RESPONSIBLE USE OF NATURAL RESOURCES IN DEVELOPMENT OF FISH PRODUCTION SYSTEMS WITH SPECIAL REGARD TO INTEGRATION

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1. Background and main objectives of the study

The water and the aquatic organisms - as renewable natural resources - always played an important role in the development of all civilisations. However, nowadays we can not state surely that these natural resources can always renew and at with full extent. The development of aquaculture was a direct consequence of the depletion of fish and the stocks and that of other aquatic organisms. The recognised necessity of the responsible use of natural resources sets new criteria for aquaculture development. Sustainability became a key issue, with special regard to the considerate use of aquatic resources and to the protection of the environment. At the same time, aquaculture development requires a holistic approach, co-operation among the users of the resources, and also integration.

There are various forms of aquaculture, which - within given conditions determined by the biological and ecological needs of the cultivated species, and the geography and the climate - are differing mainly in the rate of human intervention, or the rate of intensity. All forms of aquaculture however, are based on the availability of adequate amount and quality of water, which is an essential media for the life of living aquatic organisms.

Since water is an important resource for other economic activities, there is a need for integrated resources management. This basically means that - based on co-operative efforts of all stakeholders in the use of a given water resource - those activities get priorities in the allocation of water resources, which have the highest social benefit, and impose the least threat on the environment. Aquaculture, at its present level of development, is one of those food production methods, which is “close to the nature”, therefore could play a significant role in integrated water resources management. It should be mentioned however, that this special role of aquaculture is not always recognised.

Aquaculture development could not be limited to technology development and to providing proper technical and biological conditions for the cultivation of a given species, but it has significant socio-economic aspects as well. Though aquaculture systems show a great diversity both in types and intensity level, and their relationship with the environment, some basic types can be recognised. Some of those aquaculture systems are discussed in this study, which have a common feature, namely the considerate use of water resources, as follows: fish-cum-duck production systems; combined extensive-intensive systems; industrial-like fish production systems; integrated tropical fish pond systems. The possibilities of integrated water resources management during fish culture development in Hungary are also discussed in the study.

Aquaculture and fisheries in Hungary have been integrated well into the complex use of natural resources, even if comparing with other countries with similar conditions. Some of the integrated aquaculture technologies have been developed and applied in Hungary, gained worldwide

reputation. The results and experiences could be applied well in the utilisation of those new possibilities, which will be available after joining to the European Union. It is hoped that this study will assist the Hungarian aquaculture in its efforts to be a small, but special and integral part of the European aquaculture.

2. Materials and methods

The studies have been carried out between 1975 and 1999 at the Fish Culture Research Institute and its collaborating farms in Hungary and also in the frame of a complex international project in Vietnam at the Cantho University and at the Research Institute for Aquaculture No.2. in Ho Chi Minh City. The study is dealing with those main elements of my past activities, which are closely related to the development of sustainable fish production systems, and in which holistic approach was applied when particular problems were analysed and discussed. Since 1975, my research and development activities have been focussed on the mechanisation of aquaculture. This work included the development of fish pond aerators, fish feeders and fish harvesting equipment, and also the development of complex mechanised fish pond systems (VÁRADI, 1976, 1980, 1983, 1986, and 1995). These works are not discussed in details in the present study, however some of the results of these works were later incorporated into projects aimed at the development of integrated fish production systems

During my research and development work, special attention has always been given to the development of such systems, in which the biological and technical components form a well functioning integral unit. The technical development work has never been considered as aim of my activities, but it was a tool for the development of complex aquaculture production systems. This concept proved to be useful, when the sustainable use of the natural resources became a key element of aquaculture development, and the holistic approach was an essential precondition during the implementation of development programs. During the development of those aquaculture systems discussed in this study, special attention was given to the environmental friendliness and to the considerate or responsible use of natural resources, besides the main criteria of sustainability (efficiency, profitability and social acceptability).

