From Middle East To Middle West: Managing Freshwater Shortages and Regional Water Security

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Role of Biosaline Agriculture in Managing Freshwater Shortages and Improving Water Security

Dr Mohammad Al-Attar, Director General, International Center for Biosaline Agriculture (ICBA)

Introduction

During the 20th century the world population tripled. As populations rise, so too does the demand for water. Yet we are aware that the total volume of water on earth is finite at about 1400 million cubic kilometers of which only 2.5% is freshwater (UNEP 2002). Unfortunately most of the freshwater is locked up in the icecaps of the Antarctic and Arctic (Fig. 1) Thus the usable portion of freshwater resources is less than 1% of all freshwater and only 0.01% of all water on earth (UNEP 2002). The shortage of this precious natural resource and the increasing demand for water as the world's population increases, seriously limits development and threatens water security, at local, regional and global levels.

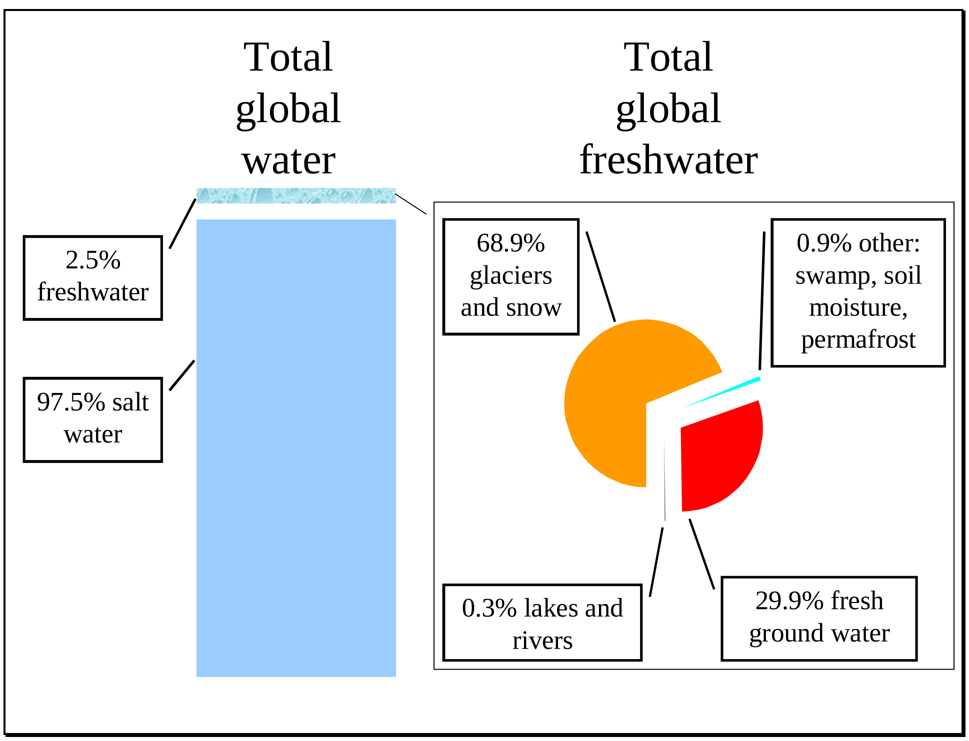

Figure 1. Global water resources. Source: UNESCO/UNEP.

Yet the distribution of freshwater throughout the world is uneven. While some parts of the world, such as South America and Asia, are well endowed with freshwater resources, other parts of the world, such as the Near East, are poorly endowed with freshwater resources. The Near East is one of the driest areas of the world. The 29 countries in the region account for 14% of the world's land area and are home to 10% of the world's human population. Yet the region has only about 2% of the world's renewable water resources. Further, this is a region characterized by high temperatures throughout much of the year and where demand for water to meet human needs is correspondingly high (ICBA 2001). Drylands in the Middle East cover 99% of the surface area.

