IDRC-MR145e

International Development Research Centre

MANUSCRIPT REPORT

Aquaculture Training Needs in Developing Asia

Chua Thia-Eng

February 1987

CANADA

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IDRC-MR145e

Aquaculture Training Needs in Developing Asia

Chua Thia-Eng[1]
Formerly Senior Aquaculturist
Network of Aquaculture Centres in Asia
F. A. O.

Collaborative project of the International Development Research Centre of Canada (IDRC) and the Network of Aquaculture Centres in Asia of the Food and Agriculture Organization of the United Nations (F. A. O.)

[1] Present Address: International Center for Living Aquatic Resources Management (ICLARM), P. O. Box 1501, Makati, Metro Manila, Philippines

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FOREWORD

On of the major constraints in aquaculture development is the lack of skilled technical manpower. For this reason, the organization and funding of appropriate training programmes has evolved as one of the major activities of the FAO/UNDP Network of Aquaculture Centres in Asia (NACA) and the International Development Research Centre (IDRC) of Canada.

NACA conducts two regular training courses: one is the postgraduate training programme for senior personnel and aquaculturists responsible for planning and implementing aquaculture development programmes, and the other is the integrated fish farming training course for senior technical personnel. NACA also organizes short-term training courses aimed at disseminating technologies developed at the Regional Lead Centres in China, India, Philippines and Thailand, and in other centres of the Network. These technologies are then adapted and modified at national institutions by the trainees to suit the local agro-climatic and socio-economic conditions, and subsequently transferred to the grass root farmers through extension and training at the national level.

IDRC has been providing financial support for selected trainees to these various NACA courses. However, it was felt that a clearer understanding of the training needs of countries in the region was needed to develop a better structured and coordinated approach for meeting training requests received. This was discussed at the Third Advisory Committee Meeting at NACA in October 1983, Wuxi, China. From this meeting, a collaborative programme was developed with NACA and IDRC to conduct a regional survey for the purpose of up-dating training requirements and training facilities available in the region. Much discussion and planning went into the preparation of a survey by questionnaires followed by field visits and interviews. Published literature and reports, were also reviewed. The survey by questionnaire was initiated in mid 1984, while field visits were undertaken intermittently from November 1984 to September 1985. The data obtained were analysed in consultation with published work and the results are presented in this report.

Dr Chua Thai Eng conducted the survey while he was the Senior Aquaculturist (Training) of the NACA project, and we wish to congratulate him for this excellent work. However, we wish to mention that the presentation of material in this publication does not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations, United Nations Development Programme or of the International Development Research Centre of Canada concerning the legal status

of any country territory, city or area of its authorities, or concerning the delimination of its frontiers or boundaries. Similarly, the data presented does not reflect the views of the above mentioned organizations.

6 December 1986

Dr P V Flores
Senior Program Officer
Fellowship & Awards
Division
I.D.R.C.
Singapore

Dr F Brian Davy
Associate Director
(Fisheries)
Agriculture, Food &
Nutrition Sciences
I.D.R.C.
Singapore

Mr Chen Foo Yan
NACA Coordinator
Bangkok
Thailand

INTRODUCTION

Aquaculture is an age old aquafarming practice in Asia with a history of not less than 3,500 years (Bardach *et al.* 1972; Huisman 1984). It has, however, remained a traditional rural occupation in many countries. While agriculture and animal husbandry were given development priority by most nations after the Second World War, especially those agriculturally based developing nations, the potential of aquaculture resources has been, unfortunately, neglected. Capture fisheries on the other hand have played a greater role, especially after the development of synthetic fiber for fishing nets, mechanical haul systems for purse seining and trawling as well as freezing facilities at sea. These scientific innovations greatly enhanced distant water fishing. Hence, from late 1940's to 1970's, fish production increased from about 20 million tonnes in 1948 to 70 million tonnes in 1970. Indiscriminate fishing has resulted in overfishing in some traditional fishing grounds (Carroz 1984; Csavas 1985) while many coastal fisheries have been exploited almost in excess of their sustainable level. Hence, the annual catch from the 1970's to the present time has fluctuated between 70 and 75 million tonnes (FAO 1985). The oil crisis in mid 1970's made fishing a very expensive venture and the price of fish escalated in many countries. In addition, the increasing pressures faced by the many coastal nations to supply cheap fish protein to meet the growing demand of increasing populations, the increasing number of displaced fishermen, and the implementation of Exclusive Economic Zones (EEZ) of coastal nations have all contributed, in one way or another, to the search for alternative means of fish production and new employment opportunities (Von Brandt 1983).

In the last few decades, considerable research efforts have been made by industrially developed nations in developing modern aquafarming technologies for large-scale husbandry of aquatic plants and animals (Pillay 1978, 1979, 1981). World recognition of aquaculture potential has led to substantial funding support from financing agencies for aquaculture research and technology dissemination.

The general upsurge of interest in aquaculture and the realization of its contribution to employment generation, foreign exchange earnings, food production and improvement of rural economy have convinced many Asian nations to include aquaculture development in their national economic development plans. Over the last few decades, some of these countries, especially China, South Korea, Thailand, the Philippines and Indonesia, have become "aquaculturally developed nations" as well as Japan (FAO 1983). However, aquaculture is still new to many nations in Asia and its development very much depends on the importation of aquaculture technology and expertise. These "aquaculturally developing nations" have yet to acquire the needed experience and skill both in the operation of aquafarms and management of the new industry.

The private sector has also begun to take an active part in developing aquafarms, especially in countries where aquaculture development is receiving incentives provided by governments and financial institutions from national, regional or international banking systems such as the Asian Development Bank (ADB 1971-83) and the World Bank (Sfeir-Younis and Donaldson 1982). In some countries, aquaculture development has taken the form of large-scale vertically integrated and capital-intensive commercial ventures (Pillay 1977). Some of the large aquaculture ventures have shown commercial success in Taiwan, Japan and China. However, many large-scale aquaculture ventures especially in "aquaculturally developing nations" are less successful. Overoptimism about the time required to adapt the imported technologies to local conditions, inadequately skilled aquaculture technical manpower, and insufficient market outlets are among the major causes of such failures (Pillay 1979).

The need to develop sufficient and appropriate aquaculture technical personnel has become more acute than before as increasing investment in aquaculture in the recent past has led to large-scale expansion of the industry (Pillay, 1981). Aquaculturists and technicians with hands-on experience are not only lacking in "aquaculturally developing nations" but also in countries where aquaculture has been practised for centuries.

SURVEY OF AQUACULTURE TECHNICAL MANPOWER REQUIREMENTS

Traditional aquaculture practices still play a very important role in the rural economy. The methods of fish farming have been developed and expanded by fish farmers through the process of trial and error. Voluminous research and publications have accumulated a wealth of scientific knowledge that could be used not only to improve and expand aquaculture but also to provide the necessary background data for the academic training of the much needed aquaculture technical personnel in many countries in the region.

Formal aquaculture training at degree levels has been a recent exercise in most universities. In most countries in Asia, aquaculture may be included as one of the fishery subjects or taught as a specialized course. Many personnel involved in the management of aquaculture projects in both public and private sectors lack adequate formal aquaculture training. The aquaculture manpower requirements needed in research and development at public research, training and extension institutions as well as private farms in Asia are yet to be determined in relation to future expansion of the aquaculture industry.

The present preliminary survey was undertaken in response to the recommendation of the Fourth Advisory Committee Meeting of participating governments of UNDP/FAO Network of Aquaculture Centres in Asia (NACA) held in Bhubaneswar, India, December 1984.

The main objective of the survey was to conduct a preliminary investigation into the aquaculture training requirements of developing countries in Asia. The survey results are expected to indicate the availability of aquaculture manpower in those countries and the areas or fields of aquaculture training most needed in the region. Time and resources constraints have limited the survey to depend largely on information supplied by various national institutions and concerned scientists and educators interviewed by the author.

Approach and method of analysis

Information presented in the survey was obtained from the following sources:

1. Returned questionnaires - National fisheries institutions in each country were invited to complete a set of questionnaires (Annex 1) covering in brief the status of aquaculture production, availability of aquaculture training and research institutions, as well as an estimate of aquaculture manpower requirements or training needs.

2. Interviews - The author verified the information obtained from questionnaires and literature by field visits and interviews with scientists, policy makers, planners and educators. Much new information was added to that retrieved from literature and through questionnaires.

3. Literature - Published literature, mission reports and fisheries statistics provide many relevant information needed by the present survey (UNEP/FAO 1984; CIFE n.d.; ADCP 1976, 1980; Haque 1984; Anon. 1979; 1985; Bicol University 1982; Pillay 1973; Brown 1983; Rabanal 1984; Zhang *et al.* 1984; Yen-Wu *et al.* 1984; Shang 1986; RAPA 1985, 1986; UPV n.d.; Natarajan 1984; Thakur 1984; FAO 1973, 1976).

For the purpose of analysis, countries mentioned in this report were sometimes grouped, based on geographical location and aquaculture characteristics as follows.

- South Asia - Bangladesh, India, Nepal, Pakistan and Sri Lanka
- Southeast Asia - Brunei, Indonesia, Malaysia, Philippines, Singapore and Thailand

o East Asia - China, (including Taiwan), Hong Kong, Japan and Korea.

GOVERNMENT POLICIES AND AQUACULTURE DEVELOPMENT STRATEGIES

The last two decades witnessed the change of government policy towards aquaculture development in many developing nations in Asia. This is best reflected by the increased budget allocated for aquaculture research and development (Table 1) which in the past formed a small part of the overall fisheries development budget. Recognizing the need to step up research efforts to fill technology gaps, many fisheries research institutions have allocated more than half of the agency budget to aquaculture research.

The higher budget, though small compared to that for agricultural research, is primarily stimulated by the greater emphasis in government policy on augmenting fish production through aquaculture. This emphasis is demonstrated by the production targets of the five-year development plans of many national governments (Table 2). The contribution of aquaculture in total fish production has been raised by most nations from about 10% of present output to between 14% in Sri Lanka and 75% in Nepal. In Southeast Asian countries, aquaculture production is expected to constitute about 20% of total fish production in the next 5 years. Sixty per cent of fish production in China is expected to come from farming by 1990.

The FAO World Conference on Fisheries Management and Development in 1984 is also expected to influence the policy of many governments to develop their aquaculture potentials. The Conference adopted action plans for the development of aquaculture on a global basis. Essential elements of the action plans included technology transfer from "aquaculturally developed nations" to "aquaculturally developing" or "underdeveloped nations", multidisciplinary research, manpower development and development of information networks (FAO 1984).

The aquaculture development strategies of most Asian nations can be briefly summarized as follows:

1. Intensification of culture methods to increase yield

   Intensive cultivation using high density stocking with greater inputs in terms of aeration, feeds and water quality management, is being increasingly practised in most nations culturing shrimps and *Macrobrachium* prawns. The high export value of shrimps and prawns is able to offset the relatively high production cost. In China, Hong Kong, Japan and Taiwan, polyculture of various species of Chinese carps with exotic and other

local freshwater species has raised yields from 1 to 10 tonnes/ha. Intensification is also the trend for cultivation of high-priced market fish such as grouper, yellowtail, sea bass, and sea bream.

2. Expansion of aquaculture

Expansion is a national development option for countries where there are plenty of land and water resources. Although fishfarming has been a priority area for development, only a small portion of potential areas are being used for aquaculture production.

3. Development of culture-based fishery or aquaranching and integrated fish farming

Increasing attention has recently been focused on the use of large water bodies in lakes, reservoirs and even seas and oceans to increase fish production through artificial recruitment and transplantation. The recent success in hatchery technology enables the integration of fishfarming with small-scale fishery development.

The reservoirs and lakes in China have been increasingly utilized for fish production through artificial stocking of fish seeds produced in hatcheries (ADCP 1979; FAO 1983). Close integration with other agriculture and animal husbandry has made culture-based fisheries in lakes and reservoirs a viable venture. Many man-made reservoirs and seasonal tanks in Sri Lanka are also increasingly utilized for fish stocking and harvested by the fishermen. Haors and ox-bow lakes in Bangladesh, mining pools and dams in Malaysia, reservoirs in urban Singapore, shallow lakes in the Philippines, and irrigational canals and ditches in Thailand are stocked to augment fish production.