My research work basically is adaptive in nature, and instead of the description of technical details and the solution of partial problems, I put the emphasis on the development of complex systems and technologies, which were tested in farming conditions. This concept is reflected in this study, where I reduced the detailed technical calculations and the description of background research to the necessary minimum, except during the discussion of the combined extensive-intensive system, taking into account that this is a new and ongoing study in Hungary. Results of my related research works are presented in my referred literatures. The practical application of the results of my research and development work has always played important role in my activities, which is also reflected in the present study. Those efforts aiming at the introduction of scientific results into the practice are not always well acknowledged by scientists as research activity, and practical people also feel certain aversion towards the direct involvement of scientists in specific development projects at the farm site. However the involvement of researchers in the practical application of scientific results has an important role in the aquaculture sector, which includes many geographically dispersed relatively small farms, where the conditions for own technical development is limited. The study also reflects the above mentioned facts. There are differences in the method and details of the discussion of the specific research projects in this study, however it is felt that it is useful to summarise and present the results of the development projects, contributing this way to the development of environmentally friendly fish production technologies.

Due to the adaptive nature and complexity of my research and development work, a great deal of

the activities has been carried out in teamwork. Regarding the project aiming at the development of fish-cum-duck integrated system, I was one of the members of the team, however the specific analyses presented in this chapter are of my own works. I played active role in the initiation and implementation of the projects aiming at the development of combined extensive-intensive systems, recycling systems and integrated aquaculture systems in Vietnam, and I have also been the team leader of these projects.

When the projects are discussed and results are presented in the study I tried to be as clear as possible to make the study easily understandable for non-scientific readers as well. I used the same principles when I drew the figures of the study, even if the figures do not meet the strict technical standards and they are out of scale.

3. Results and major findings of the study

The results of the **fish-cum-duck culture experiments** in farming conditions demonstrated well the practical viability of the various systems. There was also a possibility to compare the applicability of the various systems in different conditions. The experiences with the operation of various fish-cum-duck production systems revealed that the increasing intensity level of duck production leads to problems when traditional methods are used
(e.g. oversupply of nutrients, conflicts between the duck and fish production cycles). These problems could be eliminated either by keeping intensity level of duck production below a certain level determined by prevalent conditions, or separate the fish and the duck components, but at the same time provide controllable flow of nutrient between them.

The economical analysis of the various systems showed that the construction cost of the intensive fish-cum-duck production system with separated production units is higher only with about 15% comparing to the traditional ones, and the increase in operational cost is also not higher than 3%. Although the income of the system with separated components was somewhat lower than that of in conventional systems, it was mainly due to the difficulties with the operation of the prototype system.

It can be concluded that the separation of the fish and duck rearing components, and the controlled supply and use of nutrient rich water in the fish ponds is a viable method to use the advantages of the integration without jeopardising the economic viability of the production. The extra construction and operational costs, which result in more control of the whole system, is proportional with the benefit derived from the increased efficiency in the use of organic materials in the fish ponds, and the decreased impact on the environment.

The study on the **combined extensive-intensive fish pond system** provided useful data and information, which can be used during the overall development of pond fish production in Hungary, but also contributed to the better understanding of function of fish pond ecosystems.

The system worked satisfactorily and ensured controlled material flow between the intensive and the extensive components. The excess N, P and organic load due to the intensive feeding in the intensive ponds were reduced efficiently in the extensive treatment pond. The whole system retained 84.6 % of the organic material, 61.3 % of the nitrogen and 58.6 % of the phosphorus input. The rather uniform data of the water quality parameters in the treatment pond indicated the appropriate distribution of the effluents in the extensive pond, which was also confirmed by hydraulic investigations. No accumulation of harmful substances was detected, which could have been dangerous to the cultured fish stocks. No any growth retarding effect was observed, and no fish disease occurred.

The net yield in the intensive ponds varied between 2.62 and 3.08 t/ha during the 1999 growing season, while it was 1.45 t/ha in the extensive pond. The overall yield of the whole system was 1.45 t/ha, which is much higher than that of in conventional systems in Hungary. Preliminary economical analysis showed that the production cost of the fish was not higher if comparing to traditional pond systems, however, the water requirement was 90 % lower than that of conventional flow through ponds with the same production level. The intensity level in three ponds of the system was increased considerably in 2000. During the production of market size fish of African catfish, common carp and tilapia, 57.7, 9.75, and 5.75 t/ha net yield has been reached, respectively. Based on preliminary data available on the 2000 year growing season, some major economical data are summarised in Table 1.

