Status and sustainable management of salt affected soils in Latin America

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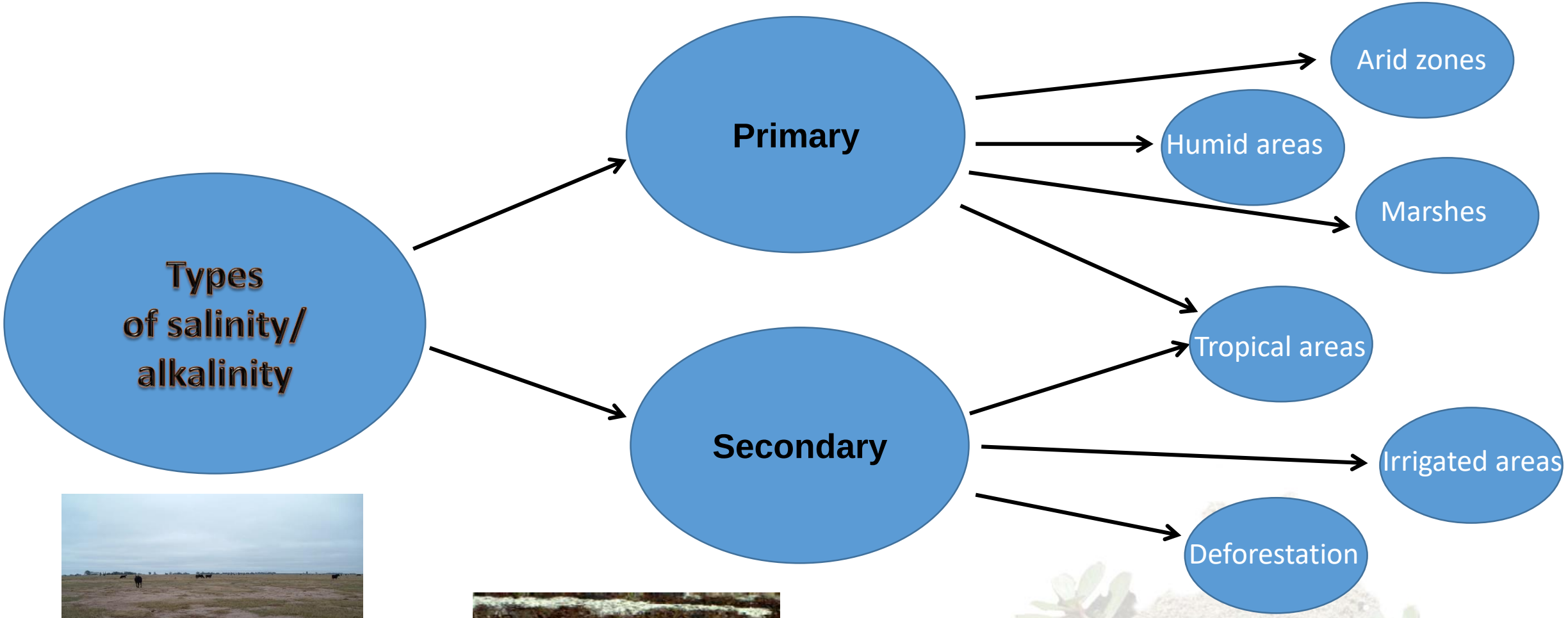
Latin America is a cultural entity extending from the Rio Grande to Tierra del Fuego, spanning for 19.2 million km². The region is vast and heterogeneous, including countries with diverse availability of natural resources and economies.

The variety of climates and soils, lead to a great variability of ecosystems, and an array of agricultural, livestock and forestry activities. Tropical to temperate/cold crops are cultivated in it.

Globally, the region is a net food exporter of a variety of primary products and industrialized derivatives.

Latin America ranks third in the world in surface with salt affected soils. Primary and secondary salinity and alkalinity are found in diverse environments throughout the region.



Primary salinization is found in arid zones, showing a variety of saline soils, like that in the highlands of Bolivia, northern Chile, western Argentina, Peru, northern Mexico and other countries. The different ecosystems usually suffer degradation, because the natural vegetation is grazed by sheep, goats, cattle and sudamerican camelids. Mining and oil extraction are also source of salts.