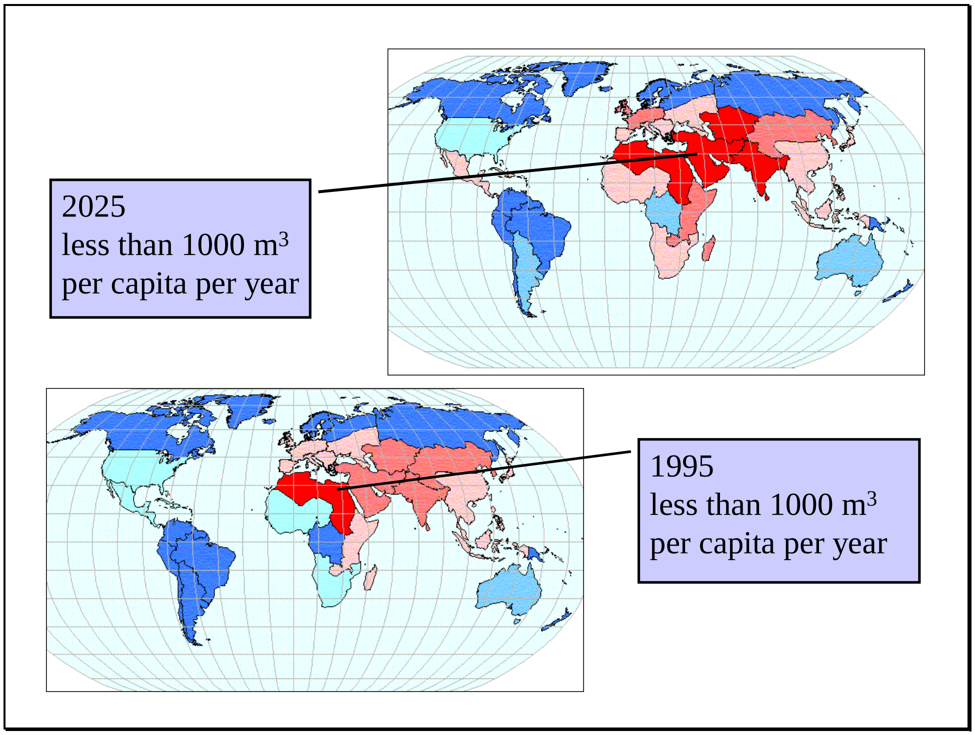

Figure 2. Water availability by region in 1995 and estimated for 2025 (1000 cubic meters per capita per annum). Source: UNESCO.

Many of the Near East countries have among the lowest renewable water resources per person in the world (Fig. 2). The average for the Near East region is 1577 cubic meters of water per person per year, while the global average is 7000 cubic meters of water per person per year (ICBA 2001). Worse still is the situation in the Middle Eastern countries such as Jordan and the six Gulf Cooperation Council countries of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (Fig. 3), where only 170-200 cubic meters of renewable water resources are available per person per year (ICBA 2001). This is less than 3% of the global average.

