

Regional and national factors relevant to site selection for aquaculture in the Federative Republic of Brazil

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Abstract

Aquaculture and Fisheries Production in the Federative Republic of Brazil has been steadily growing in the past decade. Recent official figures report 1 240 813 tonnes for 2009. Aquaculture growth in the 2003–2009 period has been 49.4 percent, from 278 000 tonnes in 2003 to 415 000 tonnes in 2009. Recently, aquaculture growth (from 2007–2009) has been even more expressive at 60.2 percent. The main cultured species is tilapia, which accounted for 132 000 tonnes in 2009, about 39 percent of all cultured fish in the country. Marine shrimp production has been stable at 60–70 000 tonnes/year. Aquaculture feeds produced in 2009 is at 300 000 tonnes for fish and 80 000 tonnes for marine shrimp. These numbers reflect the optimism felt by entrepreneurs in the aquaculture/agribusiness sector. This scenario is in good part due to steady, although slow necessary improvements in the environmental and aquaculture production policy and legislation.

Regional and national factors relevant to site selection for aquaculture

Ecology – Limnology

The Federative Republic of Brazil is a country of rivers, not lakes. However, the use of over 5 million hectares of water surface in reservoirs of hydroelectric power plants available for cage culture production of fish presents a significant potential. These waters are mostly found in the reservoirs of hydroelectric powerplants. This potential is seen by the government as having good potential for fish production, and demonstrates interest in facilitating participation of the less privileged social classes residing in the countryside along the perimeter of these reservoirs. The use of close to these waterbodies poses some challenges. Another type of large reservoir built in the past was that primarily aimed at the alleviation of droughts. These are typical of Northeastern Brazil, have been and are used for fish farming and fish stocking but nowadays are mostly considered eutrophic and/or contaminated. Their primary function has from the onset been the alleviation of human suffering, by providing water for humans and livestock. Beginning in the 1970s these reservoirs were populated with fish as an alternative to provide local populations with a protein source. Aquaculture intensification efforts in these areas is a constant. Hydroelectric power water reservoirs

and their public waters as an alternative support for aquaculture have been only recently (2000s) been in higher demand. Because of the nature of their construction and end use, hydroelectric power plant reservoirs have a particular limnology which is quite different than that of natural standing waterbodies. The water renovation characteristic, for example is different from that of a natural lake. The flushing rate of these reservoirs is regulated by human control, mostly in function of meteorological forecasts. Most of the water that flows out of the reservoir comes from the lower strata of the waterbody rather than from the surface. In large reservoirs such as Itaipu, some areas of the waterbody experience oblique vortexes from the water surface to the turbine intakes which have create very different vertical water quality parameter distribution than those found in 'normally' stratified waters in. Natural cycles may not be comparable to the 'great' lakes found in temperate climates common in the northern-hemisphere. Given the growth trend of the Federative Republic of Brazil predicted for the future years and its extensive hydrographic basins and energy potential it is natural that more dams will be built. Local human settlements and populations from the future flooded areas of these watersheds will be relocated to the perimeter of the new reservoirs. These settlers are the new stakeholders in this water resource.

Democracy and legislation

It has been only 25 years since the 1985 'restoration' of democracy. The country was under military rule for a 30 year period (1964 – 1985). This return to democracy has been marked by several changes in governance at many levels. Established institutions ruling and responsible for sectors such as fisheries have dramatically changed with some progress in terms of their attributions, but with significant dispersion of human resources. Trained scientists acting in the fisheries sector were displaced to other sectors. Focus also changed from a more industrially inclined one where issues such as pollution and environmental degradation were not considered as important in the 1980's. With the environmental awareness brought about by the Earth Summit – United Nations Conference on Environment and Development (UNCED) 1992, held in Rio de Janeiro, awareness in all sectors dealing with the environment began shifting to conform. It can be said that as a consequence the aquaculture and fisheries activities became a special Secretariat and an independent one in 2003, completely detached from the Ministry of Agriculture. In 2009, the Special Secretariat (SEAP) became a fully-fledged Ministry – the Ministério da Pesca e Aquicultura (MPA). This consolidation of public policies has led to more confidence and investment in the sector.