Table 1. Main economical indicators of the system
(Based on preliminary data from the year 2000 growing season)

	System	Intensive ponds	Extensive pond
Total income (USD/ha)	2,793	16,929	2,085
Production cost (USD/ha)	2,302	14,817	1,661
Net profit (USD/ha)	492	2,112	424
Total value of assets[1] (USD/ha)	3,563	12,336	3,115
Profitability on income (%)	18	12	20
Profitability on cost (%)	21	14	25
Profitability on asset value (%)	14	17	14

[1]The total value of assets includes the cost of reconstruction and modification of an existing fish pond system.
(1USD = 295 HUF)

The economical indicators in the table show the actual economical situation at the given stage of the development. These figures, however, could be improved significantly by increasing the yields in the intensive ponds, and optimising the efficiency of the water treatment.

The water requirement of the various **industrial-like fish production systems** can be discussed and evaluated in a uniform way by the use of a standard method, which takes into account the basic relations of the relevant biological processes in an industrial-like fish production system. The method can be used for determining the main technological parameters of a given system with special regard to the make up water requirement, and the necessary rate of water recycling. The formula for the calculation of make up water (**q**) and the recycled water ($\mathbf{q_R}$) is the following:

These equations can be applied for all type of systems, including the flow through systems and fully closed recycling systems, which represent the limits among the various industrial-like fish production systems, regarding water requirement.

Some technical details (e.g. dimensioning of the water supply system and the application of various aeration methods) have also been elaborated during the technical development of industrial-like fish production systems.

The systems discussed in this study allowed stocking density within a range of 15-100 kg/m^3, while water exchange was varying between 1-20 times per day in the various systems. It should be stressed, however, that further research is needed for the improvement of the safety and efficiency of the industrial-like systems with special regard to biological nitrification.

The main principle during the **development of tropical integrated aquaculture technologies** was the improvement of indigenous technologies with small incremental steps, taking into account local conditions as much as possible. The development program was based on the results of eco-technological and socio-economical survey of 262 family farms. Three promising integrated aquaculture technologies have been identified for development according to the following: rice-fish culture; pig and fish integration; and fish nursing in manured ponds. In collaboration with experts of local extension services, 25 family farms have been selected as partners for on-farm/farmer managed trials for the development of the selected technologies in farming conditions. The basic concept and the technology development work proved to be successful. The yields of rice-fish and pig-fish integrated systems increased by 87 and 97 %, respectively, if compared to the average yields before the introduction of the improved technologies. The yields of fingerling rearing farms have not been increased significantly comparing to the previous period when traditional technologies were used, however, the length of the growing cycle was decreased with 20%, the survival rate increased, and the quality of the fingerlings improved.

Comparative trials between the performance of the conventional Chinese type fish hatcheries and the Zoug jar hatcheries have also been carried out in the frame of the project. The advantages of jar hatchery systems, which are not commonly used in the region, were demonstrated through comparative trials, but also through practical tests. It has been revealed that the water and area requirement of the commonly used Chinese type hatcheries are 3 and
1.5 times higher, than that of the jar hatcheries, respectively. Further advantages of the jar hatcheries over the Chinese type hatcheries are the better control of processes, the more versatile and flexible use.

When the possibilities of **integrated water resources management in Hungary** is discussed, that special situation should be taken into account first of all that 93 % of the surface waters are coming from the surrounding countries. The value of the annual renewable water resources (ARWR) is
120 km^3/year. Thus the specific water availability is 11.476 m^3/year per capita, which is much higher than the 1000 m^3/year limit value, below which water availability is considered to be critical. However, the value of the annual internal renewable water resources (AIRWR) is only 6 km^3/year, which is one of the lowest in the world. If the specific value of water availability is calculated on this basis, it is only 604 m^3/year, which indicates difficulties in water supply. This is the reason why some statistics list Hungary among those countries where water is a scarce resource. Taking into account the very low value of AIRWR, and the uneven and unfavourable distribution of flow in time and space in Hungary, the conflict among the various users of water resources (aquaculture among them) is increasing. In order to understand the conflicts better and to assist their solution, a model has been elaborated as shown in Figure 1.

Figure 1. Relationship among water users and controllers, and the possible conflicts

Basically there are two possible solutions of the conflicts such as: the separated and shared or integrated use of the resources. However, the integrated use of the resources are more preferred taking into account that the integration offers more possibilities for sustainable use and protection of natural resources. Some possibilities for integration between aquaculture and various water users are shown in Table 2.