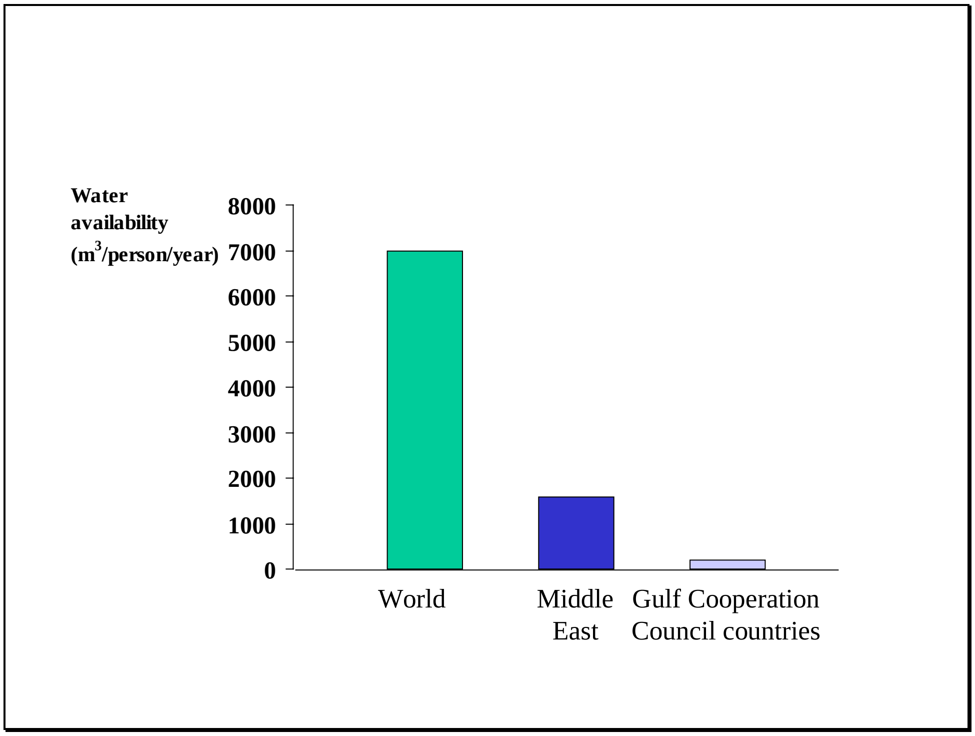

Figure 3. Availability of global water resources per person. Source: ICBA 2001

In the Near East, demand for water has been increasing due to rapid population growth and an increase in per capita consumption. This has led to water rationing in some countries: Jordan restricts water supplies in Amman to 3 days a week; and in Syria, water for Damascus inhabitants is supplied for less than 12 hours a day.

Nevertheless, agriculture still consumes the largest proportion of the freshwater in the region. One estimation indicates that water withdrawal for irrigation is 70% of the total withdrawn for human uses (Shiklomanov 1999), while the withdrawal for irrigation in the six Gulf Cooperation Council countries is 85% (Zubari 1997). Another study found that agriculture utilizes about 86% of the available water resources in the Arabian Peninsula and 80% in the Mashriq (Jordan, Syria, Iraq, Lebanon, Palestine) countries (Khouri 2000). The proportion of water utilized for domestic and industrial use is much smaller.

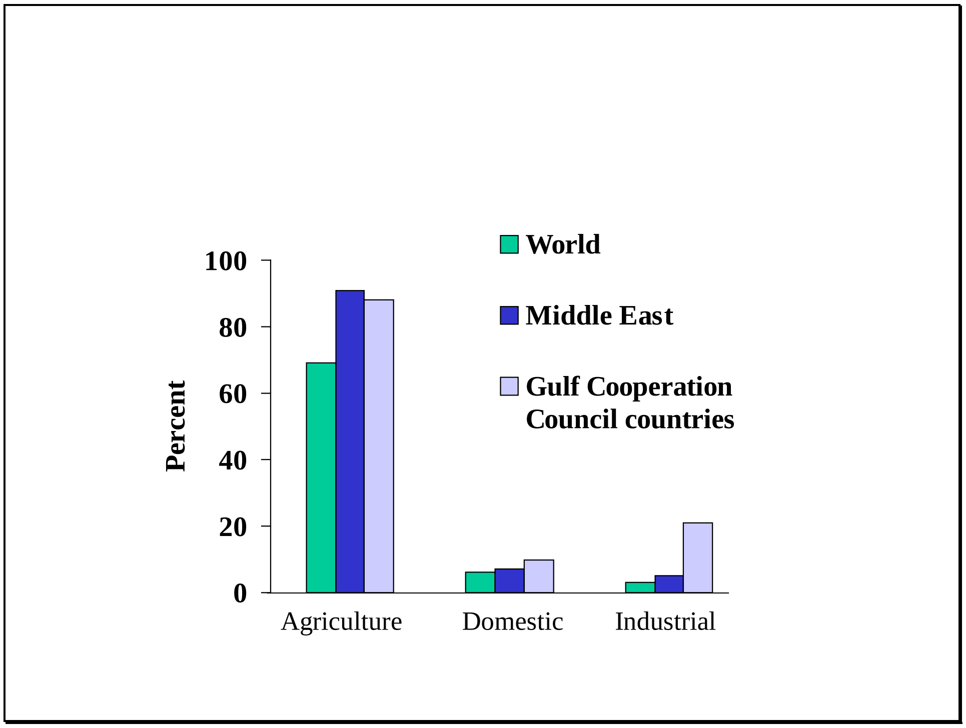

Figure 4. Use of fresh water by sector and region. ICBA 2001.

Unfortunately the use of freshwater for agriculture per person is higher (Figs. 4 and 5) in the Near East than the global use per person because of the aridity and high summer temperatures over much of the region. Thus irrigation in agriculture assumes a greater significance. Even in areas where the environmental conditions preclude intensive agriculture, there is a growing demand for water in horticulture and landscaping. In the six Gulf Cooperation Council countries, the area planted to horticultural crops increased by 12-15% per annum from 1980 to 1999. Many countries in the region, particularly in the Middle East, have a policy of being as self sufficient in food production as possible, but water limitations have kept them from achieving self-sufficiency (Cosgrove and Rijsberman 2000).

