

# Innovative Agriculture in Saline and Marginal Environments

## ICBA Capability Statement



The International Center for Biosaline Agriculture is committed to working in partnership with organizations across the globe to develop and deliver agriculture and water scarcity solutions for saline and marginal environments.



# WELCOME TO ICBA'S CAPABILITY STATEMENT

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## Introduction

**The International Center for Biosaline Agriculture - ICBA** is an international, non-profit agricultural applied research center established in 1999 in Dubai, United Arab Emirates (UAE). Originally, the Center was established as a research and development institute focused on the problems of salinity and using saline water for irrigated agriculture. Since then, it has evolved and broadened its initial focus to research and development programs focused on improving agricultural productivity and sustainability in marginal and saline environments.

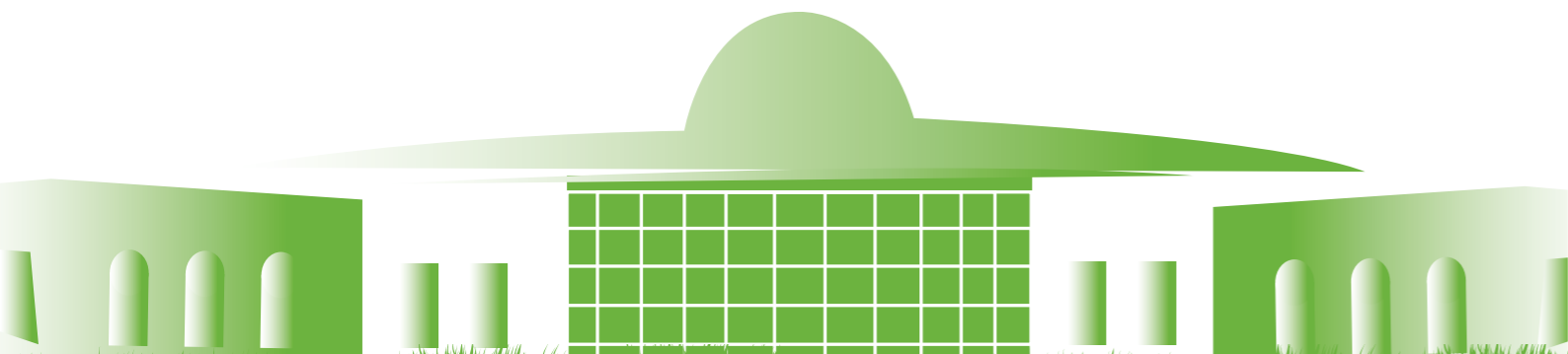
ICBA takes innovation as a core principle and adopts a multi-pronged approach for addressing the closely linked challenges of water, environment, income, and food security. ICBA's research innovations includes the assessment of natural resources, climate change adaptation, crop productivity and diversification, aquaculture and bio-energy and policy analysis.

ICBA contributes to the attainment of the global sustainable development goals (SDG1, 7, 12 & 13) by working on a number of technology developments including the use of conventional and non-conventional water (e.g. saline water, treated wastewater, industrial water, agricultural drainage, and seawater); water and land management technologies and remote sensing and modeling for climate change adaptation.

Improving the generation and dissemination of knowledge is an important strategic objective of ICBA and the Center is focusing on developing itself as a Knowledge Hub on sustainable management and use of marginal resources for agricultural production in marginal environments. With the help of its partners, ICBA innovates, builds human capital, and encourages the learning that is fundamental for change.

ICBA's work reaches many countries around the world, including the Gulf Cooperation Council (GCC) countries, the Middle East and North Africa (MENA), Central Asia and the Caucasus (CAC), South and South East Asia (SSEA), and Sub-Saharan Africa (SSA).

Much of our innovative applied research work is funded by three core donors; the Ministry of Environment and Water of the United Arab Emirates, the Environment Agency - Abu Dhabi, and the Islamic Development Bank. We gratefully acknowledge their support as well as the support of many other donor agencies that have sponsored components of our work over the years.



