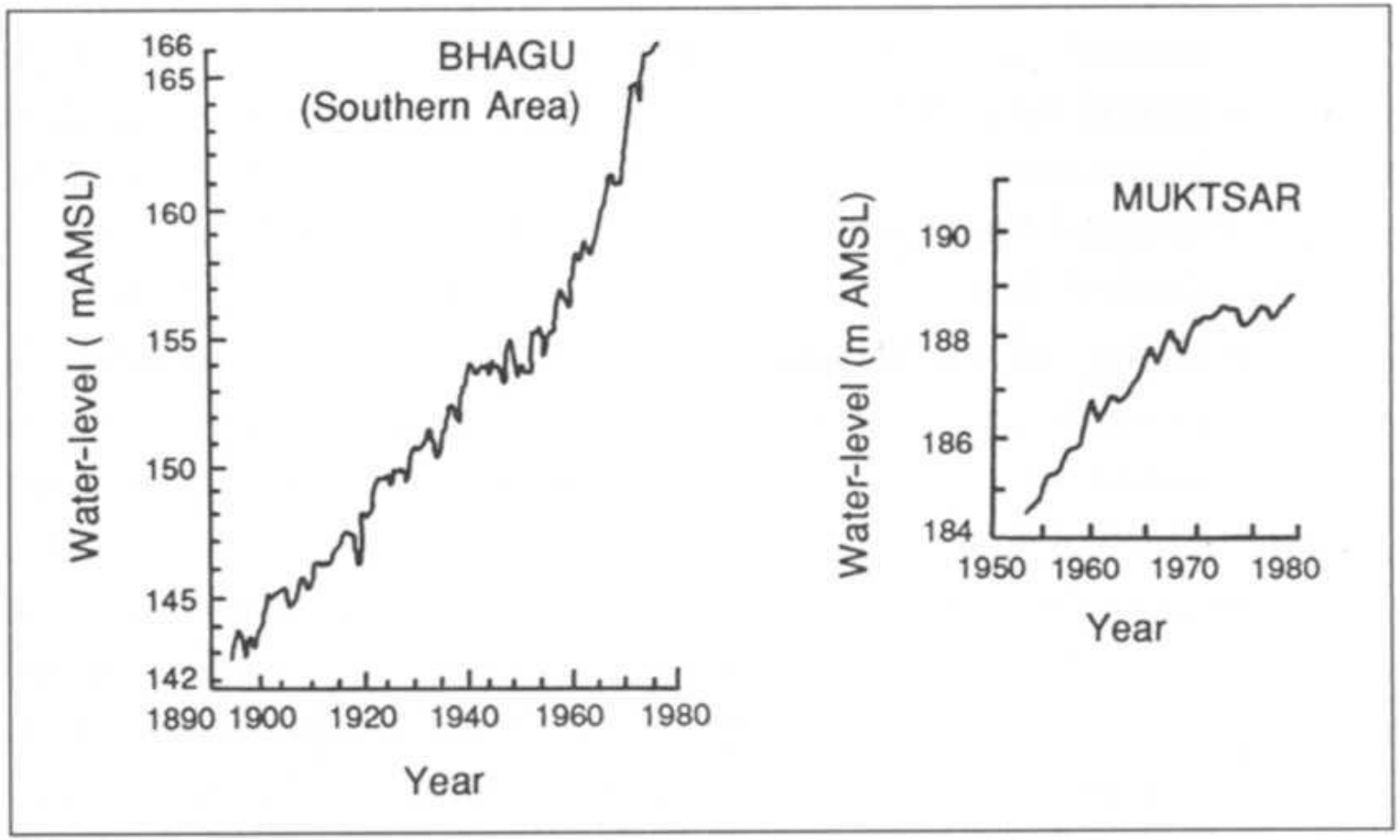
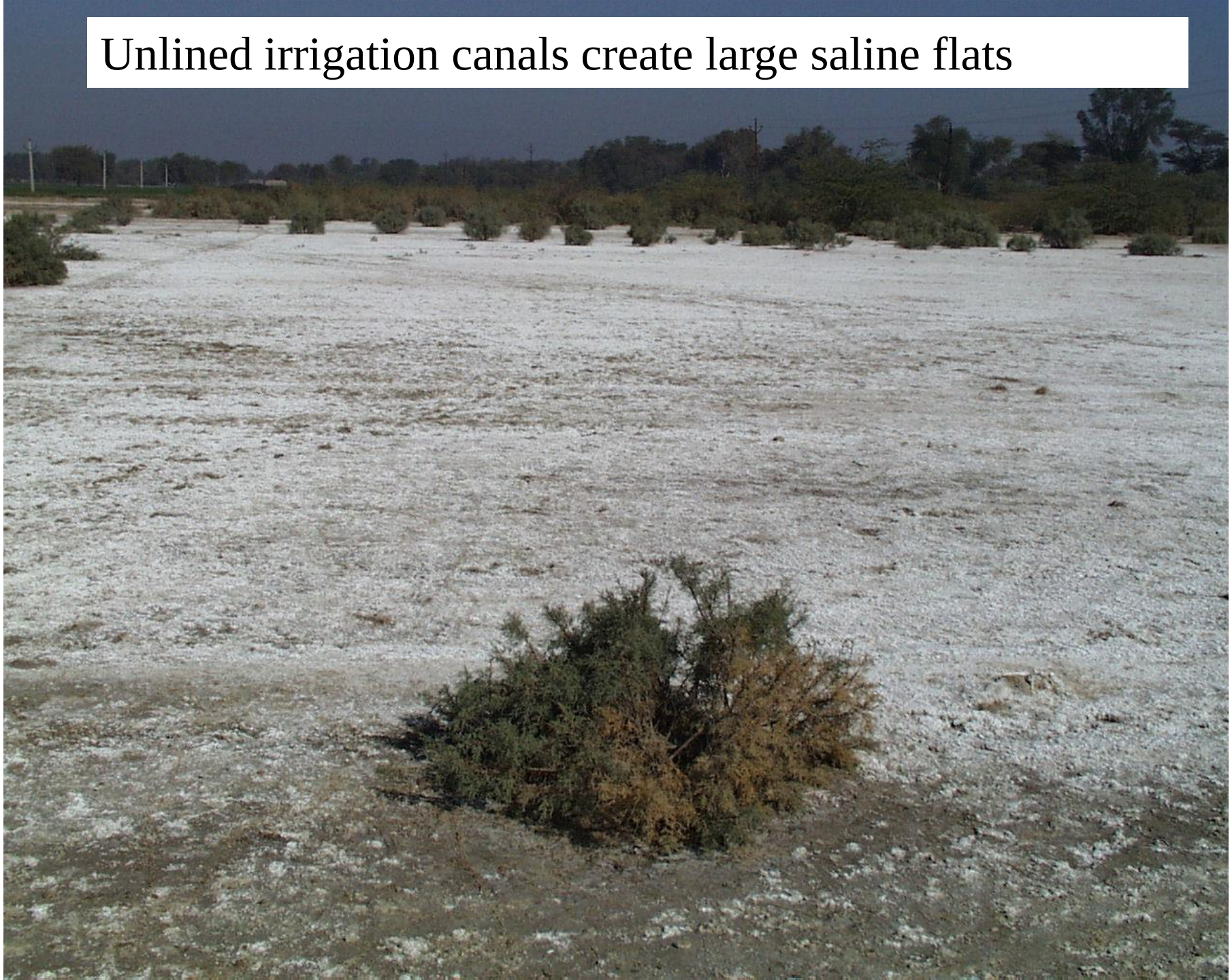
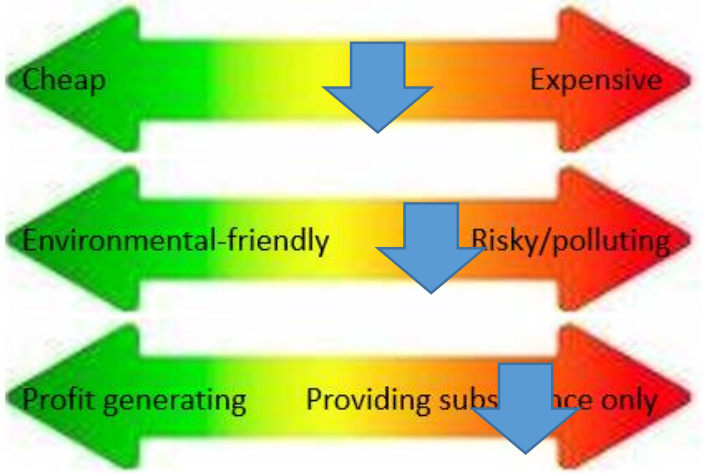


