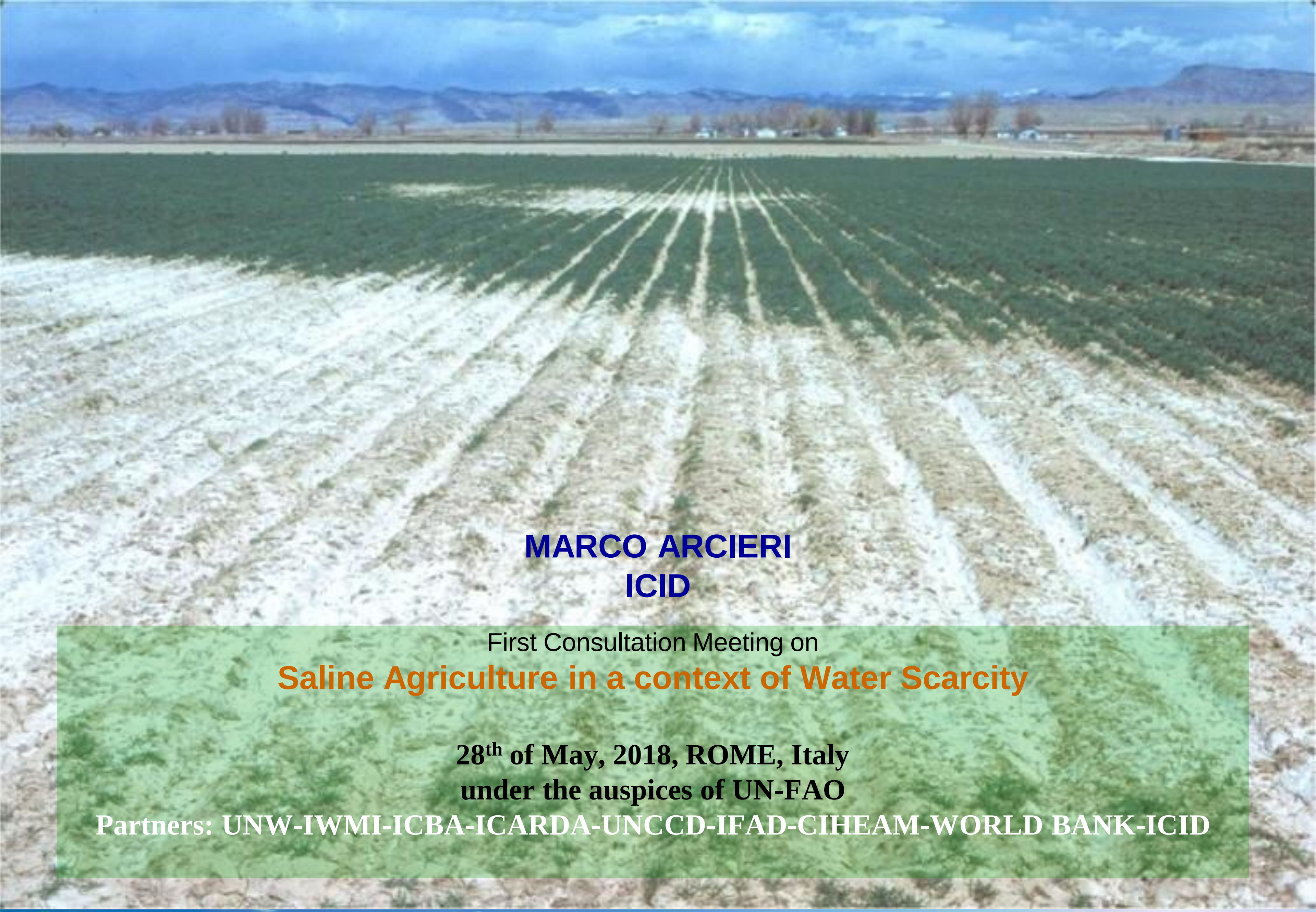


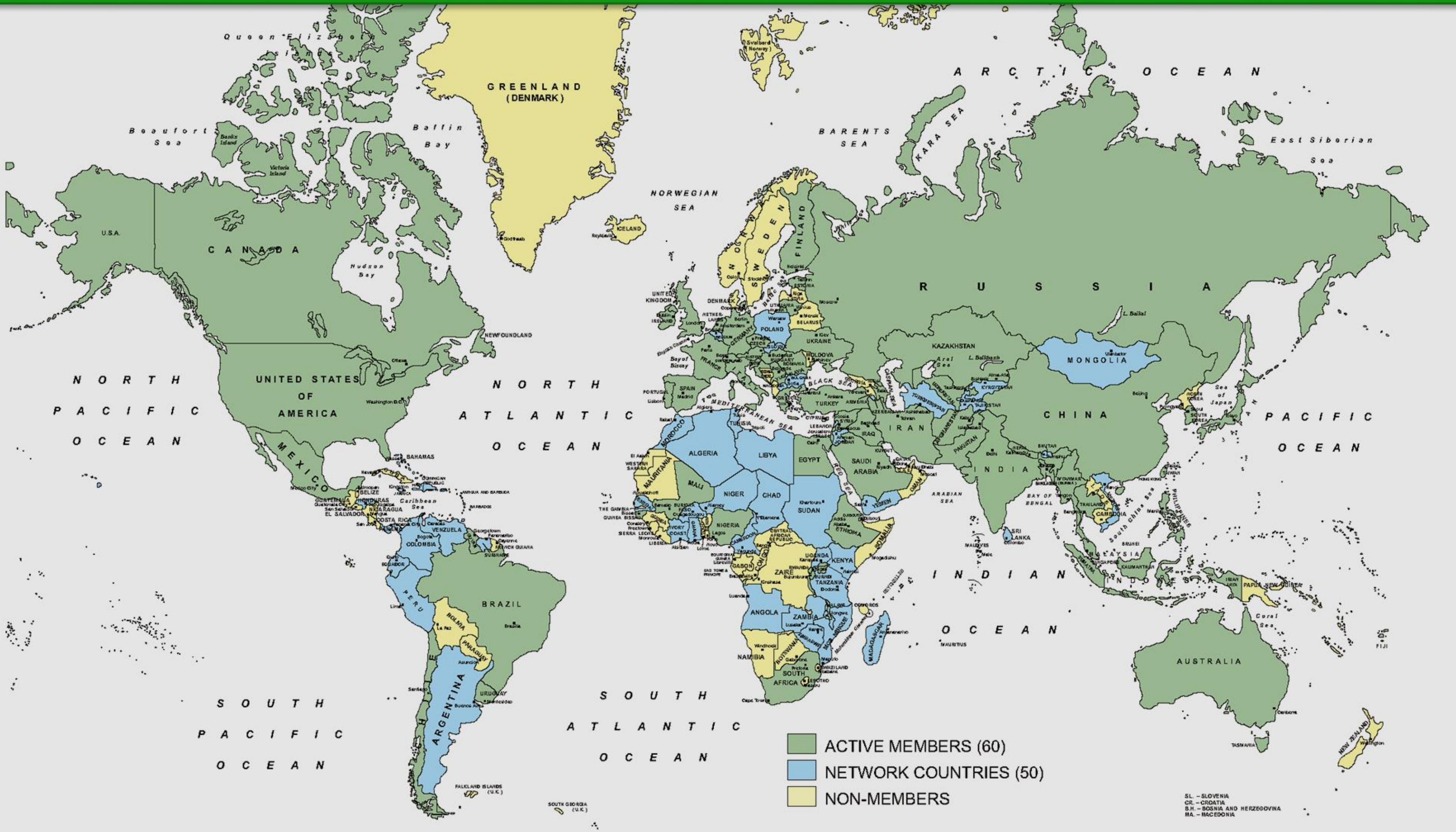
MARCO ARCIERI
ICID

First Consultation Meeting on

Saline Agriculture in a context of Water Scarcity

28th of May, 2018, ROME, Italy
under the auspices of UN-FAO
Partners: UNW-IWMI-ICBA-ICARDA-UNCCD-IFAD-CIHEAM-WORLD BANK-ICID