*" The work being done at ICBA to improve the productivity and resilience of smallholders farmers in marginal environments is vital in the pursuit of food and nutrition security. It is estimated every dollar spent on agricultural research generates \$9 in additional food for the children, women and men of developing countries."*

*Kanayo F. Nwanze,  
President of the International Fund for Agricultural Development*

MISSION

To be the global Center of Excellence for innovative agriculture in saline and marginal environments

To work in partnership to deliver agricultural and water scarcity solutions in marginal environments

VISION



# Applied research

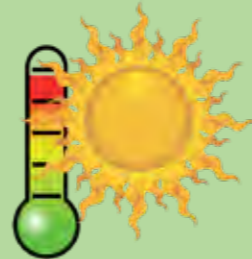
ICBA firmly believes that high-quality applied research is critical to development and is key to identifying and determining the interventions that will be most effective in addressing both the prevailing and upcoming challenges. We are among a few international research organizations in the world that specializes in marginal environment agriculture systems that aim to improve the livelihood of poor farmers living in these marginal environments

Our focus is on addressing agriculture challenges in marginal environments through research that seeks to identify, develop and test suitable innovative solutions and technologies that will increase food, nutrition and water security in addition to improving the environment and the livelihood of people living in marginal environments.

ICBA's applied research spans the food–water–energy nexus under four Thematic Areas.



**Aquaculture & Bioenergy**



**Climate Change Impacts & Management**



**Crop Productivity & Diversification**



**Natural Resources Assessment & Management**

# Research Innovation 1: Assessment of natural resources in saline and marginal environment

Strategic planning in **agricultural production systems** requires sufficient knowledge of the availability of existing qualitative and quantitative resources. When it comes to 'marginal resources' however, existing knowledge is limited. ICBA employs modeling as well as analytical tools to assess land and water resources for different types of agricultural production systems and makes land resource management and reclamation recommendations while pursuing best management practices.

Soil and water surveys, hydrological modeling, sea water intrusions and impact on groundwater quality are all explored. ICBA also tests innovative technologies related to cleaning saline and/or contaminated water; improving controlled irrigation systems; and testing different types of amendments to improve soil properties in marginal environments.

## Examples of our work

**1** To improve soil properties so as to optimize crop yields, ICBA is conducting on site trials on **biochar** generated from date palm and Conocarpus wastes to examine its moisture retention capacity. Biochar is a solid fine grain material obtained from the carbonization of biomass under oxygen-limited conditions. The use of biochar improves the physical and chemical properties of soils as it contributes to increased cation exchange capacity (CEC) which affects the ability of soils to hold nutrients, increase nutrient uptake and decrease nutrient losses through leaching.





**2** ICBA scientists and partners are using DNA-sequencing technologies to identify isolated rhizobia in the Arabian Peninsula in efforts to boost crop yield using desert bacteria. Rhizobia plays an important role in fixing atmospheric nitrogen as it forms nodules on roots and by fixing atmospheric nitrogen into ammonia it helps provide an easy and inexpensive means to enhance soil fertility and agricultural productivity. Through ICBA trials, we identified and selected the rhizobia strains adapted to salinity and heat that can be successfully used in marginal area for increasing crop productivity for leguminous plants.



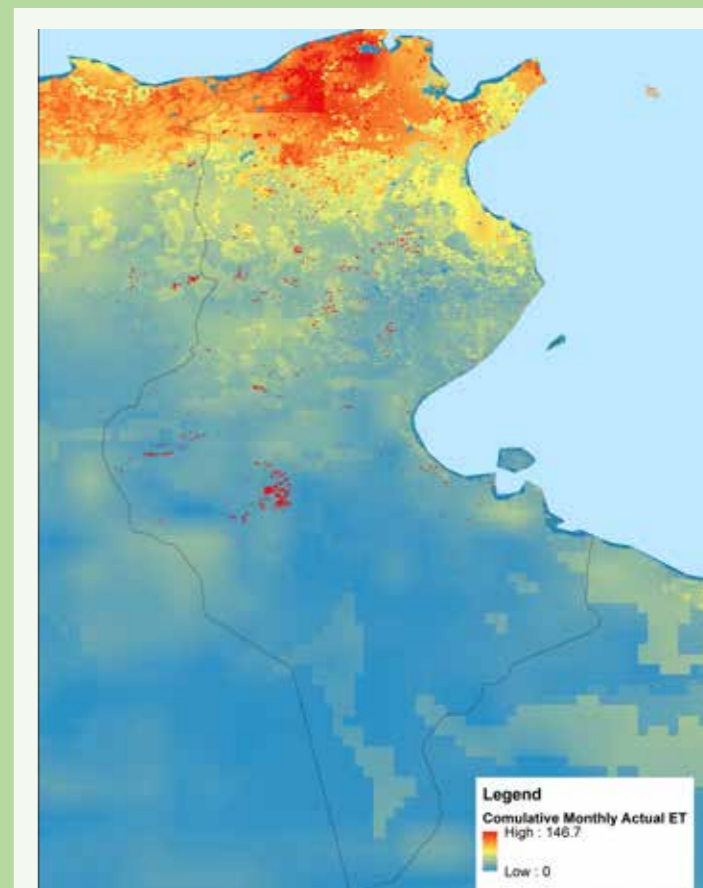
## Research innovation 2: Climate change impacts and management