Currently there are 6 hydroelectric power plant reservoirs already regulated with carrying capacity studies concluded. 14 other reservoirs are undergoing carrying capacity studies for the establishment of Aquatic Parks (areas reserved by the state for the development of aquaculture, which may contain several Aquatic Areas) and Aquatic Areas – areas within the Aquatic Parks leased to individuals or groups for aquaculture development. Areas in an Aquatic Park and in between Aquatic Areas may be used for 'compatible' activities such as Fishing.

Still, 25 reservoirs are undergoing the demarcation process covering a total of 1.6 million ha of water surface and 2 600 ha of Aquatic Areas for production.

The legal process currently established by the MPA has become a clear one for prospective aquaculture entrepreneurs with a roadmap to follow detailing the proper documentation to submit, simplifying what used to be a relatively confused process involving multiple permits with different federal agencies including the Navy. Today, thousands of groups and individuals actively practice aquaculture still without a legal permit, however reasonably sure they will obtain a full permit in the near future.

A brief summary of the more recent pertinent legislation:

- 1997 – *Resolução Conama 237* – Establishes the legal base for environmental licensing of aquaculture.

- 2003 – *Decreto 4895* – establishes conditions for Aquaculture development which must observe several criteria including sustainable development, increase in fisheries production, social inclusion and food security.
- 2004 – *Instrução Normativa 6* – lays down most basis for aquaculture projects to be managed by Aquaculture and Fisheries Secretariat as main responsible party.
- 2005 – *Instrução Normativa Interministerial #7* – establishes a max of 1 percent occupancy of public waters for aquaculture use, and guidelines for cage culture in respect to depths.
- 2005 – *Resolução CONAMA 357* – establishes max limit of 30 µg/l for TP and Cla for Aqüicultura in lentic waters.
- 2007 – *Portaria 237* – Allows for the leasing of public Waters to the Aquaculture and Fisheries Secretariat, who can then sub-lease to prospective aquaculturists.
- 2009 – *Resolução Conama 413* – Is the most complete update on the regulations for aquaculture. It basically establishes environmental licensing conditions for aquaculture for: Fish, freshwater shrimp/ prawns, molluscs, seaweed, frog. It levels rules for the concession of licenses. Minimizes pollution effects of large-scale aquaculture. It applies to any level of environmental aquaculture licensing with no losses to licensing request procedure rules already established at more regional scales such as state or municipal levels which may consider specifics of local environments. It defines the sizes of Aquaculture operations and Potential Severity of species.

Identifying issues locally specific to species, cultures, and geographies

Species

Many tropical countries such as the Federative Republic of Brazil, have a large variety of potential aquaculture species within its fish biodiversity. Domestication of species however, aquatic or not, takes decades, if not centuries. The common carp was the first species of fish to be introduced for culture purposes in the country. Its success in part is due to the familiarity of European immigrants and their descendants such as Germans and Italians. For similar reasons rainbow trout culture also became quite popular in southern states, but mostly constrained to sites at least 700 m in altitude. Although tilapia is the main species produced in the country, progress is being made with native species such as *tambaqui* (*Colossoma*), and *pacu* (*Piaractus mesopotamicus*). Tambaqui production is steadily on the increase and now at about 46 000 tonnes/year. All of marine shrimp production is based in the exotic *Litopenaeus vannamei* which has been stable at around 70 000 tonnes/year, most of it destined for export. Other cultured species include some South American striped and spotted catfishes, mostly destined for the internal market, *pacu* (*Piaractus mesopotamicus*) and to a very limited extent channel catfish (*Ictalurus punctatus*), in southern, lower latitude cooler climates such as found in the state of Paraná.

In regards to marine species the most prominent is the brown mussel (*Perna perna*) and the Pacific oyster (*Crassostea gigas*). To a lesser extent, the native scallop (*Nodipecten nodosus*) and marine algae *Gracillaria spp* and the exotic *Kappaphycus alvarezii* are cultured more or less intensively. Still on an experimental basis are a few initiatives with cobia – *Rachycentron canadum*. Other species currently being researched include snook (*Centropomus spp*), octopus, and sea bass, but still at experimental level.