Financial credits from banks and international lending institutions are now more easily available than in the past in most developing nations (Sfeir-Younis and Donaldson 1982). Government subsidies and investment incentives are being offered by some Southeast Asian nations to attract private investment and participation of small farmers (Chakrabarty 1983; ADB 1977-1983).

Priority commodities appear to fall into two groups: those that are of high market value or with great export potential such as shrimp, prawn, grouper, yellowtail, sea bass and sea bream, and those that are popular and low in the food chain such as Chinese and Indian carps, common carps, gouramy, tilapias, milkfish, local carps, mussels and oysters (Table 3).

AQUACULTURE RESEARCH AND EXTENSION SERVICES

Despite the long history of aquaculture practices in Asia, research has not kept pace with the rate of aquaculture development, especially in recent years. Government development priority and availability of investment incentives in most nations have helped to enhance rapid development of the industry in the last decades especially in many South and Southeast Asian nations. Traditional aquaculture methods which were developed by progressive fish farmers through trial and error are being modified and adapted to other regions. Scientific research in recent years has helped to improve the farming systems. However, existing techniques have yet to be improved and packaged into appropriate technologies for the husbandry of various species commodities in developing nations in Asia.

The failure to generate reliable aquaculture technology is one of the contributing factors to numerous failures in ventures in recent years. Technological transfer is equally important. Effective extension programs and services are necessary to expedite the transfer of methods from aquaculturally developed nations to those countries wanting to develop their aquaculture potential.

Aquaculture research institutions and regional organizations

Aquaculture research is being conducted as part of the national fishery program in most developing nations in Asia. Only few institutions confine their role to purely research. Many institutions have developed research, training and extension programs in aquaculture.

Of the 14 developing nations surveyed, almost all have developed fishery research institutions, many of which focus on aquaculture research (Table 4). Almost half of the 24 fishery research institutions in the 14 countries surveyed are dealing with freshwater aquaculture and the other half focus on coastal aquaculture. Only one institution (Institute of Coastal Aquaculture Engineering) located in Calcutta, India, is specialized in aquaculture engineering while another (Fisheries Mechanics and Equipment Research Institute) located in Shanghai, China has placed research efforts in aquaculture equipment and fishing mechanics.

The fundamental role of these institutions is to provide information for national aquaculture development. Research direction focuses on adaptation and verification of existing farming techniques in local conditions, and improvement of imported farming technology.

Many research institutions are relatively new and most were established in the 1970s although some institutions such as the Changjiang Fisheries Research Institute in China, the Batu Berendam Freshwater Fisheries Research Station in Malacca, Malaysia, and the Central Inland Fisheries Research Institute (CIFRI) in India were established more than three decades ago.

While almost all research institutions conduct applied research, most past research activities were based on a conventional approach instead of an interdisciplinary, production oriented approach towards generating aquaculture technologies. Adaptive and strategic research are the priority in public research institutions, although basic scientific studies to seek scientific explanations on some of the fundamental problem areas are deemed necessary.

Most aquaculture research in the past was seriously handicapped by the lack of appropriate farm and laboratory facilities as well as technical capability to carry out well designed research activities. More funds were made available either through national inputs, such as in India, China, Malaysia, Singapore, Thailand, and the Philippines or through bilateral and multilateral assistance from the Asian Development Bank, World Bank, Japanese Government, United Nations Development Program (UNDP), and the European Economic Community (EEC).

New research facilities are being established in many developing nations, such as Bangladesh, Pakistan, Sri Lanka, Thailand, the Philippines, Malaysia and Indonesia through national funds and external aid. However, apart from China and India which have comparatively larger numbers of research institutions, most countries have only two or three research institutions. There is certainly a need to increase the number of research institutions in many Southeast Asian countries so that research output in aquaculture can keep pace with its development

Another major problem confronting aquaculturists in the region is the unavailability of research funds. Many poor nations such as Bangladesh, Nepal, Burma, Pakistan and a few in Southeast Asia are often short of research funds for long-term research activities, despite enormous external aid for infrastructure and equipment.

A more serious problem in most countries in the region is the extremely low salaries of scientific researchers who have to look for another means to obtain additional income in order to maintain a decent living. This is true throughout Asia except in richer nations such as Japan, Singapore and Malaysia.

Lack of well trained technical aquaculture manpower is the other serious problem towards improving research quality. A sizeable number of researchers in fishery research institutions have not

undergone proper aquaculture training as there was no such training during that time. Most researchers lack broad-based aquaculture exposure and a large number have inadequate or no practical experience.

There is only one regional institution in developing Asia, the Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC). Established in 1973, in Tigbauan, Iloilo, Philippines, the SEAFDEC Aquaculture Department has grown into one of the largest and best equipped aquaculture institutions in Asia. It has about 700 professional and supporting staff and an annual budget of approximately US$3 million (SEAFDEC 1986, 1984). The Department's main function is to promote and undertake research essential to the development of the aquaculture industry in the region in addition to its training and information dissemination role. The department focuses its research efforts on milkfish, penaeid shrimps, seabass, tilapias, oysters and mussels.

In addition to the SEAFDEC Aquaculture Department, the following regional and international organizations contribute to a certain extent in participating and promoting aquaculture research in the Asian region:

- International Development Research Center (IDRC)
- International Center for Living Aquatic Resources Management (ICLARM)
- Food and Agricultural Organization of the United Nations (FAO)
- Asian Institute of Technology (AIT)
- Canadian International Development Agency (CIDA)
- Danish International Development Agency (DANIDA)
- East West Center (EWC)
- United States Agency of International Development (USAID)
- German Agency of Technical Cooperation (GTZ)
- Japan International Cooperation Agency (JICA)
- Oceanic Institute (OI)
- United Nations Development Programme (UNDP)
- World Bank (WB)

Extension Services

The expansion of the aquaculture industry in a country depends upon many factors. These include the development of the necessary infrastructure like roads and market facilities and the availability of production inputs such as fertilizers, seeds and feeds. More importantly, there is the need of a system of information dissemination to fish farmers on the availability of new culture technologies and their commercial feasibility in local conditions. The effective methods of information transfer to the fish farmers is through an extension service operating at the field level. Extension is the link between research, education and training on one hand, and the end users on the other. At the field level, extension workers play a very delicate role in the growth of aquaculture in the country for they are responsible for introducing aquaculture technologies where they do not exist and improving the existing ones with modern methods.

In the past, extension of aquaculture methods was largely effected by the initiatives of fish farmers themselves. As communication developed, aquaculture farming practices spread throughout the regions. However, this has taken thousands of years. With scientific inputs in technology generation, the transfer of aquaculture techniques can be readily effected within a relatively short period of time provided efficient aquaculture extension services are available. Aquaculture extension services in Asia differ from country to country depending on socioeconomic and political structures and availability of technical support services, credit facilities and marketing channels.

Aquaculture Extension in Some Asian Countries

Aquaculture extension has been traditionally included as part of the operative function of fishery or agricultural services. Such organizational structure has not been radically altered in most countries. Following are some examples.

Philippines. Aquaculture extension is one of the main tasks of the Bureau of Fisheries and Aquatic Resources (BFAR). In order to achieve the primary Bureau objective of promoting aquaculture development towards increasing fish production, BFAR has developed and implemented a Fishery Extension Program in Aquaculture which aims at the following development strategies:

1. increasing yield of existing fishponds, fishpens, cages, and open inland water bodies.

2. developing new production farms especially in sea farming of high-priced commercial species (shrimps, groupers, seabass, siganids, etc.)

The aquaculture extension program is jointly developed by the Division of Fisheries Extension of the Central office and that of the 12 regional offices and executed by the provincial/district fishery offices. A total of 330 aquaculture extension officers or almost half of the extension workers of BFAR are engaged in aquaculture extension work throughout the country. BFAR has supportive facilities located at strategic place including 31 freshwater farms, 32 brackishwater farms and 11 seafarms for seed production, field testing and demonstration of aquaculture technologies. Demonstration and training centers are being developed. A Freshwater Fish Hatchery and Extension Training Center was established through USAID assistance for training extension officers and private fishfarmers in freshwater aquaculture. Four Brackishwater Aquaculture Demonstration and Training Centers were established through UNDP assistance located at Paombong, Pagbilao, Calape and Lala (BFAR 1981; Rabanal and Juliano 1979). All the above facilities are operational.

The SEAFDEC Aquaculture Department located in Tigbauan has also developed extension training programs to train extension officers.

Thailand. The Department of Fisheries (DOF) is primarily responsible for aquaculture extension work in Thailand. The Division of Fisheries Conservation and Extension under the Administrative Directorate develops and coordinates aquaculture programs which are implemented by the provincial and district fishery officers (Department of Fisheries, Thailand 1984).

In addition to the Division of Fisheries Conservation and Extension, the following agencies also conduct aquaculture extension activities:

- Freshwater Fisheries Division
- Brackishwater Fisheries Division
- National Inland Fisheries Institute (NIFI)
- National Institute of Coastal Aquaculture (NICA)

There are about 50 fishery stations distributed over most of the 73 provinces. A great number of these are involved in breeding work and hence are providing the much needed fish seeds of the fish farmers. Because of its very successful fish breeding program, Thailand was able to export a number of its fish seeds (e.g., seabass, *Pangasius*, *Clarias*) to neighboring countries.

The Department of Fisheries has recently launched the "Accelerated Rural Development Program" which aims at promoting rural aquaculture. The Engineering Section of the Department provides technical advice on site selection, plan development, and construction supervision of village/community fishponds. The fishery station provides fish seeds and volunteers to send extension workers to fish farmers in outlying areas not generally visited by government extension workers.

India. The main activities of the aquaculture extension program in India are directed towards the expansion of composite fish culture in village and commercial ponds. Fish farming forms a part of the fisheries extension program which was first established at the Central Inland Fisheries Research Institute (CIFRI) in Barrackpore in 1950. Sixteen years later, the Ministry of Agriculture established nine more extension units. Since the late 1960's, extension units have been established part of fisheries research and development institutions under the Central Government. By 1977, separate extension offices for fisheries were established in five out of the 22 states and nine union territories.

Aquaculture extension differs slightly from state to state. Most of the 22 states have Fisheries or Agriculture Departments which provide aquaculture extension services, but some states provide fisheries extension service through the Department of Community Development or the Animal Husbandry and Veterinary Department. The Central Institute of Fisheries Education (CIFE) and many other agricultural universities also provide aquaculture extension services (Jhingran, Sinha and Sinha 1980).

The following is a list of institutes and training centers involved in aquaculture extension:

- Central Inland Fisheries Research Institute (CIFRI)
- Central Institute of Fisheries Education (CIFE)
- Central Fisheries Extension & Training Center, (a part of CIFE at Agra)
- Trainer's Training Center in Orissa
- Central Marine Fisheries Research Institute (CMFRI, Cochin)
- Freshwater Aquaculture Research and Training Center, Dhauli

CIFRI has launched an extensive "lab-to-land" program to promote composite fish farming throughout India among other techniques developed or tested by the Institute. The Fish Farmers Developing Agency (FFDA) directly extends aquafarming technology to the village farmers by developing fish farming cooperatives (Anon. 1984; Anon. 1981; CMFRI n.d.)

China. Aquaculture in China is part of an integrated agricultural activity. Some farmers (in production teams or brigader) make a primary occupation out of aquafarming and then grow crops or raise animals as a secondary activity or supplementary source of income. Others undertake it as a secondary activity and produce crops or raise animals as a main occupation (FAO 1983).

Aquaculture extension in China used to be facilitated mainly by progressive fish farmers but was limited to the traditional fish farming provinces. It did help to expand the industry but at a rather slow rate. Large-scale aquafarming was initiated only after the government issued a policy to develop the country's aquafarming potentials (Yen Wu *et al.* 1984). Hence since 1957 aquafarming production has been increasing at an average annual rate of about 15%.