This thematic program examines the impacts of climate change in marginal and saline environments, specifically from an early drought monitoring perspective, and adapts agricultural systems accordingly. High end technology is used to downscale data through remote sensing and a GIS system. Modeling simulations are employed for both climate change and crop production. Different perspectives of land and water assessments and the management of cropping systems adapted to marginal environments and policy formulation through modeling studies are assessed.

### Examples of our work

**1** Through the **Modeling and Monitoring Agriculture and Water Resources for Development (MAWRED)** project, decision makers in the MENA region are empowered in managing food and water security under current and future climate conditions through the provision of new water, crop and climate data using high tech tools. The need for such tools has never been greater in light of the growing water and food insecurity challenges facing the region.

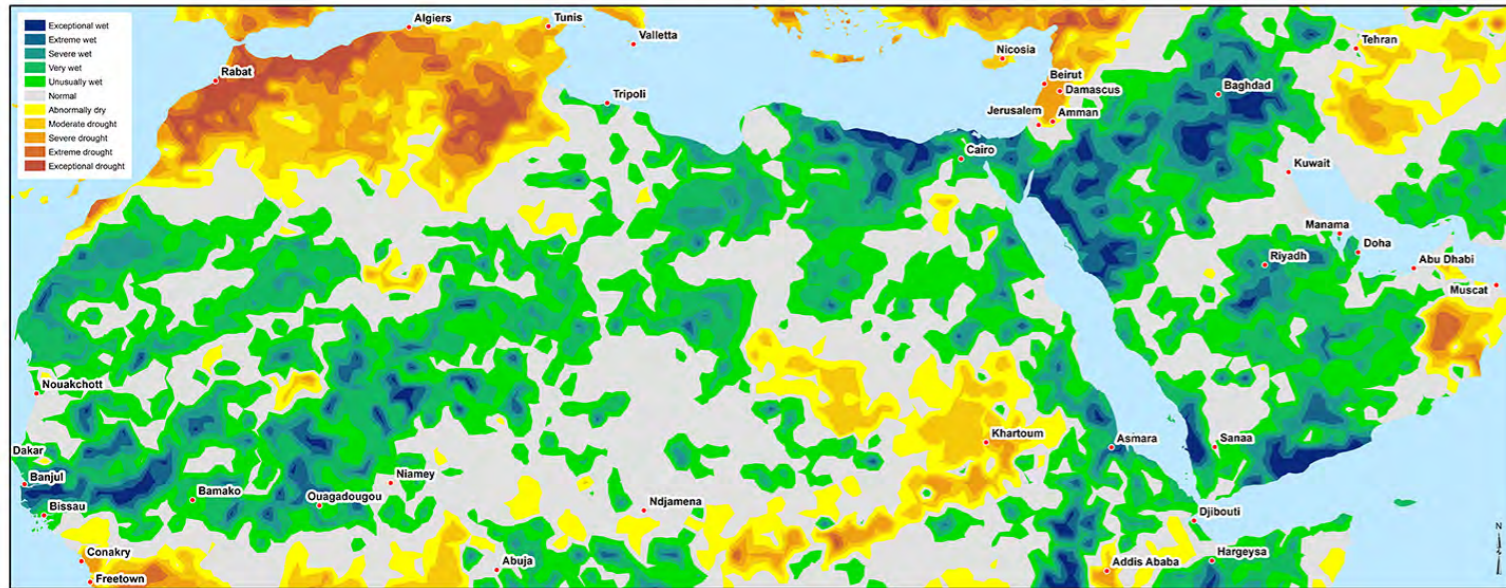
**2** Work on **Real Time Monitoring** for irrigated agriculture in MENA countries involves monitoring crops and their environments and provides a powerful tool to improve on-farm irrigation management. Electronic sensors that measure soil water content, salinity, leaf water potential and sap flow (transpiration) assess water status and flow through the entire continuum of soil, plant and atmosphere. The work is implemented in 20 agri-businesses and provides support decision tools to farmers, farmer and engineer associations, extension personnel, and researchers. This will improve water conservation and crop water productivity at the farm community level.