Although aquaculture represents only 5 percent of animal production in the Federative Republic of Brazil, its annual growth rate is higher than that of poultry (10 percent), cattle (4 percent), pork (7.9 percent), soybeans (8.6 percent), corn (7.6 percent), wheat (13.4 percent) and rice (3.4 percent). The Federative Republic of Brazil is the 4th country with highest annual aquaculture growth rate at about 23.3 percent a year.

It was only in the mid 1980s that the awareness of the country's fish diversity had some potential to contribute to fish farming, and experimentation with some native species began. Despite great progress in establishing conditions of reproduction and grow-out practices for native species like *tambaqui* and *pacu*, the impact of hybrid tilapia culture introduced since the 1970s in Northeastern Brazil had already made its mark on the national scenario. Today most, if not all states of the Federative Republic of Brazil have tilapia farming across the many hydrographic basins of the country. Brazilian funding for aquaculture research has increased significantly by interministerial agreements and the Brazilian National Research Council (CNPq). However, it is quite difficult for it to compete with international funding for farmed tilapia improvement. The most recent genetically improved varieties developed at leading aquaculture centres throughout the world soon become available in one way or another in the major aquatic farms across the country. Tilapia culture accounts for over 90 percent of cage culture in enterprises established in the hydroelectric power reservoirs. Since tilapia has become a commodity worldwide, and represents a good export product, its production chain has been officially adopted by the Brazilian government during the last decade. The same can be said for *L. vannamei* white shrimp, a hardy species cultured in several Latin-American countries which has become standard in the Federative Republic of Brazil.

Culture

Apart from early Portuguese colonists and African slaves, colonization in the Federative Republic of Brazil really only picked up at the end of the 1800s. From 1872 (year of the first census taken) to 2000, six million immigrants arrived in the Federative Republic of Brazil, most of which were heading towards Southern Brazil and the coffee plantations where slave labor was being substituted for salaried labour. Most immigrants were of Italian, German, Portuguese, Spanish and Japanese origins.

A marked difference between the newly arrived immigrants and the former indigenous peoples, the early Portuguese colonists and their Brazilian descendants – was the attitude towards food procurement. Whereas the latter were content to behave in a mostly 'extractive' fashion i.e. hunting, gathering, ranching and living on a diet of mostly wild caught animals or ranch cattle meat, the new immigrants were more eclectic in their dietary habits which traditionally consisted of farmed products and also lived in crowded quarters. The new immigrants were primarily interested in working in an agricultural environment, producing their own food and surplus for sale. They were well aware of the importance of food surplus post-harvesting processes. The fewer than 3 million native inhabitants of the Federative Republic of Brazil spread over 8.5 million km² before its discovery had little trouble in finding fresh food, and were in many cases, semi-nomadic or nomadic by culture. This may explain in part the reason why, despite lower temperatures and shorter growing season, Southern Brazil has made many significant strides in aquaculture (and agriculture) where as in tropical areas of the country such as North Brazil including most of the Amazon, the activity is still underdeveloped. One short-lived exception to this is what was probably one of the first aquaculture attempts in the New World undertaken by Mauricio de Nassau, during the Dutch control of Recife, North-eastern Brazil (1637–1644). His residence/fortress was designed with large fish ponds.

Geography

The country's coastline spans over 8000 km from 3°N just above the equator, bordering the French Republic (French Guyana) to about 34°S, the frontier with Uruguay. In the East-West axis, longitudes span from 34°W to 74°W, from the Atlantic Ocean to almost the Pacific Ocean, bordering neighbouring South American countries including

Paraguay, Bolivia, Peru, Colombia, Venezuela, Guyana, and Surinam. The continental dimensions of the country present a challenge of distances over several latitudes, climates, soil types in which old world farm stock species have not found similar environments such as occurred for example in North America during its colonial period.

