Azolla: the new paradigm of Ecuador 2012

Mariano Montaño Armijos, Ph. D.
ecosistemaguayas@gmail.com
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Steps of the research advance

My research in *Azolla* commenced in 1980, when I joined the Institute of Chemical and Environmental Sciences (ICQA) at Escuela Superior Politécnica del Litoral (ESPOL), which unceasingly has endeavored to advance knowledge of natural resources in order to help increase the production of goods and services.

By 1986, the Shrimp Aquaculture Working Group, at ESPOL, had already initiated intense research into protein supplements, inexpensive and vernacular. Thus, the first Ecuadoran Antarctic Expedition (1987-88) stimulated my ambitions to study cyanobacteria. With this goal and through my involvement in the URI/AID Coastal Resources Management Project, I spent time at the University of Rhode Island (URI), Gante (Belgium), Southwestern Louisiana and Lousiana State University (USA), Campeche (Mexico), Jaume I (Spain), the Instituto de Acuicultura de Torre La Sal (Spain), Health Center of Providence (USA) and Fisheries Research Station (Belgium).

In 2000, the Programa de Modernización de los Servicios Agropecuarios (PROMSA), approved the project "Application of Diazotrophic Symbiosis between *Azolla* and *Anabaena* as a Green Fertilizer in the Cultivation of Rice in Coastal Ecuador". In this way we were able to domesticate *Azolla*, apply it to the ricefields, and demonstrate its competitive advantages over commercial urea chemical fertilizers. Upon this base, in 2008 the National Secretariat for Higher Education, Science and Technology (SENESCYT) sponsored the project "Development of *Azolla Anabaena* and it's applications in the agriculture, livestock and aquaculture sectors". Finally, en 2009 the World Bank sponsored the project "Converting Rice Fields into Green Fertilizer Factories", finding that the *Azolla-Anabaena* represents a new paradigm for agriculture, the environment, the economy and for health. In this advanced phase, I have relied upon the support of the Autonomous University of Madrid (Spain), the University of Lisbon (Portugal) and the University Miguel Hernández (Spain).

Principal achievements

Azolla (Figure 1) is a tiny floating fern with small alternating leaves and simple roots that hang beneath the water; the cavities of its leaves shelter microscopic nitrogen-fixing *Anabaena* cyanobacteria (Figure 2). The *Azolla-Anabaena* symbiotic relationship represents a proven green bio fertilizer for rice (Figure 3) and many other Ecuadorian crops, such as bananas (Figure 4).

For centuries the *Azolla* fern has been traditionally used as a green fertilizer for rice in the lowlands of Vietnam and China, playing an important role in the economy of these countries. In the last seventy years, world commercial agriculture has depended on artificial chemical fertilizers, a technologically costly approach which is not sustainable and strongly impacts the environment and public health.

The project sponsored by the World Bank has permitted the cultivation of rice with the exclusive use of *Azolla* as a fertilizer. The trials produced an average production of 4.06 t/ha, an impressive result considering that the national average is 3.14 tons/hectare. Additionally, *Azolla* improves water quality, soil quality and the health of workers.

As a result of project fieldwork, seminars, press, radio, television and internet, many citizens now recognize *Azolla* as a natural, sustainable and economic alternative fertilizer.

Figure 1. *Azolla*: New paradigm

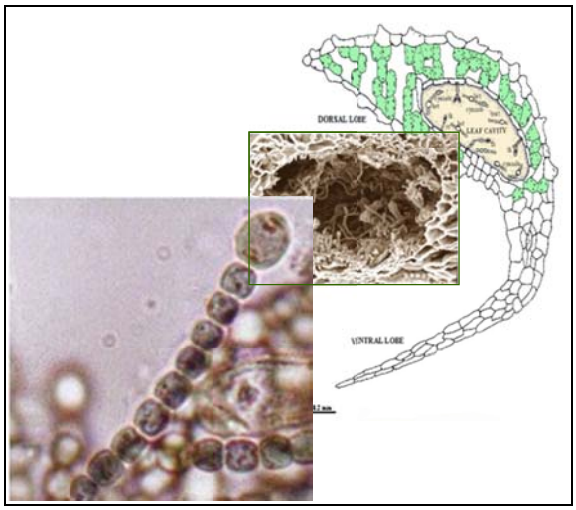

Figure 2. *Anabaena*. Scheme

Figure 3. *Azolla* fertilizing rice

Figure 3. Banana.
Differentiated growth with *Azolla*

Looking towards the future

It now remains to extend *Azolla* to more sites, so that eventually it is used in all national rice cultivation, which covers some 400,000 hectares and involves over 140,000 families.

The *Azolla* story is now unfolding on many different levels in many places. The development and spread of *Azolla* in the Guayas Ecosystem (Figure 5) introduces a new paradigm of "Tropical Knowledge".