In temperate humid and sub-humid regions mainly sodic soils are established. They are found in large flat plains with shallow saline or sodic ground-waters, like the some areas of the Pampas region of Argentina.

Some coastal and swampy areas with saline-acid soils are found in Venezuela, Colombia and other countries, and also large internal saltmarsh are found elsewhere, among them the Pantanal in southern Brazil, one of the larger wetland of the world.

In semiarid to humid tropical areas (Northeastern Brazil, Colombia, Venezuela, Cuba, the Dominican Republic and other countries), there are variable rainfall associated with shallow soils, low quality irrigation waters, lack of drainage and shallow groundwater. Large areas have been degraded by salinization and increased degradation leads to desertification, in some areas.

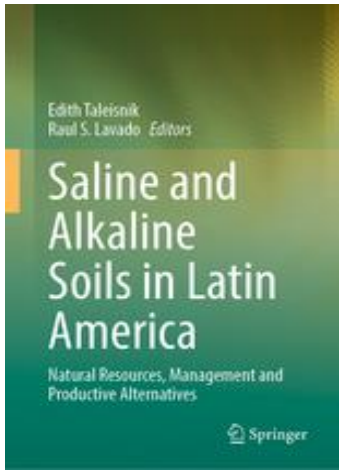
Secondary salinization occurs in irrigated areas in arid and semi-arid zones (mainly Mexico, Peru, Chile and Argentina), where intensive agriculture is practiced. This process is mainly due to non-efficient water management and poor drainage conditions and, also, as a consequence of poor irrigation water quality.

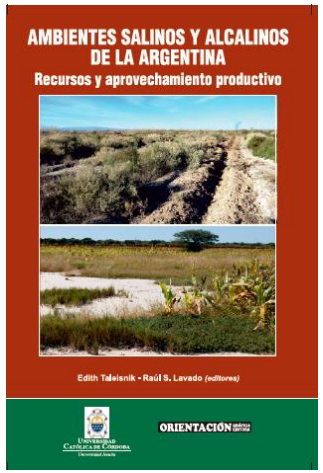
The most recent human-induced salinization has developed because deforestation and cultivation that have altered the hydrologic balance. This process of salinization occurring in areas of Argentina and Paraguay, is to some extent similar to "dryland salting" process found in Australia.

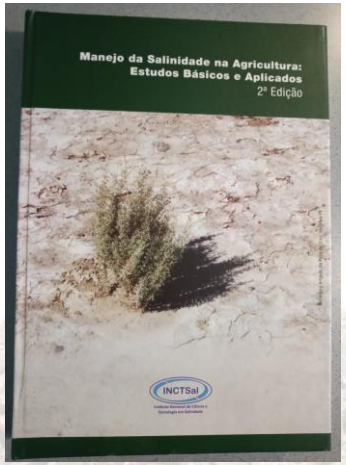
Research in the region

Research about salt affected soils was very active in 1960 to 1980, when several countries experienced large investments in irrigation schemes. Research on soil salinity at that time was mainly based on results published by the US Salinity Laboratory (Riverside). Research on those irrigated of salt-affected soils subsequently declined.

Interest on salinity-related aspects has gained new momentum in this century, mainly in Brazil, Mexico, Argentina and others. Most studies focus on the salinity relationship with vegetation, crops and microorganisms and soil and crop management and related issues. Those countries have, in total, produced more than 5200 publications since 2000 in this topic. Also, several books on saline and alkaline soils have recently been published in English, Portuguese and Spanish.

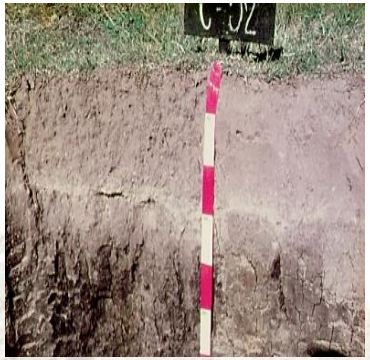




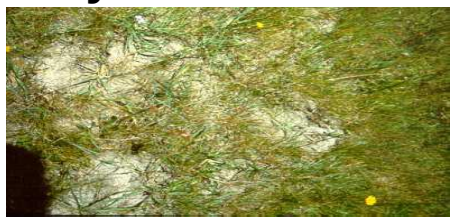


Among the most original technological and applied investigations, which contribute to the global knowledge of salinity management, can be mentioned that developed in two specific areas. They are not unique in the world, but are characterized by their local magnitude.

