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FARMING SYSTEMS RESEARCH (FSR) APPLIED TO FISH PRODUCTION: CAPTURE AND CULTURE

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Improving the incomes of fishermen and fish farmers, especially small-scale producers, is not a simple, straight-forward problem. This has been shown through fisheries and aquacultural development projects since the early 1950's. These fisheries and aquacultural development projects commonly emphasized technology and technological solutions because it was widely felt that low productivity was due to the use of traditional or primitive fishing boats and gear (1).

Because these means/tools of production (boats and gear) were traditional or primitive, it was thought that their technical efficiency could be significantly increased through motorization (outboard/inboard) and other mechanized devices (winches).

After three decades of such technological problem-solving approaches fishermen and fish farmers continue as the poorest population segment in their country. The aggregate catch of fish has increased because of the introduction of new technology but may be short-lived because of the unmanaged use of the introduced technology. As a result, fisheries over-exploitation is threatening or endangering the livelihoods of fishermen for whom the introduced technology was supposed to benefit. In some cases, irreversible resource damage has been reported because of unmanaged introduction and use of the new technology.

FARMING SYSTEMS RESEARCH

Why do we choose to apply Farming Systems Research (FSR) methodology to fisheries when fisheries differ significantly from agriculture?

The opportunities and problems of fisheries have many more similarities with agriculture than differences, and can benefit from the Farming Systems Research work in agriculture. Further, Farming Systems Research methodology has proven its research and development/extension usefulness. It is now even more widely and assiduously applied in agriculture. It has definite applications to fisheries because of its on-site research orientation.

In addition, fisheries presently are at the stage where agriculture was three decades ago. Many developing country fishermen operate small-scale, non-motorized boats and equipment (mostly powered by wind or manual labor using oars). Because of this, these boats operate very close to the shore.

Small-scale fishermen also have limited managerial, technical and mechanical skills and their fishing methods and skills are largely traditional or primitive. Agricultural producers in these countries were at one stage in a similar situation, lacking modern implement/equipment or improved farming skills.

Farming Systems Research has, among other research activities, been instrumental in developing and imparting appropriate technical knowledge and skills to these producers. Farming Systems Research can similarly contribute to improved resource use and improved fishermen welfare.

For example, experience with the introduction of fishing boat motorization has demonstrated that it takes more than just installing a motor on a boat. Many other examples can be cited where such ad-hoc introduction

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of motorization left many small-scale fishermen deeper in debt. This is because very little attention was given to the socioeconomic and sociocultural aspects and conditions of the fishermen. Feasibility studies showing improved income levels as a result of motorization are not a sufficient condition for success.

Although initially studies may show that additional returns from motorization are greater than the additional costs of motorization, the effect of a larger supply of fish landed on the existing price structure is often either assumed away or overlooked. Often-times, marketing problems have not been anticipated. Marketing can be a real constraint.

Further, fishing boat motorization is always a government initiative with funds made available by the government. Just because the government provides the funds does not mean that the socioeconomic and financial position of the recipient fishermen can be overlooked. Too often the fishermen are unable to handle the additional demands for operating costs such as fuel, repair and maintenance not to mention his limited mechanical and managerial skills and marketing knowhow. The government does not provide or advance the operating or recurring costs, just the (initial) capital investment cost.

Is a motorized boat really what the fishermen need to improve their income level? Should each and every fisherman, especially those who do not now own a boat (crew), who want a motorized boat be given one? Should the government loan to all eligible fishermen or should the government institute group or co-operative ownership of motorized fishing boats?

Because the fishing boat motorization program has spanned a few decades and appears to be popular and accessible to any interested fisherman, many fishermen have come to regard the ownership of a motorized boat as "their right" and the solution to the problems of low income. Go to any fishing village and talk to any fisherman in a developing country, one will quickly find out that such is the mental and socioeconomic attitude of the fishermen. To catch more fish and hence enjoy a higher income, a motorized boat is absolutely essential, they will tell you.

