Integrated aqua-agriculture systems revisited

Water and food security constitute two of the most vexing challenges of the 21st century that humanity has to face. Rapid population growth, productive lands and fresh water limitations, high demand for energy, and climate change all contribute to limiting the agricultural capacity to meet demand for food, feed, fiber and fuel on a global basis. In order, to alleviate this pressure, scientists are looking for synergistic solutions among productive sub-systems that maximize farm productivity and minimize, in parallel, their ecological footprint. The integration of aquaculture components with agriculture provides a means to optimize the use of water resources and decrease dependency upon chemical fertilizers, while promoting greater sustainability of the systems.

The concept of Integrated Aqua-Agriculture Systems (IAASs) is not recent. Intensive IAASs have evolved from traditional extensive polyculture systems commonly found in African and Southeast Asian countries since the 1950s, where fish have been raised while simultaneously growing crops, usually rice. The well- known paddy cam fish cultures are very popular in Indonesia, China, Japan, Malaysia, Thailand, Vietnam, Bangladesh, Ivory Coast, Liberia, Madagascar, Tanzania, Zaire and others. Fish ponds are grouped around a village or near sources of irrigation water and are primarily used to raise fish for consumption by the producers.

IAASs are characterized by several advantages such as: a) farm productivity and profitability increases without any net increase in water consumption, b) farm diversification increases through higher value crops, including aquatic species, c) re-use of water and nutrients otherwise wasted on-farm resources, d) reduction of net environmental impacts of semi-intensive farming practices and e) higher net economic benefits due to offsetting existing farm capital and operating expenses. Apart from these benefits, there are social benefits associated with IAAS. so the operational requirements of IAASs are not gender, or age specific, so broad participation by the workforce (small-scale farmers) including women and youth is possible. In addition, water authorities may achieve multifold benefits through more efficient use of marginal waste resources such as saline groundwater. The result is increased revenue without increased consumption, further offsetting the existing management and maintenance costs.

Aquaponics constitute a modern type of IAASs which demonstrates a growing trend nowadays. It is a food production system that combines conventional aquaculture with hydroponics (cultivating plants in water) in a symbiotic and controlled environment. Water from an aquaculture system is directed to a hydroponic system where the by-products are broken down by nitrogen-fixing bacteria into nitrates and nitrites, which are utilized by the plants as nutrients. The water is then re-circulated back to the aquaculture system.

Small-scale reverse osmosis (RO) 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. For this reason, since 2013, ICBA is operating an 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 IAAS was established on over 2 ha of area at ICBA experimental station comprising of an RO unit with a capacity to generate 100 m^3/day of fresh water and 150 m^3/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 demonstrated remarkable adaptability to the local conditions, implying that the species is a good candidate for the IAAS. 1500 fish were raised in the three tanks (500 fish/tank). Within four month period, fish weight increased by 160% and fish length by

Salicornia growing on brine water; in the back appears the fish tanks (with green shades) and the water reservoirs for desalinated and brine water at ICBA research station

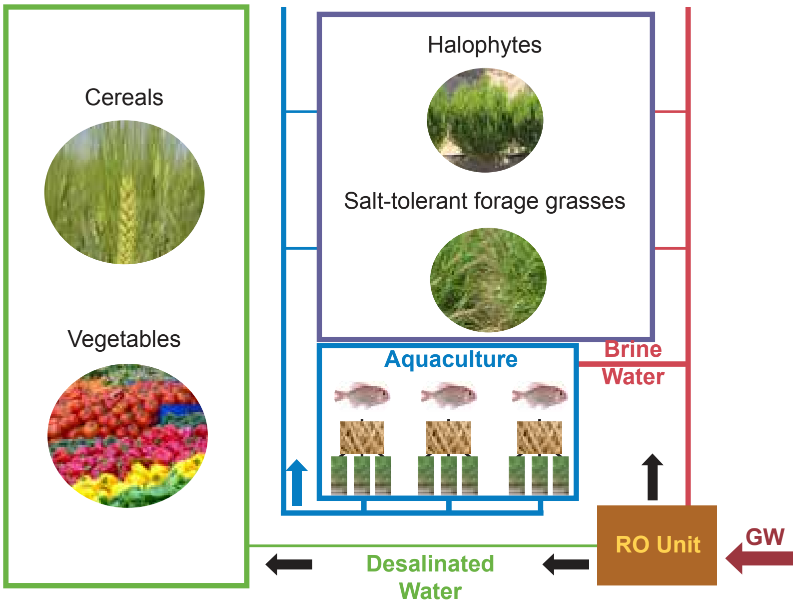

Diagram of the integrated aqua-agriculture system that is being implemented at ICBA research station in Dubai

50%. The desalinated water produced from the RO unit was used to irrigate several high value crops such as asparagus, maize, quinoa, eggplant and okra, where as the brine water from the RO unit, either solely or mixed with groundwater and the aquaculture effluents was used to grow different salt-tolerant perennial forages such as *Sporobolus arabicus*, *Distichlis spicata*, *Sporobolus virginicus*, *Paspalum vaginatum*. Selected *Salicornia bigelovii* populations were also evaluated under two water regimes (RO- and aquaculture-brine) and irrigation systems (bubblers, sprinklers). The bubble system was more efficient to enhance the performance of *S. bigelovii* plants compared to the sprinkler system. However, in both cases the brine water did not significantly impact growth.

Results from the first year show that such integrated systems can create a wealth of ecological and economic advantages in marginal environments ranging from sustaining environmental quality through productive use of brine and dissolved and particulate nutrients discharge, to generating value-added products such as such as fish, seaweeds, forages and vegetables. In this way, the sustainability of the existing RO infrastructures in the GCC region is enhanced. Cost benefit analysis will be carried to examine the economical feasibility of such a land-based IAAS in a marginal environment.

Further literature

Aquaculture in Desert and Arid Lands: Development Constraints and Opportunities: FAO Technical Workshop, 6-9 July 2010, Hermosillo, Mexico. Food and Agriculture Organization of the United Nations.

Bailis, R. & Yu, E. (2012). Environmental and social implications of integrated seawater agriculture systems producing Salicornia bigelovii for biofuel. *Biofuels*, 3, 555-574.

Neori, A., Chopin, T., Troell, M., Buschmann, A. H., Kraemer, G. P., Halling, C., Shpigel, M. & Yarish, C. (2004). Integrated aquaculture: rationale, evolution and state of the art emphasizing seaweed biofiltration in modern mariculture. *Aquaculture*, 231 (1), 361-391.

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

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Science, Policy and Politics of Modern Agricultural System Global Context to Local Dynamics of Sustainable Agriculture

New Publication

The release of the book **Science, Policy and Politics of Modern Agricultural System – Global Context to Local Dynamics of Sustainable Agriculture** co-edited by Mohamed Behnassi (NRCS, Morocco), Shabbir A Shahid (ICBA, Dubai) and Nazia Mintz-Habib (University of Cambridge UK) is an outcome of international conference (ICCAFFE2011) held in Agadir (Morocco) 19-21 May 2011. The conference was jointly organized by the North-South Center for Social Sciences (NRCS) in collaboration with GIZ Germany and IRD France. Scientists from a wide range of specializations participated in the conference. The book presents 23 chapters distributed into four themes: sustainable agricultural development facing environmental, economic and social challenges; the impact of soil degradation in terms of agricultural productivity; livestock production enhancements: recommended techniques and agro-biodiversity, climate change and livelihood: managing interdependence. The book is an excellent source of scientific information to be used by a myriad of stakeholders, such as researchers and experts, professors and students, land use planners, decision makers, NGO actors, and politicians.

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