1.- The Northeastern Brazil presents a combination of high temperatures, alternating periods of extreme rain and drought, and salt-laden soils and shallow groundwater. The native vegetation is a forest known as “Caatinga”. Deforestation was followed by irrigated agriculture.



2.- The flat Argentinean Pampas, show large lowlands with soils affected by water, including periodical waterlogging and floods, and exchangeable sodium excesses. Soils with Natric horizon predominate. The natural vegetation is a monotonous grassland. These areas are devoted to cattle husbandry.



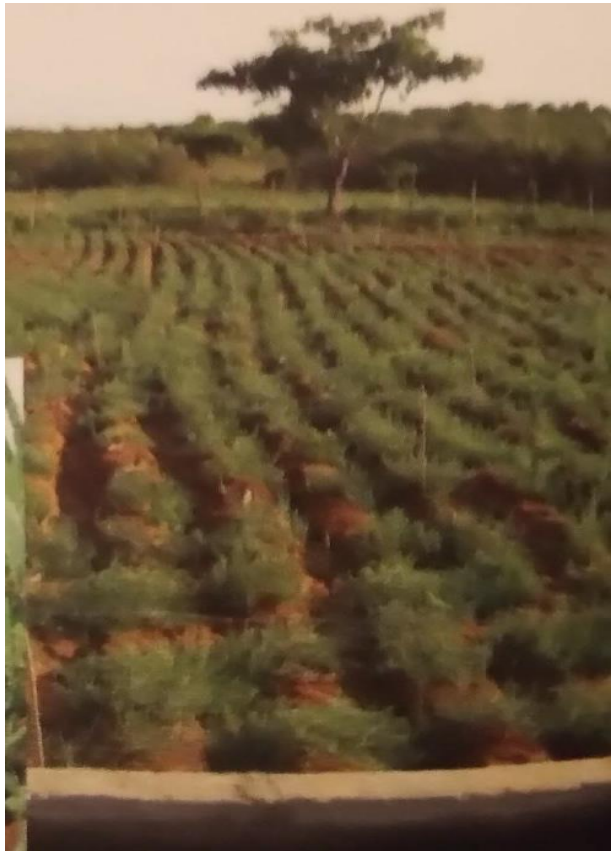
Research on soil, water and crop management in NE Brazil include the development soil and water management strategies: appropriate cropping systems (seeding density, crops rotation, intercropping), the use of brackish waters (mix, or use water of different salinity, use salty waters in the crop states of highest tolerance to salts), cultivation of halophytes and salt-tolerant crops, fertilization, application of mineral and organic amendments, etc.

Treatment	TDM	GRDM
	(kg ha^{-1})	
ECw, 0.8 dS m^{-1}	4526.4 a[2]	1864.5 a
ECw, 0.8 / ECw, 5.0 / 0.8 dS m^{-1}	4524.3 a	1827.3 a

Total dry matter (TDM), grain dry matter (GRDM) of cowpea, changing water salinity during crop cycle

A specific concern is the mitigation of socioeconomic impacts of soil salinity in agricultural lands. Thus, a technology to provide a source of income for impoverished peasants, while contributing to water and food security, has been developed. This is based on the desalination of brackish water and its use in a production system involving reject brine for farm-raised fish and the use of fish-pond water to grow organic salt-tolerant vegetables and forage for small ruminants.

Phytoremediation studies involved extraction of salts by *Atriplex nummularia* L., in greenhouse and in field conditions, in intercopping with *Leucaena leucocephala, Azadirachta indica*, *Mimosa caesalpiniifolia* and other species, as well as plant/microorganism interactions.



Other research front is the biosaline agriculture. This would allow agriculture to be extended to saline areas, marginal coastal areas and the use of sewage and effluents. The crops can be for human or animal consumption, for energy purposes, drugs. Many species native from Brazil are being studied, in some cases already in the cultivation stage. Among them, species of the genera *Conocarpus, Laguncularia, Atriplex, Herissantia, Rhizofora, Batis, Sarcocornia, Blutaparon, Remirea, Amaranthus, Myrsine and others.*

Work is being done on genetic improvement and selection of salt-tolerant species.