Figure 6-8: **Representative hydrographs of south-western parts of the Old Sirhind**

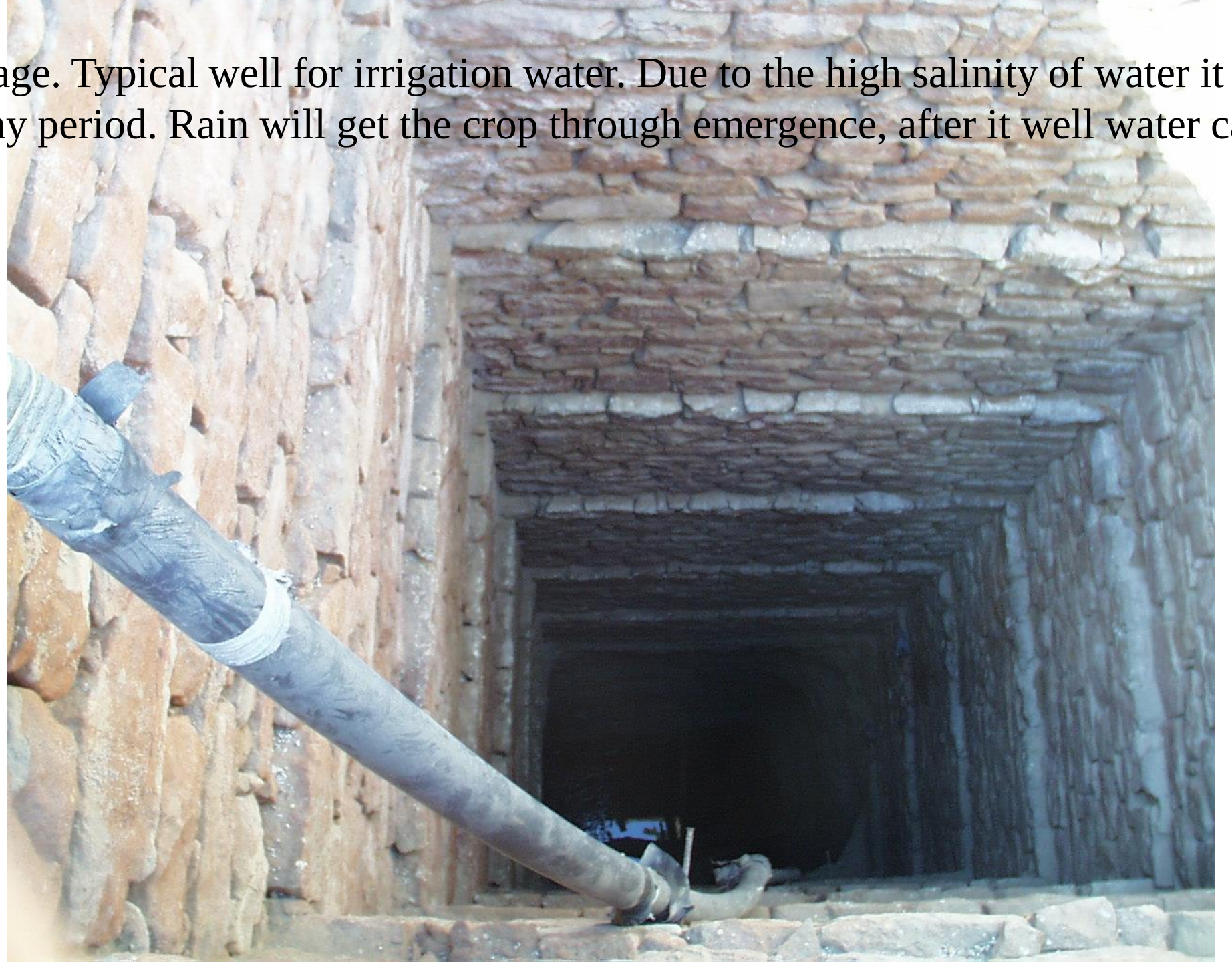
Unlined irrigation canals create large saline flats