Use of models and decision support tools

Freshwater carrying capacity

Several environmental analysis modelling tools for determining fresh water fish farming carrying capacity are being used in the Federative Republic of Brazil. These include Stella, DELFT3D and MIKE21. For freshwater the most commonly used method is the Dillon-Rigler modified by Beveridge (1984). These studies have been applied to estimate the carrying capacity of cage culture in hydroelectric power reservoirs shown (Figure 1). So far, this method has been found to be acceptable by the Ministry of Fisheries and Aquaculture experts. Due to the particular nature of the waterbodies assessed – mostly hydroelectric power plant reservoirs, and the behaviour of Nitrogen and Phosphorus in these, specialists involved in these studies, such as Drs. Ricardo Pinto-Coelho, Fernando Starling and William Severi, have expressed interest in using a method which would be based on Nitrogen rather than Phosphorus. Starling used the Dillon-Rigler method and compared the results to those from a Stella model developed for the same conditions. Table 1 summarizes the 6 major reservoirs which have so far had carrying capacity studies done and have aquaculture areas set aside for development.

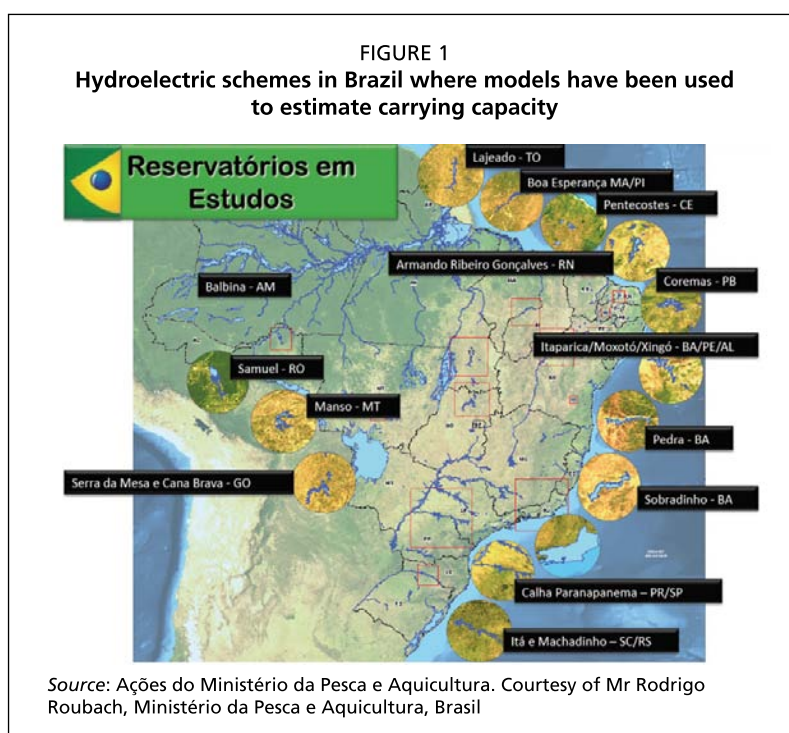


TABLE 1

Aquaculture Areas used in the Aquatic Production Parks in the Federative Republic of Brazil

Concluded demarcation	Reservoir area (ha)	Aquatic Park area (ha)	Aquatic Areas (ha)	Aquatic Areas (%)
Furnas	147 000	2 848	297	0.2
Três Marias	104 000	3 042	144	0.14
Ilha Solteira	123 000	1 352	260	0.21
Castanhão	32 500	7 396	131	0.4
Itaipu	135 000	11 570	31	0.02
Tucuruí	263 500	2 295	115	0.04
Total	805 300	28 503	978	0.12