ICID Membership network spreads over 100 countries covering about 96% of the world's irrigated area



World agriculture faces an enormous challenge over the next 40 years: produce almost 50% more food up to 2030 and double the food production by 2050

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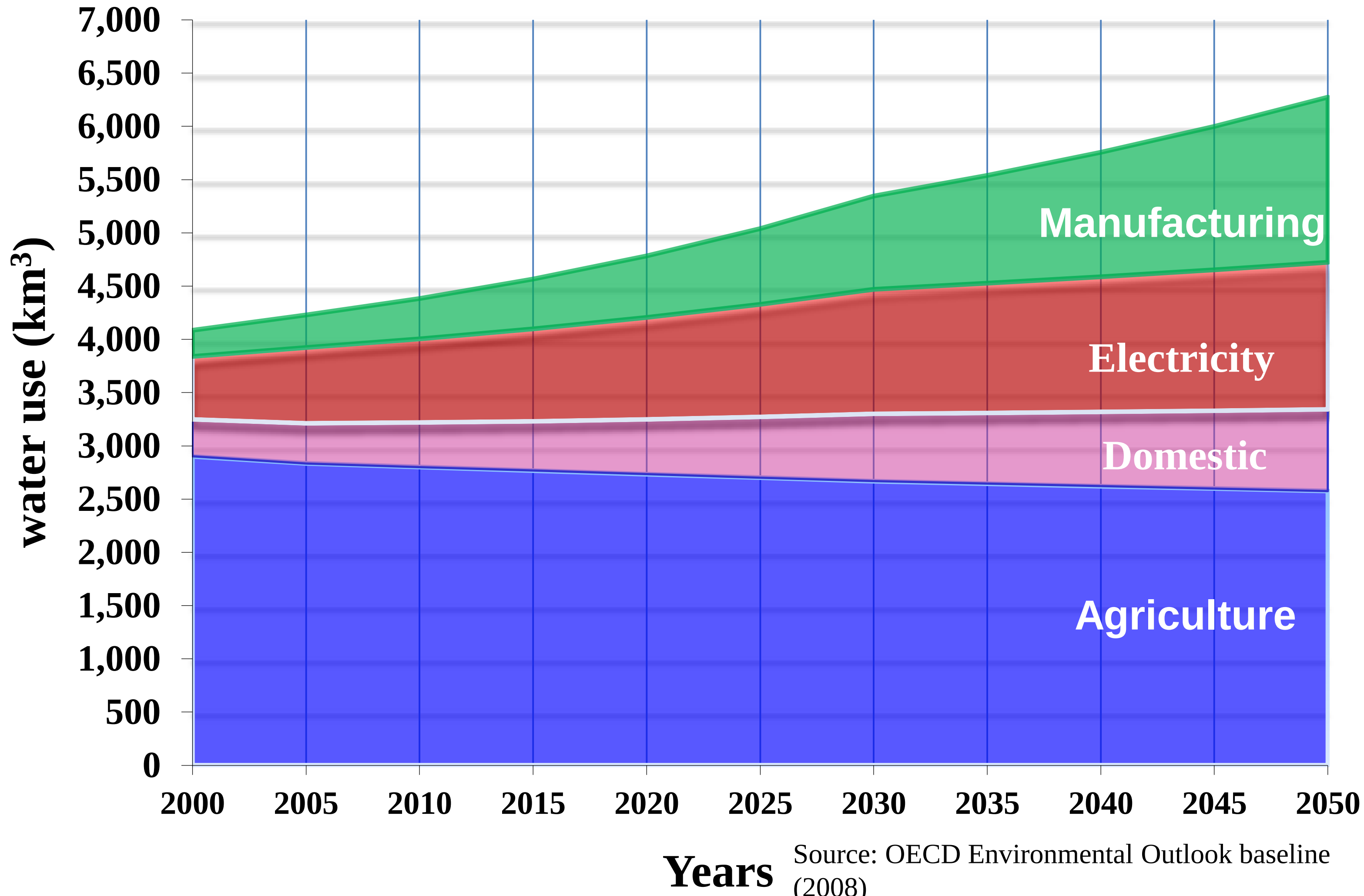
- Increasing population and urbanization
- Changing diets
- Rapidly growing water demand industrial energy domestic sectors
- Increasing area under cultivation of bio-energy crops
- Climate change impacts on environment and agriculture
- Increasing fresh water scarcity

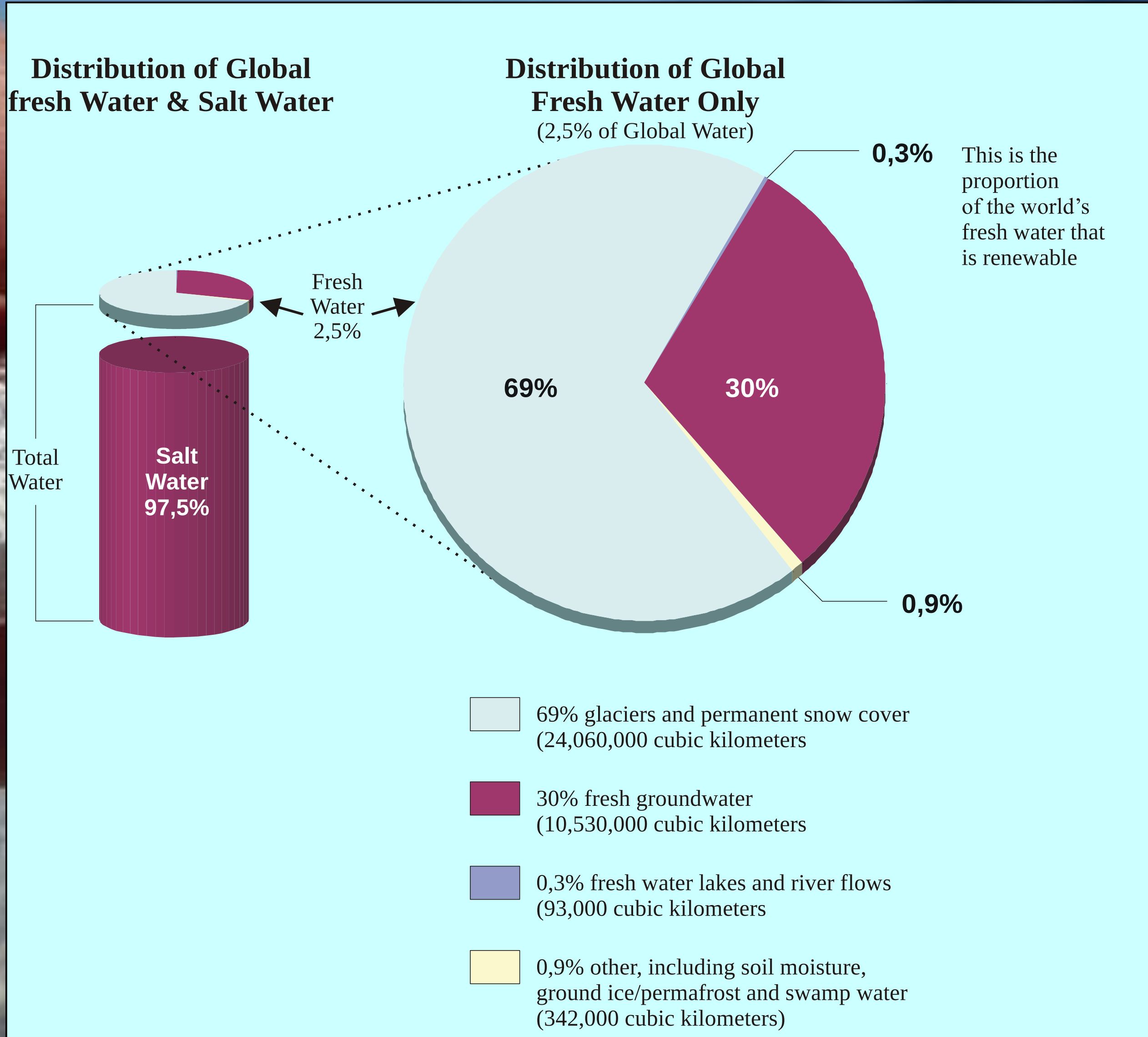
Global freshwater use: projections



Source: OECD Environmental Outlook baseline (2008)

Global freshwater use: limits

THE WORLD'S WATER



Water demand often exceeds reliable and exploitable water resources. We need to reach an appropriate balance between the limited supply and the increasingly demand which, at the moment, is heavily unbalanced.