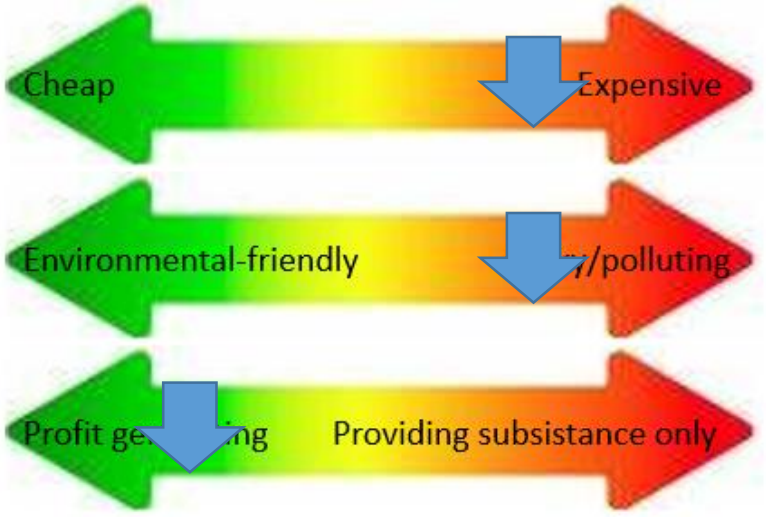
Sathin at Jodhpur, India. Due to sodicity only limited growth of the crop can be seen. Even water buffalos are permitted to browse, they do not make much damage. Needs gypsum for reclamation.



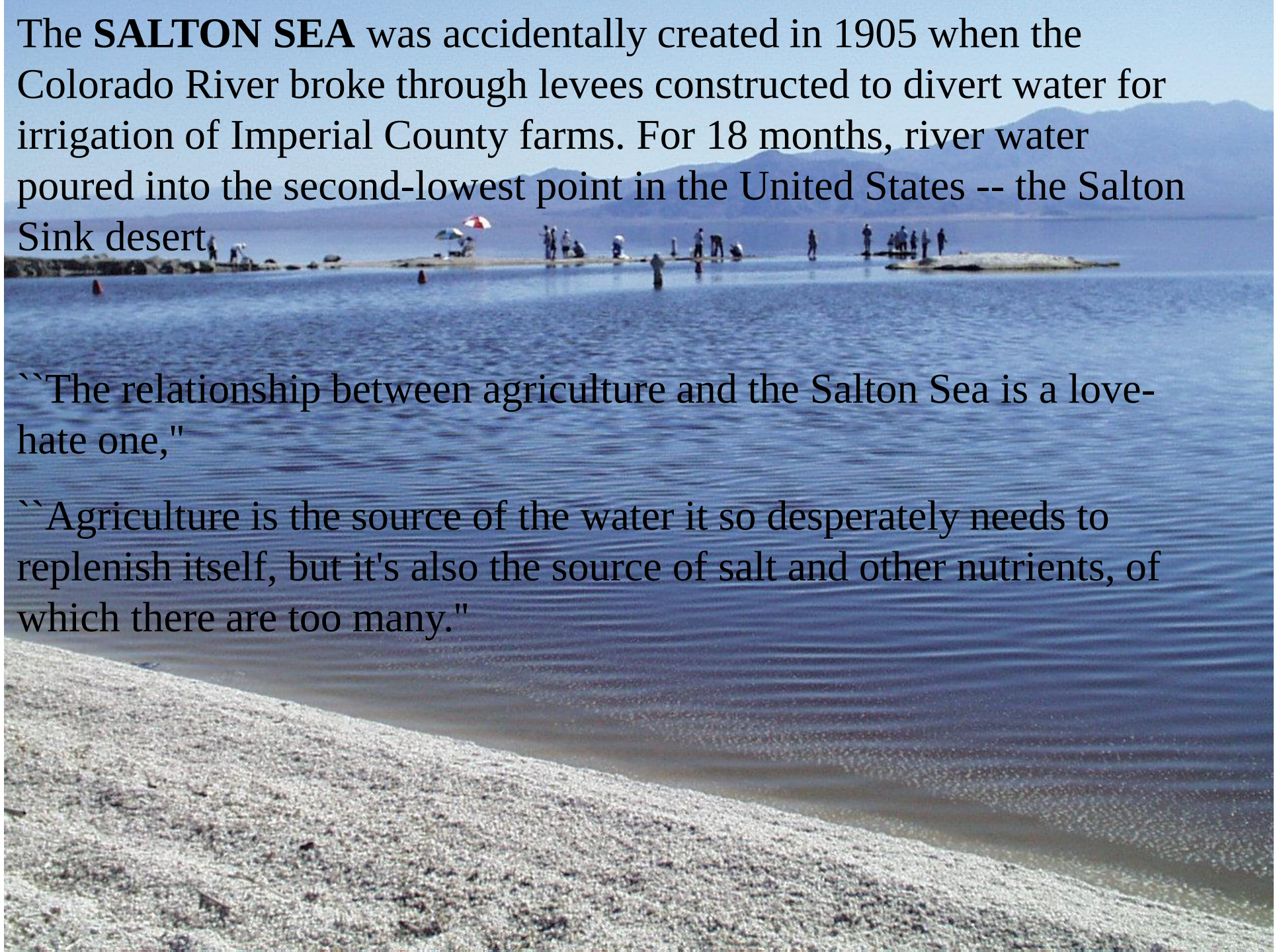
Sathin village. Typical well for irrigation water. Due to the high salinity of water it is used only in the rainy period. Rain will get the crop through emergence, after it well water can be used.