*ICBA has led the development of estimates of crop yield under certain climatic, management and plant physiological conditions. A modified crop type map of the Tunisian footprint has been produced. This work directly supports food security planning as well as strategic climate change adaptation initiatives.*

3 While the Arab region has been adapting to changes in rainfall and temperature for thousands of years, the speed with which the climate is now changing has, in many cases, outstripped traditional coping mechanisms. ICBA scientists contributed to three chapters to the World Bank's study **"Adaptation to a Changing Climate in the Arab Countries"** that drew on extensive regional knowledge and expertise for a comprehensive analysis of the potential impact of climate change in the region.

Composite Drought Index for 12/2015



*"Droughts are the primary cause of most ill health and death because they deny access to adequate water supply and often trigger or exacerbate malnutrition and famine. Since 1900, more than 11 million people have died as a consequence of drought and more than 2 billion people have been affected."*

*FAO Land & Water, Drought  
Food and Agriculture Organization*

ICBA is generating climate, water and crop production data that it plans to utilize to monitor the extent and severity of droughts, and to support effective early warning systems in targeted countries across the MENA region to highlight eminent critical changes in climate and water conditions.

### Research innovation 3: Crop productivity and diversification

This research theme focuses on the plant genetic resources and crop diversification of salt- and drought-tolerant plants that are environmentally suitable and economically viable for marginal areas. The program gives special attention on introducing new genotypes of nutritious and stress-tolerant crops. ICBA has been instrumental in conserving genetic resources from around the world, and enriches its gene bank with plant species from marginal environments. The research combines genetics and genomics approaches to develop new crops through biotechnology methods to create crop varieties that are productive and resilient in marginal and saline conditions. The program also has a special emphasis on salt tolerant seed production programs in the partner countries

#### Examples of our work

**1** The **Adaptation to Climate Change in Marginal Environments** project implemented in collaboration with IFAD, aimed to save scarce freshwater resources through introducing resilient forage and crop production and management systems that are biologically suitable for use by small scale farmers in marginal areas. Seven countries from the West Asia and North Africa region were targeted for introducing these resilient agricultural production systems that have been screened and adapted to local conditions.



**2** ICBA is pursuing a long-term initiative to identify high yielding and very nutritional quinoa varieties with elevated levels of salinity tolerance and good adaptation to the local environment of the marginal regions it targets such as the Arabian Peninsula. Under the **Quinoa for Marginal Environments in the UAE**, ICBA has been evaluating and testing the performance of various quinoa varieties for their performance under marginal conditions. As of 2015, ICBA has identified and developed four genotypes of high yielding salt- and heat-tolerant varieties that are ready for testing in other climatic zones.

**3** Working with a number of both international and local partners ICBA is introducing low cost technologies in saline desert environments in **Central Asia** in the Aral Sea and Caspian Sea basins where countries like Kazakhstan, Tajikistan and Uzbekistan suffer from fresh water scarcity. ICBA's work focused on addressing the problem through introducing highly productive, tolerant and nutritionally valuable crop varieties along with well-established promising technologies. These efforts have helped farmers grow a wider range of crops, use poor quality water efficiently, produce more feed for livestock and improve range land grazing.





ICBA established an IAAS's on over 2 ha of area at the experimental station comprising of a reverse osmosis unit with a capacity to generate 100 m<sup>3</sup> /day of fresh water and 150 m<sup>3</sup> /day of brine water. In addition, three tanks with a volume of 3000 gallons each used to raise fish with part of the brine water generated from the RO unit. The fish species *Sparidentex hasta* (sobaity seabream) introduced for aquaculture have demonstrated remarkable adaptability to the local conditions.

## Research innovation 4: Aquaculture and bioenergy

Integrated aquaculture, based on marine and terrestrial agricultural systems have great potential to boost income under marginalized conditions. ICBA, in partnership with other stakeholders, is working on pilot-scale mariculture projects by growing crops with seawater as an economic model study. ICBA's program on biofuel crops includes undertaking pilot programs and assisting with scaling up seawater-based agricultural systems - integrating marine and terrestrial culture systems for optimizing farm livelihoods. Seawater agriculture - cultivating micro- and macro-algae for biomass and energy production with seawater - with particular emphasis on potential biofuel feedstock is also explored.

### Examples of our work

1 On-going experiments at ICBA explore the economic potential of *Salicornia bigelovii* (dwarf glasswort) to be grown as oilseed, fodder or vegetable crop, as well as assess its adaptability in United Arab Emirates conditions and optimize the management practices for its cultivation. Our work includes screening, evaluating and optimizing agronomic practices for growing *Salicornia* with sea water for bioenergy. Projects implemented with

KAUST and MASDAR provide a foundation for looking at the wide range of wild *Salicornia* genotypes and through generations, identify the ones that could be used for pre-breeding programs and molecular biology/biotechnology programs.