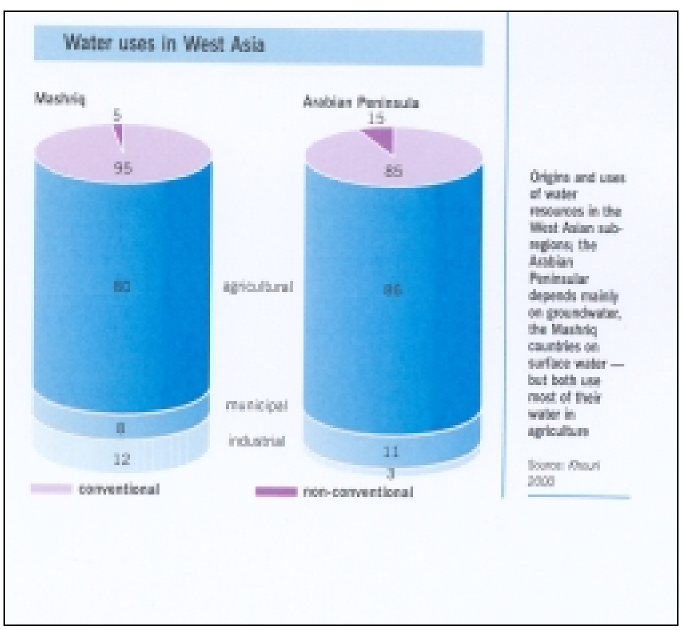

Figure 5. Water use in West Asia. Khouri 2000.

Globally, poor water management has resulted in the salinization of 20% of the world's irrigated land, with an additional 1.5 million hectares affected annually (CSD1997), significantly reducing crop production (WCD 2000). Other studies estimate the area affected annually to be much higher at 10 million hectares (Arnold et al. 1990). Evidently the true figure is somewhere in between the two estimations. Soil salinity is most serious in arid and semi-arid regions where water is scarce, rainfall is erratic and groundwater is often saline. Although some areas are saline because of the geology or geography, human activity is responsible for salinity of 77 million hectares worldwide. Of this, 45 million hectares is irrigated land (Tables 1 and 2).

Table 1. Area affected by soil salinity worldwide.

Cause of soil salinity	*Area (million hectares)*
Geological and geographical	32
Manmade factors	77
Irrigation	45

Source: IAEA/FAO

Table 2. Area of irrigated land affected by salinity in Near East countries.

Country	*Percentage of irrigated land affected by salinity*
Iraq	70
Pakistan	Over 40
Syria	50
Egypt	33
Iran	15
United Arab Emirates	25
Kuwait	85
Jordan	3.5
Central Asian Countries	50

Sources: IAEA/FAO/UNEP

It is not only irrigated land that is becoming saline but groundwater too is becoming increasingly brackish. More than 50% of groundwater in the region, it is estimated, is already saline and the proportion is increasing as the rate of extraction of water from aquifers exceeds recharge (ICBA 2001). In Saudi Arabia water levels declined by more than 70 meters in the Umm Er Radhuma aquifer from 1978 to 1984 and this decline was accompanied by a salinity increase of more than 1000 milligrams per liter (Al-Mahmood 1987). As water tables drop due to excessive extraction, intrusion of salt water increases in coastal areas. The aquifers of Bahrain, the Batenah Plains of Oman, and the United Arab Emirates are suffering severely from seawater intrusion (ICBA 2001). Groundwater salinity in most areas of the Syrian and Jordanian steppe has increased to several thousand milligrams per liter and over exploitation of coastal aquifers in Lebanon has caused seawater intrusion with a subsequent rise from 340 to 22000 milligrams per liter in some wells near Beirut (UNESCWA 1999).

Establishment of the International Center for Biosaline Agriculture

Recognizing the fact that countries in the Arabian peninsula are using up their water resources three times as fast as they are being renewed, and that available water resources will be exhausted within the next 20 years unless consumption of freshwater is reduced, the Islamic Development Bank (IDB) took the bold initiative to set up the International Center for Biosaline Agriculture (ICBA) in Dubai, United Arab Emirates.

The primary objective of IDB in setting up ICBA is to promote the use of saline water in productive sustainable agriculture in 54 IDB member countries and elsewhere. Promoting the use of saline water and salt-tolerant species to increase food and feed production has the potential to free up scarce freshwater resources and bring into production marginal areas where agriculture is currently not viable because soils are saline or water is brackish.