What are the options available and what are the alternatives that could provide a sustainable solution to avoid water conflicts and to meet the increasingly water demand in agriculture?

In the agricultural sector, the use of non-conventional or poor quality water resources as an additional source for irrigation is one of the exploitable solutions.

EXTENT OF SALT AFFECTED REGIONS

Salinity is reported to affect one billion hectares mostly located in arid and semiarid regions

Extent for salt-affected soils by Continents and Sub-Continents

Region	Milions of hectares
Africa	**80,5**
Australia	**357,3**
Europe	50,8
Mexico and Central America	2,0
North America	15,7
North and Central Asia	**211,7**
South America	**129,2**
South Asia	**87,6**
South East Asia	20,0
TOTAL	**954,8**

Country	% affected	Country	% affected
Algeria	10- 15	India	**27**
Egypt	**30 - 40**	Iran	**< 30**
Senegal	10 - 15	Iraq	**50**
Sudan	< 20	Israel	13
United States	20 -25	Jordan	16
Colombia	20	Pakistan	**< 40**
Peru	12	Sri Lanka	13
China	15	Syrian Arab Republic	**30 - 35**

Estimates of percentage of irrigated land affected by salinization for selected countries

SOIL SALINITY: SALT-AFFECTED AREAS

Salt-affected areas (Ghassemi et al., 1995)

- 7% of the earth's continental extent
- 20% of the world's irrigated lands
- Reduced crop productivity, soil degradation, increased soil erosion etc.

Salt-affected areas of the world (> 10 Mha)

Region	**Area (10^6 ha)**
North America	16
Argentina	86
Paraguay	22
Ethiopia	11
India	24
Iran	27
Pakistan	10
China	37
(Former) USSR	171
Indonesia	13
Australia	**357**

SOIL SALINITY: EFFECTS OF SALINITY ON CROPS

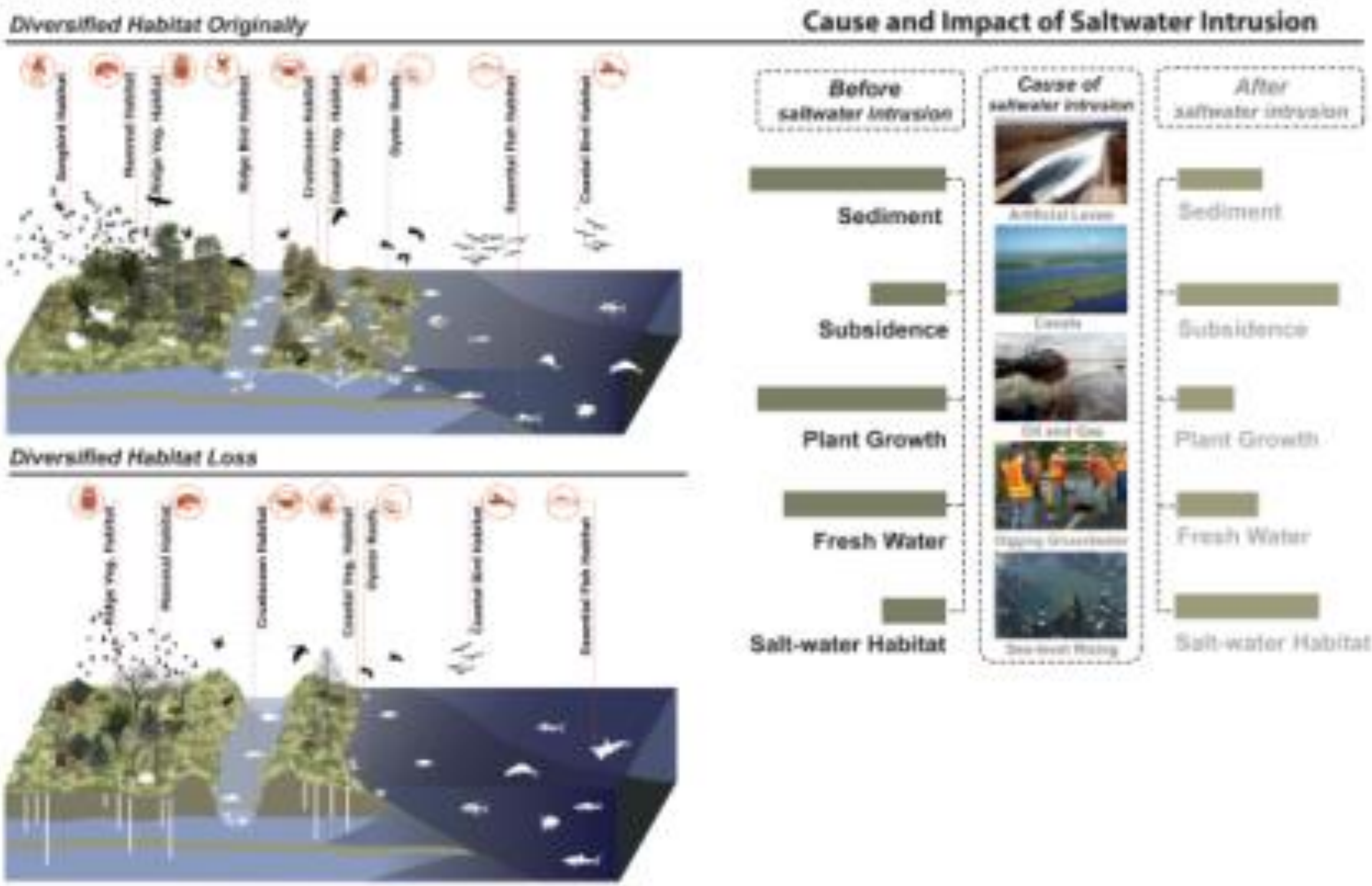
Soil Salinity Class	EC of the Saturation Extraction (dS/m)	Effect on Crop Plants
Non saline	0 – 2	Salinity effects negligible
Slightly saline	2 – 4	Yields of sensitive crops may be restricted
Moderately saline	4 – 8	Yields of many crops are restricted
Strongly saline	8 – 16	Only tolerant crops yields satisfactory
Very strongly saline	> 16	Only a few very tolerant crops yield satisfactory

(Source: FAO Natural Resources Management and Environment Department)

Saline Water Origin and Source

The important source of saline areas over the world are:

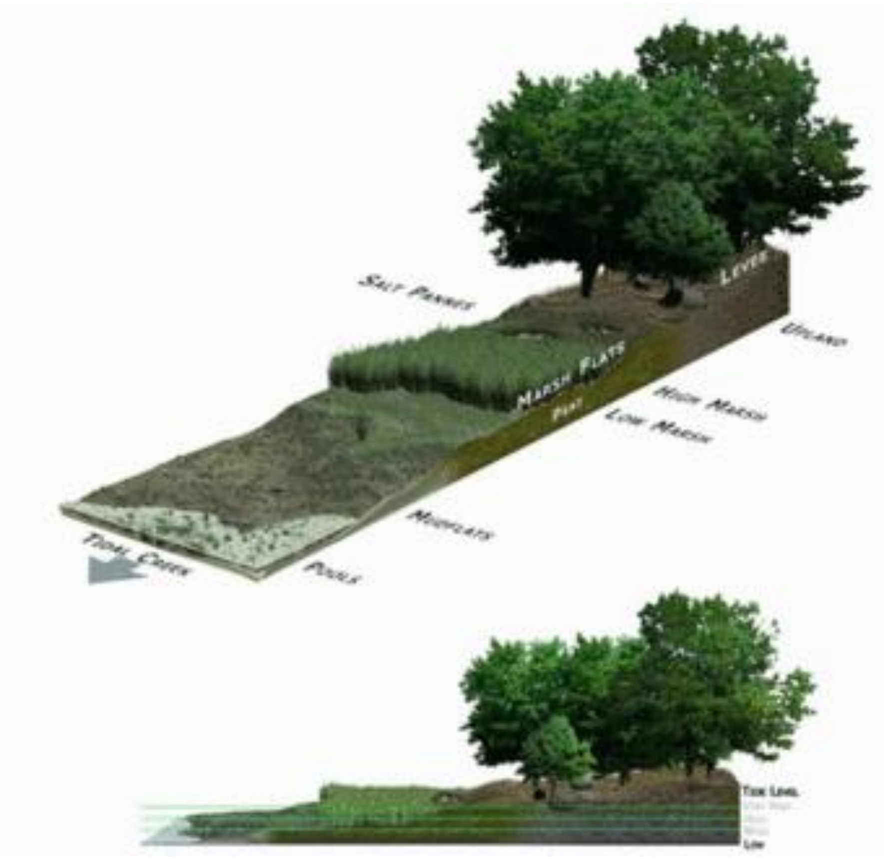
- seawater intrusion in coastal regions (uncontrolled pumping & welling)



Saline Water Origin and Source

The important source of saline areas over the world are:

- tidal influence of sea on coastal surface water



Saline Water Origin and Source

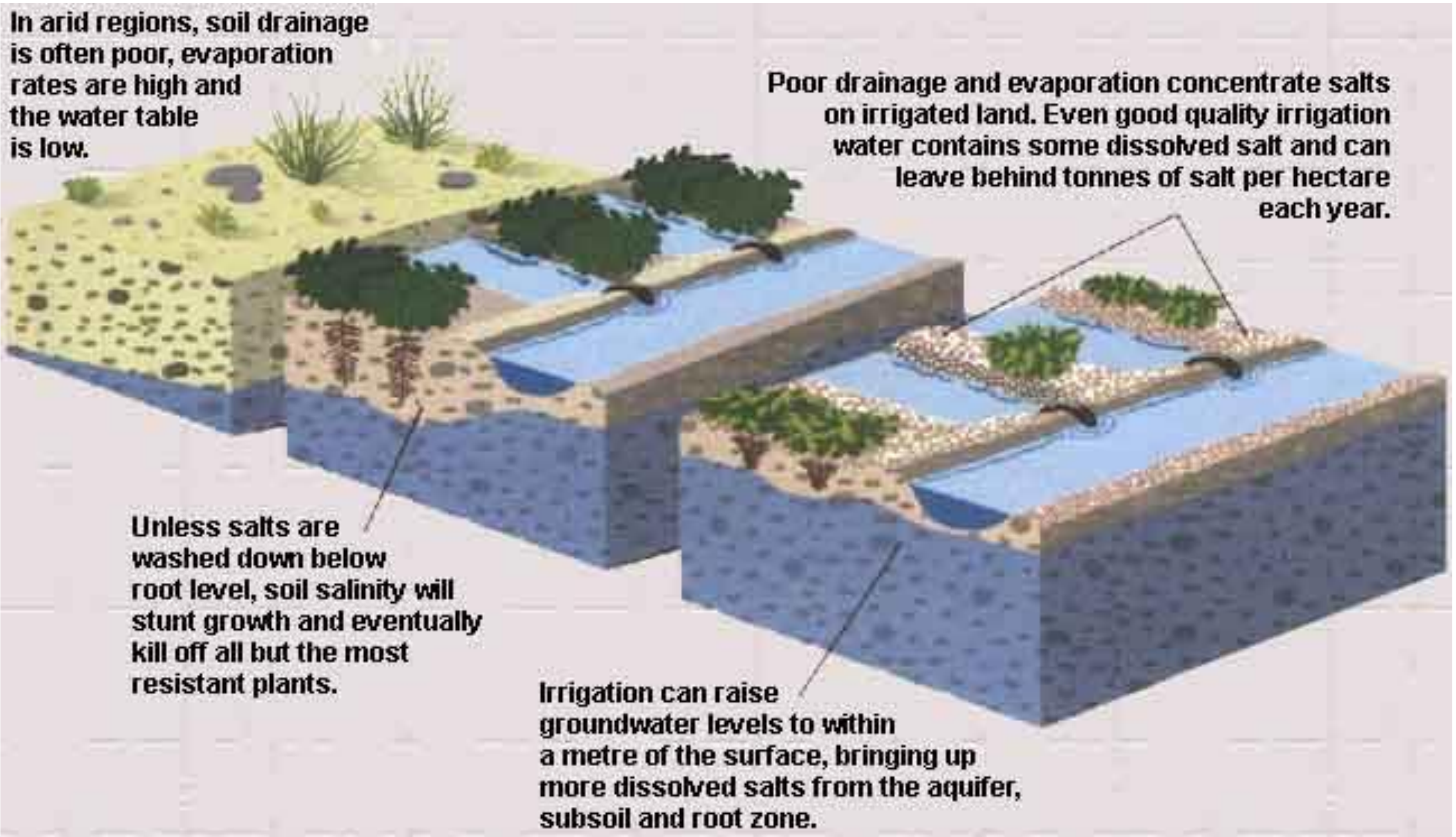
The important source of saline areas over the world are:

- ground water mineralization in rock formations

Saline Water Origin and Source

The important source of saline areas over the world are:

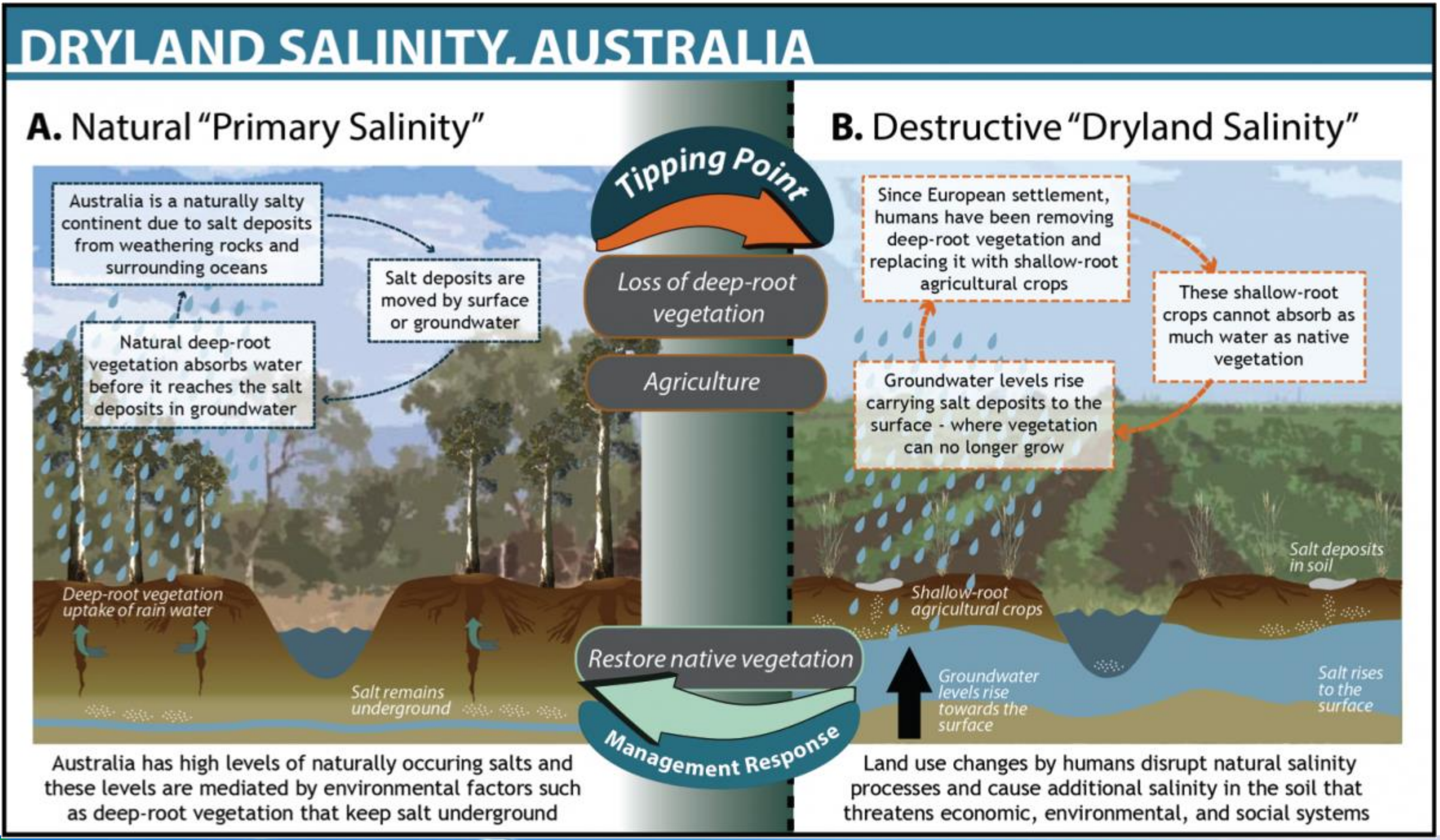
- process of evaporation/evapotranspiration, especially in arid and semiarid regions and subsequent enrichment of salts in surface and ground water