The National Bureau of Aquatic Products (NBAP) under the Ministry of Agriculture, Fisheries and Animal Husbandry develops and handles the administrative management of aquaculture extension activities. The NBAP establishes Bureau of Aquatic Products branches at provincial, city, country and district levels. The country has so far established all extension stations in 18 provinces, 3 autonomous territories, and 3 cities in an efficient network with a total extension staff of 6,516, of which 3,318 are scientific personnel. The stations are staffed with experienced extension officers who are charged with the responsibility of transferring useful research results and advanced techniques. While extension stations are confined up to country level only, production brigades are usually assigned extension workers to ensure the correct application of scientific methods in fish farming.

The Chinese Government provides economic incentives and raises the political status of extension officers by upgrading their technical capability so that they may be better equipped to transform traditional practices into modern methods through the application of scientific principles.

Another important strategy adopted by the Chinese Government in promoting extension services is to encourage and assist the establishment of private corporations to provide technical services to fish farming communities. With the adoption of the production contract/responsibility system, many private fish farming corporations have been formed to undertake production contracts, thus allowing the transfer of fish farming experience and technology to "aquaculturally less developed areas". The incentives provided in such a system are the driving force in popularizing fish farming throughout the country.

Indonesia. Aquaculture extension services are the joint function of the provincial government and the Directorate General of Fisheries. Extension work is carried out by the Regional Fisheries Services (provincial and regional levels) through the guidance of extension specialists who are trained and provided by the Directorate. Each province usually has one fishery extension specialist assigned to a number of field extension workers. Field workers teach the fish farmers improved farming techniques and give advice on pond management, bank loan applications and marketing. Field workers often work as mobile demonstration teams.

The Government has established aquaculture demonstration centers at Sukabumi (freshwater) and Jepara (brackish) to train extension workers. Extension specialists are graduates of colleges and universities.

Other developing nations in Asia. In most developing nations in Asia, aquaculture extension is the responsibility of their respective fishery agencies. The Department of Fisheries in Malaysia has a Division of Fishery Extension which also covers aquaculture extension services. Aquaculture extension falls within the function of the Directorate of Fisheries in Bangladesh, the Inland Division of the Ministry of Fisheries in Sri Lanka, the Division of Fisheries Development in Nepal and Brunei, the Provincial Department of Fisheries in Pakistan, and the Division of Fisheries in the Primary Production Department in Singapore. In short, almost all developing nations in Asia have included aquaculture extension as part of their fishery extension programs.

Supplying fish seeds seems to be the main extension service given by the governments of most developing nations. A great number of freshwater fish breeding stations have been established in the region and a few brackishwater stations have also been recently constructed for production of shrimps and brackishwater finfish. The numbers and specific types of breeding/fishery stations in each Asian country are as follows:

o	Bangladesh	96	seed multiplication centers
o	Nepal	13	fishery development stations
o	Sri Lanka	17	freshwater and brackishwater stations
o	Burma	22	fishery stations
o	Pakistan	4	provincial fishery centers
o	Malaysia	14	freshwater and brackishwater fish and shrimp breeding stations
o	Singapore	2	fishery stations

- Brunei 1 freshwater fish station

Total 169

Many of the 169 stations are seriously constrained in their extension work by the lack of technical manpower and essential facilities.

TECHNICAL AQUACULTURE MANPOWER DEVELOPMENT

The present survey attempted to obtain a close estimate of the technical aquaculture human resources in the region. It is quite easy to estimate the number of aquaculturists in smaller countries such as Brunei, Nepal and Singapore, but extremely difficult in bigger countries such as India and China, especially when information is not readily available. Through the questionnaire returns personal communication with scientists, and existing literature, the present survey was able to obtain a very rough estimate human resources in fisheries in 15 developing nations in Asia. It is a common practice in most developing nations to use a fishery officer for a wide variety of fishery and aquaculture activities.

Aquaculture Manpower Resources

More than 15,600 scientific personnel are working in various fisheries institutions in the countries surveyed. The figure certainly represents the main bulk of the fishery scientists in the Asian region (Table 5). How many of these are actively involved in aquaculture work is not yet known. With the increasing focus on aquaculture in many developing nations, the number of fishery workers involved in aquaculture research, training and development is believed to be substantial.

In China alone, more than 98,500 personnel are involved in fishery activities. At least 8,200 fishery scientists are involved in research, training and extension work, while about 22,558 personnel do hatchery work. Many of these technical personnel do not have university degrees but have become aquaculturists through practical experience. Only about 14,400 college fishery graduates were produced in China from 1949 to 1983. Women in China participate actively in fishery and aquaculture activities. Over 22% of the aquaculture personnel in China are female professionals.

India also has a large number of professional and technical personnel involved in fisheries and aquaculture, although their total number is not yet available. Research institutions in India are found to be

adequately staffed with highly qualified scientific personnel (Table 5). In fact, India has the largest number of such personnel among the developing nations in Asia. More than 90% of the scientists in research institutions, e.g., Central Inland Fisheries Research Institute and Central Marine Fisheries Research Institute, are university or college graduates and almost half have masteral doctoral degrees.

A similar pattern can be seen in other research and training institutions in Bangladesh and Pakistan. In contrast, however, highly qualified professional and technical fishery personnel are relatively scarce in many fishery agencies in ASEAN countries. Most of them end up in research institutions and the universities.

Manpower development

About a decade ago, there were no appropriate institutions in developing nations in Asia conducting aquaculture training for college graduates. It is therefore not surprising that many of those who landed jobs in aquaculture research, extension and training have not had basic training in aquaculture science.

Degree training

In the early 1970s, few colleges and universities offered aquaculture as part of their fishery curriculum, but during the last 10 years, many have started developing it as a specialized field. Aquaculture is now becoming a popular subject in many institutions in the Philippines, Thailand, China and India, and many more universities are offering aquaculture in their degree training programs.

Despite the interest and enthusiasm that aquaculture training has been generating, well organized aquaculture programs with a practical hands-on aspect are still limited. Universities that offer a Bachelor's or Master's degree in aquaculture are quite few. The five colleges in China (Table 6) do offer aquaculture training at the undergraduate level but focus mainly on freshwater aquaculture. The Shanghai Fisheries College which was recently upgraded as a fishery university offers a more well-rounded program covering a broader area of aquaculture science. Aquaculture forms a substantial part of a fishery degree course at Kasetsart University in Thailand, University of the Philippines in the Visayas and Central Luzon State University in the Philippines, University of Agriculture in Malaysia and Central Institute of Fisheries Education in India. In some universities, aquaculture is briefly covered as a lecture topic or a special subject within fishery, applied biology, aquatic biology or zoology courses.

The following postgraduate degree courses on aquaculture have recently been developed in universities and institutions in the Philippines, India and Thailand:

1. Master of Aquaculture - offered by the College of Fisheries, University of the Philippines in the Visayas since 1980; this one-year course was organized in collaboration with the SEAFDEC Aquaculture Department and FAO through the Network of Aquaculture Centres in Asia (NACA) (ADCP 1980).

2. Master of Science in Aquaculture - offered by the Asian Institute of Technolgy , beginning 1986 (AIT 1986).

3. Master of Science and Ph.D. in Mariculture - organized by the Center for Advanced studies, jointly conducted by the Central Marine Fisheries Research Institute (CMFRI) and the Kerala Agriculture University in Cochin (CMFRI n.d.).

Short-term training

Limited training opportunities at the college and university level could not meet the increasing need for technical skills in aquaculture especially pertaining to hatchery technology, culture systems and disease control. This situation and the need to transfer existing aquaculture technology to countries that are badly in need of them have resulted in the conduct of short-term, ad hoc specialized training courses for technicians.

National training courses were organized by national aquaculture agencies to cater to specific needs of the countries. Some countries such as China, Philippines, Thailand and India have organized short-term national and regional training courses on their areas of specialty. These activities have contributed significantly to the transfer of aquaculture technologies to many developing nations in the region. The regional training course on integrated fish farming offered by China in the 1970's at the Pearl River Fisheries Research Institute and later at the Asian Pacific Research and Training Center for Integrated Fish Farming at Wuxi in the 1980's has done a lot to develop integrated fish farming in many developing nations in Asia. The induced spawning technology for Indian major carps and composite fish farming in undrainable ponds, which have been the subject of training courses at both national and regional levels, have greatly contributed to the increase in pond yield throughout South Asia (Natarajan, 1984; Thakur, 1984). The regional training courses in shrimp hatchery, sea-bass culture, and cage culture organized by the Department of Fisheries in Thailand, the SEAFDEC Aquaculture Department in the Philippines, and FAO have all greatly facilitated the transfer of farming technologies throughout Southeast Asia.

In short, the numerous short-term training courses have indeed created a remarkable impact on fish farming in the region. Two international agencies, in particular, have made important achievements in developing aquaculture training courses in the region. The SEAFDEC Aquaculture Department has so far provided training for more than 6,207 technicians all over the world (SEAFDEC 1984, 1986). The FAO, through its numerous regional projects such as the South China Sea Programme, Bay of Bengal Program, and the Network of Aquaculture Centres in Asia, substantially improved the transfer of aquaculture technology to benefit a large number of small farmers in the region through training of aquaculture technicians and managers.

Technical Skills Requirement

The types of aquaculture systems and level of operation needed for the region largely depend on the aquaculture development priority, the socioeconomic conditions, and the availability of technical skills in the country concerned (ADCP, 1976; Pillay, 1977; 1979). The nature and level of manpower needed will also differ considerably between "aquaculturally developing nations" and "aquaculturally developed nations".

Hatchery Operation and Management

A major constraint to aquaculture development is still the insufficiency of seeds to meet the growing demands during the expansion of fish farms. Despite success in artificial propagation of Chinese and Indian major carps sea bass *(Lates)*, walking and river catfish *(Clarias* and *Pangasius)* , siganids *(Siganus)*, milkfish *(Chanos chanos)*, mullets *(Mugil)* as well as a number of shrimp species, *(Penaeidae)*, prawns *(Macrobrachium)* and mollusks, oysters, mussels, many fish farms are still constrained by seed shortage.

Existing hatchery techniques depend much on the experience and dedication of hatchery operators and there are not many in the region with hands-on experience. The situation is even more acute in countries where there are no traditional fish farming practices. Hatchery technologies for most species are far from perfect and need considerable technological modification and refinement. Some countries such as Malaysia, Bangladesh, Sri Lanka and Pakistan resort to importing hatchery technicians or experts from Taiwan, Thailand, Japan, the Philippines or other western nations, to establish and run hatchery operations. Some cases were very successful but most cases, especially, the larger farms oftentimes only ended up in debts.

The only key to the solution of fry supply shortage is the strengthening of the national capability in hatchery operation and management and the stepping up of scientific research to improve hatchery technology for different species commodities of crustaceans, finfish and mollusks. China, for example, has almost achieved self-sufficiency in Chinese carp fry and fingerling production. Almost all fish farms in the Yangtze River and Pearl River basins are using hatchery bred fry instead of those from the wild (FAO, 1983).

Modern Aquaculture Technology

Traditional fish farming practices have evolved over years of modification and refinement by experienced fish farmers and through scientific research, into modern aquaculture technology that improves yields, augments production and increases the rate of economic returns. Well-organized fish farms have impressive yields because of efficient operational management and modern technology. However, there are still large areas of fishponds being inadequately managed and usually producing below the national average. The application of modern technology to revolutionalize the aquaculture industry is unquestionably a requisite in fish farming development. On this score, China has demonstrated great success (FAO, 1983).

Modern technology in fish farming makes use of scientific inputs in terms of feeds, techniques, aerators, etc., to increase production per unit area. Sound farm management is essential to ensure economic viability and increase profitability

Adequately trained aquaculture technicians are very much needed to be able to apply scientific methods in fish farming. Technicians with skills in the following technical areas will be most useful:

- aquaculture system - operation and management
- feed technology
- disease and control
- intensive farm management.

In tropical Asia, the following culture systems are appropriate and widely used: cages, ponds, pens, and rafts. The commodities most preferred are various carps, tilapias, catfish, mudfish, sea bass, milkfish, mullets, groupers, shrimps, *Macrobrachium* prawns, oysters, mussels and cockles (Bardach, 1972, Brown, 1983). Hence, technical skills in farming these are essential.