Imperial Valley CA, USA, cotton field with furrow irrigation. Salt efflorescence can be found in the furrows.



Imperial Valley CA Outlet for tailwater in an experiment.

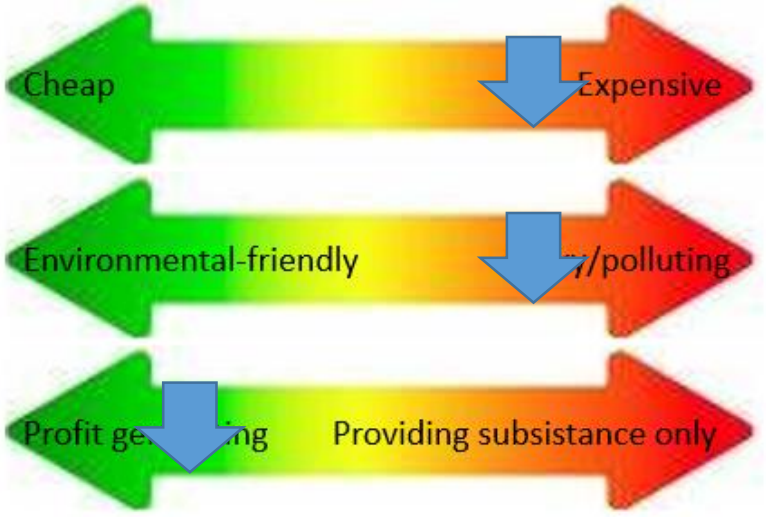


The **SALTON SEA** was accidentally created in 1905 when the Colorado River broke through levees constructed to divert water for irrigation of Imperial County farms. For 18 months, river water poured into the second-lowest point in the United States -- the Salton Sink desert.