Saline Water Origin and Source

The important source of saline areas over the world are:

- water logging and secondary salinization of soils



Saline Water Origin and Source

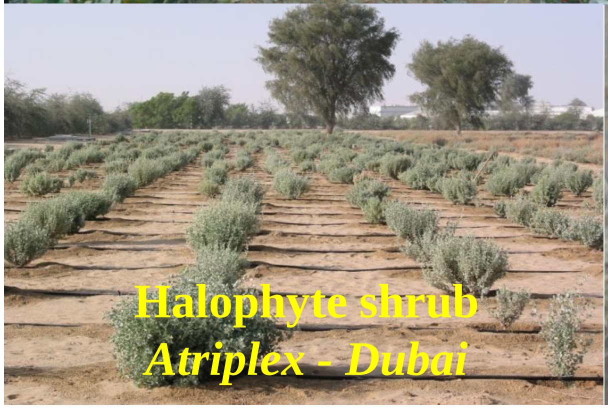
The important source of saline areas over the world are:

- drainage and sewage effluent

POOR QUALITY WATER

- **Saline water**
- **Brackish groundwater**
- **Wastewater**

Saline water can be used to produce food and fodder. Some varieties of tomato, sugar beet, barley, Bermuda grass are salt tolerant.



ICID WORKING GROUPS

Working Group on Environment (WG-ENV)

Mandated to:

- **Provide guidance on the environmental aspects of drainage and irrigation systems**
- **Management of sustainable agriculture in extreme environments**
- **Maximising positive and minimizing negative aspects of irrigation and drainage**

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Working Group on use of Poor Quality Water (including wastewater) in irrigation (WG-PQW)

Mandated to:

- **Promote safe management of poor quality water**
- **Consider the required institutional and legislative aspects**

Management Practices Of Saline Irrigation Water

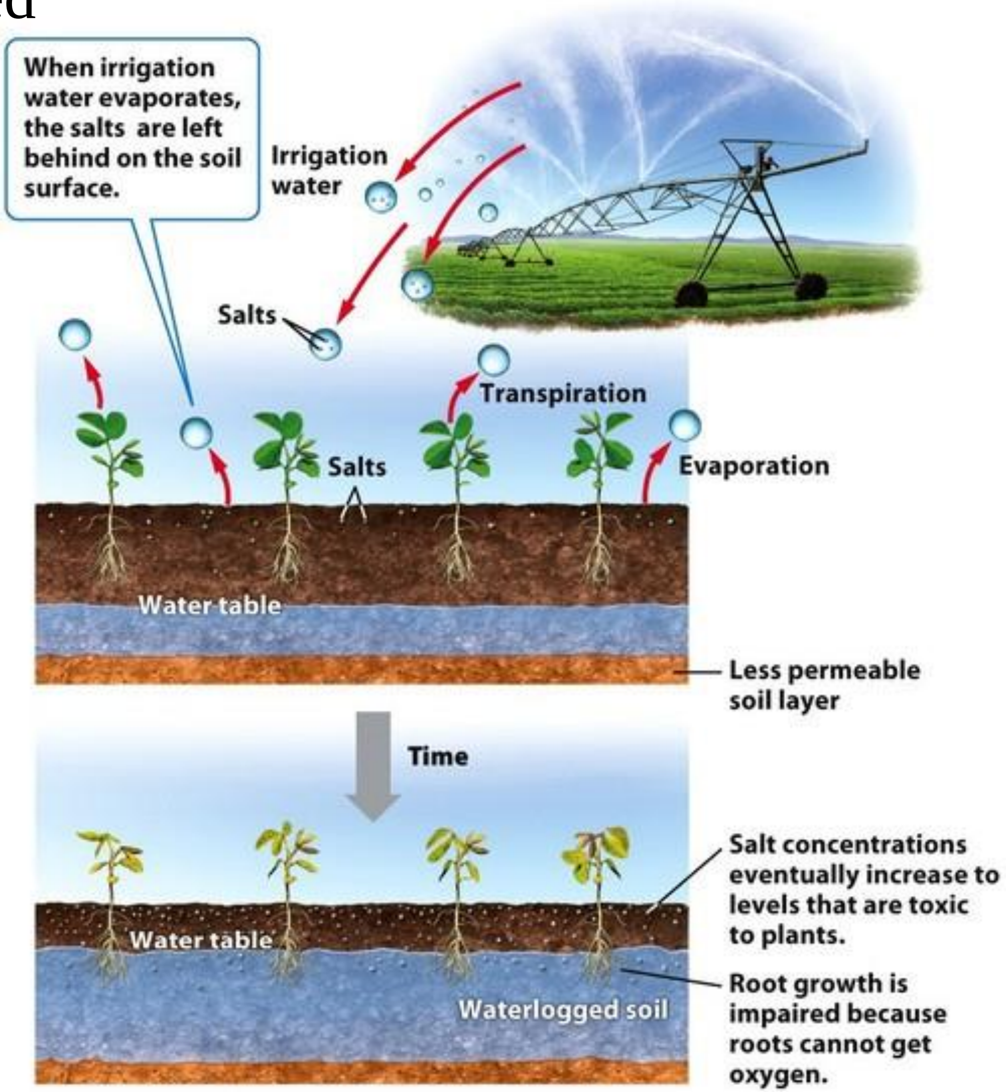
There is usually no single way to control salinity, particularly in irrigated land several practices can be combined into an integrated system that functions satisfactorily.

- ***Hydraulic Management:***
  - Leaching (Requirement, Frequency)
  - Irrigation (System, Scheduling)
  - Drainage (System, Depth, Spacing)
  - Multiple water resources (Alternating, Blending)
- ***Physical Management***
  - Land levelling
  - Tillage, Land preparation, Deep ploughing
  - Seedbed shaping (Planting resources)
  - Sanding
  - Salt scarping
- ***Chemical Management***
  - Amendments
  - Soil conditioning
  - Fertility, Mineral Fertilization
- ***Biological Management***
  - Organic and Green Manures
  - Crops (Rotation, Pattern)
  - Mulching
- ***Human Management***
  - Farmer
  - Socio-Economic Aspects
  - Environmental Aspects
  - Policy

AGRICULTURE MANAGEMENT UNDER SALINE CONDITIONS

The following practices are required for optimum crop growth conditions:

1) Water Management



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- Irrigation practices
  System - Method - Scheduling

The main problem with **sprinkler irrigation** using saline water is the wetting and possible burning of foliage, but salt-removal efficiency tends to be substantially higher than with flood or trickle irrigation.