Discipline Specialists

Aquaculture development is also being geared towards intensification of farming operations (ADCP 1976). This especially occurs in situations where labor and land/space are expensive and highly technical skills are available. Associated with intensive aquafarming systems are problems of disease control and treatment, water and feed quality and quality of fish seeds, all of which require discipline specialists especially in fish diseases, feed technology, water management, fish genetics, economics, marketing and aquabusiness management. These areas are very weak in the region and are identified as important disciplines on which training should be focussed to supply the necessary technical manpower.

Planning and Management Specialists

The long gestation period taken in aquaculture development is primarily due to the lack of economic and political pressure to utilize aquafarming for rural development. Public awareness has now been created and many developing countries have turned to aquaculture as one priority area for rural development. This has sometimes caused the large-scale removal of mangrove forests to make way for the farming of shrimps and finfish, the conversion of rice fields for fish culture, the clustering of lakes and lagoons with cages and fishpens. The numerous failures recently experienced in large aquaculture ventures in many countries such as the social unrest caused by resource use conflict in Laguna de Bay in the Philippines, are some examples of lack of adequate planning and efficient management of resources.

Aquaculture planning is important to nations conscious about conservation of their natural resources to ensure sustained utilization. Also essential are aquaculture managers who know sound scientific and business principles. But since the region has a dearth of personnel with sufficient broad-based training needed for planning, executing aquaculture development programs or managing aquafarms, the Network of Aquaculture Centres in Asia decided to establish training courses to train senior aquaculturists in these specific aspects.

Aquaculture Training Requirements

A number of proposed training courses fall under the three main areas identified earlier under "Technical skills Requirements". These courses are listed below.

Aquaculture planning and management

- Broad-based, multidisclipnary training course for senior aquaculturists
- Refresher course for administrators and senior officials

Hatchery operation and management

- Shrimp training and hatchery operation
- Hatchery management of finfish

Modern farming technology

- Mollusk culture
- Brackishwater fish culture in ponds
- Cage and pen culture

Specialized areas

- Fish nutrition and feed technology
- Fish disease
- Aquaculture engineering
- Fish genetics

The number of slots requested by each agency/government reflects the level and nature of aquaculture training requirements. The requested slots are summarized in Table 6.

Senior-level, broad-based, multidisciplinary aquaculture training (one year duration, Master's degree)

The purpose of the training course is to provide senior government officials and persons who are or will be engaged in aquaculture planning and development programs with a broad exposure to various aspects of aquaculture. The training also aims to equip the participants with knowledge of modern concepts in aquaculture science and with opportunities for full practical experience.

The NACA Senior Aquaculturists Training Course is especially designed to meet the above objectives. So far about 100 graduates have been produced over the last five years. Many of the graduates

are assuming leadership roles in their own countries. The course is well designed and skillfully executed. One unique feature of the course is the two-month practical training in China, India, Philippines and Thailand which gives the trainees an exposure to various aquaculture practices and methods of operation and management in the region. The University of the Philippines in the Visayas (UPV) runs a similar course for its own graduates although it collaborates with NACA in offering a Master's degree to those NACA participants registered at UPV.

A slightly similar training course was opened by the Asian Institute of Technology in 1986. It is also a one-year postgraduate program but with a much more restricted scope than the NACA course.

As far as the writer is aware, there is no other training course in any part of the world that is comparable in scope and practical exposure to that designed and conducted by NACA.

Although NACA has already produced 100 graduates, the region is still in need of some 300 or more to meet development requirements.

Refresher course for administrators and senior officials

Most countries surveyed have expressed the need to conduct refresher courses for administrators and senior officials to expose them to the latest advances in aquaculture technology. Field visits coupled with round-table discussions on relevant issues pertaining to aquaculture development and management are appropriate activities for such refresher courses.

Shrimp hatchery operation and management

Many developing nations especially in the tropical and subtropical regions have invested heavily in the forming of shrimps (*Penaeus* spp) and prawns (*Macrobrachium*) primarily for the lucrative export markets. Shrimps and prawns remain to be the main target aquafarming commodity for private investment. A multi-million dollar aquaculture infrastructure comprising thousands of hectares of brackishwater ponds has been developed in Southeast Asia. Small and medium-sized shrimp farms have also been mushrooming in recent years especially in Malaysia, Thailand, Philippines and Indonesia. However, a major constraint is, again, the unsteady supply of seeds. Many big operators overcome this problem by establishing their own shrimp/prawn hatcheries, but then, experienced hatchery technicians are scarce, while the demand is high. A lot of the medium- and large-scale operators have thus resorted to importing hatchery technicians from

Thailand, Taiwan and the Philippines and have had to pay exorbitant salaries which added further to the already heavy investment.

The Asian Development Bank has provided loans for developing shrimp farming in the Philippines, Bangladesh, Sri Lanka, Thailand, Pakistan, Burma and Indonesia. The demand for shrimp fry should be expected to rise even more.

Considering the world's projected additional demand of 200,000 tonnes by 1990 which is expected to be met through shrimp farming, the prospect for shrimp hatchery development is undoubtedly promising while the demand of shrimp technicians is indeed going to be very great. At least an additional 6.7 billion fry will be required considering the traditional farming methods of stocking at one fry per square meter. This will in turn need at least 1,333 small-scale hatcheries with a capacity of 5 million postlarvae annually. The number of hatcheries rquired will be correspondingly reduced with increasing hatchery capacity. If three technicians are required to handle one small-scale hatchery, the number of hatchery technicians needed for producing the required amount of shrimp fry is estimated to be about 4,000. As many countries are expanding or developing shrimp farming, the demand for shrimp technicians will most likely be far greated than the estimated figure.

Hatchery management for finfish

Hatchery technology for production of fry and fingerlings for the Chinese and Indian carps is now available. While China has developed an efficient hatchery technology to produce billions of carp fry and fingerlings for her own need, fry shortage is still the problem in many northern provinces. Similarly, although hatchery production of the Indian major carps has been developed in India for more than two decades now, almost half of the country's fry and fingerling requirements depend on wild collections. Many countries in Southeast Asia are still importing the Chinese carp fry from Hong Kong, China and Taiwan. Hence, there are ample reasons to justify the development of hatchery manpower capability.

As the target species found in the region somewhat vary from country to country, hatchery management for different species of finfish is necessary. In Southeast Asia, hatchery management technology for sea bass, groupers, milkfish, siganids, catfish and red tilapia is a priority consideration. In China, mullet is a preferred target commodity.

Integrated fish farming

An increasing number of countries in Asia have adopted integrated fish farming in the development of their rural economy. The system has been efficiently applied in Chinese agriculture to effectively utilize organic waste from animals for fish production. Almost 90% of fish farming practices in China are integrated either with crop production or animal husbandry or both.

The Asian Pacific Training and Research Center for Integrated Fish Farming in Wuxi, China has been running a 4-month training course since 1981. The course coverage is comprehensive and includes the polyculture of Chinese carps; breeding and fingerling production; integration with cash crops, poultry, pigs, cattle and other domesticated animals. The training course is well-received and has contributed significantly in the transfer of the Chinese system of integrated fishfarming to developing nations in Asia. The demand for such a training course is still very high (Table 7).

Brackishwater fish farming in ponds

Pond cultivation of brackishwater finfish and crustaceans such as shrimps, milkfish, mullets and sea bass is very popular in number of Asian nations. Expansion of aquaculture industry is expected to intensify fish culture operation in existing brackishwater ponds, which abound in Indonesia and the Philippines, for culture of the milkfish and shrimps. Other countries in the region are also opening up brackishwater swamps for shrimps (most countries), milkfish (Sri Lanka), mullets (China) and sea bass (Thailand and Philippines). Modern pond farming technology for brackishwater finfish and shrimps will certainly help in promoting yields and increasing income. The demand for such training course comes mainly from India, Indonesia, Malaysia and China (Table 7).

Cage and pen culture

Cage culture technology was developed in the 1960's but became popular only in the 1970's and 1980's. In fact, cage culture has been shown to be viable and productive as an aquafarming system in lakes, reservoirs, lagoons, bays and even in open coasts. Apart from the farming of some filter feeding fish such as silver and bighead carp, rohu and catla, which do not require supplementary feeding in eutrophic lakes and reservoirs are also cultured. Cages are often used for carnivorous or omnivorous species especiallly for groupers, sea bass, siganids (Thailand, Malaysia), grass carp (China), tilapia (Philippines) and common carp (Indonesia).

Pen culture on the other hand, is exclusively developed and extensively applied in the Philippines. Countries with shallow lakes and lagoons are adopting the pen system to increase lake productivity.

Training requirements are, however, still needed in the region to promote efficient utilization of the farming system which poses the least conflicts with other competitors for water and land resources utilization.

Mollusc culture and product management

Oyster and mussels have been traditionally cultivated in East and Southeast Asia using the traditional poles or stakes methods as well as the bottom culture method. The development of raft and long line methods enable

shellfish growers to expand the culture site beyond the shallow water close to the coast. The method is easily adaptable. The product, however, often faces the threat of organic or heavy metal contamination. Depuration has become a process closely associated with shellfish farming to ensure safety for human consumption and quality control for export.

Many species of molluscs are popular food items in East and Southeast Asia but are seldom consumed in most South Asian countries despite widespread malnutrition in many of the countries in the region. Mollusc farming has hardly reached a commercial scale. While much needs to be done to alter consumers' preferences through public education, it is timely to acquire the necessary farming technology to prepare for molllusc farming once domestic demand has increased.

Fish nutrition and feed technology

Future trends of aquaculture are towards intensification of culture operation to increase yield. Fish feed is one of the basic inputs. Knowledge of feed technology in developing appropriate feeds based on fish nutritional requirement is a very essential part of modern aquafarming.

FAO has conducted a few training courses in the past years on fish feed technology but the number of technicians trained is limited. Feed technologists are even more essential in larger fish farms where feeds using local ingredients can be economically prepared.

Fish disease and control

Knowledge of fish diseases and their control and prevention is critical in ensuring target production according to schedule. Disease outbreak is more common in an intensive farming system. The outbreak of fish disease in Thailand in late 1982 and early 1983 which wiped out large quantities of the culture finfish in ponds had caught Thai scientists unprepared. Lacking the means to control it has resulted in the loss of several millions of dollars. Technical skills to prevent and subsequently control diseases are important skills that large fishfarms may be able to provide. Monitoring water quality and providing preventive measures to avoid disease outbreak are the primary functions of public agencies. Hence, disease monitoring laboratories and enough fish pathologists are much needed in the country. Apart from some of the bigger countries, many developing nations do not have trained fish pathologists or technicians who are able to assist in preventing, and if necessary, combating an outbreak.

Aquaculture engineering

This is a subject area that has been ignored in the past. Aquaculture facilities require significant inputs in systems design and construction, which most civil or structural engineers are not familiar with. Most of them know little about aquaculture and, therefore, fail to understand the biological needs of the target species.

Over the years, a new discipline called aquaculture engineering has evolved, covering systems design, construction, operation, site selection, etc., and utilizing engineering knowledge in other freshwater or brackishwater aquaculture practices. Fortunately, training in aquaculture engineering was popularly received. One of the training courses organized a few years ago was an FAO-sponsored freshwater aquaculture training course in Hungary.

Fish genetics

The role of fish hybridization in aquaculture development is gaining more and more importance. New hybrids and genetical strains have been developed in recent years and have been augmenting yields and profitability. The red tilapia is one result of such a research effort. Regional capability in biotechnical research especially among developing nations needs to be strengthened so that they may have sufficient technical manpower to develop new strains of genetic hybrids and established aquaculture cloning technology. Needed skills should be acquired from developed nations.

