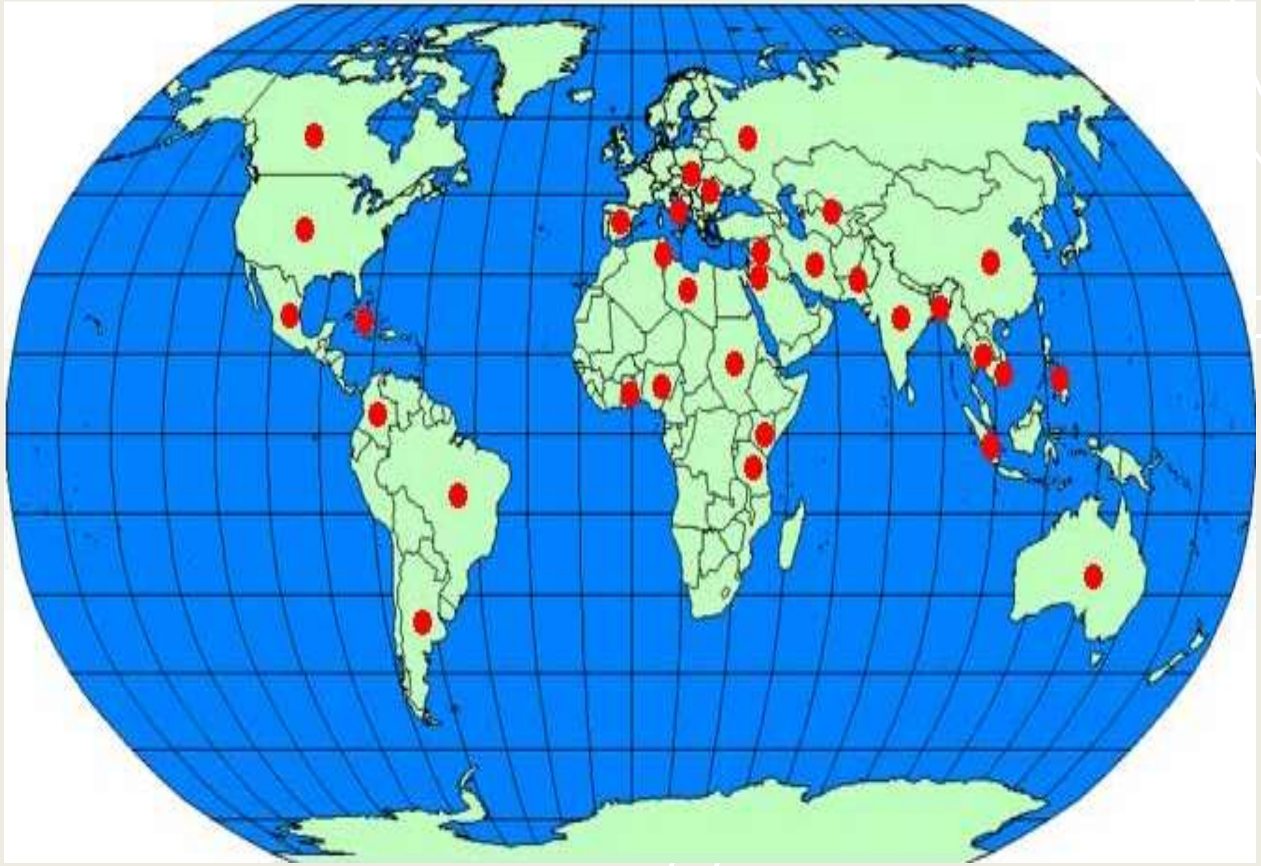
ECONOMIC UTILIZATION OF SALT AFFECTED LAND AND GROUND WATER FOR SUSTAINABLE AGRICULTURE



Dr. Nizamuddin Depar, PS/Head

Nuclear Institute of Agriculture (NIA), Tando Jam

Global (118 countries) : 833 M ha

Surface (0-30cm) : 424 M ha

Subsurface (30-100cm) : 833 M ha

Top soil: saline 85%, sodic 10%, saline-sodic 5%

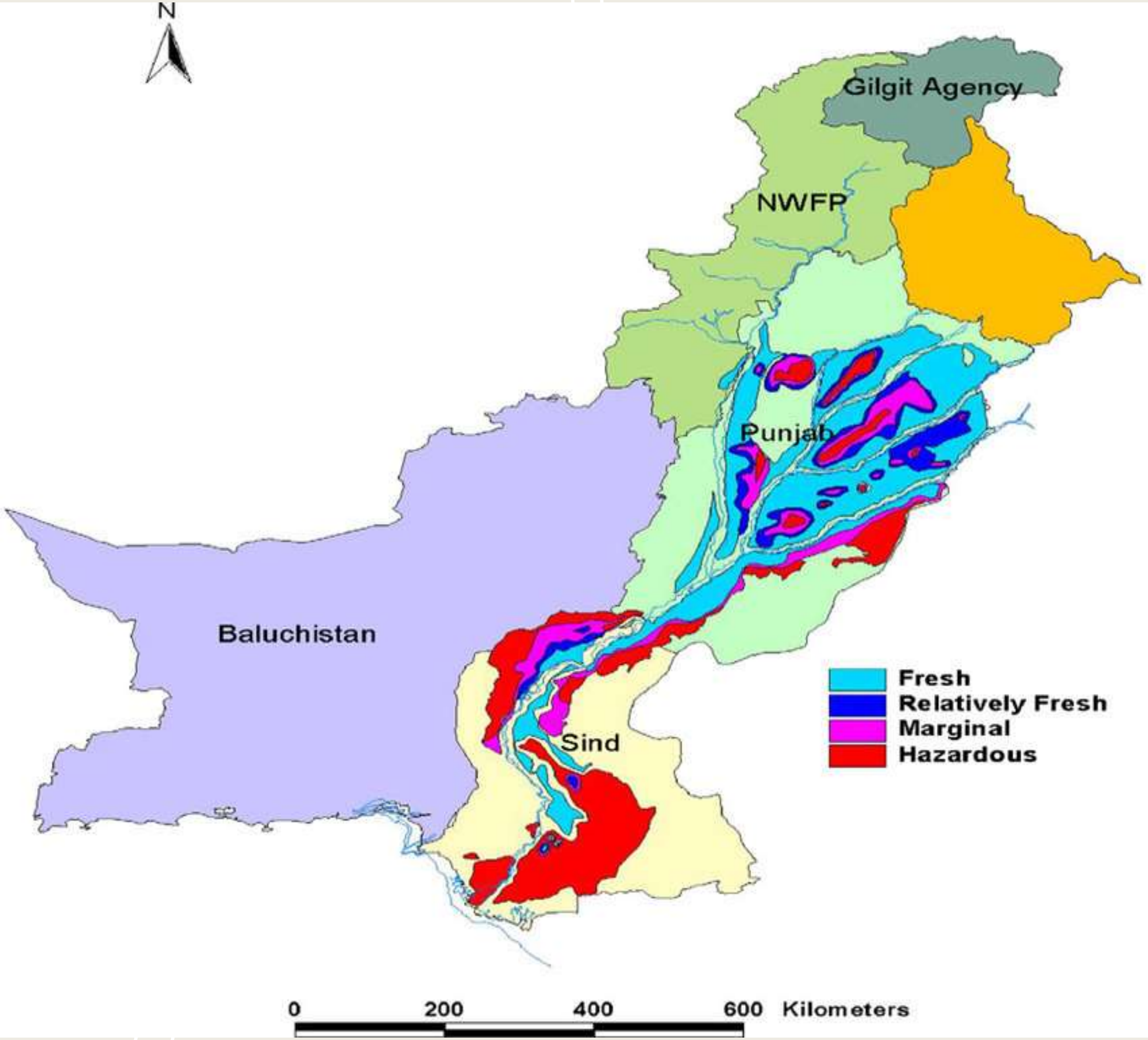
Subsoil: saline 62%, sodic 24%, saline-sodic 14%