2 Small-scale reverse osmosis desalination systems are increasingly used by farmers in GCC countries to irrigate crops, but a key environmental issue is the safe disposal of the produced brine as the conventional disposal systems are expensive and unproductive. As a result, good management practices need to be formulated. Since 2013, ICBA has been operating an **Integrated Aqua-Agriculture Systems (IAAS)** at its premises, which uses both the desalinated and brine waters in a study that aims to make use of aquaculture waste into a resource with benefits to the environment and farmers. The success of this project will lead to the safe disposal of brine as well as open up new income streams for farmers desalinating water in the UAE and other countries.



## Policies for resilience

ICBA analyzes policies and undertakes socioeconomic studies on food and nutrition security, and water and land management at various scales in marginal environments, to provide recommendations to national, regional and global level partners. Our work is directed at assisting in assessing and managing agriculture, water, land, and climate change. ICBA also provides in-depth assessment opportunities for value adding to market chains. Our approach is governed by fostering stakeholder engagement and creating partnerships.

Another key area under this theme has been preparing strategic documents for organizations and countries in the fields of water, agriculture and food securities for GCC and other regions. ICBA provide strategy development support services to governments globally. Some of these services include, advising governments on soil and water salinity strategies. We also advise governments on how to enact climate smart agriculture policies.

### Examples of our work

1 In response to the increasing water quality deterioration, decline in productivity and farm abandonment due to soil salinization, ICBA partnered with the UAE Ministry of Agriculture and Fisheries to develop a **national strategic plan for combating salinity and protecting water resources from pollution and salinity**. The strategy identifies alternative scenarios for sustainable water resources and production systems to bring about a more efficient and sustainable use of natural resources.

2 The **UAE agriculture strategy** provides decision-makers with information they need to make policy decisions that will guide development of the agricultural sector in the short (5 year) and medium (10 year) term. This includes developing national agricultural policies, criteria, and standards that will improve agricultural productivity while meeting national environmental management objectives and the need for food security.

3 In response to the UAE government's vision for achieving sustainable development of natural resources and water security, ICBA partnered with the Ministry of Environment and Water to develop a **strategic framework for the sustainable management of all water resources** in the UAE. A challenging feature of this strategy is ensuring that the water sector is responsive to the dynamic growth path that has been charted for the country while taking into account that renewable water resources in the country are among the lowest in the world.

4 The **Kuwait investment strategy** in food security provides future demand and supply for Kuwait including investments for local and offshore production, processing, imports, consumption, regulatory and fiscal framework, prices, ingredients and boundaries. The strategy leads to creating an investment policy to secure major food commodities for the country for the next 20 years.



# Up-scaling innovation and technology

Agriculture in marginal and saline environments is in need of innovation and technology systems that can boost production and productivity. Since its establishment in 1999, ICBA has been successful in developing best management practices, developing stress tolerant crop varieties, and technological innovations that address the challenges of farmers in marginal and saline environments. For these innovations to be effective, they have to be fully adopted and utilized properly by local farmers.

ICBA's up-scaling efforts start with carrying adaptation research of the innovations developed by our scientist to test their appropriateness and scalability within targeted countries. Through the employment of a breadth and depth of scientific expertise and specialization, we study real-life situations, including the culture and needs of the local communities. This allows us to create customized, integrated solutions that are suitable for local conditions and that further human development. In collaboration with our partners from other expert institutions, we then offer the most effective and efficient measures to produce the desired impact.

## Examples of our work

**1** Under the **Adaptation to Climate Change in Marginal Environments**, ICBA and its partners worked on increasing the productivity of degraded and lost lands through establishing Farmer Field Schools in Egypt benefiting 2000 farmers from advanced seed production. The skills of poor rural women in farm labor techniques especially economic production of dairy products was raised which positively impacted the livelihood of poor households. Additionally, the project demonstration sites have become specialized centers for biosaline agriculture within the targeted countries ensuring long term sustainability and reach.



**2 Hi-Tech Greenhouse:** ICBA believes that greenhouse agriculture is a viable way to grow high-value crops in arid regions. Improving the water and energy efficiency of greenhouse agriculture is key for the most economical technology adaptation and proper selection of horticulture crops. Instead of cooling pad and fan systems, there is a need to introduce misting, cooling tunnels and other technologies combined with hydroponic systems. ICBA has invested in such new generation greenhouses and testing new crops for the region.