Table 2. The possibility of integration between aquaculture and various water users

Drinking water supply/ **Sewage treatment**	• **Fish rearing in drinking water reservoirs** • **Vegetation control by fish in drinking water reservoirs** • **Sewage treatment in fish ponds**
Agricultural production	• **Utilisation of manure from animal production** • **Utilisation of by-products and wastes of plant origin** • **Rearing of water fowls on fish ponds** • **Willow, reed and bulrush production fish ponds**
Irrigation, water storage	• **Irrigation of effluent waters from industrial-like fish production plants and fish ponds** • **Fish rearing in water reservoirs and irrigation canals** • **Vegetation control by fish in water reservoirs and irrigation canals**
Industrial production/processing	• **Use of heated effluents from power stations and other industrial plants for fish culture** • **Utilisation of by-products and wastes from processing plants either as manure or feed**
Water transport	• **Vegetation control of navigation canals by fish**
Tourism	• **Rearing fish in waters for recreational purposes** • **Vegetation control in waters for recreational purposes** • **Operation of aquaria and ornamental ponds** • **Provisions for hunting water birds** • **Provisions for eco-tourism, bird watching and other water related recreations** • **Presentation of fish culture and water related old professions and traditions** • **Organisation of display harvests (agro-tourism)**
Recreational fisheries	• **Production of stocking material for recreational waters** • **Elaboration and implementation of fish stocking, water management and habitat improvement programs for water areas used for recreational fisheries** • **Provisions for angling in fish ponds**
Commercial fisheries	• **Production of stocking material for water areas used for commercial fisheries**

	• **Elaboration and implementation of fish stocking, water management and habitat improvement programs for water areas used for commercial fisheries**
Environmental protection	• **Maintenance of habitats for aquatic and water dependent animals and plants** • **Fish rearing in protected areas** • **Maintenance of in-situ and ex-situ gene banks, propagation and restocking of endangered and protected fish species**

There is a need for the structural development of the Hungarian fish production sector in order to meet the criteria of the responsible use of resources, which has important market consequences as well. During this development, the diversification of the pond fish production sector is unavoidable. The structural changes wouldn't mean that fishpond production would loose its importance in food production, however, it means that the presently rather rigid structures and homogenous technology patterns will be diversified. The main directions of the diversification are shown in Figure 2.

Figure 2. The main directions of the diversification of pond fish culture in Hungary

The diversification, the increasing variability and flexibility of the sector will facilitate the integration of pond fish production with other activities as shown in Table 2.

Integration, however, has different dimensions. Besides biological and technical considerations, the institutional and legal aspects have significant importance. According to the principle of integrated resources management, the aquaculture sector should be involved appropriately in the planning and decision making process, which is aimed at the rational allocation and responsible use of water resources. Since aquaculture sector is fragmented, consisting of numerous relatively small farms all over in Europe, there is a need for coordinated and organised efforts in order to participate efficiently in the integrated management of natural resources. Therefore, the role of producers associations will increase in the future.

4. Summary of the new results of the study

(1) The possibilities of the implementation of conventional fishpond integration went through considerable changes during the past decades mainly due to the increased intensification of one or more components of the systems. I studied the possibilities, how the advantages of the integration could be realised at higher intensity level. I used the fish-cum-duck production system as a model, and analysed the structure and function of some main types of system under farming conditions. I found that the main advantages of the fish and duck integration (utilisation of organic materials, N and P in fishponds) could be attained at higher intensity level, if the fish and duck components are separated and their linkage (material flow) is controlled. The feasibility of this type of integration has been illustrated through practical example. The principle, namely the separation of components and controlled linkage between them, could also be used for the integration of extensive and intensive fish production systems.

(2) A special integrated fish and duck production system was developed for large-scale application in teamwork with my participation. The ducks were produced in a 1 ha separated enclosure, supplied with a central drinking and swimming canal, from where the water rich in nutrients was supplied to the fish ponds either by gravity or pumps in a controlled way. I analysed the economy of the system and found that the investment cost was about 15 % higher, while the operation cost was about 3 % higher in comparison to a conventional fish-cum-duck production system, where the ducks are raised on the dike. Based on my investigations I concluded that the increased investment and operational cost are proportional with the benefit resulted in the better efficiency of nutrient utilisation in the fishponds and the reduced impact on the environment. Technical and technological guideline for the design and operation, and also for the applicability of this type of system in various geographical and fish farming conditions was elaborated.