Sarcocornia ambigua **culture with saline water in NE Brazil**

Argentina has active research on salt affected soils, mainly alkaline, of temperate humid areas. Research focus mainly at increasing biomass productivity and reducing soil salinity and alkalinity by changing the hydrological balance of the soils. They include grazing management on natural grassland, seeded pastures, agro-hydrological management, plant introduction, fertilization, among others. Experiments with cultivated pastures include tall wheatgrass, megathermic grasses, some leguminosae and local grasses.

Grazing management

Megathermic biomass accumulated in a year (kg ha $^{-1}$ - DS)

Forage	Yields
Chloris gayana (Grama Rhodes)	5.010 a
Panicum Coloratum (panicgrass)	5.496 a
Natural grassland	2.632 b

Two natural grassland fertilization experiments (g m^2)

Site / Soils	Treatments	Average First year	Average second year
Chascomús / T. Natraquoll	Control	237.31	309.40
	Urea - 200 kg ha^{-1}	215.50	345.10
Uribelarrea / T. Natrudoll	Control	61.40	210.10
	Urea - 200 kg ha^{-1}	62.50	425.90

Other prominent activities are characterization, collection and multiplication of native and naturalized species, and their incorporation into breeding program. Breeding efforts have produced new salt-tolerant forage plant cultivars, already commercialized by local companies (i.e. Rhodes grass tetraploid). Breeding alternatives have been also used to increase salt tolerance in the naturalized *Melilotus albus* and *Lotus* sp.

Using biotechnology, salt tolerance mechanisms have been successfully incorporated into commercial grain crops, like soybean.

The recent processes of soil salinization in semiarid deforested areas have been studied in the great Chaco area and now it is focusing in ways to alleviate the degradation process (forest fractionation, changing cropping systems, etc.).

The salinization processes in irrigated areas is an important issue. In some areas drainage and better irrigation technics improved the situation noticeably but in other cases salinization is still growing.

Situation of secondary salinization in fully irrigated areas of Latin American countries

Mexico: 6.5-7 million ha under irrigation, approximate estimates indicate: 10-20% affected by varying degrees of salinity or sodicity.
Cuba: It is estimated that around 50% of the irrigated area (2 million ha) are affected by various levels of salinity and sodicity.
Venezuela: It is estimated that 25-30% of the 250,000-300,000 irrigated ha are affected by various levels of salinity and sodicity.
Brazil: There is evidence of salinization processes that affect at least 25-30% of the irrigated area.
Peru: Salinization problems were identified in around 300,000 irrigated ha, 150,000 ha with high levels of salinity. Particularly, soil salinity is a problem that affects approximately 40% of the total agricultural area of the Peruvian coast
Argentina: 1.8 million ha under full irrigation, with 23.5% affected by varying degrees of salinity or sodicity, varying from 11% in the north to 36% in the southern irrigated areas. Irrigation is also applied in humid areas, mainly flooded rice and supplementary irrigation for temperate field crops. Some alkalinization problems arises.
Dominican Republic: it has been estimated that about 80,000 ha, mainly in the eastern part of the country, are affected by some degree of salinity and sodicity.
Colombia, Chile, Bolivia and other Latin American countries presented also large areas affected by secondary salinization.

In summary, the salt affected soils in Latin America are located from arid to wet areas, in dryland or irrigated conditions, coastal areas and in tropical zones.

Most of these soils were originated under natural conditions, but the area increases with secondary salinization, which is caused by anthropic induced processes, mainly associated with hydrological changes caused by irrigation and other unsustainable practices. These processes negatively, sometimes irreversibly, affect the productive capacity of soils in the region, with a significant economic, human health and social impact.

Research about salt affected soils flourished, in several countries, sixty to forty years ago, when salinity research and evaluation was active in fully irrigated areas.

More recently, in some countries, research has activated but focusing in:

- **Tropical areas with periods of extreme rains followed by drought and saline subsoils and/or saline groundwater.**
- **Temperate flat humid areas subjected to excess of water and sodium.**

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GLOBAL SYMPOSIUM ON SALT-AFFECTED SOILS

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