Problems and frustrations such as these can be minimized if Farming Systems Research methodology is judiciously applied to understand fishermen problems. Farming Systems Research methodology may point out that motorization is not the answer to the problem of fishermen poverty. The Asian Development Bank and the World Bank no longer provide loans for the purchase of boats and equipment. Instead, they are turning to aquaculture.

Upgrading fisheries technology through motorization is not among the solutions in cases of over-exploitation. Rather, the solution lies in reducing fishing pressure (reducing the number of fishermen and boats). This can be accomplished through either providing other gainful employment (e.g. aquaculture, post-harvest handling of catch) or organizing for group fishing with rights of ownership of the group fishing fleet. Such problem dissection can be facilitated by Farming Systems Research methodology because of the on-site research orientation. Fishermen and researchers work together from the beginning.

Improving the socioeconomic welfare of fishermen and fish farmers through raising their productivity and incomes takes more than technology. There is a need to understand the fishermen and fish farmers, firstly as individuals and members of their respective communities, and secondly their communities as a whole. It is also imperative to understand their working environment and the external forces influencing their activities and decision-making process.

If technology were all it took to improve the quality of life in developing countries, then the technology which brought social well-being to the developed countries could be directly transplanted. Such has not been the experience of technology transfer from the West (except perhaps the ubiquitous automobile).

A good illustration is the continuous implementation of Japanese technology of big boats and big machines and equipment instead of sharing Japanese knowledge and experience with their system of fishing rights and resource use and conservation. If technology is all it takes, then big boats and sophisticated equipment would have improved the lot of many fishermen long ago.

CHANGE FOR WHOM?

To a point, change must emanate from concerns shown by government for its citizens, especially citizenry living in abject poverty. To alleviate such indecent poverty, governments have been known to impose top-down technology transfer. The justification often made is that productivity is low because of the persistent use of primitive or traditional technology. The record of such top-down technology transfer has been one with limited success. Why else are fisherman still living in utter poverty after three decades of research and development/extension effort?

WHAT IS FARMING SYSTEMS RESEARCH?

On-site research began in recognition of the limited success with imported technologies developed for environments which are clearly different from those of the exporting countries. Agricultural research and technology development is highly locale-specific in many respects. This is not commonly appreciated by those in charge of fisheries research planning.

Rarely is research in fisheries a problem restricted to one discipline. The combined experiences and background of different scientists contribute to a more thorough investigation of research problems. The effectiveness of such efforts is increased many times over the usual independent action of one scientist.

Farming Systems Research is multi-disciplinary and inter-disciplinary involving biological, social, technical (engineering), political and institutional disciplines. All these disciplines are used to build upon local knowledge: know-how, know-what, know-when, know-why, and know-where.

The first rule of Farming Systems Research is to take into account the actual conditions and circumstances under which the target producers are operating. The research to be conducted revolves around these conditions and circumstances to effect beneficial changes thought desirable from the producers' perspective. The researchers work for the target producers, constantly improving the solutions arrived at each incremental stage, that is, evolutionary rather than revolutionary.

APPLYING FARMING SYSTEMS RESEARCH TO FISH PRODUCTION

Because of continuing poverty, tropical small-scale fisheries urgently require the introduction of beneficial changes into their existing systems. The study of existing systems of fishing (productive endeavors) and their communities can provide necessary information to research personnel on which to base their work in developing and testing solutions to fishermen's and fish farmers' problems.

Linking fishermen/fish farmers and research personnel serves to improve communication and interchange and heightens the research personnel's understanding of fishermen's/fish farmers' problems and needs.

Three aspects of the Farming Systems Research methodology are presented in this paper. The first is concerned with developing improved technology but not necessarily new technology, consistent with the desires and circumstances of the target community. The second is to introduce new technology as a supplemental or alternative activity to the existing activities in an area. The last one concerns bold changes, or beginning from scratch, to develop new systems (i.e. revolutionary).

Farming Systems Research is one means of developing necessary technology and knowledge to increase the overall productivity of the production system. The end result is improved welfare of the target clientele.