**3 Sap Flow Measurements:** Since 2013, ICBA has been working in partnership with the Environment Agency Abu Dhabi and scientists in New Zealand to measure the actual sap flow in date palms (transpiration) as a function of hourly evapo-transpiration. This will enable operators to determine the amount of water required by this major crop compared with the amount actually applied, helping them to develop improved irrigation guidelines that will generate considerable water saving.





## Award winning research on date palm

In March 2011, ICBA was recognized during the Khalifa Date Palm Awards when it was one of the eight winners chosen out of 131 regional and international participants with its research on the potential of Arbuscula Mycorrhizal Technology for Date Palms.

*" ICBA has a global mandate that can be joined with the FAO mandate for impact. It is for this reason that we are signing this partnership MOU, to work more in partnership with ICBA, to work better together and to contribute jointly to our common goals for sustainable development."*

*Dr. José Graziano da Silva,  
Director General of the United Nation's Food and Agriculture  
Organization (FAO)*

# Private sector led partnerships for innovation

We work in partnership with private sector firms to test the applicability of their innovations and technologies in marginal environments. We do so by putting their technologies to the test at our Center. Private sector firms provide the technology and financial backing for each experiment while ICBA provides the technical support.

## Examples of our work

**1** ICBA is working in partnership with IRIS system technology to compare the agronomic performance of cow pea irrigation water supply between the current evapotranspiration reference (ET<sub>o</sub> based method in use in ICBA and the new soil tension technology deployed by IRIS system. Using soil sensors, the IRIS system provides automatic irrigation only when the crop requires irrigation. This is quite different compared to a manually operated irrigation system which remains in operation even when not required to do so, especially during rainy seasons. The aim of this experiment is to establish whether the IRIS system will indeed deliver water savings. The success of this experiment will lead to the wide spread use and adaptation of precision based and water efficient high tech tools in the MENA region.



**2** DuPont, a global private company that has developed a subsurface irrigation pipe technology that simultaneously desalinates saline or brackish water and irrigates crops by releasing non-saline water vapor (pervaporation). Water is released through the walls of the pipes and leave concentrated water behind. The concentrated water (also called as rejected water) is then flushed periodically to remove accumulated salts and contaminants. ICBA is evaluating DuPont technology for growing plants using saline or brackish water at ICBA field station.

**3** ICBA collaborated with First AFG to initiate a joint research program to evaluate its produced water from saltwater treatment processing. The treatment process permanently alters the salt molecules from saline water; neutralizes the salt molecules and the produced salt water can be safely used for crop production without any negative salt related growth restrictions. A prototype of the salt-water treatment plant was provided to ICBA to evaluate the suitability of the produced treated water for growing crops at ICBA experimental farm in Dubai, United Arab Emirates.

# Technical assistance

At ICBA, we believe that technical assistance is essential in creating sustainable change. Consequently, ICBA provides a wide range of technical services by working with individual host countries, international organizations and the key private sector actors at multiple levels, that work on improving agriculture productivity and water use efficiency in the agricultural sector. Our technical assistance includes data analysis and targeted research and development services aimed at providing our clients with the tools to foster sustainable development in their respective environments. The range of areas covered:

- Managing water and irrigation systems.
- Land degradation and soil management in marginal environments
- Soil management
- Climate change modeling and adaptation
- Drought monitoring and warning systems
- Biosaline agriculture technologies
- Plant biodiversity and biotechnology, specifically as it relates to stress tolerant crop varieties
- Genomics
- Environmental impact assessments

Our staff applies a versatile technical assistance framework aimed at effectively leveraging our technical expertise and in field facilities and technologies in order to achieve sustainable results.



## Examples of our work

**1** In response to the systemic challenges caused by harsh climate change and facing the area surrounding the Euphrates and Tigris rivers, ICBA is providing technical support through the “Collaboration Program: Euphrates and Tigris” to improve dialogue and trust among the basin countries. ICBA is providing a platform for regional institutions from Turkey, Syria, Iran and Iraq to evaluate and discuss strategic transboundary management options and develop an operational plan that will improve water management and increase information and knowledge exchange. Cooperative efforts for more efficient and productive use of transboundary water in the Euphrates and Tigris river basins will help improve local livelihoods and enhance food security.