FAO, 2024)

Pakistan has a total area : 79.6 M ha,

Cultivated : 22.05 M ha

Salt affected : 6.28 M ha



(GOP, 2020 and 2012)

Population is > 220 million (incr. rate 2%)

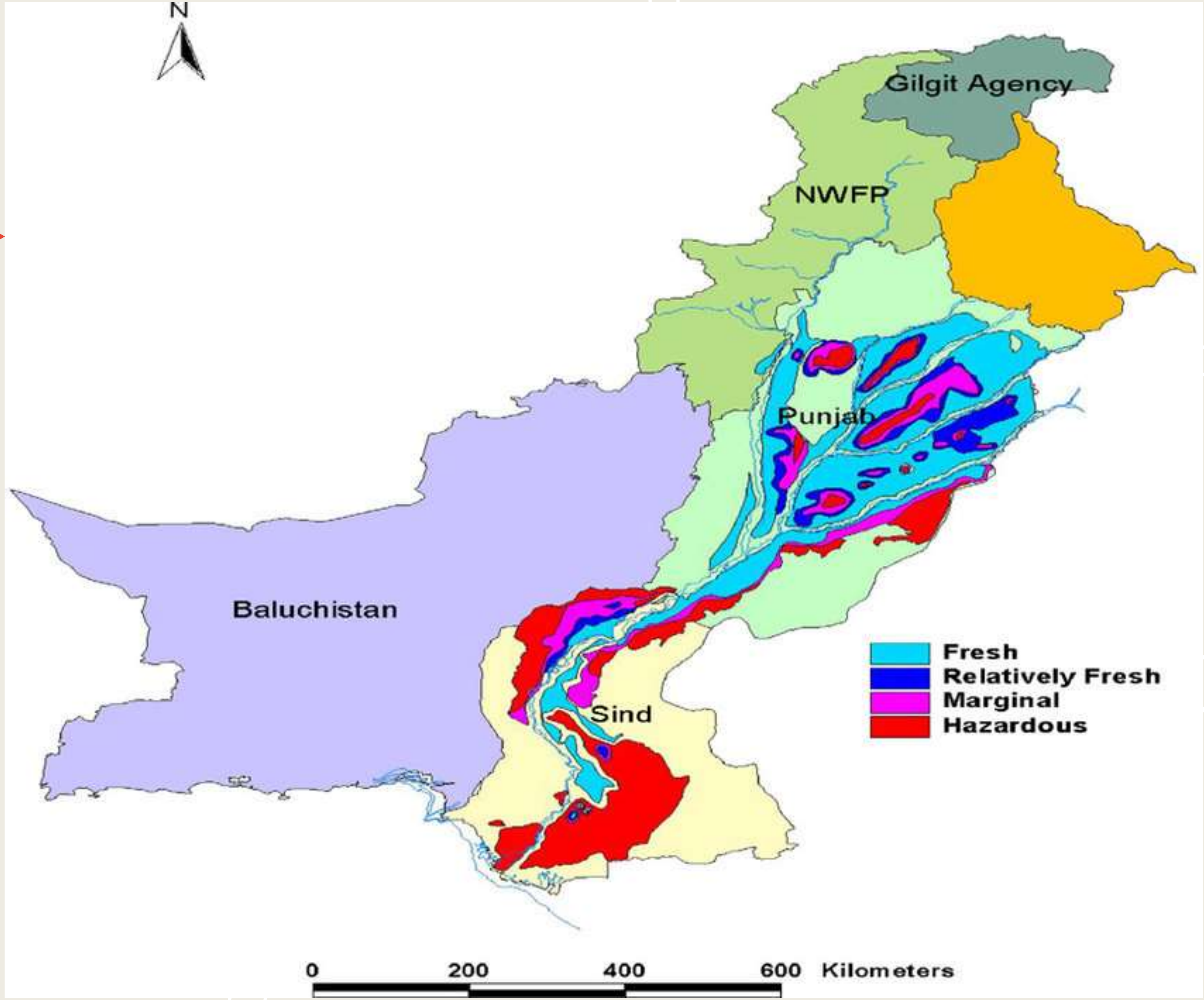
To feed this:

we need to grow more food by ↑ and

An increase of 50% in food,

40% in energy

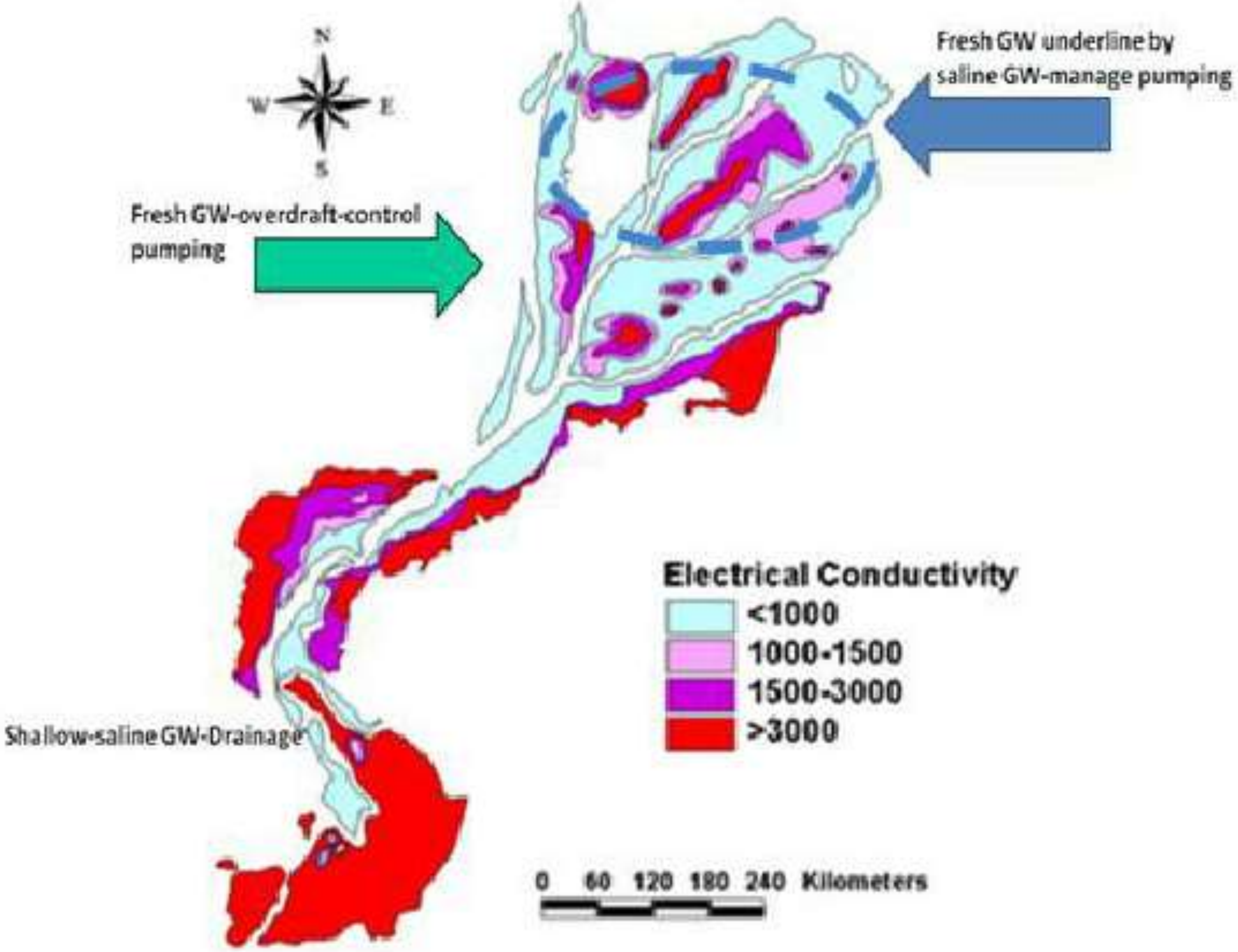
30% in water by 2030



Under-nutrition is the largest killer of under-five children and is responsible for the death of 3.1 million children each year

G. K. Hassan et al., 2022

Groundwater Quality



Scenarios

- **Normal soil and fit irrigation water**
- **Saline soil and fit irrigation water**
- **Normal soil and saline water**
- **Saline soil and saline water**

Site-specific strategy for management considering the soil-water-economics, etc.

Salt-affected Land

Saline Land with Sparse Natural Vegetation

Severely Saline Sodic Soil

Salinity Effects on Plants

Patchy growth in Saline Field

Dead vegetation

Classification of Salt-affected Soils

Classification	EC (dS/m)	pH	% Na (ESP)	Physical Condition
SALINE	$\geq$ 4	< 8.5	< 15	Normal
SODIC	< 4	> 8.5	$\geq$ 15	Problem
SALINE - SODIC	$\geq$ 4	> 8.5	$\geq$ 15	Problem

These are the critical limits for classification and severity of problem will be more as the values increase.

Salinity classes of irrigation waters

Salinity - EC ($\mu S\ cm^{-1}$)	Salinity class	Salinity hazard
100 - 250	C1	Low
250 - 750	C2	Medium
750 - 2250	C3	High
> 2250	C4	Very high

Residual sodium carbonates (RSC) and suitability of water for irrigation

RSC (meq l^{-1})	Suitability of water for irrigation
< 1.25	Safe
1.25 - 2.50	Marginal
> 2.5	Unsuitable

Innovative Solutions:

Physical

Leveling Scraping
Sub-soiling
Sanding Planting
Method

Chemical

Amendment Soil
conditioning
Fertilizers

Engineering

Leaching
Flushing Irrigation
Drainage

Biological

Green Manuring
Mulching
Biosaline
Agriculture

Chemical approaches

- **Leaching of salts with quality IW**
- **Use of Gypsum**
- **Use of acids**

  Sulfuric Acid (H_2SO_4)
- **The use of organic wastes (press mud)**

Sulfurous acid generator

Acid application

“Nanotechnology”

Nano-gypsum and nano-fertilizers for efficient soil amendment of SAS

$CaCO_3$ suspension + $H_2SO_4 \rightarrow CaSO_4 \cdot 2H_2O$ (gypsum)

$CaSO_4 \cdot 2H_2O$ (gypsum) + Heating $\rightarrow CaSO_4 \cdot 0.5H_2O$ (bassanite)

The investigating temperature was from 30 to 900 °C with a heating rate of 30 °C per minute.

Hossain and Ahmed 2022

Hydrogel & Superabsorbent Polymers

Improve soil moisture retention in saline conditions and can retain water 400 – 500 times more than its weight.

Chitosan solution was taken in a beaker and carrageenan solution was added dropwise with magnetic stirring at 3000 rpm, which was continued for four hours.

The resulting solution of nanoparticles was centrifuged at 3000 rpm for 15 minute

Laura et al., 2024

Preparation of chitosan solution:

Weigh chitosan was dispersed in sodium acetate buffer solution (pH 4.0) and stirred vigorously for five hours, continuously, to obtain 0.25% w/v, 0.5% w/v, 0.75% w/v, and 1% w/v concentrations of chitosan solutions.