(3) That principle of integrated aquaculture systems development, namely to separate components and link them in a controlled way can also be applied for the development of integrated systems with two fish production components. Based on this principle, the model of a water-efficient and environment-friendly combined extensive intensive fish production system has been elaborated. The system comprises an intensive component of small ponds, and an extensive pond for water treatment. The water is circulated between the two components. Such systems ("fish pond recycling systems") are relatively new all over the world. The new fishpond recycling system at Szarvas comprises six intensive ponds with a total area of 1 ha (15.000 m^3), and a
20 ha extensive pond, which also serve as a water treatment unit. The water recycling between the extensive and intensive components is ensured by efficient pipe propeller pumps, which have not been used in aquaculture in Hungary so far. The system has been operating successfully since 1998 in farming conditions. The facilities for water control provides adequate flow rate and water distribution in the extensive pond. Since the water requirement of the intensive ponds is ensured through recycling, its volume 90 % less comparing to conventional flow through systems. Based on the results and the experiences of the studies, the guideline for the design and operation of the system has been elaborated.

(4) Detailed investigations have been carried out on the water and nutrient budget of the combined extensive-intensive system using the methods elaborated in the Fish Culture Research Institute. It was clearly demonstrated that there has not been accumulation of harmful substances, which would be dangerous to the fish in the intensive system. The fish didn't show any symptoms of diseases and their growth rate was acceptable throughout the three years of the experiments. The yields in the intensive ponds were increased gradually in the intensive ponds from the beginning of the experiment; due to the limitations under farming conditions and also in order to minimise risk. In 1998, the average yield in the intensive ponds was
1.4 t/ha, which was increased to 2.8 t/ha in 1999 and to 9.1 t/ha in 2000. Based on the results of the investigations on the nutrient budget in 1999 it can be concluded that the yields of the intensive ponds could be further increased, before the water quality would become limiting factor of the intensive production. It was also demonstrated that 84,6 % of the organic material,
61,3 % of the total nitrogen and 58,6 % of the total phosphorus load were retained or processed by the system, expressed as percentage of the total organic material and nutrient input.

(5) Based on the preliminary data of the production in 2000, preliminary economical evaluation has also been carried out. It can be generally stated that the system works economically in farming conditions. It was demonstrated that even in this stage of the development, the profitability on income, cost and assets were 18, 21 and 14 %, respectively. According to my model calculations, the profitability indicators could be increased from 18 to 23 % on income, from 21 to 30 % on cost, and from 14 to 22 % on asset value, if African catfish, common carp and tilapia were produced on 38, 50 and 12 % of the intensive pond area, respectively, with the same yields as in the year 2000. When the economy of the system is analysed, it should also be taken into account that the wider species variety of the production in the intensive ponds results in higher income from the sale of high value species, and the programmable supply to the markets

and processors also improves the cash-flow situation. Besides, fish could be produced in natural-like environment in the extensive pond, and the product could satisfy special consumer's requirements, and command for higher prices. Such systems are applied in production scale only in Israel, thus the Hungarian aquaculture could improve its comparative advantages if the R&D work aiming at the development of combined extensive-intensive systems, and also the introduction of such systems into the practice would be expanded and accelerated.

(6) Based on thorough analysis of the technical and technological parameters of various industrial-like fish production systems, categorising the system according to their water use, a general mathematical description of the water requirement of the systems has been elaborated. The method, which was elaborated by the team led by myself, can be used for determining those main technical and technological parameters, which are needed to reach a desired production goal in a specific system. The equations can be used for the determination of specific water requirement both for open flow through and closed recycling systems, which represents the two extreme limits among the various type of industrial-like fish production systems. The method provides a good basis for the elaboration of a computer program for end users, which may be useful during the planning and operation of industrial-like fish production systems, which are playing a yet moderate, but increasingly important role in the Hungarian fish production.

