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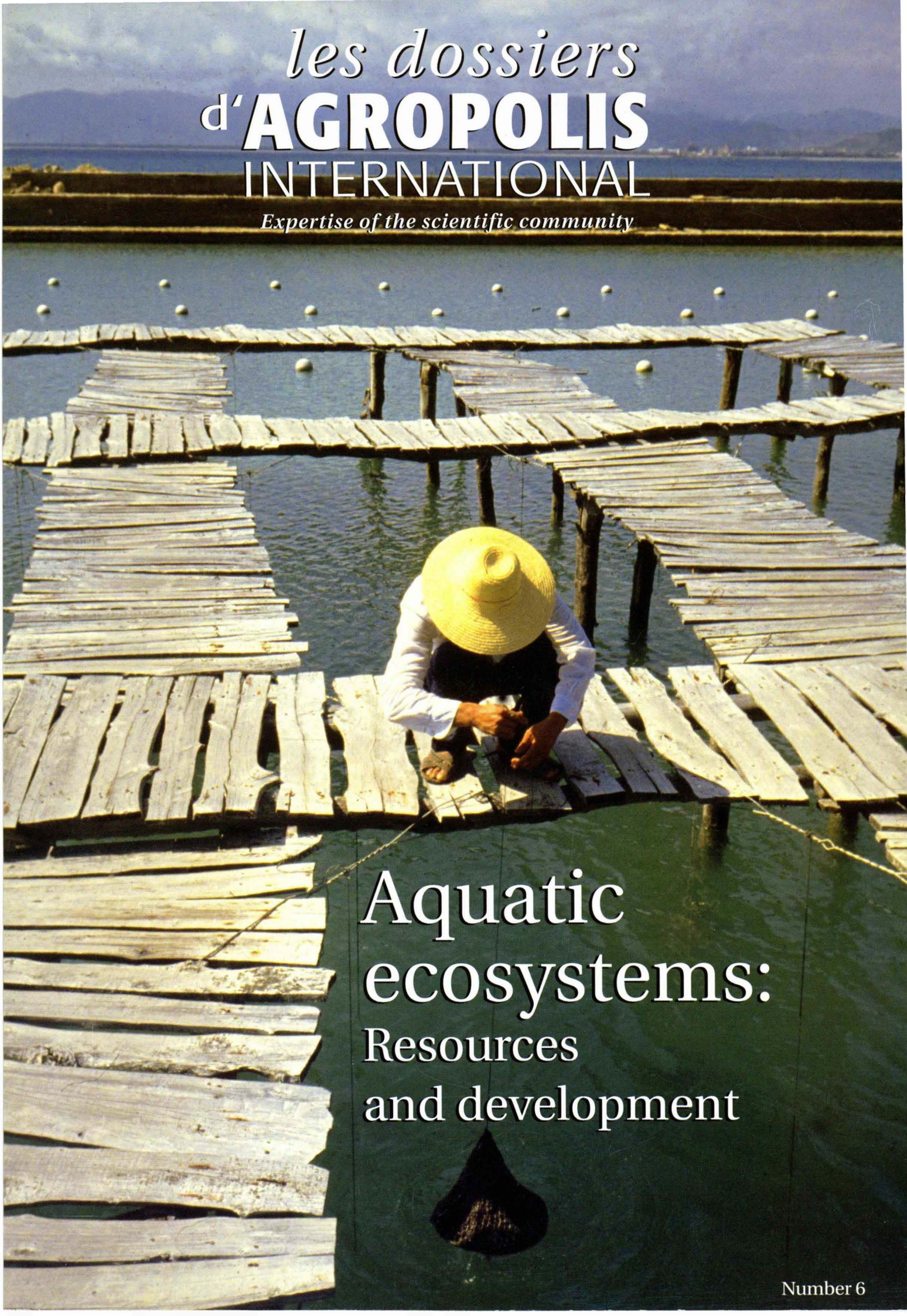

Aquatic ecosystems:
Resources and development

Number 6

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Fish culture in floatting cages in the lake of the Cirata dam (West Java, Indonesia).

Aquaculture: *issues and changes*

World aquaculture production was 4 million t in 1970. This production has increased substantially since 1980, and in 2003 it reached the 50 million t landmark (plants included). This is one of the greatest growth rates of all food production, and now exceeds that of poultry and pig production. The contribution of aquaculture to the human diet has increased from 1 kg/inhabitant/year in the 1970s to more than 6 kg in 2005. This change is a marked contrast with that of fisheries catches: stagnation of landings and even regression have been recorded at between 90 and 95 million t for about 10 years. Concerning fish farming production, 50% comes from sea waters (mainly molluscs and aquatic plants), 45% from fresh waters (mainly fish), and 5% from brackish waters (mainly shrimps). Many species are produced: more than 220 animal and plant species were recorded in 2002, including 25 that accounted for 90% of the production.