Considering that large areas of land in aquaculture are still grossly underutilized (e.g. in the Philippines and Indonesia), the scope for production intensification clearly exists (2,3). Yet, why have large tracts of land under aquaculture not been fully utilized? Maybe research to underpin such full utilization has missed the target. Perhaps research is not matched to the prevailing reality of the grass-root situation the producers are faced with? The need for on-site (on-farm) research is clearly indicated for the fisheries.

Lessons from Farming Systems Research work in agriculture can be invaluable in adapting Farming Systems Research to fisheries problems. It is worthwhile to remember that it is the business of research to promote change in a socially favorable manner (10).

FISH PRODUCTION DEFINED

The utilization of living aquatic resources for food production and other economic purposes is classified into either capture or culture fisheries (1). For our purpose, capture and culture fisheries are different forms of fish production at different levels of management and technical sophistication or human intervention.

Capture fisheries are really aquaculture practised without any management, that is, no artificial stocking, only drawing upon naturally occurring fish populations. No yield-increasing or yield-protecting inputs of production are applied. The fish are just harvested (similar to hunting) with no concern given to sustaining the stocks of fish. This system of fish production is actually aquaculture practised in its truly extensive form (6). The fish stocks are not managed.. for optimum growth and rational exploitation. The oceans and seas are one large uncontrolled "fish pond".

Culture fisheries or aquaculture involves human intervention, control and management to reap higher production by the application of all available and known techniques of production such as the use of supplemental feeding, stock manipulation (e.g. stocking rate), use of fertilizers, control of water parameters, predator, pest and disease control, and improved genetics through breeding. This is intensive aquaculture.

Between these two extremes are forms of aquaculture with various degrees of managerial and technical sophistication. Figure below depicts the various possible levels of managerial and technical sophistication of fish production (1, 12).

The distinction between capture and culture fisheries will be used less and less because as the limits to the natural production from the wild (capture) are reached, fish production will increasingly come from culture. Many authors (9) have reported an increasing trend of fish production from aquaculture. Many finfish and shellfisn which were previously landed from the wild are now increasingly produced through domestication (implying control and management). A good illustration of this trend is from Japan where cage culture is very well established in its inland seas. In fact, in a most recent article, Rhodes (1985) reports that aquaculture is the fastest growing sector of fisheries.