(7) The results and experiences of my research and development work on the field of the mechanisation of aquaculture have contributed to the development of various experimental and large-scale industrial-like fish production systems, which resulted in qualitative changes in the aquaculture production in Hungary. I demonstrated through experiments that the natural zeolites could be used efficiently for ammonia removal in warm-water recycling systems. The results of my experiments with the bio-filter of the recycling system of the Fish Culture Research Institute contributed to the improvement of the performance of the water treatment unit and the overall efficiency of the system. I have also conducted complex studies on the oxygen budget and the control of the dissolved oxygen level in various fish production systems. Based on my investigations on the water treatment and oxygenation in recycling systems I arrived to the conclusion that there is a realistic low cost alternative of the "over mechanised" and "over automatised" recycling systems, which have been designed and operated in developed countries. One of the main features of such simple recycling systems is the use of airlift pumps. Myself initiated the introduction of airlift pumps into the Hungarian aquaculture for aeration, water circulation and fish harvest, and I also actively took part in the development of various types of airlift pumps. The use of air-lift pump for aeration and water circulation, and the regular sludge removal were basic features of a semi-scale system, which was successfully operated in the Árpád Cooperative at Szentes. The operation of the intensive fish production system of the Szarvas-Fish Company (which was built in the frame of a Hungarian-Norwegian joint venture) is also based on the use of airlift pumps and regular sludge removal. I have actively involved in the design and initial operation of both systems utilising the results of my research work, and my experiences.

(8) Hungarian experts have been involved for decades in international aquaculture development programs, aiming at the improvement of food supply of developing countries. I have been one of these experts in the past twenty years, and these missions offered good opportunity for the involvement in the development of integrated aquaculture systems. During the implementation of the Dutch government supported so called West-East-South (WES) Project in Vietnam between 1994-1998, the team, which was led by myself demonstrated the feasibility and efficiency of the development of indigenous technologies by small incremental changes. Using this principle, on-farm (farmer-managed) trials were carried out in selected 25 family farms, where the yields in rice-fish and pig-fish integrated systems were increased by 87 and 97 %, respectively, if compared to the average yields in the previous years. It was found during the implementation of the WES Project that the supply of good quality fingerling is a major bottleneck of aquaculture development. Thus special attention has been given to the development of fish hatcheries. The

advantages of jar hatchery systems, which are not commonly used in the region, were demonstrated through comparative trials, but also through practical tests. It has been revealed that the water and area requirement of the commonly used Chinese type hatcheries are 3 and 1.5 times higher, than that of the jar hatcheries, respectively. Further advantages of the jar hatcheries over the Chinese type hatcheries are the better control of processes, the more versatile and flexible use. In order to improve the performance of the fish hatcheries, the model of simple filters for removing iron and suspended solids have also been elaborated.

(9) Based on the results of my works and experiences attempt has been made to summarise findings and recommendations, which may contribute to the aquaculture development in Hungary during the process in finding appropriate responds to the new challenges in the next decades. The relationships between the various users and controllers of the aquatic resources and the possible conflicts have been analysed. It was found that the shared used of resources or integration has a basic role in conflict resolutions. The conflict analyses clearly demonstrates that there is a need to take into consideration not only the laws and regulations, but the expected responds of NGOs, the media and the public during aquaculture development. In my studies I determined the possible directions of the diversification of fishpond uses. The specific aquaculture production as a function of the renewable water resources has been compared in various European countries. It was revealed that the specific aquaculture production in Hungary (78 t/km^3) is much lower than that of in those countries, where water resources are efficiently utilised like in Israel (7.578 t/km^3) or in Denmark (2.543 t/km^3). This fact indicates the potential of aquaculture development in Hungary, and draws the attention to the application of new scientific results, which are also demonstrated in the present study, and among which integration plays an important role. The main possibilities of integration between aquaculture and other water users have also been analysed and described.

5. Practical application of the results

Although the farm trials with the new type of **fish-cum-duck production systems** were stopped due to the political and economical changes and the consequent difficulties in the agricultural sector in the beginning of the nineties, it is highly recommended to revitalise the program. The practical application of the results and experiences could contribute to the development of sustainable food production technologies in Hungary. The Akvapark Association at Szarvas would provide a good framework for the application and demonstration of the new type of systems and technologies, and also for transferring information to other farms, even on international level. Basic technical conditions and high level professional background are available in the members of the Association, with special regard to the Szarvasi Kacsafarm Kft, the Szarvasi Halas Kft, the Agro-Aqua Kft, and the INNOFLEX Kft.

