On-farm demonstration of implementing Integrated Agri-Aquaculture Systems (IAAS) in desert environments

Dionyssia Angeliki Lyra, Khalil Ur Rahman Butt, Basel Ahmad Al'raj

International Center for Biosaline Agriculture, PO Box 14660, Dubai United Arab Emirates

Introduction

Farmers, due to increasing groundwater salinity, use small-scale RO plants to produce desalinated water for crops irrigation. However, good management practices are lacking, since the brine water is discharged in the soil contaminating the fresh groundwater, leading to a vicious circle.

Challenge

The safe disposal of the produced brine remains a key environmental issue. The conventional disposal systems are expensive and unproductive. The project addresses this challenge by transforming this common waste into a resource through IAAS with benefits for the environment and farmers.

Materials and Methods

A land-based IAAS supported by a RO-unit was established at ICBA in 2013 to demonstrate how less productive farms can be transformed into productive farms using different technologies (Figure 1). The RO-unit desalinates brackish groundwater (16000 ppm) and can produce desalinated water (60 ppm) at 100 m3/day and brine (24000 ppm) at 150 m3/day. The desalinated water is used to irrigate a large variety of high value crops. About 2/3 of the reject brine is used to irrigate salt-tolerant forages and halophytes, whereas the rest (1/3) is directed to the aquaculture system. The mariculture system comprises fish, sedimentation and seaweed tanks in a sequential manner. Three tanks each of 3000 gallons volume are used to grow fish (500 fish/tank). Four water treatments are used for salt-tolerant forages and halophytic crops irrigation: a) direct RO-brine, b) RO-brine combined with groundwater, c) aquaculture-brine and d) aquaculture-brine combined with groundwater.

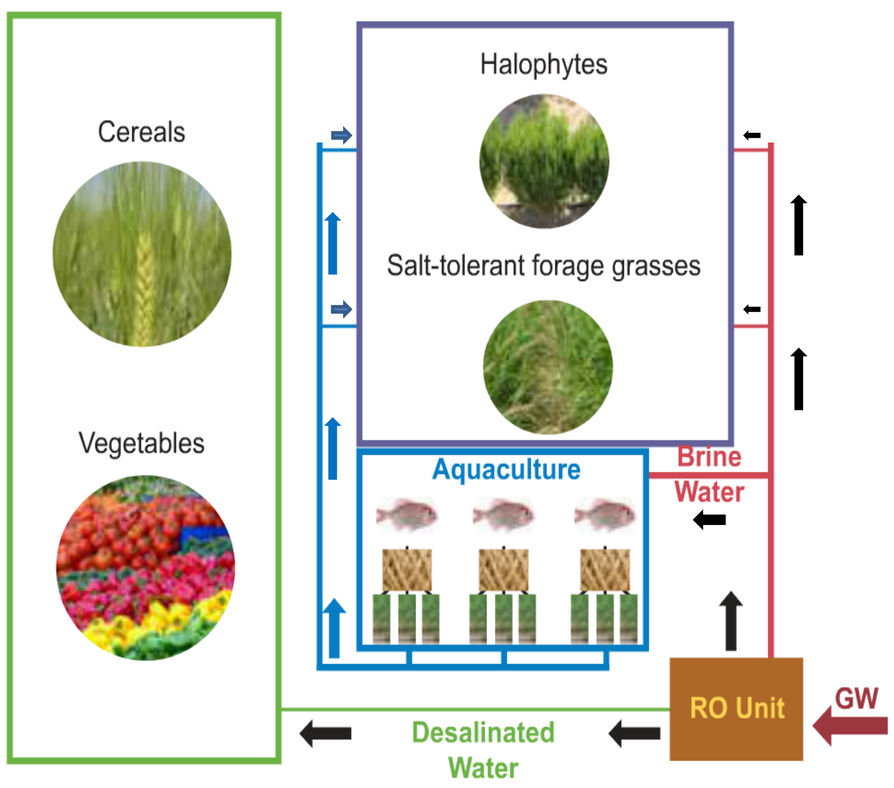

Figure 1: Layout of the IAAS design implemented at ICBA research station.

Key Results and Discussion

1. All available water resources in the field (desalinated, RO-brine and aqua-brine) were successfully used to irrigate high value crops, halophytic species and grow fish.

2. High value crops produced good yield, however, optimization of the management practices is needed in order to enhance the agronomic performance of the plants and increase the production further.

3. The fish species Sparidentex hasta (sobaity seabream) was successfully grown in the inland aquaculture system. Over a period of six months fish weight, length and width increased by 74%, 89% and 46% respectively.

4. Water analyses showed that the concentration of total nitrogen was higher in the aquaculture brine (1.23 mg/l), due to ammonia and nitrate produced from fish activities, compared to groundwater (0.50 mg/l), desalinated (0.73 mg/l) and RO-brine (0.62 mg/l). Desalinated water was characterized as poor in nutrients, so extra fertilization was added to sustain vegetables good growth and yield.

5. Soil salinity was very low in plots where vegetables and other high value crops were irrigated with desalinated water and ranged from 0.4 to 3.1 g/l in all soil depths (0-25, 25-50, 50-100 and 100-150 cm). Higher salinity values were measured for soil samples collected from the plots where brine treatments were applied and varied between 1.4 and 15.9 g/l.