Example of low elevation sprinkler irrigation

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Drip irrigation provides the best conditions of soil water potential, avoiding leaf injury and salt accumulation at the wetting front. Limitations lie in the higher initial cost, low root soil aeration, dense root mass, constant power and water supply needs, besides higher level of know-how.

Surface drip irrigation

AGRICULTURE MANAGEMENT UNDER SALINE CONDITIONS

The following practices are required for optimum crop growth conditions:

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- Irrigation practices
  System - Method - Scheduling

Sub surface drip irrigation can be efficient, but provides no means of leaching the soil above the source. Unless the soil is leached by rainfall or surface irrigation, salt levels will certainly become toxic. This system, is not suitable over the long-term, especially when salts are also high in water supply.

Sub surface drip irrigation

AGRICULTURE MANAGEMENT UNDER SALINE CONDITIONS

Sub surface (10-12 cm below surface) drip irrigation

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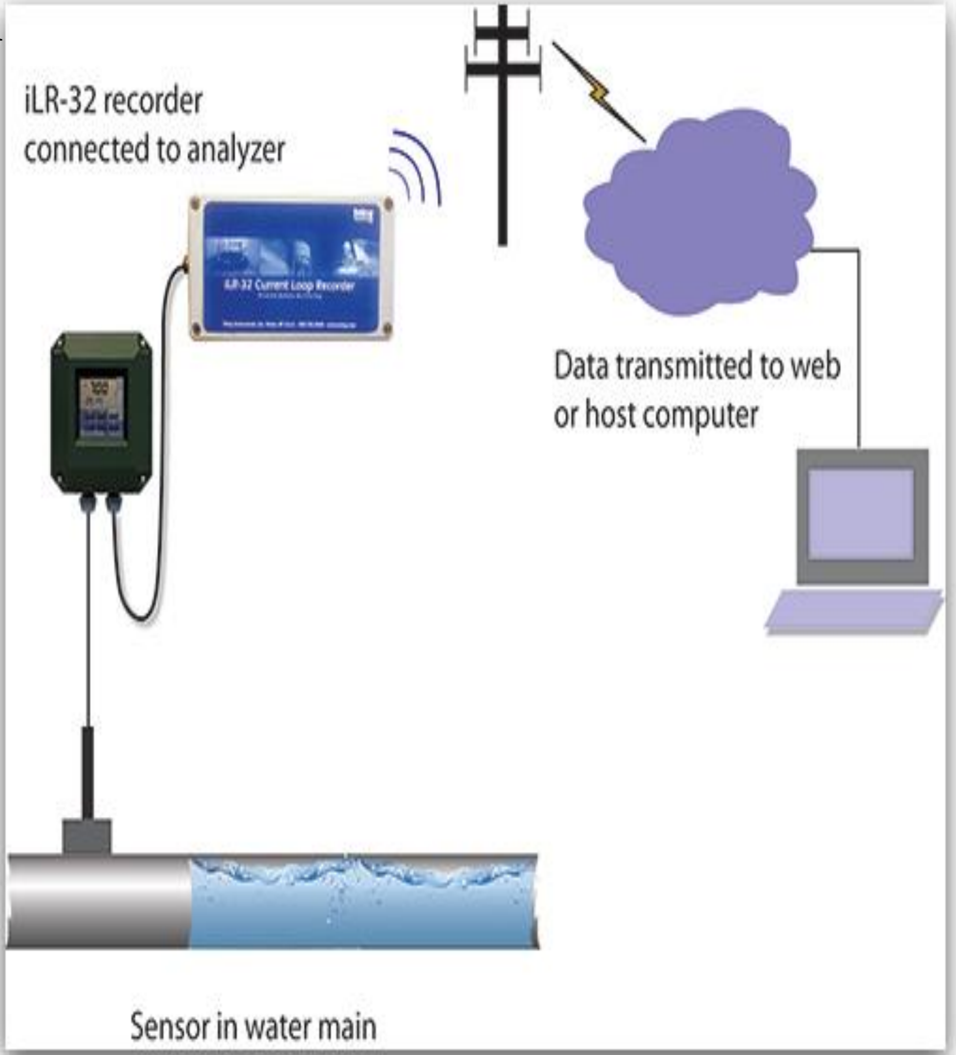
  System - Method - Scheduling
- Monitoring of water quality



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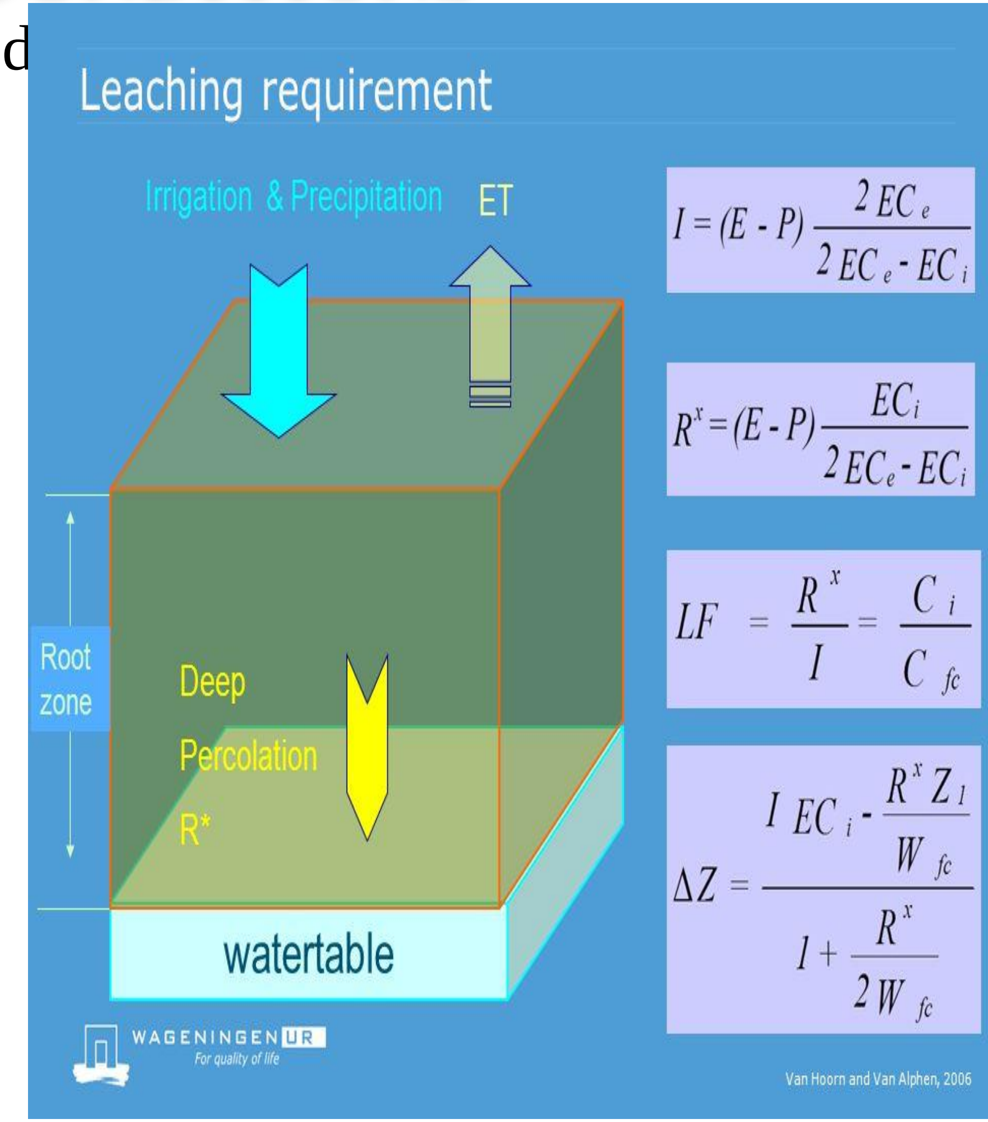