The aquaculture 'boom' over the past 20 years is mainly the result of increased production in developing and emerging countries (90%), with a major share from Asia (93%), particularly China (71%). The contribution of developed countries has dropped from 42% in 1973 to 9.2% in 2003. Moreover, productions that were already well established in the 1970s accounted for most of this boom: fresh water fish, mainly in ponds, and molluscs along coastal areas. Japanese oysters and silver carp were the two most farmed species in the world in 2004. More recent production volumes of sea fish and shellfish in brackish waters are still lower, even though their contribution in value is higher; sea fish, salmonids and shellfish represented 14% of the total volume production, but 40% in terms of value in 2003.

Fresh water aquaculture (45% of total aquaculture production) has a number of specific characteristics. It can be closely integrated in agricultural production systems (agriculture and animal breeding) *via* shared water use, recycling of lifestock wastewaters into fertilizers for aquaculture ponds, or the use of raw agricultural by-products as fish feed. This mainly involves species with a short food chain (carp, tilapia, etc.). It is mostly implemented through extensive and semi-intensive production systems within which mixed farming, fertilization and complementary feeding are basic elements. However, over the last 20 years, intensive farming of fresh water species has developed on a very large scale in floating cages, mainly in Southeast Asia, in a global farm production intensification setting.

Sea water aquaculture is based especially on carnivorous fish with a long food chain. It is conducted in floating cages in intensive or semi-intensive production systems. The species can be divided into two groups according to the extent of control of their farming cycle: species reared under a fully controlled farming system (bass, sea bream, salmonids) and those in which fry fished in the natural environment (yellowtail, tuna) are fattened;

Aquaculture is now substantially progressing (estimated at 4-5% per year until 2020), thus giving rise to the following challenges.

■ **Environment quality** plays a major role in aquaculture, especially shellfish aquaculture, a farming system which is one of the most sustainable added values with respect to ecological productivity in coastal areas. It seems essential to relaunch ecotoxicological and ecopathological research in order to gain insight into and control phenomena such as toxin production by algal blooms and bioconcentration of pollutants.

■ **Research on feeding** in intensive aquaculture systems will have to focus on reducing the impact of effluents through enhanced feed efficiency and use, while anticipating the unavoidable reduction in fish oil and fish meal resources and preserving the quality of the products. Concerning this latter point, alternative solutions will involve the diversification of protein supplies (particularly by adding products from plant sources) and agroindustrial waste bioconversion processes.

■ **Pest control,** which is an important aspect of aquaculture, particularly intensive aquaculture, will have to favour approaches involving natural resistance (enhanced by genetic selection), induction of nonspecific defence mechanisms combined with ecopathological approaches.

■ **Promotion of sustainable production systems,** beyond their economic viability and environmental impact management, the expectations and needs of citizen-consumers, including fair trade activities will have to be taken into account.

■ **Fresh water aquaculture of low-value species** (USD1/kg) will remain a major aquaculture component, particularly in developing and emerging countries. Rational intensification of these systems is a major complex issue as it requires a combination of traditional know-how and scientific approaches (nutrition, ecology, limnology, genetics, sociology, etc.).

■ **The domestication of new native species** of aquacultural interest is a major future challenge for aquaculture. By ensuring that the biological cycle of the farmed species takes place entirely in captivity, this will enable fish farmers to manage their stocks without having to obtain juveniles from the natural environment and to initiate genetic improvement programs. Moreover, this is the best defence against the introduction of exotic species and enables production diversification, which is a constant aim of fish farmers, particularly in developing countries where fish represents an essential source of protein. This approach must be accompanied by careful management of genetic resources within the farmed populations or in terms of the impact on natural populations.

■ **Finally, genetic improvement** will be a key to the development of aquaculture as in all land farming chains. Present aquaculture species have a substantial and promising selection and adaptation potential (to environments and/or specific farming situations) since they are not or only slightly domesticated. Many traits are the focus of genetic improvement (adaptation capacities, growth, yields, flesh quality, resistance to some pathogens, sterility, etc.) and the breeding methods are diversified (selection, polyploidisation, monosexing, etc.). Genetic progress will have major implications for the future of subsectors since it has a direct impact on the economy, product quality, environmental friendliness (sterilization promotes biodiversity preservation by limiting contamination of wild populations) and animal ethics *via* enhanced animal welfare.

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