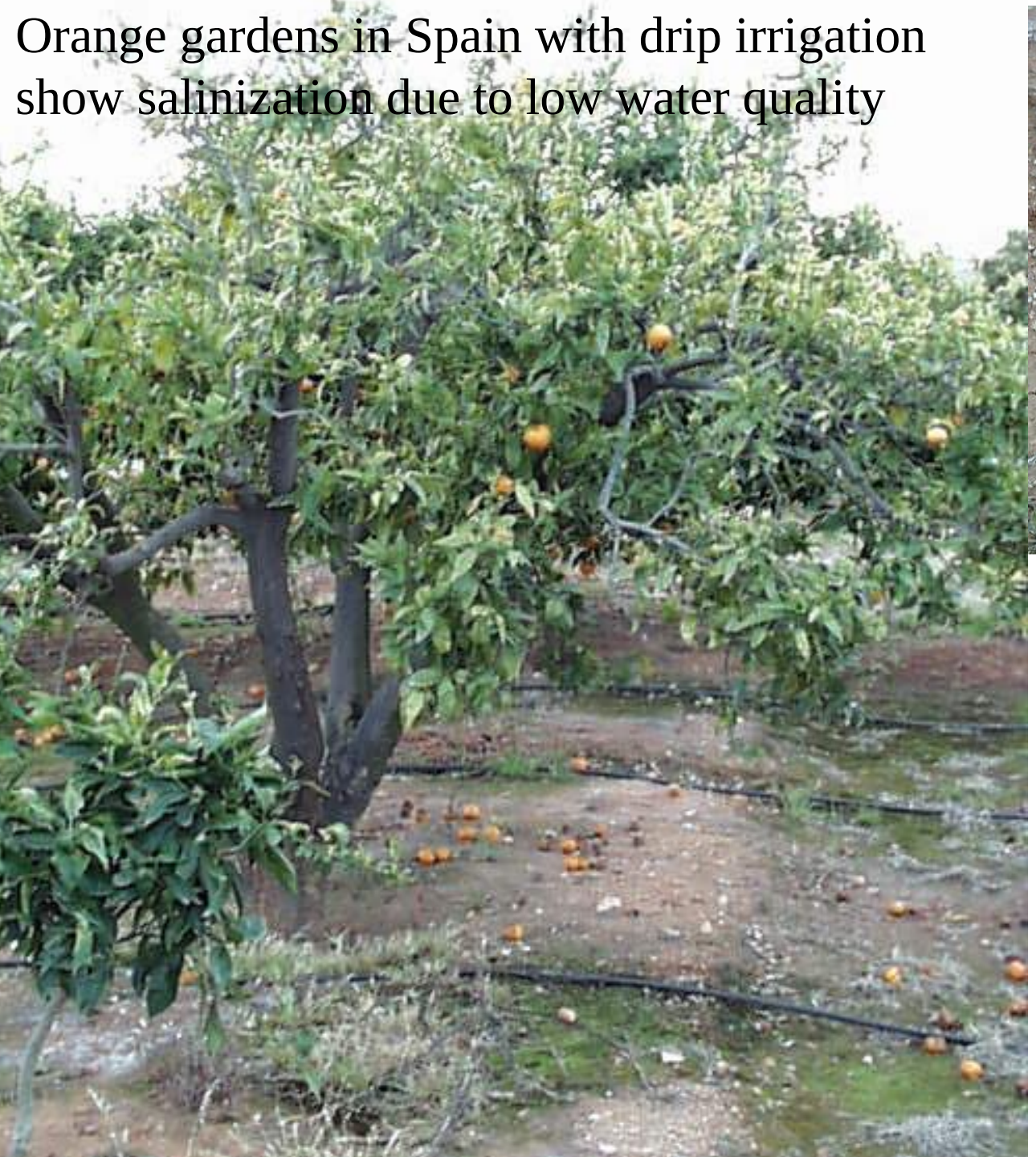
``The relationship between agriculture and the Salton Sea is a love-hate one,"

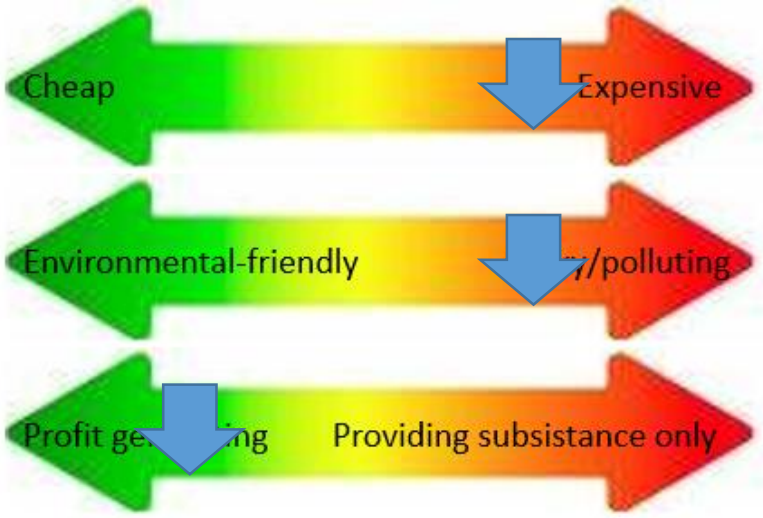
``Agriculture is the source of the water it so desperately needs to replenish itself, but it's also the source of salt and other nutrients, of which there are too many."

Irrigation is a major factor of soil salinization in the Nile Delta



Orange gardens in Spain with drip irrigation show salinization due to low water quality





Most critical issues of management of salt-affected soils

- consideration of the least favourable/most **limiting soil properties**
- selection of **proper land use** type, such as grassland, cropland, paddy, fishpond, forest;
- selection of a **suitable crop** for the particular soil conditions;
- preliminary **evaluation of the drainage conditions** of the area where irrigation is planned;
- selection of the **optimal irrigation technique**, water quality and drainage of the plots;
- **proper disposal of drainage effluents**.

Food and Agriculture Organization of the United Nations

World Soil Day

Halt soil salinization, boost soil productivity

5 DECEMBER 2021

Thank you for the attention!

GLOBAL SOIL PARTNERSHIP