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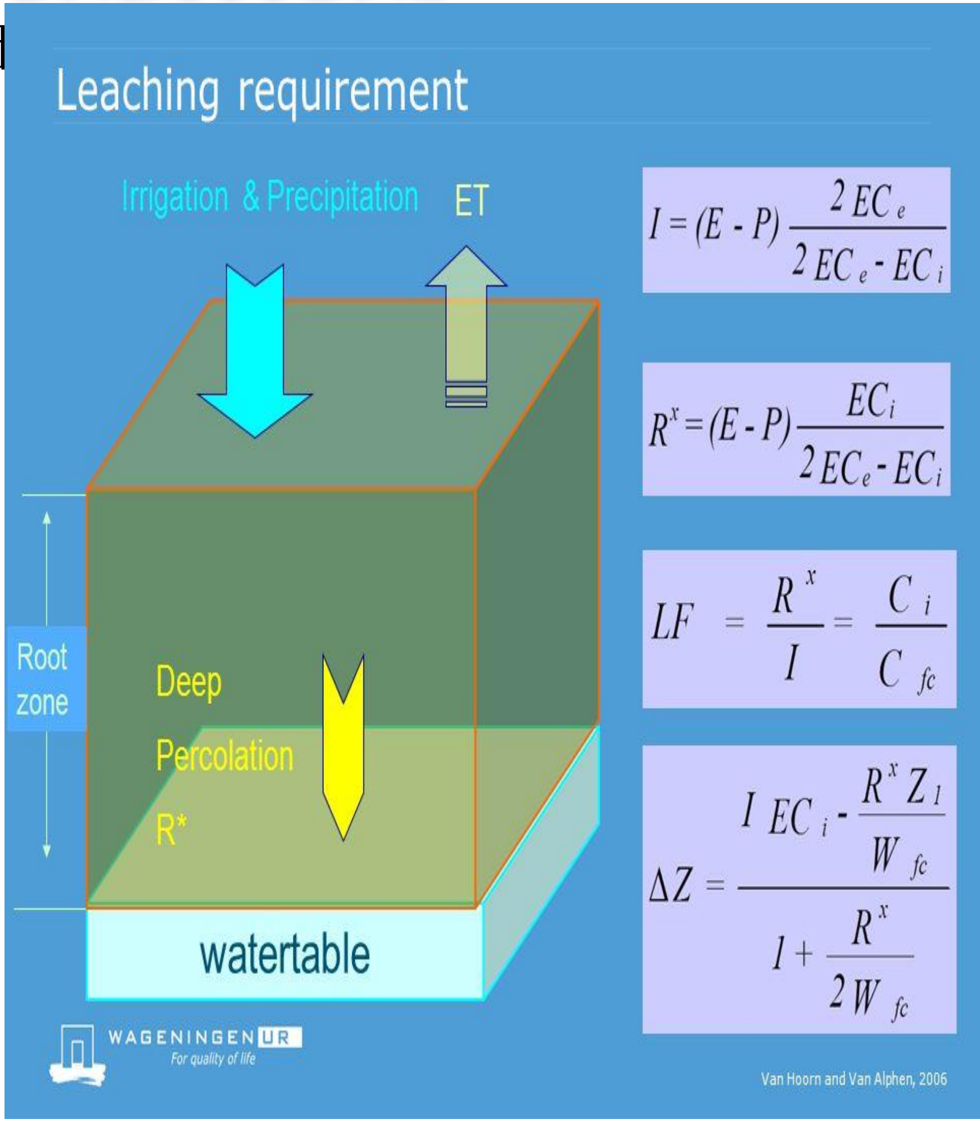
Good L.R. efficiency can result in more effective water use in the first instance, a reduction in the salt load needing disposal and a substantial reduction in the volume of drainage water.



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- Conjunctive use of saline and fresh water

    1) Blending Water (network dilution)

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2) Good and poor quality water (recycling-alternation)

2) Crop Selection & Nutrients Management

- Introduction of salinity tolerant crops

Sugar Beet cultivation.

AGRICULTURE MANAGEMENT UNDER SALINE CONDITIONS

2) Crop Selection & Nutrients Management

- Introduction of salinity tolerant crops

Asparagus cultivation.

2) Crop Selection & Nutrients Management

- Introduction of salinity tolerant crops

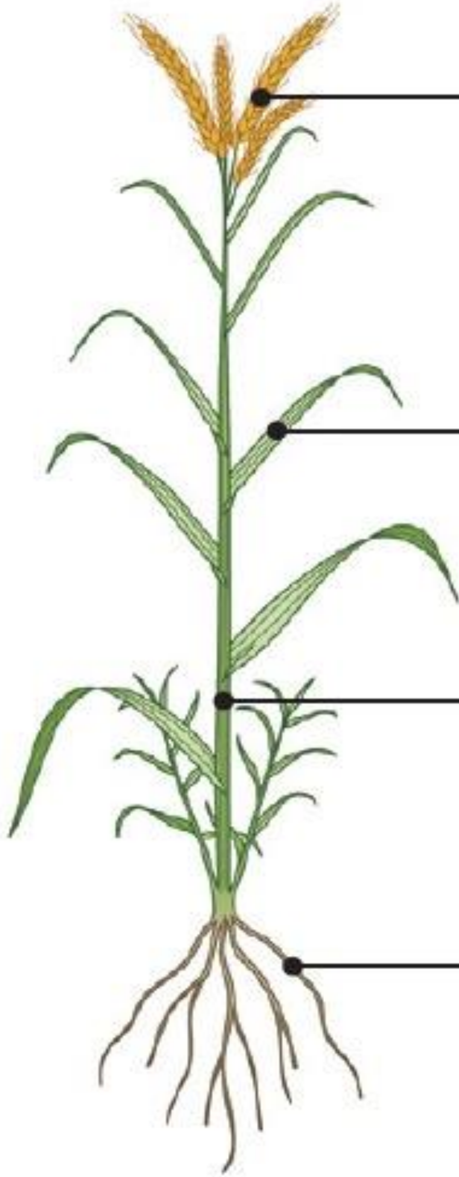
Introduction of salt tolerance crop species like ***quinoa***, ***asparagus*** or ***sugar beet*** may result in more resilient crop rotations and high value cash crop products.

Quinoa cultivation.

Adaptive mechanisms of salt tolerance

Cells

- Osmotic adjustment
- Cell wall modification
- ROS detoxification
- Vesicle trafficking
- Transport proteins
- K^+ and NO_3^- homeostasis
- Vacuolar compartmentation
- Compatible solutes



Organs

Flower and fruit:
- Altered flowering time
- Retranslocation of photosynthate

Leaf:
- Salt partitioning into: sheath/petiole instead of lamina or epidermis rather than mesophyll
- Retranslocation of salt or excretion

Stem:
- Control of long-distance transport
- Storage of salt in stem

Root:
- Exclusion of ~95% of salt in soil solution
- Removal of further salt from xylem
- Symbiotic associations or PGPR
- Root architectural changes