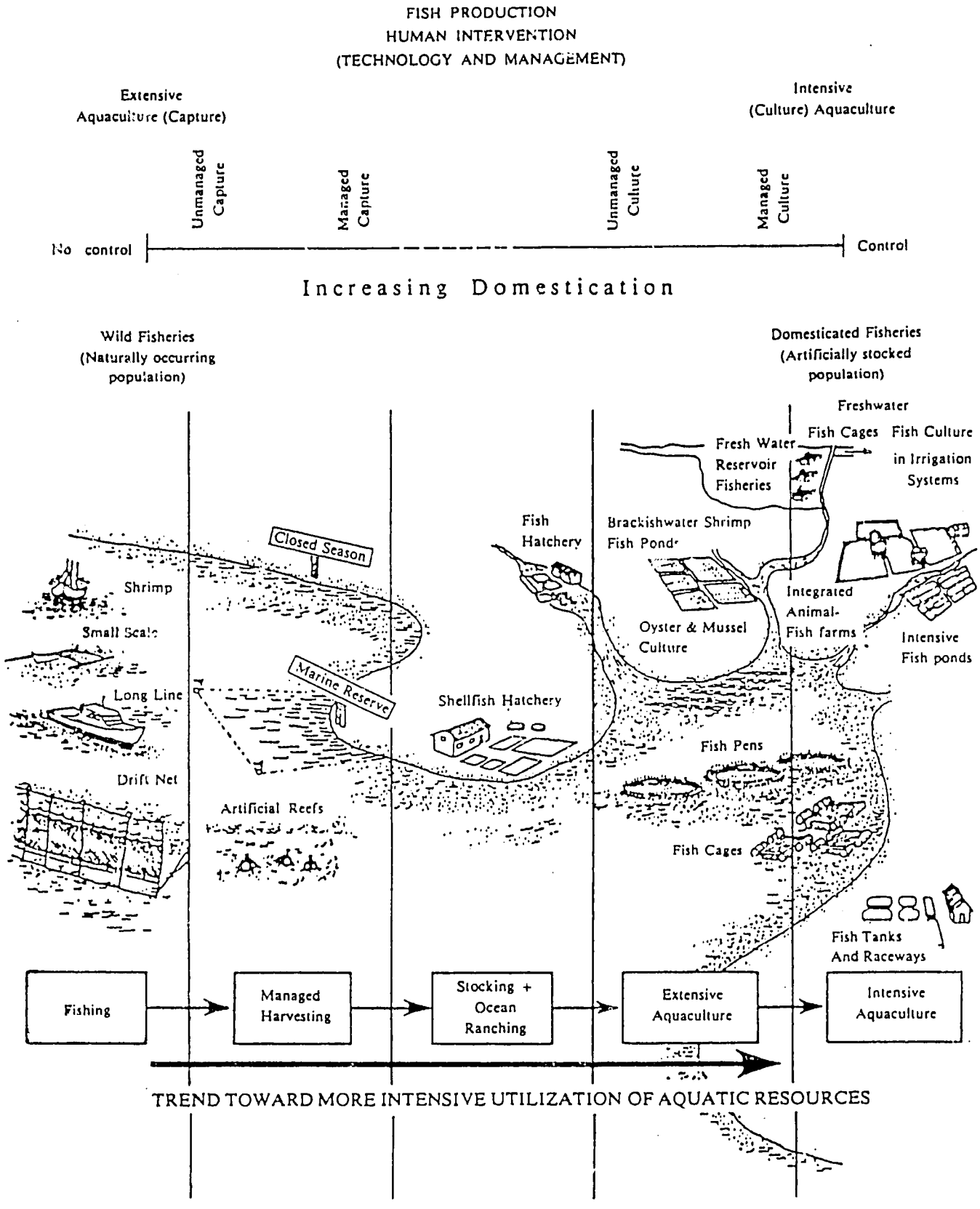

Figure. Different levels of technological and managerial sophistication of fish production (1, 12).

The trend away from capture to culture fisheries is inevitable because the productivity of open waters is very low and will become even lower with increasing fishing pressure. More efficient use of water and other resources is thus indicated for culture fisheries. Over the last 10 years, the rate of growth of fish landings from the wild has stabilized.

FISHERIES OF TOMORROW

Based on the estimates made by the United Nations' Food and Agriculture Organization, landings of fish on a worldwide basis is approaching the maximum sustainable yield (MSY). Partly as a result of this, and dynamic economic forces (e.g. escalating energy costs), aquaculture will increasingly be relied upon to produce the required fish.

Presently the global harvest of fish is about 70 millions tons. It is calculated that once this harvest exceeds 100 million tons, the existing breeding stock will be adversely affected. Predictions have been made that within 3 to 10 years, there will be a worldwide shortage of fish.

But this overlooks the management of such renewable resources. The application of science and technology cast in the Farming Systems Research framework along with the necessary political will, discipline and hardwork can be brought to bear on the rational utilization of the fisheries.

With the acceptance of the 200-mile extensions of national jurisdiction and authority over fisheries by many countries, rational exploitation, development and management of fisheries is now feasible. This is because 95% of the fish presently landed are found within the 200-mile limit. Although capture fisheries presently account for about 90% of the total world fish catch, fisheries scientists recognize that further increase in world catch from the wild is not likely given the high energy costs, unenforceable management regulations and unmanaged use of existing capture fishing technology (1).

Because of this, aquaculture will become more important. Recent advances in aquaculture technology, especially of artificial spawning and genetics, and fishfeed formulation, will ensure aquaculture's role in fish production. Already, success with sea ranching and open water stocking of fish have been reported. As long ago as 1962 the Japanese Government initiated a restocking program of their surrounding seas (13).

CHARACTERISTICS OF FISHERMEN AND THE FISHERIES THEY EXPLOIT

Since Farming Systems Research's thrust is to conduct research according to the target clientele's circumstances, the first order of procedures is to identify and examine the characteristics of the production systems; in this case, the fisheries, fishermen and their community. No two fishing villages are alike.