Preparation of carrageenan solution

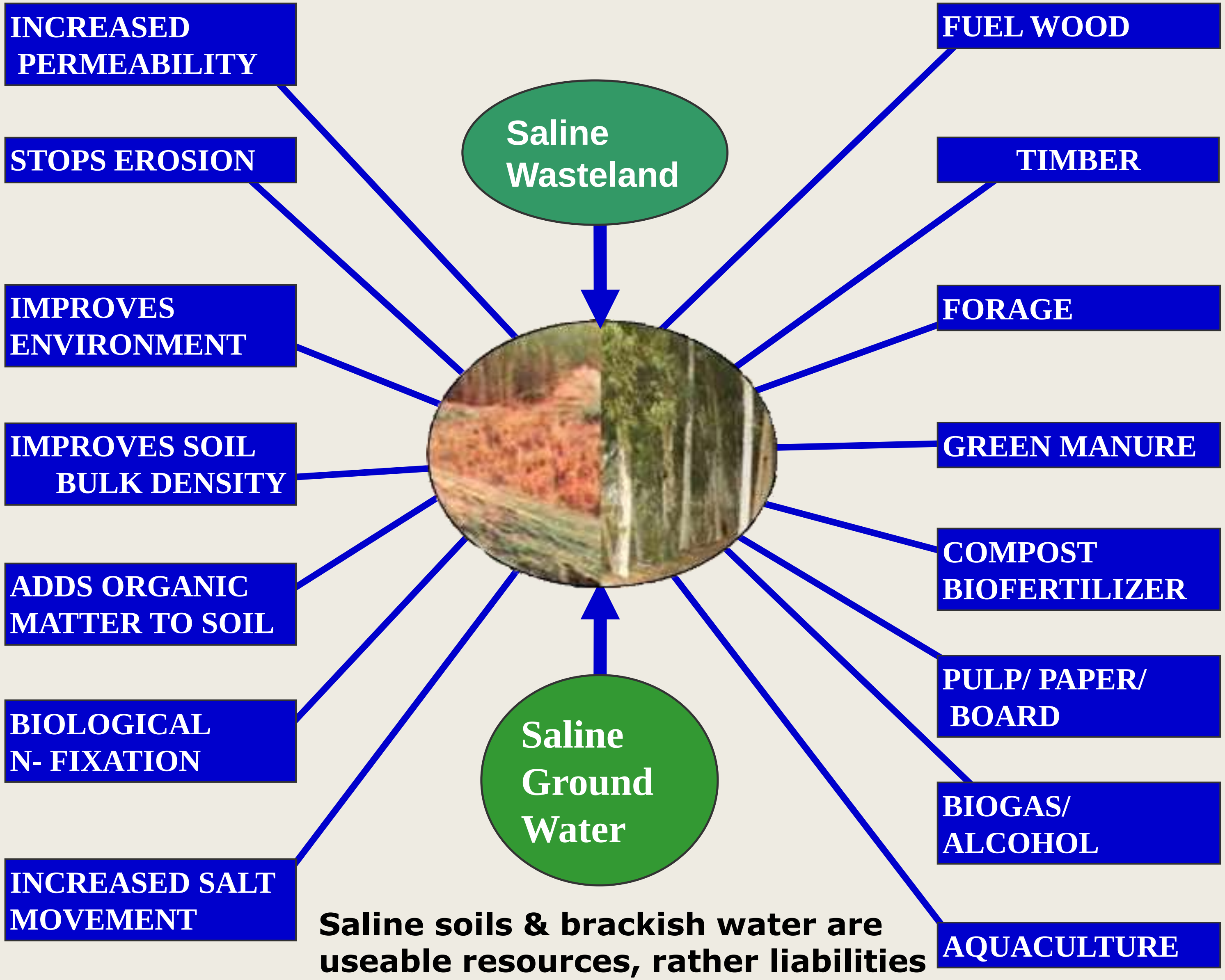
Weigh quantity of carrageenan was dispersed in water and boiled at about 80°C to form 0.05% w/v, 0.1% w/v, and 0.2% w/v of clear carrageenan solutions.

Biological approach / Biosaline Agriculture

Economic utilization of salt-affected land and saline (brackish) water through profitable and integrated use of genetic resources (plants, livestock, fish, insects, microbes) and improved agricultural practices

Biological or Bio-saline Approach

Growing salt tolerant plants for biomass, usable directly or converted to value-added products



Saline soils & brackish water are useable resources, rather liabilities

Key Technologies

Irrigation technologies and management

Land management technologies

Use of alternative water

Alternative crops

Hydroponics and Aqua-ponics

OMICs

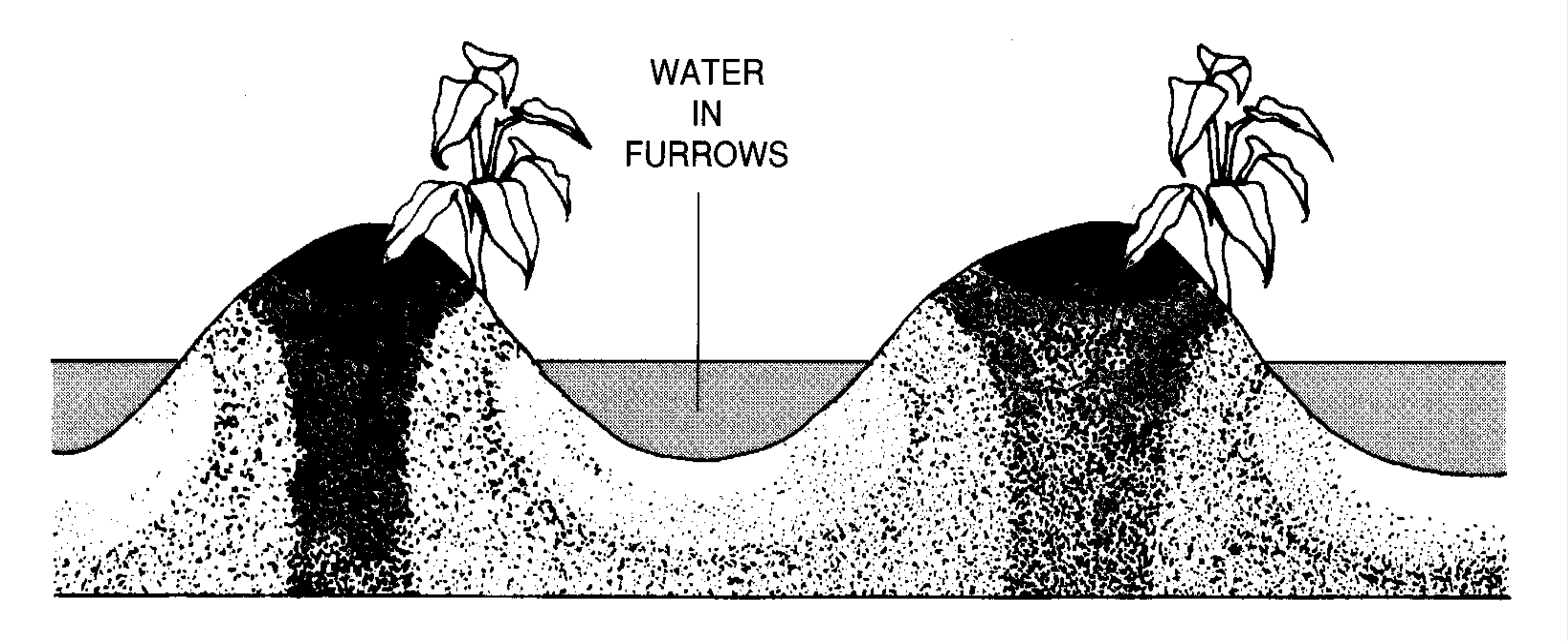
Modelling, remote sensing, databases

Best management practices

Poor structure along the soil profile (A-B) contributes to low hydraulic conductivity and waterlogging (C-D)