AGRICULTURE MANAGEMENT UNDER SALINE CONDITIONS

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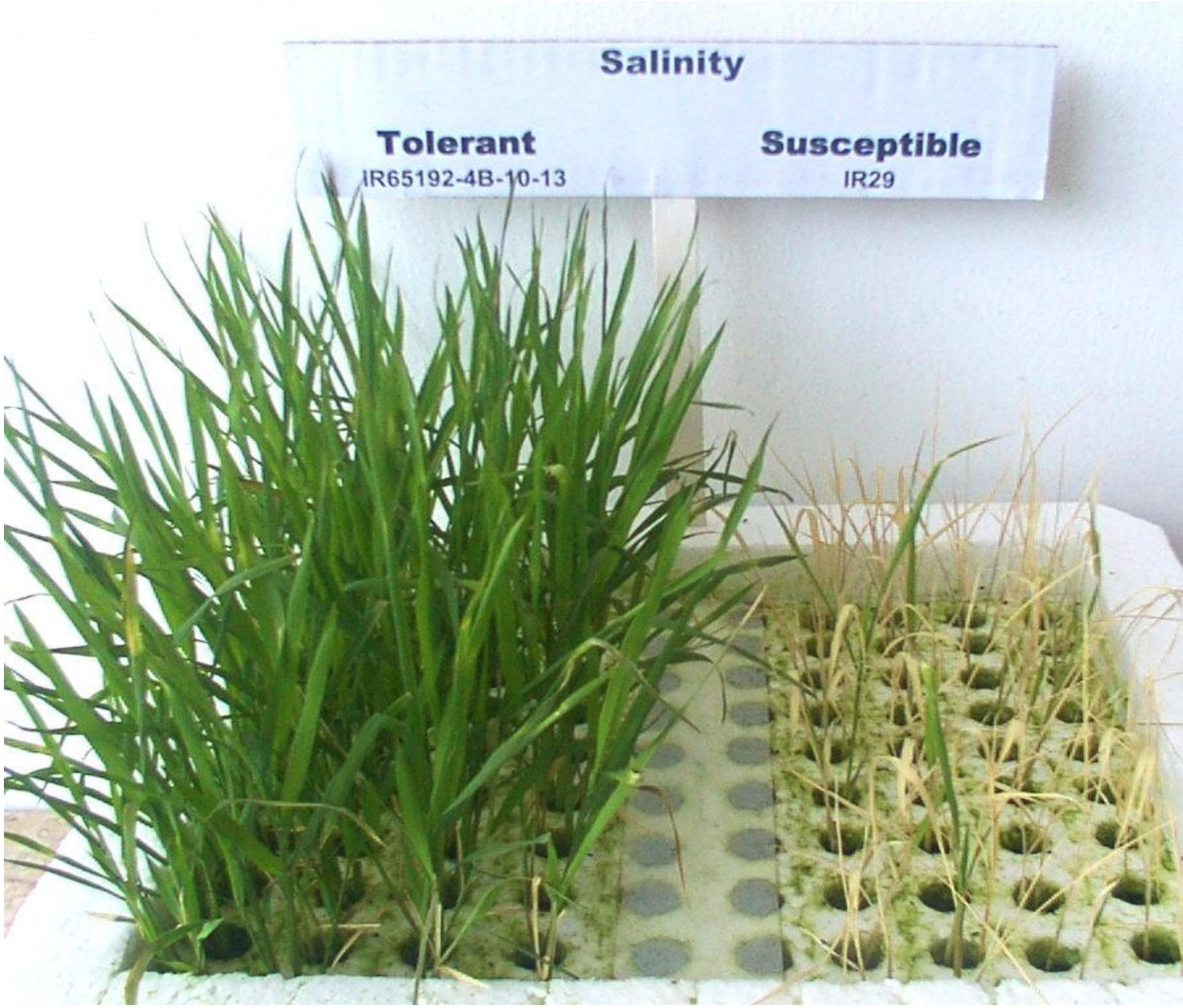
- Selection of salt tolerant varieties



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- Increase fertilizers K (decrease Na content in plant tissue)
- P/K leaf spraying (increase nutrients)
- Introduce high salinity tolerant crops

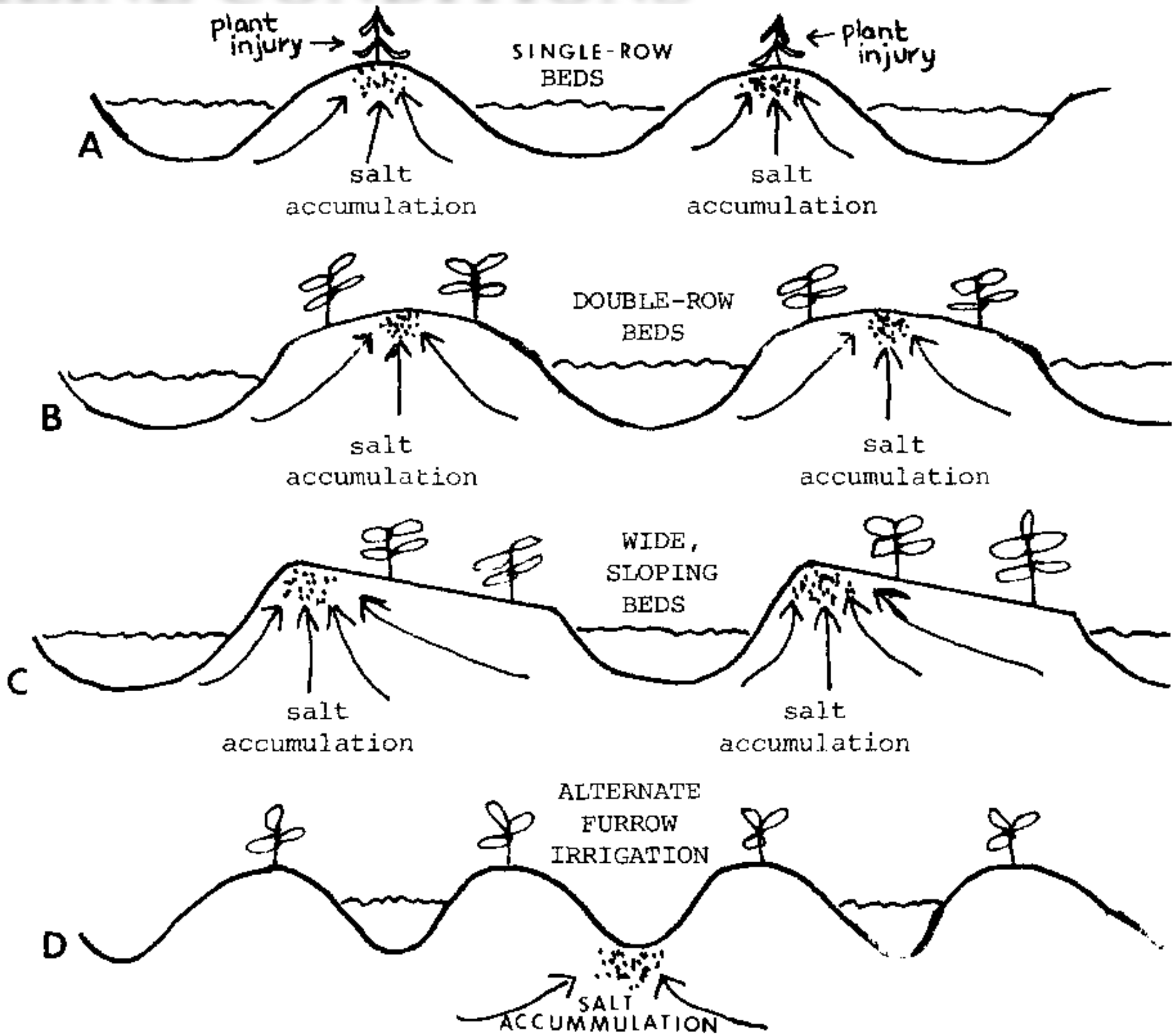
Salicornia brachiata cultivation. Plants are grown on saline soils irrigated with seawater (CSMCR, Bhavnagar, INDIA - the insert shows fruiting plants).

3) Land Management

- Levelling & ridge sowing

AGRICULTURE MANAGEMENT UNDER SALINE CONDITIONS

Typical salt accumulation pattern in ridges and beds soils irrigated by furrows



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- Organic mulching: reduces soil evaporation and temperature

4) Soil Improvement

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- Regular monitoring of soil salinity

Concluding Remarks and Recommendations

Saline water is a potential source for irrigated agriculture. Its sustainable and safe use can be exploited, in order to maximize freshwater saving. To achieve these goals, we need:

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- New technologies (desalinization...?) and appropriate management strategies, systems and practices, to be developed and implemented. These must be fostered by means of adequate dissemination, education and training.

Concluding Remarks and Recommendations

❖ To introduce a **participatory approach** in saline irrigation. The use of saline water and its management are part of a complex process which needs adequate knowledge at farmer's level. Farmers' participation and involvement in planning are the key points leading to success and/or failure in saline irrigation projects.

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- Provide facilities for research workers; improving the Institutional **Capacity Building** in this field training is an essential tool.

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- To study the trade-off between provision of full drainage and drainage volume reduction.

THANK YOU

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