The Center became operational in September 1999, with financial support from the Islamic Development Bank (IDB), the Arab Fund for Economic and Social Development (AFESD), and the OPEC Fund for International Development. The Center now has additional support from the International Fund for Agricultural Development (IFAD), the International Atomic Energy Agency (IAEA), the UAE Government, Dubai and Abu Dhabi Municipalities, and the private sector in Oman and Saudi Arabia.

This new center, now three years old, has already made strides in screening salt-tolerant species and developing techniques for using saline water irrigation in agricultural systems. ICBA recognizes the importance of scientific sustainable irrigation practices utilizing salty water and the importance of ensuring that salts do not accumulate in the fields implementing biosaline agriculture.

For example, in screening salt-tolerant plants, initial tests at ICBA have shown that elite pearl millet germplasm from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), tested and proven to be heat and drought tolerant, has also proven to be salinity tolerant. Such salt-tolerant crops could form an integral component of a sustainable cropping system providing both food and feed.

As to developing saline water irrigation, in partnership with the private sector, ICBA is testing technologies to use low quality saline process water generated during oil drilling to grow food and feed in Oman. Petroleum Development Oman, a private company, sought ICBA's help in developing a technology to filter process water generated during oil drilling through reed beds and to test salt-tolerant species, which can be cultivated with this treated but still salty water. Such technologies could make economic use of saline water, which would otherwise be wasted, and barren land.

Role of biosaline agriculture in managing freshwater shortages

What is "biosaline" agriculture and what role can it play in managing water shortages?

In many regions where freshwater is scarce, brackish or salty water is available and even abundant. Such water can be used to cultivate salt-tolerant plants. Salt-tolerant plants can also be grown where soils are saline, either because of geological or geographical factors or because of bad irrigation practices.

At present little is known about the quantity, quality and distribution of salty and brackish water. Assessment of water resources has focused almost exclusively on freshwater resources. Recent advances in biosaline agriculture now merit assessment of saline water resources and their potential for agricultural use. As a pilot study, an assessment of the saline water resources in five countries of the Near East, funded by the International Fund for Agricultural Development is being undertaken.

Likewise, little is known about productive uses of salt-tolerant plants, although plants have been selected for salt-tolerance since humans first started to domesticate wild plants for agriculture. The interest in selection for salt tolerance, however increased dramatically in the late twentieth century as concern about food security grew. Now there is wide acceptance that many salt-tolerant species can be used for food or fodder, timber production, horticulture, oil production, and other industrial uses. Some vegetables, such as asparagus, red beet, and zucchini squash, are salt tolerant, as are some fruit trees such as date palm and pomegranate.

Cereal crops vary tremendously at the species, cultivar and genotype levels. Crop varieties developed in the Middle East have better salt tolerance than varieties developed elsewhere. Barley is the most salt-tolerant cereal followed by sorghum and rice. Pearl millet is another crop that shows promise in salinity tolerance.

Forage crops hold good promise of being both salt-tolerant and suitable for cultivation on marginal lands. The most salt-tolerant grasses are wheat grass and Bermuda grass, followed by Rhodes grass and fescues.

However, the most promising salt-tolerant species for productive cultivation are halophytes, salt-tolerant wild plants that are now being included in pasture improvement programs in many salt-affected regions of the world. Many provide high quality fodder and use water very efficiently. Some of the important halophytes being investigated for productive use at ICBA are *Distichlis palmieri*, *Sporobolus airoides, Salicornia bigelovi, Atriplex lentiformis,* and *Salvadora persica*. While many of these species have potential as solely fodder crops, others, such as *Salicornia* may have multiple uses. *Salicornia* can be grown not only as oil seed crop but the plant tips can also be harvested as a high-value salad vegetable crop.

The conservation of plant genetic resources is critical to developing new plant varieties that are ecologically friendly and can flourish with less fertilizers, pesticides and in increasingly marginal lands where conditions are not ideal. While there are many genebanks for traditional agricultural plant species, ICBA has set up a genebank specifically to steward salt-tolerant plant genetic resources for future generations. The genebank houses over 200 salt-tolerant or potentially tolerant plant species and over 6000 accessions of these species from all over the world.