AQUACULTURE TRAINING FACILITIES

There are adequate aquaculture training facilities in Asia to cater to regional training activities. Excellent facilities are available in a number of national/regional institutions. Their field and laboratory facilities are adequate to train aquaculture personnel for the region. These institutions include the following:

1. SEAFDEC Aquaculture Department, Philippines - (most aspects of brackishwater and freshwater aquaculture training)

2. Freshwater Aquaculture Center, Central Luzon State University, Philippines - (freshwater aquaculture, tilapia)

3. Brackishwater Aquaculture Center, University of the Philippines in the Visayas, Philippines - (pond culture, milkfish, sea bass)

4. National Inland Fisheries Institute (NIFI), Thailand - (freshwater aquaculture, *Clarias*, *Chana*, *Pangasius*)

5. Chachoengsao Fishery Station, Thailand - (*Macrobrachium*)

6. National Institute for Coastal Aquaculture (NICA), Thailand - (shrimp, sea bass, cage culture)

7. Asian Institute of Technology, Thailand - (Postgraduate Masteral degree course on aquaculture)

8. Central Institute for Fisheries Education (CIFE), India - (general freshwater aquaculture training, Indian major carps)

9. Freshwater Aquaculture Training and Research Center, Dhauli, India - (composite fish culture, hatchery for Indian major carps)

10. Central Marine Fisheries Research Institute, Cochin, India - (Postgraduate degree on mariculture)

11. Shanghai Fisheries University, Shanghai, China - (freshwater aquaculture)

12. Asian Pacific Training and Research Center for Integrated Fish Farming, Wuxi, China - (breeding of Chinese carps, integrated fish farming)

Many have likewise upgraded the infrastructure of their fishery stations or established new training and demonstration centers for national aquaculture training and extension activities. Many of these national centers have elaborate pond and laboratory facilities, dormitory and lecture rooms and libraries. A few of this institutions are new but some are established stations. These stations together with the above institutions play a prominent role in developing the necessary aquaculture manpower requirement in the Asian region.

ROLE OF EDUCATION/TRAINING INSTITUTIONS IN AQUACULTURE MANPOWER DEVELOPMENT

Aquaculture was seldom included in the curriculum of most academic institutions in Asia prior to the Second World War. In the 1950's and 1960's aquaculture began to gain increasing attention. It was taught as a subject under the general course such as applied biology, fisheries, or biology. In professional schools, aquaculture was increasingly emphasized. The 1970's saw the accelerated development of the aquafarming industry in many developing nations. Specialized training courses were organized by

international institutions such as FAO to provide technical training to fishery workers involved in aquaculture extension activities. Despite FAO efforts, the inadequacy of appropriate aquaculture technicians and aquafarming managers has constantly remained one of the main constraints in the expansion of the industry.

Japan has taken the leading role in aquaculture research and training as early as the 1960's and has trained a number of fishery scientists in the field.

Not until the late 1970s had tertiary institutions incorporated aquaculture as a specialized course. Some fishery oriented universities established aquaculture department which since then placed greater focus on aquaculture as a professional field. Universities that established aquaculture departments include Kasetsart University (Thailand); Agricultural University (Malaysia); Shanghai Fisheries University (China); Xiamen, Dalian, Changjiang and Zhejiang Fisheries Colleges (China); and University of Brawijaya (Indonesia).

The educational institutions have indeed played a crucial role in producing aquaculture personnel for the region. The present survey was not able to determine the actual number of aquaculture graduates produced by the various institutions, although the number is comparatively small. The University of the Philippines in the Visayas, in collaboration with the SEAFDEC Aquaculture Department and NACA, has produced considerable number of post-graduates from 20 countries since 1981. The university is currently producing about 20 to 15 graduates per year. The five fisheries colleges in China are estimated to have produced about 14,400 fishery graduates from 1949 to 1983, a large number of whom have specialized in aquaculture. The 54 fisheries colleges in the Philippines are estimated to have produced about 7,000 graduates, many of whom have received varying levels of aquaculture training. However, a great number of these university/college graduates were not able to be of immediate use to the industry.

A common complaint of the industry against college graduates is the lack of:

- hands-on practical experience in aquaculture practices,
- management capability, and
- exposure to various aspects of practical aquaculture.

Basically the industry requires aquaculture technicians who can produce at the hatchery and farm levels. They also need farm managers who can manage inputs to ensure production and profitability. The government requires trained personnel who can help develop realistic and feasible aquaculture development plans and execute them.

The inability of educational institutions to produce the expected quality of trainees and graduates for the aquafarming industry is due to varied reasons. The prominent ones are:

- poor design of course curriculum
- lack of proper field facilities
- inappropriate instructors
- funding constraints

A well designed curriculum is essential to ensure the expected product quality. Most aquaculture curricula lack the integration of various related disciplines and contain too many biology courses. Inadequate field facilities such as ponds or demonstration farms coupled with inadequate funding support limit aquaculture training in many colleges and universities to a more theoretical approach instead of a heavy practical orientation.

Most university instructors have had little or no practical exposure to or training in aquaculture. Such technical limitation on the part of the instructors restricts the interdisciplinary, practical approach to aquaculture training.

Although more and more regional aquaculture training activities have been organized utilizing experienced aquaculturists and consultants to help in filling up the current technical manpower gap in the region, the primary role of supplying the technical personnel for the expansion and sustenance of the industry still belongs to the educational institutions. The needs, therefore, is to strengthen already existing aquaculture training programs. There is no doubt of the need to review existing course curricula at the undergraduate and postgraduate levels so that the courses can be tailored to produce practical aquaculturists and aquaculture managers instead of the standard academic exercise. Field facilities are an important prerequisite for effective implementation of the training program.

EXTERNAL ASSISTANCE FOR AQUACULTURE MANPOWER DEVELOPMENT

External assistance for aquaculture development has increased since 1978 (Table 8). A substantial amount was earmarked for developing nations in Asia (Josupeit 1984).

Over the last decade, external assistance for aquaculture development has placed considerable emphasis on manpower development (Csavas 1985). ADB provides substantial loans for training technical

and administrative personnel; the same is true for the World Bank. The role of FAO in manpower development in the region is initiating aquaculture training courses at vocational and postgraduate levels through many of its in-country and regional aquaculture and fishery projects. The International Development Research Center (IDRC) has provided training fellowships for national staff to upgrade their technical capability and academic qualifications. Aquaculture is one of its priority areas. Other donor agencies such as CIDA, Commonwealth Secretariat, JICA, etc., are providing fellowships to enable aquaculture staff in the developing nations to participate in aquaculture training in the region or in other parts of the world.

CONCLUSION AND RECOMMENDATIONS

Aquaculture is a high-priority area in the rural and economic development efforts of many Asian nations. The industry has now passed its long gestation period and is at a stage of rapid growth, urgently requiring appropriate manpower to manage and sustain this growth.

Existing educational institutions in the region are yet to develop their capability to produce the technicians needed by the industry and to improve their course curricula and training approach. The industry still needs to solve the problem of lack of adequate field facilities and experienced instructors, and in some nations, adequate funding support and well-designed education curricula.

The availability of qualified manpower is very important in demonstrating the commercial viability of aquaculture technologies and in minimizing investment failures due to human incompetence. National efforts and external assistance in organizing and supporting aquaculture training in Asia are essential to ensure effective implementation of carefully formulated training courses. The role of national training institutions is expected to move towards this direction. The aquaculture training facilities, which the region already has, should be properly and effectively utilized through regional cooperation in order to speed up technical manpower development.

Research and extension services have not been keeping pace with the expansion of the aquafarming industry. Lack of well-defined and articulated research directions and effective extension programs is a major reason. Too much emphasis on applied research and lack of emphasis on basic problems and information gaps pertaining to culture systems or biological requirements of culture species are also some of the aggravating factors. Extension services need to be improved in terms of appropriate technical advice, demonstrations, feeds and seed supply, market outlets, etc., to help solve the problem of poor farm design and low yield.

In the light of the above constraints in aquaculture, the following are recommended:

1. More effort should be directed towards developing appropriate technical aquaculture manpower to respond to the needs of the expanding industry.

   Existing postgraduate aquaculture training curricula in academic institutions should be strengthened as a long-term resource for generation of technical manpower for the growing industry. A comprehensive review of different aquaculture curricula in Asia will be very useful and timely in providing the appropriate training framework and direction.

   Research and extension efforts and directions should be intensified to generate and extend information on aquafarming technologies. The capability to undertake strategic and even basic research in resolving technology inadequacies needs to be developed. More capable research and extension personnel should be produced.

2. A comprehensive survey of the aquaculture manpower requirements of the region must be undertaken at the national level. The survey should cover human resource needs for research, training and extension.

3. Training courses specifically for aquaculture planners and managers, hatchery technicians, extension workers, professional fish farm operators and discipline specialists have to be organized to support the aquafarming industry.

4. Extension service should be geared towards modernising the aquaculture industry. Fish farmers can acquire professional skills and capabilities if they are taught scientific principles in fish farming practices.

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to the International Development Research Center (IDRC) of Canada for partial support in this preliminary survey of the aquaculture training needs of developing nations in Asia. The survey was conducted while the author was in active service with the

Network of Aquaculture Centres in Asia of FAO. The editorial of Mr. J. Maclean of the International Center for Living Aquatic Resource Management (ICLARM) is acknowledged.

References

ADB (Asian Development Bank). 1983. Appraisal of the Aquaculture Development Project in the Philippines. Report No. PHI: Ap-64. 104p.

ADB. 1983. Appraisal of the Aquaculture Development Project in Sri Lanka. Report No. SRI: Ap-29. 103p.

ADB. 1982. Appraisal of the brackishwater aquaculture development in the Republic of Indonesia. Report No. INO: Ap-78. 114 p.

ADB. 1980. Appraisal of the Sumatra Fisheries Development Project in thr Republic of Indonesia. Report No. INO: Ap-57. 132p.

ADB. 1980. Appraisal of the Aquaculture Development Project in Nepal, Report No. NEP: Ap-23. 115p.

ADB. 1980. Appraisal of the Inland Fisheries Development Project in the Socialist Republic of the Union of Burma. Report No. BUR: Ap-15. 120p.

ADB. 1979. Appraisal of the Aquaculture Development Project in Pakistan. Report No. PAK: Ap-29. 88p.

ADB. 1978. Appraisal of the Laguna de Bay Fish Pen Development Project in the Republic of the Philippines. Report No. PHI: Ap-35. 87p.

ADB. 1978. Appraisal of the Aquaculture Development Project in the Kingdom of Thailand. Report No. THA: Ap-20. 90p.

ADB. 1978. Appraisal of the Second Fisheries Development Project in the Socialist Republic of the Union of Burma. Report No. BUR: Ap-9. 131p.

ADB. 1977. Appraisal of the Aquaculture Development Project in the People's Republic of Bangladesh. Report No. BAN: Ap-17. 116p.

ADCP. 1976. Aquaculture Training in Asia-Report of the Regional Workshop on Aquaculture Planning in Asia, Bangkok, Thailand, 1-17 October 1975. FAO Rome, Italy. 154p.

ADCP. 1980. Curriculum for the training of aquaculturists in the Asian Aquaculture Network. ADCP/RFP/80/13. FAO, Rome. 35p.

AIT. 1986. Aquaculture training in Asia. Brochure of Asian Institute of Technology, Bangkok, Thailand.

Aminul Haque, A.K.M. 1984. Agricultural education in Bangladesh: Current thinking in curriculum development. Expert consultation conference of the Asian Association of Agricultural Colleges and Universities (AAACu) in collaboration with UNESCO, Manila, 9-13 July 1984. 17p.

Anon. 1985. Report on aquaculture conference, Malaysia, 9-12 December 1985. Published by Fisheries Department, Malaysia, 72p.

Anon. 1984. Report of the working group on fisheries for formulation of Seventh 5-year plan (1985-1990). Ministry of Agriculture (Department of Agriculture & Cooperation), Krishi Bahan, New Delhi. 152p.

Anon. 1981. (Mimeo). An introduction to Krishi (Fisheries) Vigyan Kendra and Trainer's Training Centre, Kausalyagang, Dist. Puri, Orissa. FAO/UNDP Course for Aquaculturists in Asia and the Pacific at the Lead Centre (RAS/76/003), FARTC, Dhauli and other establishments of CIFRI, Barrackpore from 27 Sept. to 24 Oct. 1981.

Anon. 1979. National Inland Fisheries Institute. Thailand. Inaugural Report 1976-1978. Produced under the auspices of the Freshwater Fisheries Division, Department of Fisheries, Ministry of Agriculture and Cooperatives. Royal Thai Government. Bangkok, Thailand.