The incorporation of *Azolla* into rice cultivation in the Guayas Ecosystem will play a strategic role in our nation as, aside from producing greater quantities of higher quality rice, will also provide (1) fertilizer for agriculture, (2) food for livestock, (3) water treatment for the Daule, Babahoyo and Guayas Rivers, (4) aquaculture industry improvement in the Guayas Estuary, (5) fisheries stimulation in the Gulf of Guayaquil, (6) soil enrichment, (7) biota recovery and (8) carbon credits.

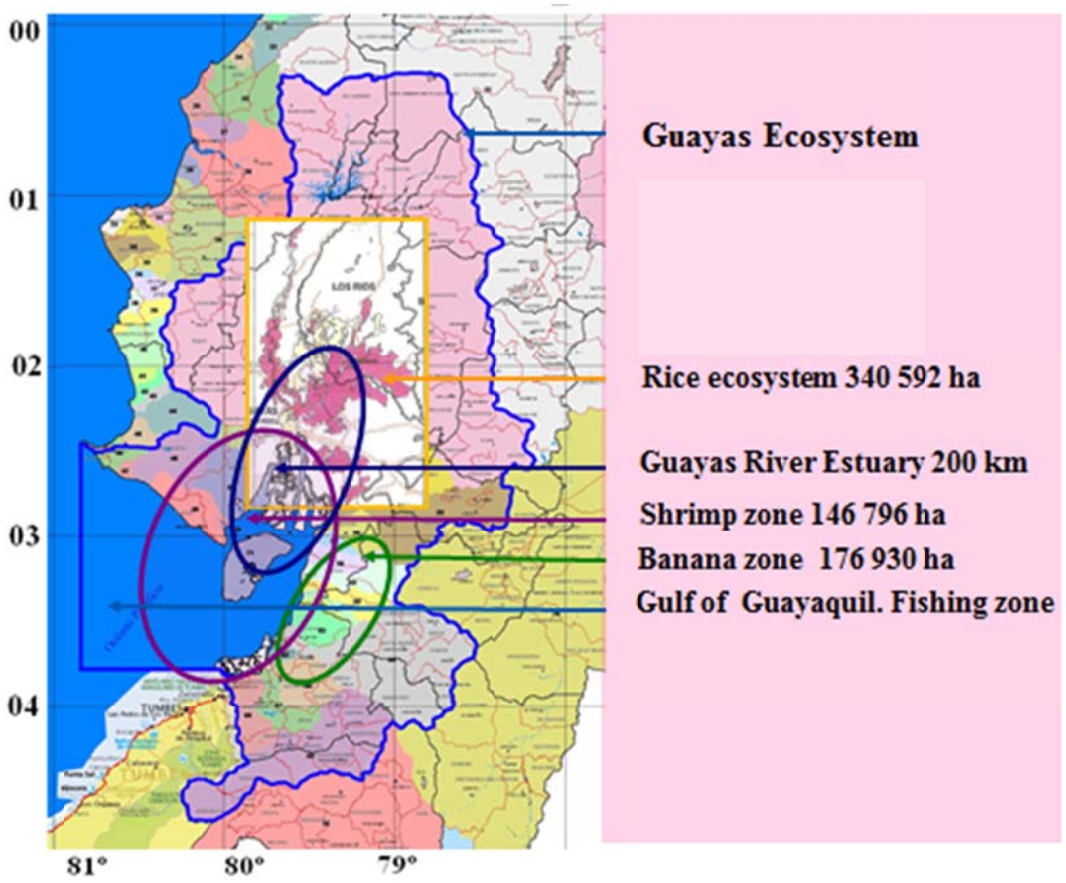

Figure 5. *Azolla*: A powerful lever for transforming rice cultivation in Ecuador

The annual economic value of the goods and services mentioned, in millions of US dollars, is:

Product/Service	US$ Millions	Commentary
Fertilizer for agriculture	313	The ecosystem of rice farms along the coast has the capacity to produce fertilizer for all of Ecuadorian agriculture.
Food for livestock	200	The high protein content of *Azolla* makes it ideal as animal feed.
Water treatment	120	The use of *Azolla* in rice cultivation will serve as an immense and extraordinary natural water filter for the Daule, Babahoyo and Guayas Rivers.
Aquaculture improvement	150	The purified water will play a substantial role in increasing the value of shrimp mariculture.
Fisheries stimulation	60	Fish stocks and catch will increase in the Gulf of Guayaquil due to improving water quality.
Soil enrichment	20	Soil texture, porosity and organic material content will increase, thus raising its economic value.
Biota recovery	100	Decreasing use of agrochemicals will improve natural ecosystems, water quality and flourishing of natural biota.
Carbon credits	88	The application of *Azolla* in rice cultivation can be incorporated into carbon credit markets decreasing contributions to global warming.

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