**2** Understanding soil resource, its capabilities and limitations is an essential pre-requisite for the sustainable and profitable development of a nation. ICBA provided technical assistance services to the UAE government for carrying the **Soil Survey of Abu Dhabi** and the **Soil Survey for the Northern Areas in the UAE**. These surveys provide a comprehensive set of information to aid land-use planning and agricultural expansion. As part of this effort, ICBA produced national soil maps, thematic maps (suitability for – irrigated agriculture, rangeland, wildlife habitats, landfill; mineral resources and other maps-vegetation, salinity, current land use, etc.). Additionally, a web-based Soil Information System was created to allow for the storage, processing, retrieval and management of soil-related information.



## Creating and sharing knowledge

Generating, maintaining and sharing knowledge across regions and research areas in agriculture is a multi-pronged means for ICBA to reach out to local farmers by providing them with the necessary skills, educational material and resources for application. As a result, poor farmers in marginal and saline environments can improve their livelihood now and for future generations.

Within the ongoing 2013-2023 Strategy period, ICBA will utilize the latest digital technologies to launch much needed **Knowledge Hubs** that facilitate an exchange of information on relevant topics in agriculture related to marginal and saline environments via virtual meetings, workshops, conferences, webinars and e-forums. These channels will ensure the continuous flow of and accessibility to the latest information across a wide spectrum of recipients. Our vision is that by 2020, we will have established the following knowledge hubs that serve the needs of marginal environments and smallholders farmers living off of these uncompromising lands:

- 1 **Biosaline Agriculture** - a one-stop shop for information and open discussions on the various halophytes, and salt-tolerant varieties of popular crops.
- 2 **MAWRED** - a data and training hub that provides insight on water, crop production, climate change and droughts in the Middle East and North Africa (MENA) region.
- 3 **Wastewater Reuse** - a regional platform that facilitates sharing of results, information, lessons learned, and best practices on wastewater reuse in the MENA region.

*" With the help of our partners we will innovate, build human capital, and encourage the learning that is fundamental for change."*

*ICBA Strategy 2013-2023*

ICBA recognizes that publications enhance science outreach and exchange of knowledge and technology across networks of researchers, academia and communities of practice. During 2009-2013, ICBA scientists contributed to 165 publications including edited books, manuals, publications in peer reviewed refereed journals, conference proceedings, scientific magazines and newsletters.



## Capacity building and training

Supporting sustainability at the local and regional level is the foundation for ICBA's capacity building initiatives related to marginal and saline environments. We provide a wide range of hands-on tools which can serve as models for direct implementation, complete with indicators to measure and track rates of success over time.

In addition to the technical capacity building support that we provide, we also offer a host of training programs at the Center and in 15 different countries. Offerings can be in English, Arabic or the local language of the host

country. In the past, ICBA has offered tailor made training courses in French and Russian languages and is in position to provide support when called to do so.

Training programs at ICBA, which include different training modules according to thematic areas as well train-the-trainer, are tailored according to partner's needs and requirements and cover a broad array of topics. Opportunities for discussions are included as are visits to the Center's laboratories and fields to practice the learned information directly. Besides face-to-face training, e-learning is also provided to reach a wider scope of participants.