Bardach, J.E., J.H. Ryther and W.O. McLarney. 1972. Aquaculture: The farming and husbandry of freshwater and marine organisms. Wiley InterScience.

BFAR. 1981. Annual Report 1981. Bureau of Fisheries and Aquatic Resources. 860 Quezon Avenue, Quezon City, Metro Manila, Philippines.

Bicol University. 1982. Assessment of the fisheries manpower supply and demand in the Philippines. Report of the Educational Development Project's Implementing Task Force (EDPITAF), Ministry of Education, Culture and Sports. 258p.

Brown, E. Evan. 1983. World fish farming: Cultivation and economics. Avi Publishing Company, Inc., Westpost, Connecticut, U.S.A.

CIFE. n.d. Education, research and training programmes. Central Institute of Fisheries Education (CIFE), brochure.

CMFRI. n.d. Centre of Advanced Studies in Mariculture- Progress report for the period June 1979-December 1984. Central Marine Fisheries Research Institute (CMFRI), Cochin, India.

Carroz, J.E. 1984. World fisheries face changes and challenges. Mazingira 8(3): 17-23.

Chakrabarty, R.D. 1983. Fish production in ponds under the subsidy programme in Sri Lanka. J. Inland Fish., Vol. 2:107-111.

Csavas, Imre. 1985. Problems of inland fisheries and aquaculture. IPFS Symposium resource paper. 36p.

Department of Fisheries. 1984. Department of Fisheries: Organization, personnel, budget. FAP/WAP-13. Fisheries Advisor Project DOF/CIDA (906/08201) Thailand. Department of Fisheries, Bangkok, Thailand.

FAO. 1973. Directory of Fishery Training Institutions. FAO Fish. Tech. Paper (129): 202 p.

FAO. 1976. International Directory of Fish Technology Institute. FAO Fish. Tech. Paper (152): 124 p.

FAO. 1983. Special problems of inland fisheries and aquaculture. Committee on Fisheries (COFI), 15th Session, Rome, 10-19 October 1983. WFI/83/8. FAO, Rome, Italy.

FAO. 1984. Report of the FAO World Conference on Fisheries Management and Development. Conference held in Rome, 27 June to 6 July 1984. Food and Agriculture Organization of the United Nations, Rome.

FAO. 1985. Review of the state of the world fishery resources. FAO Fish. Circ. (710) Rev. 4:61p.

FAO/RAPA. 1986. Directory of Marine Fisheries Training and Education Institutions in Countries Bordering the Bay of Bengal. RAPA Publication: 1986/8: 53 p.

Huisman, E.A. 1984. The possible role of aquaculture in transmigration in Indonesia. International Jounral for Development Technology 2:55-64.

Jhingran, V.G., V.R.P. Sinha and M. Sinha. 1980. Trends in development of present day aquaculture in India and their socio-economic impact. Tropical Ecology and Development. 1209-1218.

Josupeit, H. 1984. A survey of external assistance of the fisheries sector in developing countries. 1978 to 1984.

Natarajan, A.V. 1984. Overview of CIFRI's contribution to research, training and transfer of technology in fish and brackishwater aquaculture and management of natural fishes. *In*: Souvenir, Fourth Advisory Committee Meeting of NACA (FAO/UNDP Project) 3-6 December 1984. Bhubaneswar, Orissa, India. Central Inland Fisheries Research Institute (Indian Council of Agricultural Research), Barrackpore, West Bengal, India, p.1-18.

Pillay, T.V.R. 1981. State of aquaculture 1981. Paper presented at the World Conference in Aquaculture and International Aquaculture Trade Show, Venice, 21-25 September 1981. Organized by the World Mariculture Society.

Pillay, T.V.R. 1979. Status of aquaculture 1976. *In*: Advances in aquaculture, P:1-9. T.V.R. Pillay and Wm. A. Dill, editors. Fishing News Books Ltd. London.

Pillay, T.V.R. 1978. Progress of aquaculture. *In*: Ocean Yearbook 1, (ed.) E.M. Borgese and N. Ginsburg. University of Chicago Press, London.

Pillay, T.V.R. 1977. Planning of aquaculture development. Fishing News Books Ltd. London.

Pillay, T.V.R. 1973. The role of aquaculture in fishery development and management. Technical conference on fishery management and development. Vancouver, Canada. 13-23 February 1973. Fi:FMD/73/3-47. 24p.

RAPA. 1985. Agriculture in Asia-Pacific region-A pictorial profile. RAPA Monograph 1985/8. Regional Office for Asia and Pacific Region. FAO, Bangkok. 133p.

Rabanal, H.R. 1984. Management of aquaculture fisheries. Third lecture series in honor of Dr. Hilario A. Roxas. Sponsored by the Alphi Chi Chapter, Phi Sigma Biological Honor Society. University of the Philippines, Diliman, Quezon City, Philippines, 17 December 1984. 17p.

Rabanal, H.R. and R.O. Juliano. 1979. Aquaculture extension: How it could be a potent force in fisheries development in the ASEAN region. Paper presented at the ASEAN Seminar/Workshop on Fisheries Extension on February 20, 1979 at the Tropical Palace Hotel, Paranaque, Metro

Manila, Philippines. South China Sea Fisheries Development and Coordinating Programme. 11p.

SEAFDEC. 1986. SEAFDEC Aquaculture Department: A review of the years 1973-1985. Aquaculture Department, Southeast Asian Fisheries Development Center, Iloilo, Philippines, 160p.

SEAFDEC. 1984. Annual Report. Aquaculture Department, Southeast Asian Fisheries Development Center, Iloilo, Philippines.

Sfeiner-Younis, Alfredo and G. Donaldson. 1982. Fishery sector policy paper. The International Bank for Reconstruction and Development. The World Bank, U.S.A., 79p.

Shang, Y. C. 1986. Coastal aquaculture development in selected Asian countries: Status, potential and constraints. FAO Fish. Circ. (799):63p. FAO Rome, Italy.

Thakur, N.K. 1984. Role of KVK & TTC in transfer of technology of carp farming. *In*: Souvenir, Fourth Advisory Committee Meeting of NACA (FAO/UNDP Project) 3-6 December 1984. Bhubaneswar, Orissa, India. Central Inland Fisheries Research Institute (Indian Council of Agricultural Research), Barrackpore, West Bengal, India, p. 91-98.

UNEP/FAO. 1984. Directory of marine environmental centres in East Asian Seas. UNEP Regional Sea Directories and Bibliographies. FAO, Rome. 138p.

UPV (University of the Philippines in the Visayas). n.d. Five Year Development Plan (1985-1989).

Von Brandt, A. 1983. The impact of energy shortage in the development of capture fisheries in the exclusive economic zone. Keynote address on the International Conference on Development and Management of Tropical Living Aquatic Resources, August 2-5, 1983. 26p.

Yen-Wu *et al.* (editors). 1984. Fishery economics of China (1949-1983). Agriculture Economics Institute of Political Science Academy of China. Ministry of Agriculture, Animal Husbandry and Fisheries. Fishery Economic Society of China. 1,767p. (In Chinese).

Zhang, Haifeng, Yu Xiaogun and Liu Hanhui (ed). 1984. A brief introduction to the Chinese Institutions of Ocean Science and Technology. China Ocean Press. 240p.

Table 1 Budget allocation for research and development

Institution	Country	Year	Fisheries budget (million)	Aquaculture budget (million)	Per Cent (%)
Directorate of Fisheries	Bangladesh	1984	TK506.825	TK 279.17	50
Central Inland Fish Research Institute	India	1984	Rs 19.747	Rs 14.492	73.4
Central Marine Fisheries Research Institute	India	1983	Rs 31.80	About 40%	40
Fisheries Development Division	Nepal	1985-90	Rs370.0	Rs 370.0	100
Directorate of Fisheries Sind Province	Pakistan	1984	Rs 19.0	Rs 14.0	73.7
Directorate of Fisheries Punjab Province	Pakistan	1984	Rs 35.963	Rs 35.963	100
Pakistan Agriculture Research Council	Pakistan	1984	Rs 1.04	Rs 1.04	100
Ministry of Fisheries	Sri Lanka	1984	Rs235.417	Rs 51.655	21.94
National Aquatic Resource Agency	Sri Lanka	1984	Rs 8.070	Rs 1.12	13.88
Zoology Department, Ruhuna University	Sri Lanka	1984	Rs 6.00	Rs 1.00	16
Fisheries Department	Brunei	1983	B$ 9.8	B$ 0.4	4
Fisheries Department[1]	Malaysia	1984	M$ 21.0	M$ 8.3	n. a.
National Inland Fisheries Institute	Thailand	1984	B 706.136	B 14.316	2
Freshwater Aquaculture Centre, CLSU	Philippines	1984	P 0.450	P 0.375	83
Aquaculture Department, SEAFDEC	Philippines	1984	-	US$ 3.58	100

(1) including all fisheries research and extension

n. a. = not available

Source: Based on returns of questionaires.

Table 2 Fish production target under 5-year development plan of Asian nations

Country	Development Plan	Aquaculture Production Target (year)	Per cent of total fish production
Thailand	6th 5-year plan (1987-1991)	378,000 (1991)	15.3 - 14.8%
China	5-year plan (1986-1990)	9.44 mmt (1990)	60%
Pakistan	6th 5-year plan (1984-1989)	66,000 mmt (1989)	15.4%
India	7th 5-year plan (1985-1990)	700,000 (1990)	
Sri Lanka	5-year plan (1979-1983)	35,530 (1983)	14.3%
Indonesia	4th 5-year plan (1984-1988)	450,000 (1988)	16.0%
Brunei	No computation.		
Burma	Not available.		
Nepal	7th 5-year plan (1985-1990)	7,710 (1990)	75%
Bangladesh	Not available.		
Philippines	5-year plan (1985-1990)	755,000 (1990)	29%
Malaysia	Not available.		

Table 3 List of priority species cultured in Asia

Commodity	Pond Culture	Cage Culture	Pen Culture	Integrated Farming	Off-bottom Culture	On-bottom Culture	Culure-based fishery	Intensification of cutlure systems	Expansion of Aquafarms
Shrimp (Penaeid)	All countries except Nepal	-	-	-	-	-	-	C/M/P/Ind/Sin/T/C(T)	All countries except Nepal, Sin, and HK
Prawns (Macrobrachium)		HK/M/P/ T/Sin	-	-	-	-	-	HK/M/P/T/Sin	
Grouper					-	-	-	M/T/Sin	M/T/P
Seabass	T/P	M/T/Sin	-	-	-	-	C	C/HK	C
Chinese carps	C/N/SL	-	C	C/HK	-	-	-	Ind	Ind
Common Carps	Ind	Ind	-	Ind	-	-	In/Ba/Pa/SL		In/Ba/Pak/SL
Indian Carps	In/Ba/Bu/ N/Pa/SL	-	-	In	-	-	SL/P	P/C/C(T)	SL/P/C
Tilapia	SL/C/P	P	-	C	-	-	P	C(T)/P	P/in
Milkfish	P/C(T)/ Ind/SL	-	P	-	-	-	-	-	C
Mullets	C	-	-	-	-	-	-	-	T/M
Trichogaster	T/M	-	-	T/M	-	-	-	C/C(T)	-
Eels	C(T)/C	-	-	-	-	M/T/Ind	-	-	M/T/Ind
Cockles	-	-	-	-	P/T/Sin	-	-	-	P/T
Mussels	-	-	-	-	P/T/E	-	-	-	P/1/C
Oysters	-	-	-	-	C	-	-	-	C
Prophyra	-	-	-	-	-	P/M/Ind	-	-	P/M/Ind
Eucheuma	-	-	-	-					

Bangladesh = Ba
Burma = Bu
Brunei = Br
China = C
China (Taiwan) = C(T)
Hong Kong = HK
Malaysia = M
Nepal = N
Philippines = P
Indonesia = Ind
India = In
Pakistan = Pak
Singapore = Sin
Sri Lanka = SL
Thailand = T

Table 4. Research institutions in 14 nations.