Unlike temperate fisheries, tropical fisheries are multi-species with a relatively small count of fish in any one shoal. It is also multi-gear, multi-user and multi-community. In other words, tropical fisheries are not homogeneous. Many communities of fishermen share more or less similar resources. Because it is not homogeneous, it is critical that the target fishermen or fish farmers be grouped according to common or dominant similar characteristics.

An important characteristic of fishermen and their communities in developing countries is that they have generally been bypassed in national development efforts to bring the country in to the 20th century. As a result, basic infrastructures such as roads linking coastal villages to markets are poorly developed.

Fisheries are greatly affected by weather and seasons. These can be unpredictable. Fishing activities are greatly constrained by the uncertainty of weather conditions. Unlike agricultural production in which the inputs and outputs can be estimated to determine its productivity and efficiency with a relatively high degree of certainty, such is not the case with fisheries production. When a fisherman goes out to sea, he is not certain he will be able to catch fish. There is a possibility that he will return with an empty hole. Returning to shore without any fish means that he has to shoulder the entire cost of his unproductive fishing trip. Agricultural producers can expect some output unless it is a complete crop failure. Also, the predominant method of fishing is still highly labor intensive, especially among small-scale fishermen.

In addition, many small-scale fishermen in developing countries, especially those who work as crew fishermen (i.e. non-boat owning) have the attitude that the ownership or acquisition of a motorized fishing boat is synonymous with higher incomes. This is not a healthy attitude and if not remedied can lead to serious over-fishing and more poverty. Collective or group ownership of boats and gear is a more rational approach. These fishermen, however, must relearn the spirit of collective action and community-mindedness. With modernization, the tendency to be individualistic is eroding the spirit of the common good and the common interest (gotong royong).

But most important of all, fishermen depend on a resource which does not yet have a satisfactory property rights regime. What one fisherman refrains from catching, other fisherman may decide to harvest. This characteristic should be clearly recognized and considered in developing and testing Farming Systems Research-generated solutions to fisheries problems.

Combined, the factors above give rise to a working environment

which is harsh and full of uncertainties. Many fishermen eke out a hand-to-mouth existence and remain poor with no ready cash for anything. Because they are poor and unskilled, their access to credit is limited. Credit made available through government programs has stiff conditions in the form of collateral requirements and unnecessary bureaucratic procedures. This frustrates fishermen efforts.

Their illiteracy and trusting nature also expose fishermen to malpractices or exploitation. Besides their skills as fishermen, they do not possess other skill which can be used outside of fisheries. Consequently, government efforts at encouraging fishermen to take up non-fishing income-generating employment have not been too successful. The government, however, continues to search for ways and means to expand employment opportunities whether fishing or non-fishing in the coastal areas. Training and retraining programs have been carried out to ensure some degree of success in attracting fishermen out of the fisheries.

Attracting fishermen out of the fisheries is predicated on the fact that most tropical small-scale fisheries are over-crowded. Because the fisheries are over-crowded, reducing the number of fishermen, and thus reducing fishing effort (pressure), will reduce waste and redundancy of capital. As a result, incomes will increase and resource allocation in the fisheries will improve.

Another dimension to the over-crowding problem of tropical fisheries is the peak and slack periods of labor utilization in fishing villages. Because of the seasonal nature of fishing dictated by the vagaries of weather, fishermen find themselves underemployed part of the year and fully occupied the rest of the time. It is this slack period of at least 4 months of the year that Farming Systems Research can contribute to identifying and examining alternative income-generating opportunities for the fishermen.

The first task of Farming Systems Research in this context is to obtain a time tabled flow of labor use of fishermen. With such a flow chart of labor use, the search for gainful activities during the slack period can be made easier. Gainful activities can be found which minimize conflicts in the demand for labor. The same can also be done for other slack resources. In fact, problems of seasonality of resource use among small-scale producers, whether in agriculture or fisheries is all too common.