To manage freshwater shortage effectively and improve water security for all, we will need to adapt and transfer technologies to farmers in the developing world, particularly regions such as the Near East where freshwater resources are dwindling and salty water is abundant. There have been rapid advances around the world in the use of saline water for irrigation, including development of irrigation systems, improved water management, and control of salinity within the root zone. Many tools are now available for monitoring irrigation systems and managing salinity. These systems have been successfully packaged and widely used in many countries such as the United States, Australia, South Africa and some European countries

More than 50% of the land irrigated at present has been severely damaged by secondary salinization-alkalinization as well as water logging (Arnold et al. 1990). This partly due to poor irrigation and drainage, and partly due to improper selection of site, method and design of irrigation systems. Every year about 10 million hectares of irrigated land must be abandoned as a consequence of the process (Arnold et al. 1990). This hazard is particularly great in developing countries. A worldwide study by Dregne (1991) estimated that 145.5 million hectares are under irrigation, of which 38 million hectares (30%) are moderately or severely damaged by desertification/salinization. The principal cause is the imbalance between excessive irrigation and inefficient drainage (Kassas 1992).

Such imbalances can be redressed by appropriate technology. For example, ICBA was requested by officials in Abu Dhabi to help reclaim salt-affected agricultural lands by draining water logged soils. A drainage system was designed by ICBA and resulted in restoring productivity to over 100 hectares of agricultural land.

Hence, ICBA's role as an applied research center is not to duplicate the significant body of research relating to salinity in agriculture but to develop and refine available technologies that can be adopted by farmers to improve economic returns using saline water for irrigation. The Center will act as a focal point for gathering information on what has already been done and what is already known in the field. ICBA will provide this knowledge and information to farmers and landscape managers in the developing world through collaborative projects and its developing networks—the Global Salinity Network and the Inter-Islamic Network for Biosaline Agriculture.

Awareness is growing that global water security can only be achieved if all parties work together to develop Integrated Water Resource Management (IWRM) practices on a local, national and regional scale. Biosaline agriculture contributes to IWRM by developing the potential of salt-affected lands, saline water and salt-tolerant plants to increase agricultural production, improve livelihoods and conserve the environment.

Biosaline agriculture contributes to two of the primary objectives of global integrated water resource management:

1. To produce more food and create more sustainable livelihoods per unit of water applied (more crops and jobs per drop) and ensure access for all to the food required for healthy and productive lives.
2. To manage human water use to conserve the quantity and quality of freshwater and terrestrial ecosystems that provide services to humans and all living things.

Plant and environmental responses to water and salinity are highly dependent on climate, soils, topography, and management regime. Transferring irrigation and salinity technology from one environment to another requires an integrated approach. Systems must be developed to monitor the impact of the introduction of new technologies to ensure their maximum impact on sustainability and profitability. The role of ICBA is therefore to not only to acquire, evaluate, assess, and transfer information or expertise from around the world but to work in partnership with those responsible for introducing new technologies into farming systems or greening programs in the region. Research and development projects are collaborative and, as needs are identified, collaborators' skills are developed in training courses which bring participants from as far afield as Senegal and Bangladesh.

Conclusion

How will biosaline agriculture help in managing freshwater shortages and improving water security? Today, 1 kilogram of wheat needs at least 1000 liters of virtual freshwater, or water utilized to grow the wheat plants that produced the kilogram of grain. If a salt-tolerant crop were grown instead, the 1000 liters would have both freed up1000 liters of freshwater for other uses and utilized brackish or saline water, an otherwise wasted resource.

Can biosaline agriculture make a difference? Biosaline agriculture technologies use salty water productively. Plants that tolerate salt in water and soil are being evaluated for productive use, perhaps replacing varieties that will only grow in sweet soil irrigated by freshwater. Biosaline agriculture focuses not on prime, productive areas but on bringing into production unused or little-used marginal lands where plants are difficult to grow and which support few livestock. If economically useful plants are grown with salty water and on saline land more food and feed can be made available globally and land abandoned because the soil has become saline can be put to economic and sustainable agricultural use. An alternative supply of saline water that can be used in agriculture will relieve pressure on freshwater resources.

Freshwater we all know is scarce, shortages are commonplace and increasing. Let us conserve freshwater by using salty water instead to grow more food and feed. Biosaline agriculture can be part of the solution to integrated water resources management 'linking social and economic development with protection of natural ecosystems and . . . land and water uses across the whole catchment area or aquifer.' (GWP 2000) We cannot afford to waste water, even saline water, and neither can we afford to forsake salt-affected lands. Let us manage freshwater resources and improve water security where possible by making use of two unused resources, salty water and salt-affected land, and put them to productive use using the techniques of biosaline agriculture.

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