The wider scale practical application of **the combined extensive-intensive, and the industrial-like fish production systems** would be a major contribution to the structural development and modernisation of the Hungarian fish production sector, in which extensive pond fish production is dominant at present. The new systems at Szarvas and elsewhere should also function as reference centers in order to facilitate the further practical application of the type of systems and technologies. The member farms of the Akvapark Association operate three industrial-like fish production systems, and one combined extensive-intensive system, and collaborate closely with the Fish Culture Research Institute (HAKI), which is also a member of the Association. The institute is also going to establish an experimental station at Réti-major Fish Farm of the Aranyponty Cooperative, where a combined extensive-intensive fish production system will be built by the assistance of HAKI. Besides efficient water use, the recycling systems make possible the conservation of heating energy, temperature control, and thus all year round fish production, which is important in cool and temperate climate. The minimal heat loss and the use of

geothermal energy contribute to the economical viability of the recycling systems, which otherwise expensive to be built and operated. There is a need, however, to continue experimental work with special regard to the variability of the technological parameters of the systems, through which the systems could be adapted better to prevailing conditions at a given site, and the needs of various species going to be cultivated. The improvement of the economical viability of the systems is the most important aspects in the future development of the industrial-like fish production systems.

The results of the **integrated aquaculture development project in Vietnam** greatly helped that through the activities of the Fish Culture Research Institute, Hungary represents herself in important networks in the Asian regions, such as the International Network for Genetics in Aquaculture (INGA), and the Network of Aquaculture Centres in Asia (NACA). The relations with FAO and with the relevant directorates of the EU have also been strengthened as a result of the international recognition of the project. One of the results of the past project is the agreement between the Hungarian Ministry of Agriculture and Regional Development and the Vietnamese Ministry of Fisheries that provides a good framework for the continued collaboration with Vietnamese aquaculture research institutions, and also facilitates the further involvement of HAKI in international projects aiming at the development of tropical aquaculture technologies.

The experiences in **integrated water resources management** in Vietnam and Hungary demonstrate that the conflicts between resource users could be handled and minimised. Pond fish production, which is in close relation with nature and shows great diversity, could be an important component of the needed integrated water resources management. The involvement of pond fish production in integrated water resources management should not jeopardise the traditional values of pond fish culture, but makes necessary some changes in the rather homogenous structure and function of pond fish culture in Hungary. Food production will remain a dominant feature of the sector; however, various services will get more significance in future operation of pond fish farms. The diversity and the structural and functional changes of the pond fish production sector also facilitate the integration of pond fish production with other activities. Fish farmers and professionals working in the fish production sector in Hungary have already been acquainted with some of the results of the development programs discussed in this study, mainly through the activities of the Fish Culture Research Institute and the Hungarian Fish Farmers Association. There is a need, however, to improve information exchange and collaboration between scientific institutions and farmers, in order to get accepted new concepts and to introduce new methods and technologies into the practice. The recent Aquaflow Project, which is supported by the EU and the OMFB, could help to reach these objectives. The activities, which are discussed in this study contributed indirectly to the involvement of Hungary in the Aquaflow Project, which became a European-wide information network in aquaculture. The research and development works discussed in the study, also facilitated the participation of Hungary in various European fisheries organisations such as European Inland Fisheries Advisory Committee (EIFAC), Federation of European Aquaculture Producers (FEAP), and also the collaboration with the Directorate-General for Fisheries of the European Commission.

6. Publications in topics of the study

1. **Váradi L**., 1976. AIR-O-LATOR tólevegőztető berendezés üzemi vizsgálata. Halászat, XXII (69): 72-74 p.

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3. **Váradi L**., 1980. Tólevegőztető berendezések vizsgálata. "Az öntözés és halastógazdálkodás hatékonysága". CIGR vitaülés, Budapest.

4. Csávás, I., Majoros, F. and **Váradi, L**., 1980. Technology of pellet feed manufacturing for warmwater fishes in the experimental fish feed mill of the Fish Culture Research Institute Szarvas, Hungary, In: J. E. Halver and K. Tiews (eds), Finfish Nutrition and Fishfeed Technology. Vol. 2: 75-86.

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