Carrying Capacity in the marine/coastal environment

Marine aquaculture in the Federative Republic of Brazil is still concentrated in Southern Brazil, and mostly around mussel and oyster production. GIS support and carrying capacity models for coastal areas are still being developed together with the activity itself. The expansion of the shellfish farming sector has been rising steadily, and stakeholders of several different interests in the concerned areas have participated in preparatory discussions and planning meetings promoted by the MPA for the Local Plans for Mariculture Development (PLDMs), such as the one developed for Santa Catarina state in Baía Sul de Santa Catarina, by Florianópolis (W 48°36', S 27°44'). So far, only this coastal state – the largest producer of farmed shellfish in the country – has presented its PLDM to the MPA. The plan was developed by EPAGRI – the state Agriculture extension agency – and based on a GIS model developed by Luis Fernando Vianna which incorporates an Analytical Hierarchy Process for the decision-making which was supported by many stakeholders during several meetings. The participatory approach resulted in the identification of over 130 'descriptors' of influences to the aquaculture activity by stakeholders, and a relative rating of their importance as perceived. However, a proper carrying capacity support model resulting in a shellfish biomass potential tonnage to be cultured was not carried out. The results suggested the best/most proper/acceptable areas for the ministry to 'set aside' for delimitation of the Aquaculture Parks and Aquaculture Areas. The results of this work which began in 2004 were concluded in 2009, with approval of all the aquaculture communities and stakeholders involved in the study. It incorporated the historical oceanographic data available.

Currently two other PLDM's are being carried for coastal aquaculture in the Federative Republic of Brazil. One is being done by NeoCorp Ltda., for Rio de Janeiro state (W 44°30', S 23°10'), and employing MIKE21 software (www.mikebydhi.com/). Another PLDM is being carried out for the state of Bahia (W 38°34', S 12°50') by BahiaPesca the state's fisheries extension service, which is currently employing the DELFT3D (www.deltares.nl/en/) modelling software to understand the hydrodynamics of the Todos os Santos Bay before actually proposing indicated areas for aquaculture development. Bahia has the longest coastline among Brazilian states with over 1 100 km. Both of these studies are guided by the MPA's policy to fully respect environmental aspects, contemplate the sustainability of the activity and suggest harmonious integration of aquaculture with local fisher communities while taking into account conservation of local ecosystems which include abundant mangroves present in Bahia and the traditional coastal fisheries of Rio de Janeiro. However, from the initial information available, an aquaculture potential biomass capacity does not appear to be in formulation.

Main gaps and improvement needs according to the EAA

Difficulties initially faced by aquaculturists in the Federative Republic of Brazil included the lack of specific environmental legislation, existence of costly license fees and public prices above payment ability of small producers. Also, difficulties in being able to handle the complexity of information necessary to the licensing process, a lengthy analysis process, and general impediment of access to 'aqua' credit, as opposed to proponents for agricultural land-based rural activities. Consequently, there was little if any stimulus for investment or entrepreneurship in aquaculture, much less good production practices.

These obstacles have been gradually overcome in updates in legislation especially with the *CONAMA 413* resolution which has better defined parameters, criteria and procedures on a country-wide basis applicable at all levels. Currently there is the possibility of small enterprises to be relieved of licensing, allowing important stakeholders such as fishers and riverside communities to participate in aquaculture production. The possibility of relieving licensing for small enterprises or licensing

the activity by block of enterprises, also allows fishermen and other cooperatives and associations to start up aquaculture. As a result the licensing process tends to be swift and a real incentive for sustainable aquaculture practices and better controlled.

Current and future issues and bottlenecks

The studies so far undertaken to determine aquaculture carrying capacity in the Federative Republic of Brazil have been done mostly for artificial freshwater reservoirs whose primary function is water for hydroelectric power generation. It is then a complex issue to evaluate the 'environmental services' of these relatively recent artificial ecosystems in the context of EEA.

New reservoirs such as the Belo Monte project in the Amazon damming the Xingu river which would be the world's third-largest hydroelectric project poses many questions. There are few studies of similar cases in other tropical countries. These new reservoirs will cover extensive areas and will involve the disruption of several migratory species of freshwater fish including *Colossoma*. This species migrates extensively and has an important role in primary production distribution in the Amazon basin which is still not well understood. It is known that *Colossoma* for in the flooded areas of forests sometimes very distant from areas where it eventually spawns. *Colossoma* die in large numbers in marginal lakes by main rivers in the Amazon thus contributing to the enrichment of these habitats, many kilometres away and downstream from where they feed. In what ways can the EEA take this into consideration? Knowing what the ecosystem's carrying capacity is, and how to share it with human activities and presence within defined acceptance levels still to be defined constitutes a complex problem.

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