Salvadora et al., 2023

Managing Saline Soils



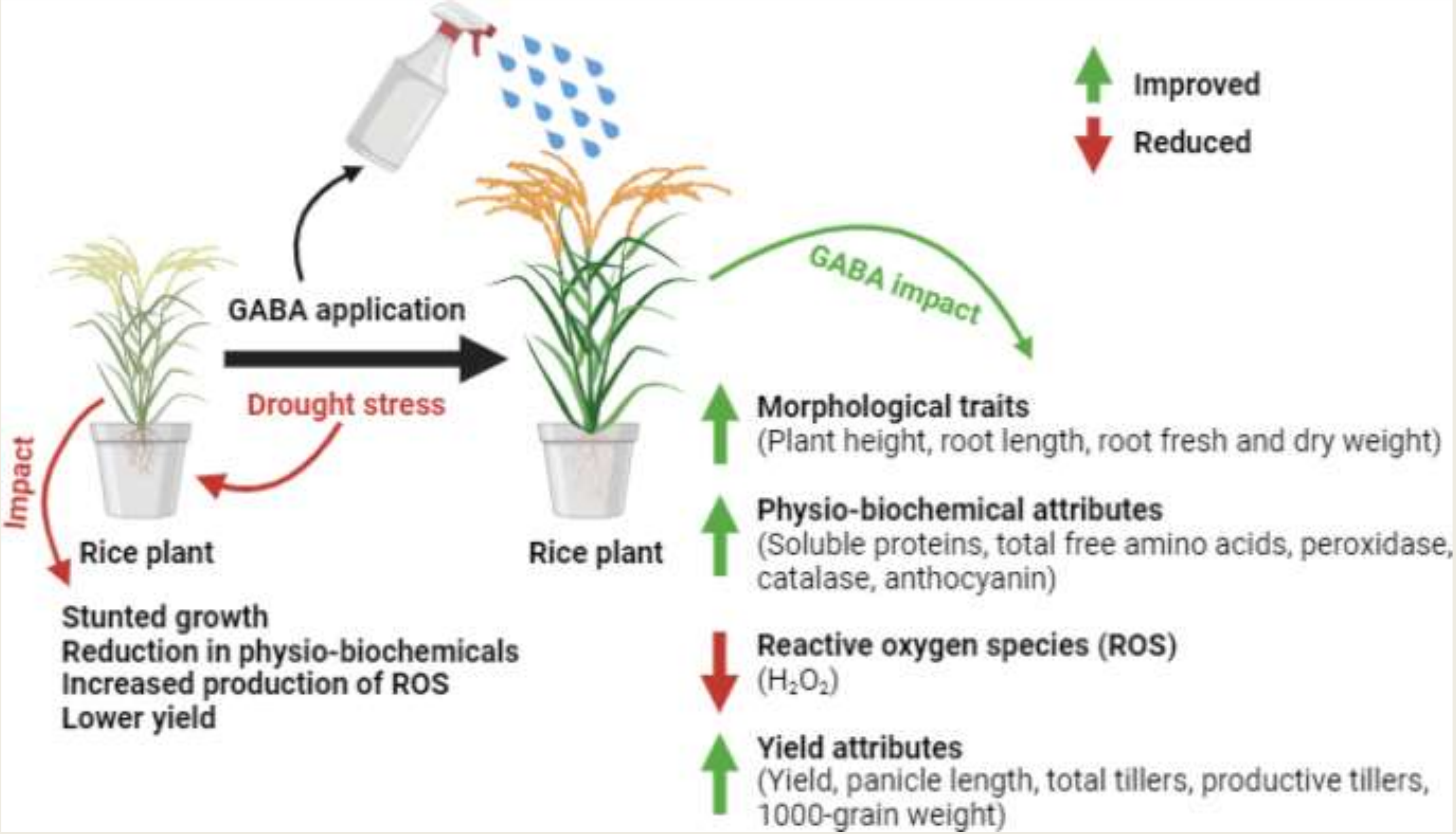
“GABA shunt”

The bypass system identified by the researchers, called the ‘GABA shunt’, allows wheat plants to stop using one of their salt-sensitive enzymes when threatened by saline soil.

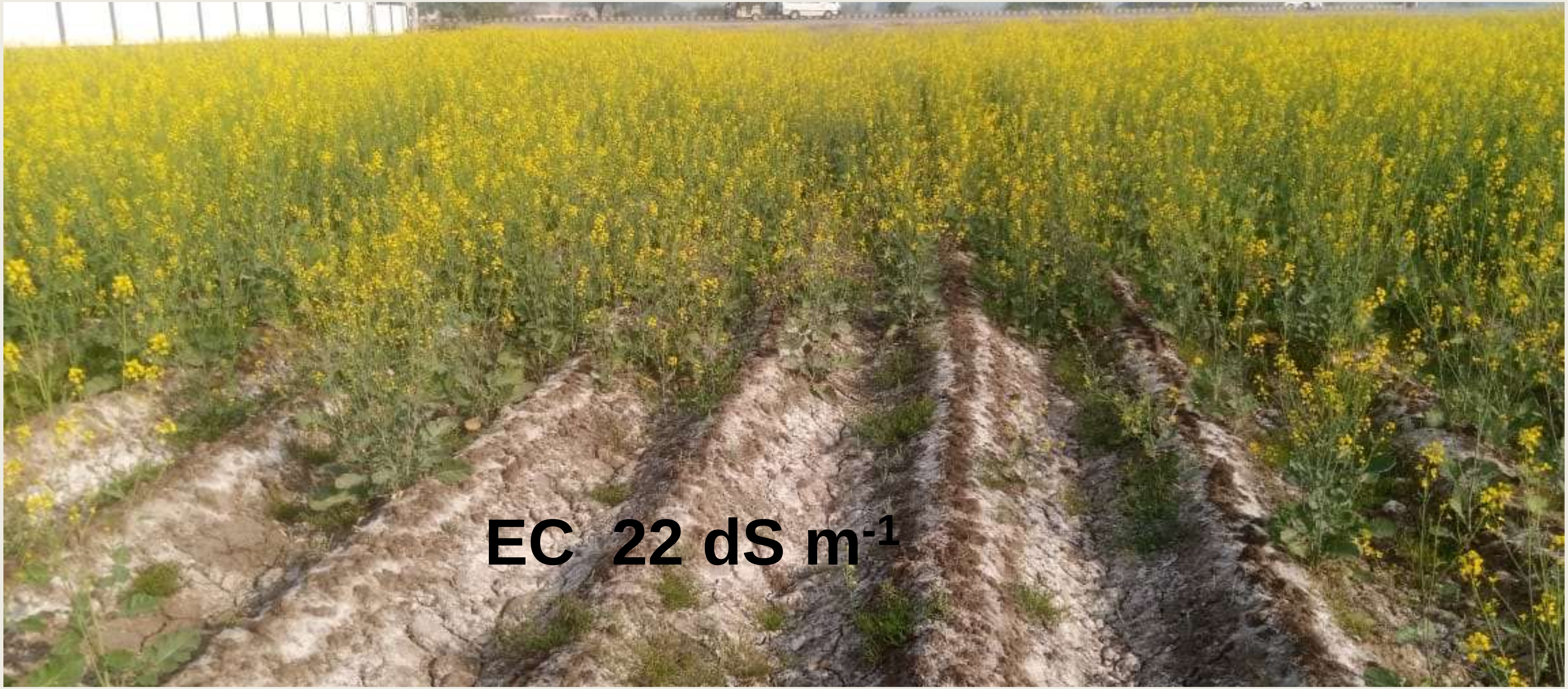
According to Dr Taylor, studying GABA shunt could lead to advances in the fight against salinity.