## Our value proposition

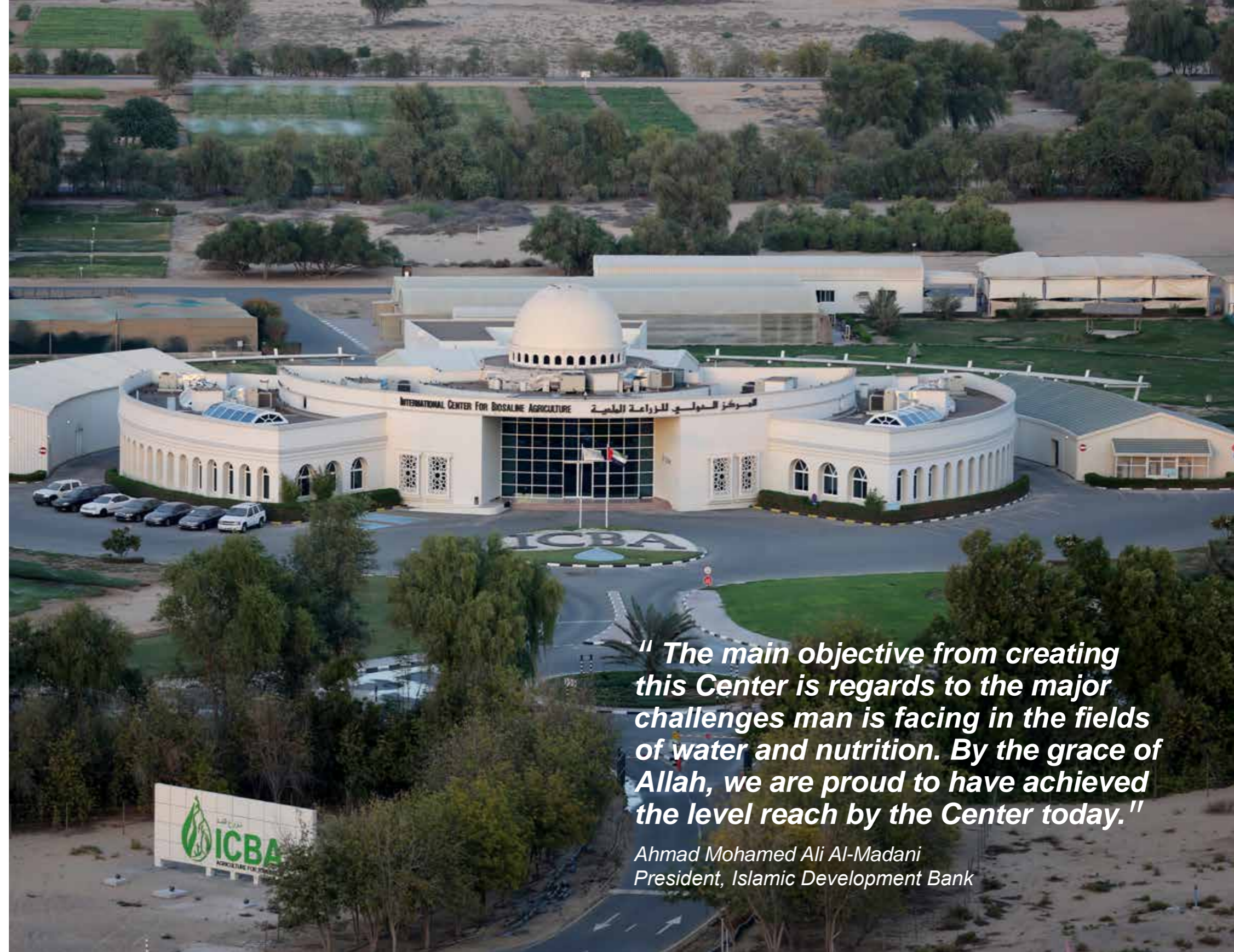
A world class 100 hectares facility is located at ICBA headquarters in Dubai, United Arab Emirates (UAE), housing research and training capabilities including an experimental farm, soil, water, biotechnology and agronomy laboratories, a gene bank of salt-tolerant germplasm, a unique soil museum, greenhouses, and training facilities. Over thirty-five hectares of land available to ICBA is fully dedicated to research purposes.

In addition to the headquarters in the UAE, ICBA has an office in Uzbekistan that covers Central Asia and maintains solid relationships with key national and regional organizations in Tajikistan, Uzbekistan and Kyrgyzstan. In 2015, ICBA will open an office in Ethiopia that will oversee all our projects in the African continent.

ICBA's international team includes scientists specializing in soils, crops, molecular biology, water, remote sensing and GIS, as well as experts in policy, socioeconomics, knowledge management and capacity building. Since its establishment in 1999, ICBA has led the way in research on problems and solutions related to agricultural productivity in saline and marginal conditions.

Solid partnerships have been formed with key international and national research, academic, nonprofit, private, public and government institutions, along with a wide network of farmers in all the countries where ICBA has leverages public funding and creates synergies to address food, nutrition and water challenges.

Fourteen years later, many changes have taken place – technologically, socially and politically. Many advances have been made, hurdles overcome, and partnerships forged. Still, with the expanding global population along with the fast changing global climate, the challenges of salinity and land degradation are increasing at an accelerating rate, while the demand for food has never been higher. Through quick mobilization and in partnership with like minded organizations, ICBA remains dedicated to improving the livelihood of some of the world's most poor and impoverished people living under marginal conditions.



***" The main objective from creating this Center is regards to the major challenges man is facing in the fields of water and nutrition. By the grace of Allah, we are proud to have achieved the level reach by the Center today."***

*Ahmad Mohamed Ali Al-Madani  
President, Islamic Development Bank*





## ABOUT ICBA

**International Center for Biosaline Agriculture - ICBA** is an international, non-profit organization that aims to strengthen agricultural productivity in marginal and saline environments through identifying, testing and facilitating access to sustainable solutions for food, nutrition and income security.

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