6. Aquaculture effluents enriched in fundamental nutrients (nitrogen and phosphorus) improved halophytes biomass production compared to RO-brine treatments. Salicornia biomass values increased by 200% and halophytic forages by 12% (Sporobolus virginicus) and 34% (Distichlis spicata) (Figure 2). As a result, the revenues increased proportionately.

7. Results showed that the revenues increased making the assumption that farmers receive government subsidy for RO-units installation.

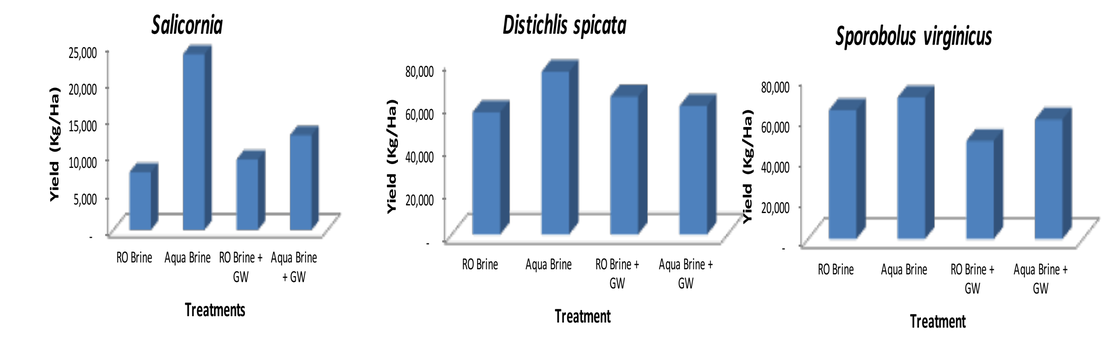

Figure 2: Biomass yield (kg/ha) for Salicornia and salt-tolerant grasses under four irrigation treatments: a) RO-brine, b) Aqua-brine, c) RO-brine mixed with GW and d) Aqua-brine mixed with GW.

8. Results also suggested that the profitability of the desalinated part could increase, by cultivating high value crops of shorter growth cycle that could be cultivated more than once throughout the growing season such as leafy vegetables.

9. A SWOT analysis was developed to identify the strengths, weaknesses, opportunities and threats of IAAS implementation in arid regions (Figure 3).

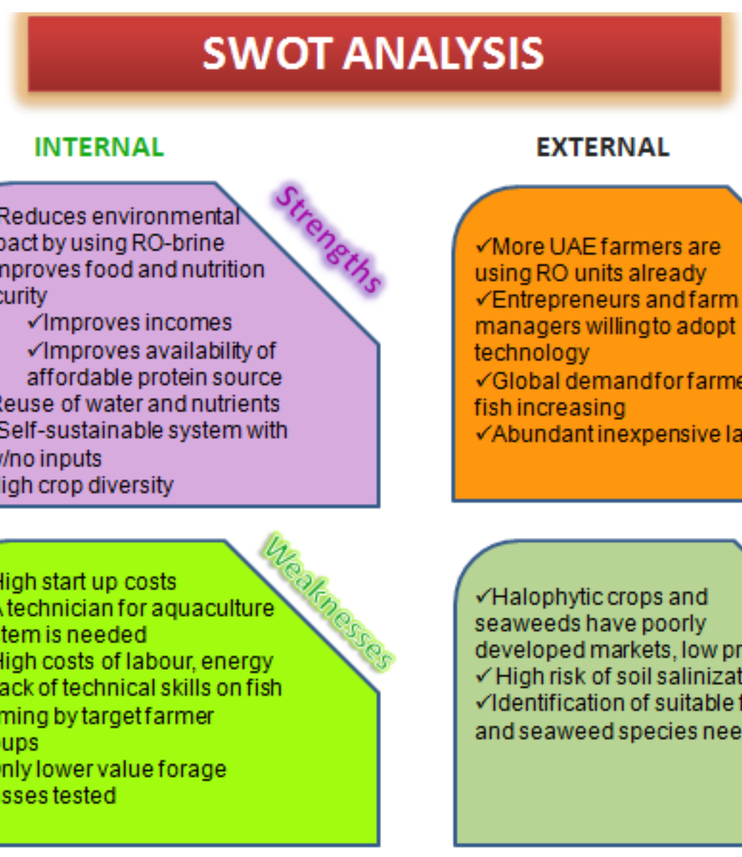

Figure 3: SWOT Analysis for IAAS implementation.

Conclusions

Our three year experience has shown so far that such integrated systems can create a wealth of ecological and economic advantages in marginal environments dealing with salinity issues. The benefits range from sustaining environment quality through productive use of brine and dissolved and particulate nutrients discharge to generate value-added by-products. In this way, the sustainability of the existing RO infrastructures in the region is enhanced.

Key references

Sánchez A.S., Nogueira I.B.R. and Kalid R.A. (2015). Uses of the reject brine from inland desalination for fish farming, *Spirulina* cultivation, and irrigation of forage shrub and crops. *Desalination*, 364:96-107.

Stevenson K.T., Fitzsimmons K.M., Clay P.A., Alessa L. and Kliskey A. (2010). Integration of aquaculture and arid lands agriculture for water reuse and reduced fertilizer dependency. *Experimental Agriculture*, 46(02): 173-190.