When GB synthesis and accumulation takes place, GABA is not synthetized under salinity.

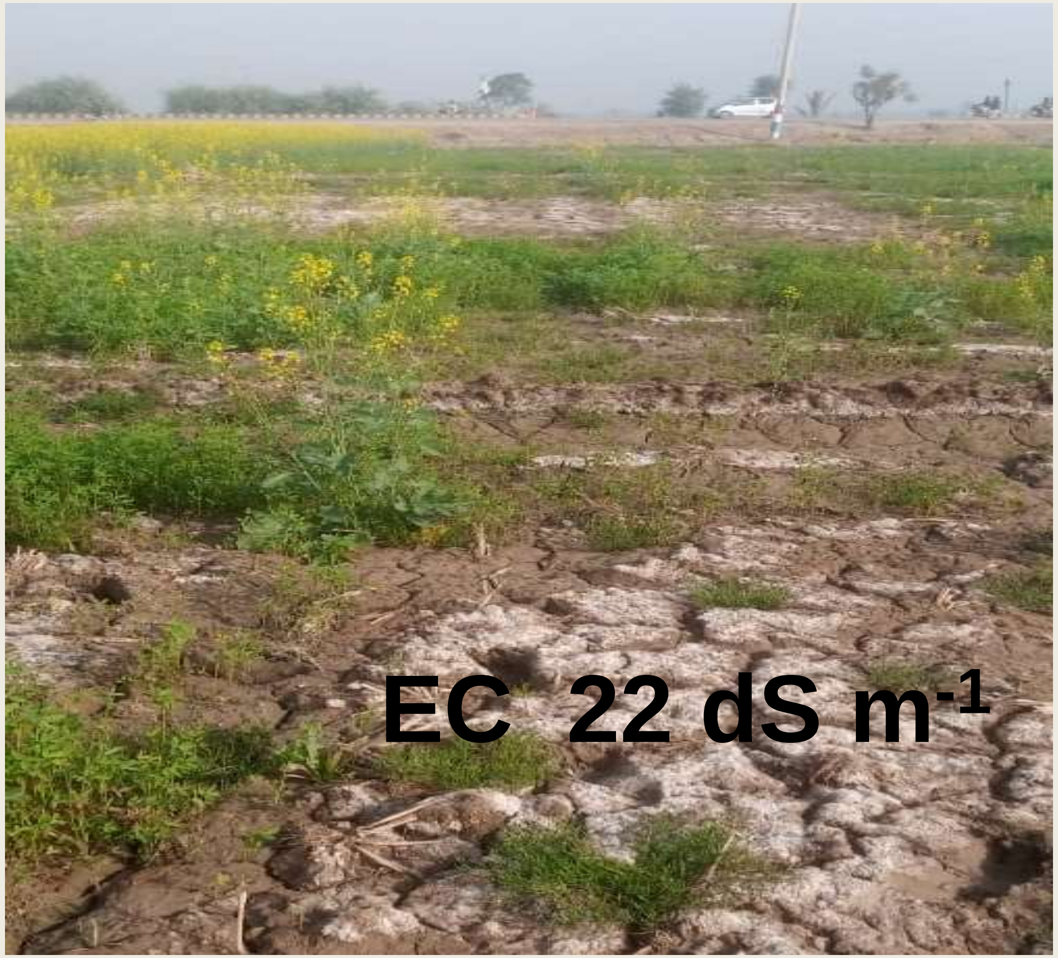
GB, together with proline, is so efficient in protecting salt stressed plants not only from osmotic imbalance, but also from oxidative stress.

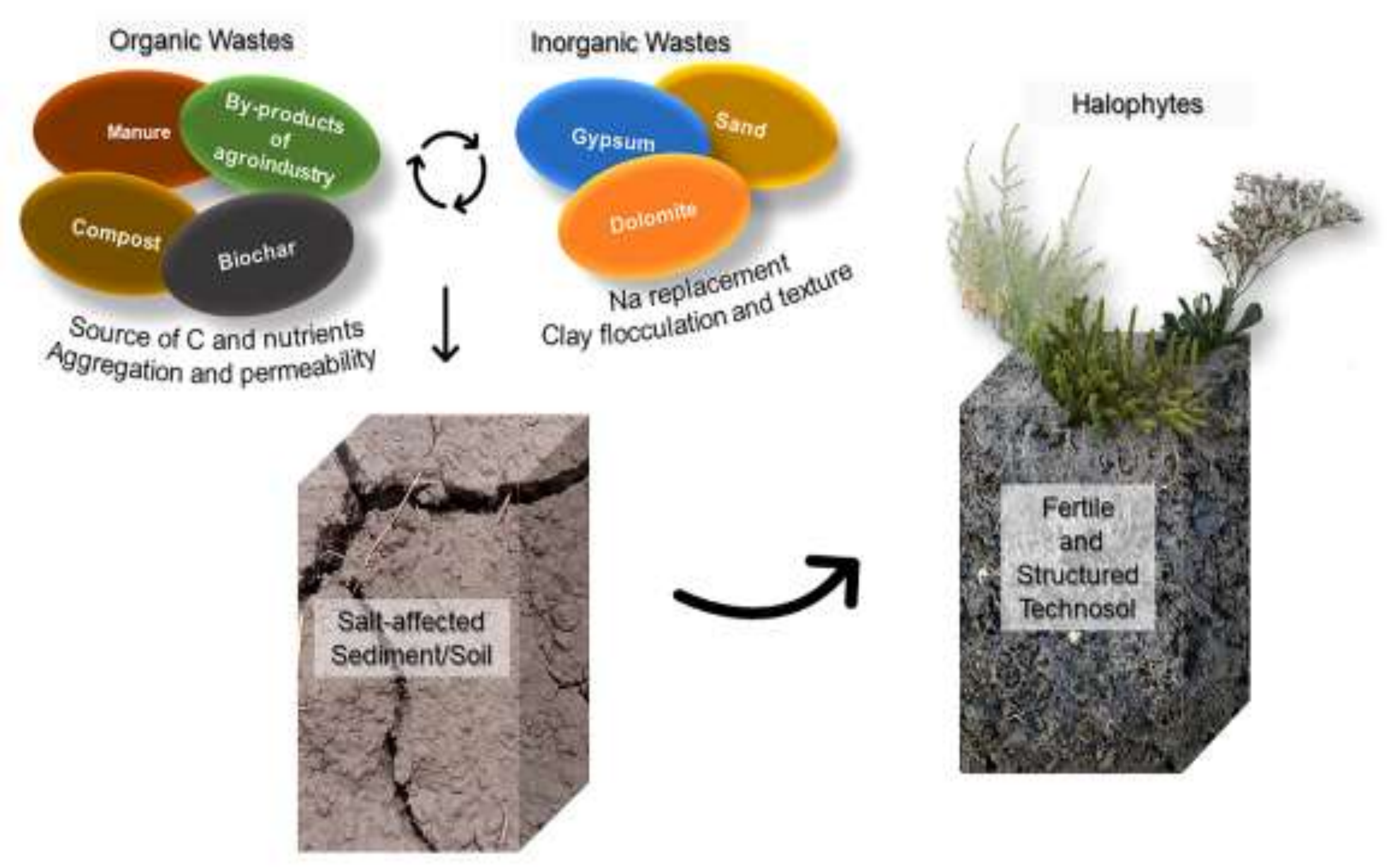


Effect of foliar application of GABA on the morpho-biological and yield attributes of aromatic rice