Country			
Bangladesh	1. Aquaculture Experiment Station, Mymensingh	Freshwater pond culture breeding of Indian carps	Newly constructed; under DOF; also serves as extension station
	2. Mariculture and coastal aquaculture Research Station, Coxs Bazard	Coastal aquaculture; shrimps	Under DOF[1]
Brunei Darussalam		- None -	
Burma	Thaketa Fishery Research Station	Macrobrachium	Under People's Pearl Fisheries Center
China	1. Huang Hai (YellowSea) Fisheries Research Institute, Qingdao, Shandong	Coastal and mariculture	Under the Academy of Fishery Science Research (AFSR)[2]
	2. Nanhai (South China Sea) Fisheries Research Institute, Guangdong	Coastal and mariculture	Under AFSR
	3. Changjiang (Yangtze River) Fishery Research Institute, Hubei	Freshwater aquaculture	under AFSR
	4. Zhujiang (Pearl River) Fisheries Research Institute, Guangdong	Freshwater aquaculture	under AFSR
	5. Heilong Jiang Fisheries Research Institute, Harbin	Freshwater aquaculture	Under AFSR
	6. Freshwater Fisheries Research Center, Jiangsu	Freshwater aquaculture	Under AFSR
	7. Fisheries Mechanics and Equipment Research Institute, Shanghai	includes aquaculture	Under AFSR
Hong Kong	1. Agricultural and Fisheries Department	Aquaculture	2 research stations
	2. Zoology Department of Hong Kong University	Oyster culture	
	3. Marine Science Laboratory of the Chinese University of Hong Kong	Mariculture	
India	1. Central Inland Fisheries Research Institute (CIFRI)[1]	Freshwater aquaculture	Under India Council of Agriculture Research (ICAR), has 24 sub-stations, extension service
	2. Central Marine Fisheries Research Institute[1]	Mariculture	ICAR, has sub-stations
	3. Aquaculture Engineering Department, Indian Institute of Technology	Aquaculture engineering	

Table 4 (continuation). Research Institutions in 14 nations.

Country	Institutions/Agencies	Main Research Focus	Remarks
Indonesia	1. Research Institute for Freshwater Fisheries (RIFF)	Freshwater aquaculture	Under Agency for Aquaculture Research & Development (AARD); has sub-stations doing extension service
	2. Research Institute for Coastal Aquaculture Fisheries (RICAF)	Brackishwater aquaculture	Under AARD; 3 stations doing extension service
Malaysia	1. Fisheries Research Institute[1]	Macrobrachium	Located in Penang, Under Fisheries Department
	2. Batu Berendum Freshwater Fish Culture Research Station	Chinese carps, Leptobarbus	Located in Malacca, under Fisheries Department
Nepal	N. A.		13 Fisheries Development Centers doing extension work and fish breeding
Pakistan	Fisheries Research Division, Pakistan Agriculture Research Council	Pond culture	
	Fisheries Research Institute, Punjab		New state institution
Philippines	SEAFDEC Aquaculture Department	Shrimps, milkfish, rrabbit fish tilapia and seabass	Regional institution with a number of substations
Singapore	Changi Fisheries Research Station, Primary Production Department	Cage culture - grouper, seabass	Coastal aquaculture
	Freshwater Fish Research Station, Sembawang	Aquarium fish	
Sri Lanka	National Aquatic Resource Agency (NARA)	Aquaculture technology assessment - shrimps and finfishes	
Thailand	1. National Inland Fisheries Institute (NIFI)	Freshwater fish breeding	
	2. National Institute for Coastal Aquaculture (NICA)	Brackishwater aquaculture	

1 with fisheries/aquaculture extension stations.
2 Academy of Fishery Science Research under the Ministry of Agriculture, Animal Husbandry and Fishery, PROC
DOF = Department of Fisheries

Table 5. Fishery Scientists in Asia

Name of Institution	Total Professional & Technical Staff	Doctorate	Master	Bachelor	Diploma	Certificate	Others	Aquaculture Training
Bangladesh								
Directorate of Fisheries	635	2	100	320	0	213	0	7
Burma								
Department of Fisheries	44	0	8	36	0	-	-	1
People's Pearl & Fisheries Corporation	202	1	-	201	-	-	-	-
Brunei Darussalam	10	0	1	3	6	0	0	1
China								
Colleges	1182	No Information						
Research Institutions	3781							
Extension Worker	3318							
Hong Kong								
Agriculture & Fisheries Department, Fisheries Branch	82	4	1	12	8	57	0	1
India								
Central Inland Fisheries Research Institute (CIFRI)	398	50	193	125	28	2	-	1
Central Marine Fisheries Research Institute (CMFRI)	422	48	131	223	20	-	-	No Info
Central Institute of Fisheries Education (CIFE)	188	11		106		71		
Central Institute of Fisheries Nautical & Engineering Training	313			29	35	249		
College of Fisheries, Cochin	30	14	16	-	-	-	-	-
College of Fisheries, Mangalore	80	No Information						
College of Fisheries, Ratnagiri	15	No Information						
College of Fisheries, Tuticorin	31	No Information						
University College of Fisheries, Orissa	9	No Information						
University of Department of Industrial Fisheries, Cochin	7	No Information						
Indonesia								
Research Institute for Freshwater Fisheries (RIFE)	50	2	6	42	-	-	-	No Info
Research Institute for Coastal Aquaculture Fisheries (RICAF)	67	3	10	54	-	-	-	6
Directorate of Fisheries Resource	42		4	38	-	-	-	4

Table 5. Fishery Scientists in Asia

Name of Institution	Total Professional & Technical Staff	Doctorate	Master	Bachelor	Diploma	Certificate	Others	Aquaculture Training
Fisheries Education & Training Institute	99	No Information						
Regional Marine Fisheries Technical Training & Development Center, Sorong, Irian Jaya	10				3		7	
Regional Marine Fisheries Technical Training & Development Center, Ambon, Molluccas Island	11	0	1	9	-	1	-	-
Regional Marine Fisheries Technical Training & Development Center, Belawan, Medan	39	No Information						
Korea (South)								
National Fisheries Administration	362	5	30	158	103	66	0	0
Malaysia								
Department of Fisheries (Peninsular Malaysia)	141	0	15	88	14	20	4	7
Department of Fisheries (Sarawak)	60	0	0	4	54	2	0	0
Department of Fisheries (Sabah)	60	0	0	8	4	28	20	0
Universiti Pertanian Malaysia	87	7	27	9	0	0	44	
Nepal								
Fisheries Development Division	53	0	23	28	0	2	0	7
Pakistan								
Pakistan Agricultural Research Council	9	3	6	0	0	0	0	2
Department of Fisheries in Sind	32	0	12	20	0	0	0	0
Department of Fisheries in Punjab	146	3	36	88	-	-	19	0
Philippines								
University of the Philippines in the Visayas	110	19	43	45	1	2	0	17
Central Luzon State University	12	1	7	5	0	0	0	12
Fishery Industry Development Council	36	0	5	24	1	0	6	5
SEAFDEC Aquaculture Department	434	12	72	350	0	0	0	0
Bureau of Fisheries & Aquatic Resources	2024	No Information						
BFAR Region I	(22)	(0)	(4)	(15)	(4)	(0)	(3)	(0)
Singapore								
Division of Fisheries	18	1	2	13	2	0	0	1
Sri Lanka								

Table 5. Fishery Scientists in Asia

Name of Institution	Total Professional & Technical Staff	Doctorate	Master	Bachelor	Diploma	Certificate	Others	Aquaculture Training
Division of Inland Fisheries	48	0	9	39	0	0	0	8
National Aquatic Research Agency	28	4	8	15	1	0	0	0
University of Ruhuna	18	6	3	9	0	0	0	0
Fisheries Training Institute, Colombo	16	No Information						
Thailand								
Department of Fisheries	833	No Information						
National Inland Fisheries Institute	(79)	(6)	(20)	(18)	(0)	(31)	(4)	(2)
National Institute for Coastal Aquaculture	(12)	No Information						
Phuket Marine Biological Center	(7)	No Information						
Sichang Marine Science Research & Training Station	6	1	3	2	0	0	0	4
Kasetsart University	39	14	16	7	0	2	0	9

Source: Based on returns from questionnaires and literature.

Table 6. Training institutions

NAME OF INSTITUTION	ACADEMIC LEVEL	THRUST	REMARKS
1. Bangladesh			
Bangladesh Agriculture Univ., College of Fisheries	B, M	Fisheries	Theoretical aspects covered
2. Burma			
Moulmein Marine Science College	B	Marine Science	Aquaculture taught as part of fisheries courses
3. Brunei			
University of Brunei Darussalam	B	Biological Science	none
4. China			
Shanghai Fisheries University	B, M	Freshwater aquaculture	Degree course on aquaculture
Dalian Fisheries College	B	Freshwater aquaculture	- - - - - do - - - - -
Xiamen (Amoy) Fisheries College	B	Marine aquaculture	- - - - - do - - - - -
Zhanjiang Fisheries College	B	Freshwater aquaculture	- - - - - do - - - - -
Zhejiang Fisheries College	B	Freshwater aquaculture	- - - - - do - - - - -
5. Hong Kong			
Chinese University of Hong Kong Marine Biological Station	B, M	Marine Biology	Courses on aquaculture
6. India			
Central Institute of Fisheries Education	Dipl, B, M	Freshwater culture	Masteral degree course on fisheries including aquaculture
Central Marine Fisheries Research Institute, Center of Advance Studies	M, P	Mariculture	Masteral degree course on mariculture
Bangalore Agriculture University, College of Fisheries	B, M	-	Courses on aquaculture
Kerala Agriculture University College of Fisheries	B, M	-	Courses on aquaculture
Konkan Agriculture University	B	Fisheries	Aquaculture included as a subject of fisheries education
Tamil Nadu Agricultural Univ., Fisheries College	B	Fisheries	- - - - - do - - - - -
University of Kerala, Dept. of Aquatic Biology and Fisheries	B	Fisheries	- - - - - do - - - - -
7. Indonesia			
University of Brawijaya, Dept. of Aquaculture	B	Aquaculture	Aquaculture taught as subject
Diponegoro University, Dept. of Fisheries	B	Fisheries	Limited subjects on aquaculture
Bogor Agriculture University	B	Fisheries	Course on aquaculture
Pajadjaran University	B	Fisheries/Marine Science	Aquaculture taught as subject
Univerisities Islam	B	Fisheries/Marine Science	- - - - - do - - - - -
Universitas San Ratulangi	B	Fisheries/Marine Science	- - - - - do - - - - -
Hasanuddin University	B	Fisheries/Marine Science	- - - - - do - - - - -

Table 6 (Cont'd). Training Institutions.

	NAME OF INSTITUTION	ACADEMIC LEVEL	THRUST	REMARKS
8.	Malaysia			
	Universiti Pertanian Malaysia, Faculty of Fisheries	B, M, P	Aquaculture	Degree course on aquaculture
	Universiti Sains Malaysia, School of Biological Sciences	B, M, P	Aquatic biology	Aquaculture as a subject in aquatic biology
9.	Nepal			
	Tribhuvan University, Dept. of Zoology	M	Zoology	Aquaculture as a subject in zoology
10.	Pakistan			
	University of Sind, Dept. of Freshwater Biology and Fisheries	B	Zoology	Aquaculture as a subject in zoology
	University of Agriculture, Dept. of Zoology and Fisheries, Faisalabad	M	-	Aquaculture as advanced course in Master degree
	University of Karachi, Institute of Marine Science	M	Marine Science	Mariculture course for Master degree students
11.	Philippines			
	University of the Philippines in the Visayas, College of Fisheries	B, M	Brackishwater aquaculture	Masteral degree in aquaculture
	Central Luzon State University, Freshwater Aquaculture Center	B, M	Freshwater aquaculture	Master degree in inland fisheries (fish culture)
	Mindanao State University, College of Fisheries	B	Aquaculture	Courses on fish culture
	Bicol University, College of Fisheries	B	Aquaculture	Courses on fish culture
12.	Singapore			
	National University of Singapore	B, M, P	Zoology	Aquaculture is taught as part of fisheries course
13.	Sri Lanka			
	University of Colombo, Dept. of Zoology	B	Zoology	Aquaculture as subject of zoology course
	University of Kalayani, Dept. of Zoology	B	Zoology	- - - - - do - - - - -
	Rhuna University, Dept. of Zoology	B	Zoology	- - - - - do. - - - - -
14.	Thailand			
	Kasetsart University, Faculture of Fisheries	B	Aquaculture	Degree course on aquaculture
	Asian Institute of Technology	M	Aquaculture	Master degree course on aquaculture
	Phuket Community College	B	Aquaculture	

Source: Based on returns of questionnaires and literature.