UNIT OF ANALYSIS

Besides using the stock of fish as the only unit of analysis, a more manageable unit of analysis for Farming Systems Research purpose is a designated fishing ground and fish culture area. Of course the fisherman and fishing boat, and fish farmer and fish farm continue to be used as the unit of analysis at the micro-level.

A fishing ground can be categorized into two types, namely, those earmarked for coastal aquaculture (e.g. cage culture, seaweed culture), and those earmarked for capture fisheries (e.g. harvest of sedentary species, harvest of mobile species). In the latter, one fishery statistical area can be considered one fishing ground.

Having chosen the unit of analysis, the definition of a fishing system is next spelled out. Following standard Farming Systems Research terminology, a fishing system comprises a set of fishing boats and gear operated by a group of fishermen in a fishing ground. Those fishing boats and gear and the fishermen having features which are common to be sufficiently homogenous can be grouped into one *recommendation domain.*

The *recommendation domain* for fish culture comprises the set of fish farms which have also many similar characteristics. Fish farmers practise what essentially is the same type of production, having access to more or less similar inputs and face similar operating circumstances and constraints.

With the recommendation domain defined, the next step is to gather information on the following:

- target clientele's aspirations, felt needs, problems and capacities
- climate of the fishing ground/fish farms
- aquaecosystem of the fishing ground/fish farms
- existing production practices (technology) and resource use patterns
- demographic and socioeconomic data of households
- resources/inputs at disposal of target clientele
- disposal of output
- external forces influencing system under investigation.

This information can facilitate a deeper understanding of the system or recommendation domain under study. Such a working knowledge of the recommendation domain is essential to begin to identify the immediate or pressing problems of the target clientele. Farming Systems Research is then brought to bear on the problems singled out for analysis and resolution.

For the most part, Farming Systems Research revolves around minimizing or eliminating constraints to higher productivity or higher incomes. The solutions are tested and results either predicted or recorded for evaluation and further improvement on an incremental basis. It bears repeating that the recommendation domain must compose of sufficiently diverse fishing boats in a fishing ground or fish farms in a locale that any recommendations arising from Farming Systems Research work can be applied and transferred. For this reason, the recommendation domain must be carefully defined and sufficiently broad to minimize the problems of irrelevancy or inappropriateness.

DESCRIPTION OF A FISHING SYSTEM

A fishing system can be conceptualized as a set of elements or components which are interrelated and interact among each other. Thus, a fish production system whether of capture or culture origin, is the result of interactions among the many interdependent components.

The nucleus of the system revolves around the fishermen whose households or families and means of livelihood are closely linked. These must not be separated. A fishing system can be described as the manner in which the households or families allocate different quantities and qualities of inputs such as capital, labor, management and fishing grounds/fish stocks, fishing boats, engines and gear, fish ponds, fish seeds (fry/fingerlings) to which they have access.

They will combine all these inputs in a manner which will maximize the attainment of the goals/objectives they are striving for. Because of the considerable overlap between the unit of production and unit of consumption these limited-resource producers/consumers find it difficult to break out of the poverty trap. Given their present knowledge mostly comprising traditional production practices, and limited budget with competing needs for consumption first and production next, it is unlikely that they will be able to improve their welfare on their own.

Outside intervention in the form of government assistance is needed to educate these small-scale producers on ways to help them to provide for their families and themselves. Farming Systems Research which emphasizes a farming systems perspective (FSP) is one such model which takes the producers' situation as the focus of problem-solving.

A fishing system can either be an existing or a completely new system. The latter implies that a new area is taken and a new system is designed. In the literature, this is referred to as New Farming Systems Development (NFSD).

For example, because the population in some countries such as Indonesia is unevenly distributed, with more than 60% living on two islands of Java and Bali, the potential and scope for new farming systems development in virgin coastal areas is very great.

EXISTING SYSTEMS

Scattered unevenly throughout the Indonesian archipelagic coastal areas are fishing (marine) and fish farming (brackishwater) communities. Further inland are found freshwater fishing (riverine, lake) and also fish farming communities. There are approximately two million fishermen and fish farmers in the country, of which 45% are found on Java alone.