EC 22 dS m^{-1}


EC 16 dS m-1


EC 22 dS m-1



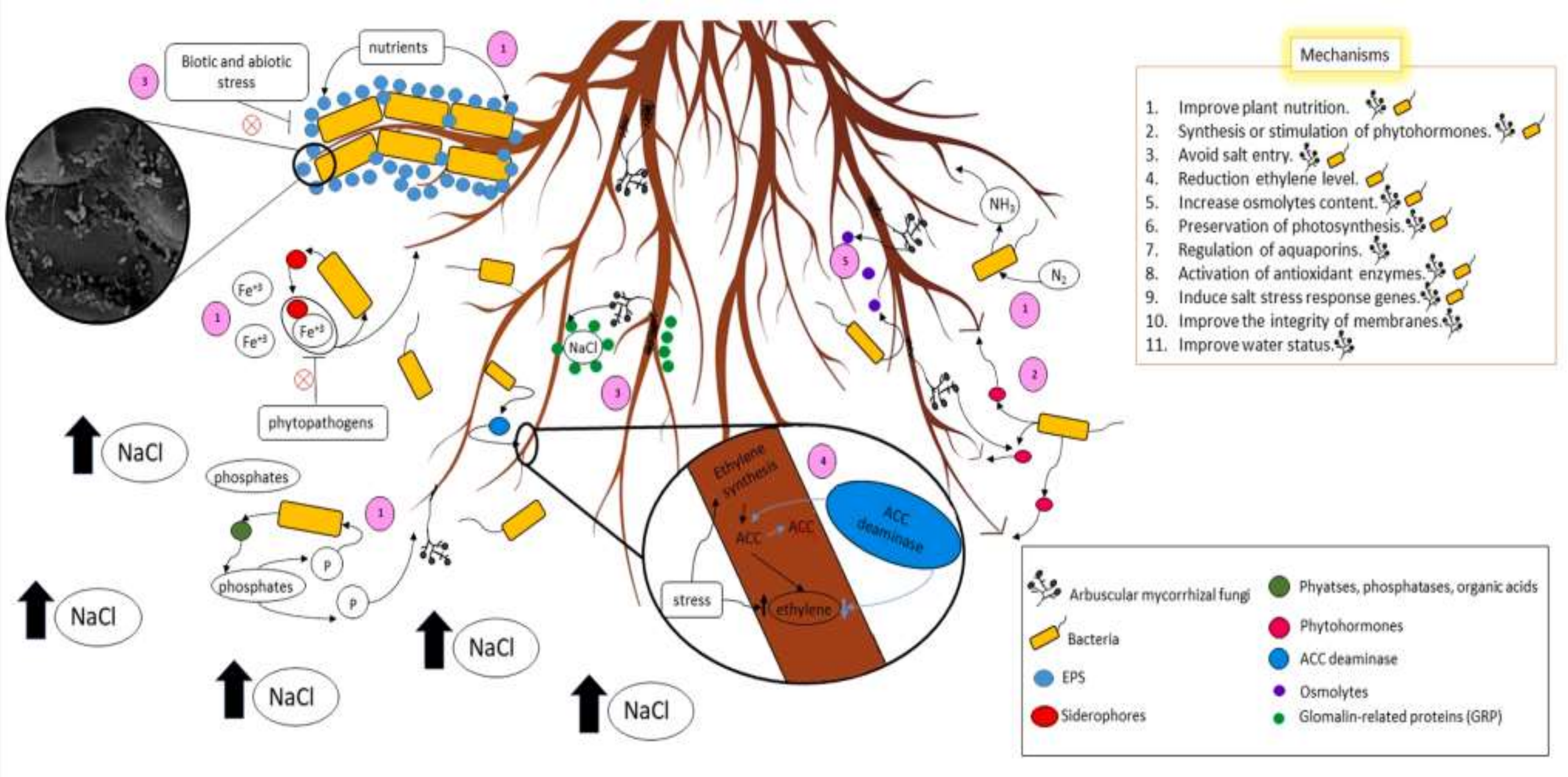
The residues improve fertility and structure of salt-affected soils and cultivation of halophytes

Salvadora et al., 2023

Biological fertility (microbial biomass, number of earthworms)

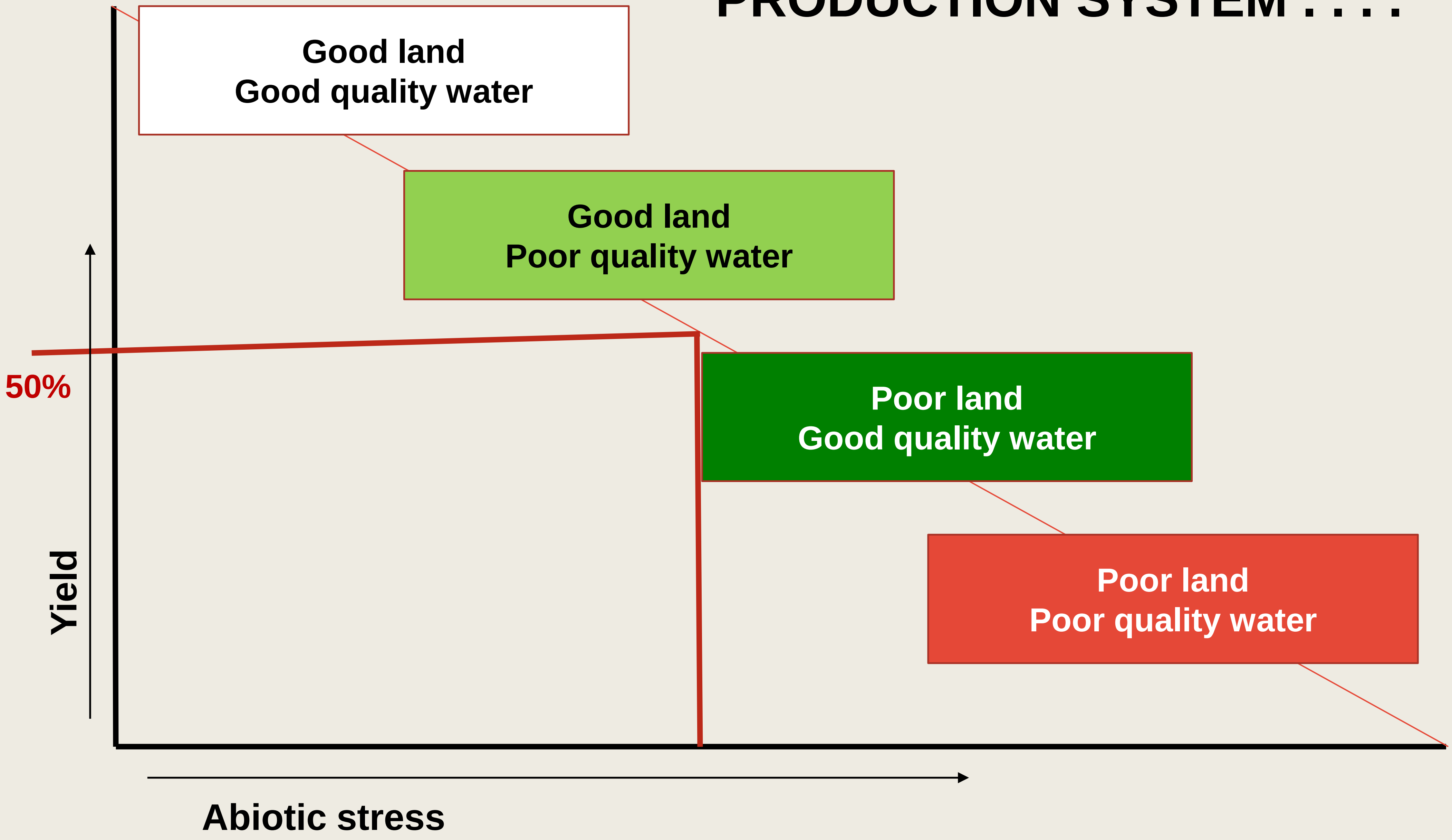
Regular organic matter application and gypsum is key to improve soil biological activities