TABLE 7. Aquaculture Training Needs of Developing Nations in Asia.

INSTITUTION	AQUACULTURE PLANNING & MANAGEMENT		HATCHERY TECHNOLOGY		MODERN FARMING SYSTEMS				DISCIPLINE TRAINING			
	AT[1]	RC[2]	FINFISH[3]	SHRIMP[4]	IFF[5]	BW POND[6]	CPC[7]	MC[8]	AE[9]	FD[10]	FNFT[11]	FISH GENETICS
SINGAPORE												
Division of Fisheries	2	-	1	-	-	-	-	-	-	1	1	-
Nat. Univ. of Singapore*	1	-	-	-	-	-	-	-	-	1	-	1
SRI LANKA												
Division of Fisheries	20	4	3	6	6	6	2	2	2	2	2	-
Nat. Aqua. Res. Agency	3	3	-	2	2	2	-	2	2	2	3	1
Universities*	2	-	1	1	1	1	-	1	1	1	1	1
THAILAND												
Kasetsart University	5	3	1	1	-	1	1	1	1	1	2	2
DOF Institutions	10	14	11	1	9	6	11	2	8	9	12	1
Sichang Mar. Station	-	-	1	1	-	-	-	-	1	-	1	1
TOTAL BY COUNTRY												
Bangladesh	21	8	27	22	50	7	4	2	10	12	8	2
Burma	18	8	30	12	9	6	6	-	6	9	9	2
Brunei Darussalam	2	3	3	5	2	4	5	2	1	2	2	1
China	40	20	-	10	-	15	2	-	8	27	27	13
Hong Kong	0	1	2	1	1	-	1	-	1	1	1	1
India	92	43	56	26	32	34	27	17	44	52	35	3
Indonesia	33	26	44	35	76	64	41	27	61	18	11	2
Korea (South)	8	3	3	2	3	3	2	3	2	2	2	2
Malaysia	20	34	17	34	19	15	5	13	13	19	15	2
Nepal	18	12	18	-	18	-	6	-	6	7	7	2
Pakistan	22	12	15	11	11	5	8	3	8	11	17	2
Philippines	63	29	18	21	14	23	23	15	25	20	18	5
Singapore	3	-	1	-	-	-	-	-	-	2	1	1
Sri Lanka	25	7	4	9	9	9	2	5	5	5	6	2
Thailand	15	17	13	3	9	7	12	3	10	10	15	4
TOTAL	380	223	251	191	253	192	144	90	200	197	174	44

[1]Aquaculture training course for senior aquaculturists (broad-based, multidisciplinary, postgraduate) = 1-2 years

[2]Refresher course for administrator and planners

[3]Hatchery management for finfish

[4]Shrimp hatchery operation and management

[5]Integrated fish farming

[6]Brackishwater fish culture in ponds

[7]Cage and pen culture

[8]Molluscs culture

[9]Aquaculture engineering

[10]Fish diseases

[11]Fish nutrition and feed technology

*Estimated by the author except those figures for China

Note: The figures are mainly based on returns from concerned fishery institutions/agencies in the respective countries. These do not represent the absolute requirement of the countries but pooled aggregates of major agencies/institutions.

TABLE 7. Aquaculture Training Needs of Developing Nations in Asia.

INSTITUTION	AQUACULTURE PLANNING & MANAGEMENT		HATCHERY TECHNOLOGY		MODERN FARMING SYSTEMS				DISCIPLINE TRAINING			
	AT[1]	RC[2]	FINFISH[3]	SHRIMP[4]	IFF[5]	BW POND[6]	CPC[7]	MC[8]	AE[9]	FD[10]	FNFT[11]	FISH GENETICS
BANGLADESH												
Directorate of Fisheries	18	8	20	16	50	4	4	2	6	10	6	-
Universities (Bangladesh Agric. Univ.)*	2	0	2	2	0	0	0	0	2	2	2	2
Bangladesh Fisheries Dev. Cooperation*	1	0	5	4	0	3	0	0	2	0	0	-
BURMA												
Dept. Fish. & People's Pearl Fish. Coop.	18	8	30	12	9	6	6	-	6	9	9	2
BRUNEI DARUSSALAM												
Dept. Fisheries	2	3	3	5	2	4	5	2	1	2	2	1
CHINA												
All government inst. under Min. Fish. & Animal Husbandry	40	20	-	10	-	15	2	-	8	27	27	13
HONG KONG												
Dept. Agri. & Fish.	0	1	2	1	1	-	1	-	1	1	1	1
INDIA												
Central Inland Fish. Res. Inst. (CIFRI)	45	7	4	4	4	2	4	2	2	5	8	1
Central Marine Fish. Res. Inst. (CMFRI)	10	5	10	5	2	-	7	2	10	5	5	1
Central Inst. for Fish. Education (CIFE)	10	1	2	2	2	2	2	1	2	2	2	1
Fish. Dev. Commission	27	30	40	15	24	30	14	12	30	40	20	-
INDONESIA												
Directorate Liv. Res. Mgmt.	25	20	25	25	70	50	25	20	50	-	-	-
Freshwater & Coastal Aqua. Res. Inst. (RIFF+RICAF)	8	6	19	10	6	14	16	7	11	18	11	2
KOREA (South)												
Nat'l. Fish. Administration	8	3	3	2	3	3	2	3	2	2	2	2
MALAYSIA												
Dept. Fish. (P. Malaysia)	8	20	8	20	12	10	-	8	8	15	10	-
Dept. Fish. (Sarawak)	2	2	2	2	-	1	1	1	1	1	1	-
Dept. Fish. (Sabah)	4	10	5	10	5	2	2	2	2	1	2	-
Universiti Pertanian Malaysia	6	2	2	2	2	2	2	2	2	2	2	2
NEPAL												
Fish. Dev. Division	16	12	16	-	16	-	5	-	5	5	5	-
Tribhuvan University*	2	-	2	-	2	-	1	-	1	2	2	2
PAKISTAN												
Directorate of Res. (Fish.)	10	4	5	5	3	3	3	3	4	3	3	2
Directorate Fish., Sind Prov.	7	-	6	6	4	2	1	-	2	6	12	-
Directorate Fish., Punjab Prov.	5	8	4	-	4	-	4	-	2	2	2	-
PHILIPPINES												
De La Salle University	1	1	1	1	1	1	1	1	1	1	1	-
Central Luzon State Univ.	1	2	-	1	-	-	-	-	1	1	1	1
Fish. Ind. Dev. Council	26	13	5	5	5	5	5	5	5	5	5	-
Univ. of the Phil. in Visayas	21	8	6	7	5	2	5	6	4	3	5	2
SEAFDEC Aquaculture Department*	-	-	2	-	-	-	2	-	2	-	-	2
Bureau of Fish. & Aquatic Resources (Region I)	14	5	4	7	3	15	10	3	12	10	6	-

Table 8 External assistance for aquaculture development (X 10^3 US dollars)

	World Bank	ADB	Inter Development Bank	UN Systems	EEC	Bilateral
1978	2,688	3,122	133	4,187	1,126	4,901
1979	4,168	8,640	133	5,073	1,545	10,655
1980	8,754	13,640	2,333	6,551	2,698	10,980
1981	10,674	16,005	2,333	6,111	2,698	17,225
1982	16,432	13,613	4,800	5,672	2,001	15,113
1983	20,477	13,486	5,300	5,600	2,754	13,103

Source: Josupeit 1984

SURVEY OF TRAINING NEEDS FOR TECHNICAL AQUACULTURE PERSONNEL IN ASIA AND THE PACIFIC REGION

Name: _____ Title: _____

Department: _____

Address: _____

Country: _____.

1. What is the current fish production in your country? (If exact data not available, please give an estimate figure).
   a. Total production _____
   b. Production from aquaculture _____
   c. Aquaculture production by commodities (if available)
      (i) Finfish _____
      (ii) Crustacean _____
      (iii) Mollusc _____
      (iv) Seaweeds _____

2. Please indicate below those aquaculture systems or practices and specify which are important or have great potential for cultivation in your country.

   (A) Culture Practices (Place an "X" mark)

   1. Pond culture _____
   2. Cage culture _____
   3. Pen culture _____
   4. Integrated fish farming _____
   5. Rice-fish culture _____
   6. Running water culture _____
   7. Raft culture _____
   8. Stake culture _____
   9. Others _____

   (B) Species (Specify)

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____
   6. _____
   7. _____
   8. _____
   9. _____
   10. _____
   11. _____
   12. _____
   13. _____
   14. _____

3. Please list the number of technical staff in your Department/Institution as indicated below. (Please place the number in the appropriate column).

Qualification	Discipline			
	Aquaculture	Fisheries	Sciences	Others
a. Doctorate degree	_____	_____	_____	_____
b. Master degree	_____	_____	_____	_____
c. Bachelor degree	_____	_____	_____	_____
d. Diploma	_____	_____	_____	_____
e. Technical certificate	_____	_____	_____	_____
f. Others	_____	_____	_____	_____

4. How many from your Department/Institution have been trained in aquaculture?

Training Course	Number
a. Aquaculture training of one year duration	_____
b. Short-term aquaculture training on specialized field	_____

5. What is the budget allocated for aquaculture development/research in your Department/Institution?

a. Total Department budget _____
b. Budget for aquaculture development/research _____

6. Please list on-going or projected research/development projects of your Department (including aided projects by funding agencies such as ADB, World Bank, etc.).

	Project Title	Budget
a.	_____	_____
b.	_____	_____
c.	_____	_____
d.	_____	_____
e.	_____	_____
f.	_____	_____

(Please use additional paper if there is no adequate space).

7. What categories of technical manpower are most needed by your institution to build up aquaculture capabilities?

Categories	Purpose	Number needed
a. Senior aquaculturists with broad based multidisciplinary training (1 year or more)	a. Planning, executing and implementing aquaculture program	_____
	b. Training of national staff in colleges, universities and national extension centres	_____
b. Aquaculture technicians with specialized training in:		
– Shrimp farming and hatchery operation (3 months)	a. Technical skill development	_____
– Hatchery management for finfish (3 months)	a. Technical skill development	_____
– Fish nutrition and feed technology (2 months)		_____
– Fish Diseases (2 months)		_____

Categories	Purpose	Number needed
– Mollusc culture (3 months)	a. Technical skill development	_____
– Integrated fish farming (4 months)	a. Technical skill development	_____
– Brackishwater fish culture in ponds (4 months)	a. Technical skill development	_____
– Cage culture and pen culture (4 months)	a. Technical skill development	_____
– Aquaculture engineering (4 months)	a. Technical skill development	_____
c. Refresher course for aquaculture planners/managers and administrators (3 weeks)	– Upgrading of knowledge in technology and management skill	_____

8. To be completed by educational institution

   If aquaculture is included in the curriculum of your institution, please indicate the subjects on aquaculture taught and for what level of students?

	Subject	Level (College, Technical School)
a.	_____	_____
b.	_____	_____
c.	_____	_____
d.	_____	_____
e.	_____	_____
f.	_____	_____
g.	_____	_____
h.	_____	_____
i.	_____	_____
j.	_____	_____

   (Use additional paper if necessary)

9. Name the institution in your country that provides aquaculture training and state the level of training (e.g., college, university, technical school).

   _____
   _____
   _____
   _____
   _____
   _____

10. Is your institution willing or interested to help train aquaculture personnel from the region? If so, in what way could your institution help?

    _____
    _____
    _____
    _____
    _____
    _____

Please return questionnaire to the following not later than 30 July 1984.

Dr. T.E. Chua
NACA Training Coordinator
Regional Lead Centre in the Philippines
SEAFDEC Aquaculture Department
P.O. Box 256, Iloilo City, Philippines