Microbial benefits to plants against saline conditions



Salvadora et al., 2023

PRODUCTION SYSTEM . . . .



What is the challenge . . . .

Scaling up

Economical

Environmental

Social

The Challenge.........

Production systems in salt affected farms is technically feasible

The scaling up from small experimental plots to large areas

The Scaling Up …

Seed production and availability – who is responsible?

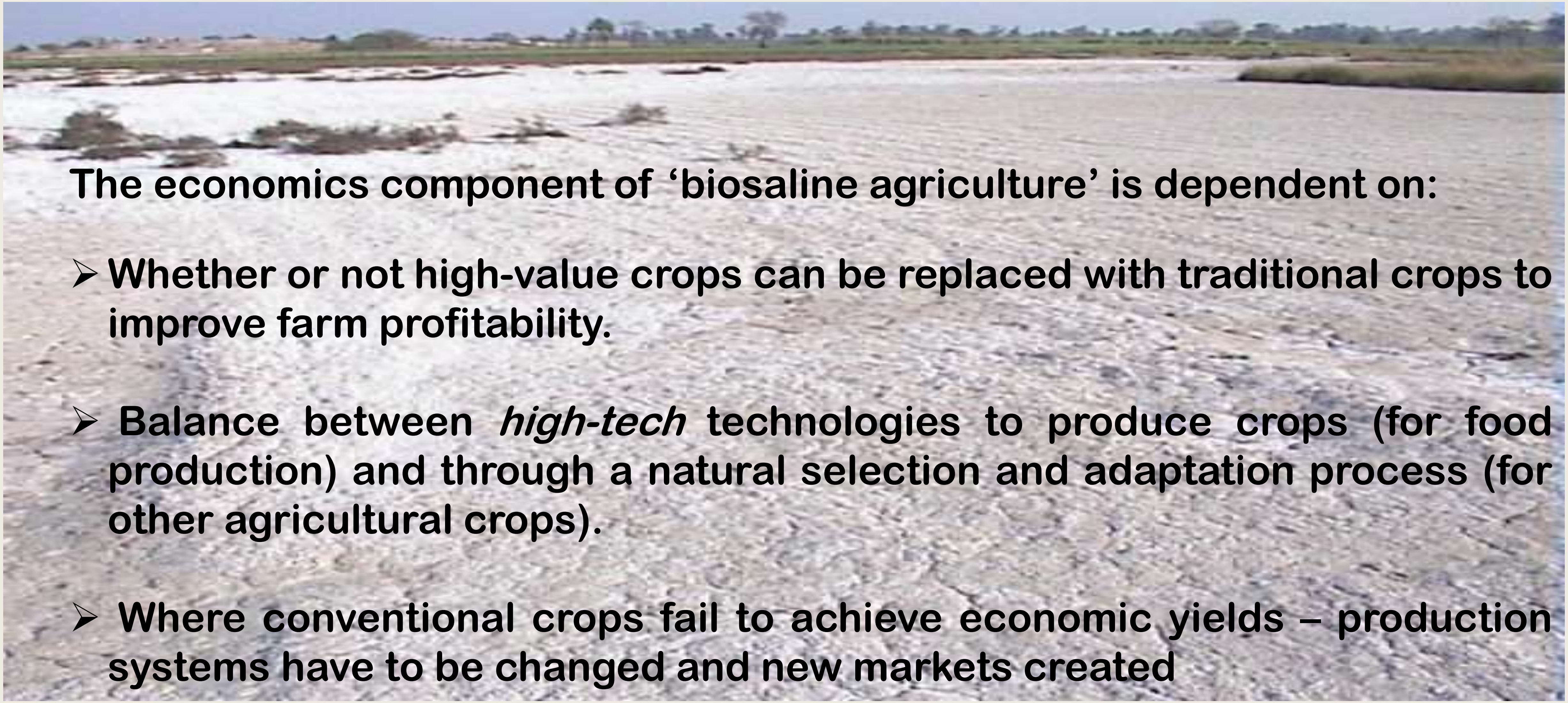
Role of national agricultural system(s) to promote the research – to developmental stage

The Extension service – is it strong?

Public-private partnership, how much is it effective?

If private sector is not interested, who will do the scaling-up?

How farm economics can be improved to make bio-saline agriculture sustainable?



The economics component of ‘biosaline agriculture’ is dependent on:

- Whether or not high-value crops can be replaced with traditional crops to improve farm profitability.

- Balance between *high-tech* technologies to produce crops (for food production) and through a natural selection and adaptation process (for other agricultural crops).

- Where conventional crops fail to achieve economic yields – production systems have to be changed and new markets created

How farm economics can be improved to make bio-saline agriculture sustainable?

- Selection, hybridization, breeding and use of omics for domesticating wild species and developing economically useful crops

- Effective governmental policies to support investments of farmers to move from conventional farming (under saline and marginalized condition) to more of an ‘unconventional’ production system(s).


Soil is not a Property,
It’s a Legacy,
So Preserve for Future generations.