Except for about 5,000 fishermen involved in long lining, pole and line fishing for tuna and skipjack, and trawling for shrimp in the waters off Irian Jaya and Maluku, the remaining one million marine fishermen are mostly small-scale fishermen. Of the approximately 274,000 and 134,000 boats engaged in marine and inland open water fisheries, only 21% and 26% are motorized. This rate of motorization of the country's fishing fleet is lower than Thailand, Malaysia and the Philippines. In many respects, this is a blessing in disguise because many lessons can be learned from these neighboring countries on how not to motorize the fishing fleet.

The Directorate General of Fisheries also reports that outboard motor fishing boats are relatively more costly to operate than inboard motor fishing boats. Unfortunately, there are more outboard than inboard motor fishing boats in Indonesia. This can be cited as a partial example of inappropriate technology and a case for Farming Systems Research input.

The motor type, however, is only part of the total fish production technology. The outboard motors, especially those using kerosene, may be appropriate for some areas but not everywhere.

Just as there are different types and sizes of boats and motors, the gear types are equally numerous. The most common fishing gear in use are handlines, pole and line, gill nets, lift nets, long lines, seine nets, troll lines, muroami and in certain waters trawls. It is calculated that about 60% of the total marine fish landings are caught with the use of seine nets, gill nets and lift nets. Some of these nets are interchangeable.

Different categories of crew operate these boats - boat captain, boat navigator, master fisherman and crew fisherman. Crew size ranges from 1 manboat to 30 manboat.

NEW SYSTEMS

Because of security implications along its 81,000 km coastline, many with sheltered bays and gulfs, New Farming Systems Development (NFSD) can be applied to open up and develop these new areas into settlement schemes under the country's transmigration program. So far, transmigration of fishermen and fish farmers out of crowded Java has not been as successful as could be. The development of new fish production systems integrated with the forestry, agriculture and other resource endowment of the virgin areas represents a very exciting area for the application of Farming Systems Research methodology.

ECONOMICS AND FOLLOW-UP

As soon as possible and at every stage of Farming Systems Research work, changes introduced must be economically monitored. This will ensure that the changes introduced are economic and the target clientele

see the benefits of adoption. More significantly, continuous economic evaluation will provide a basis of feedback assessment whether to continue or to modify/revise or to abandon the suggested changes. Also economic monitoring can help to avoid costly mistakes in Farming Systems Research generated changes even if technically attractive.

To succeed, the solutions developed must meet three criteria: first, solutions/changes should require low cash outlay; secondly, solutions should have short pay-back period, and lastly, changes should be easily replicated and stable.

Follow-up is another important aspect which can ensure adoption and success. Whenever possible the target clientele should assume full responsibility of the introduced changes at the earliest possible time. Their sense of participation will be greatly enhanced; they are not merely consulted but are involved in the true sense of the word. Thus, introduced changes must not only be technically feasible and economically attractive but also require regular follow-up.

CONCLUSIONS

The socioeconomic plight of small-scale fishermen in developing countries is well documented. So far, government assistance has not had an impact on the welfare of these fishermen. The indictment and revelation that many Research and Development programs have generally failed because they did not meet the needs of the target clientele are usually used as further justification for more Research and Development.

Continuous research supervision is essential. The common denominator found in the success story of research carried out by International Agricultural Research Centers (IARCs) is that there is adequate supervision. By and large, this needed supervision is still lacking in national agricultural research (NAR) programs. This implies that NARs should be giving more attention not only to institutional support but also commensurate compensation and incentives to its own research personnel to do field work.

At the same time, the price and income structures of the country's economy must also permit its producers (farmers, fishermen and fish farmers) to earn enough to be worth their continued effort to keep producing. An appropriate incentive structure across all strata of the country's population must be present to support social progress. There should be no difference in treatment between urban and rural population.

Constituting a multi-disciplinary team is an easy task. But getting the multi-disciplinary team so assembled to work multi-disciplinarily is another entirely different dimension and more problematic to implement. Field experience shows that although multi-disciplinary teams can often work together as a team the different disciplines are not effectively integrated.

Leadership in a multi-disciplinary research setting is very critical. Multi-disciplinary research does not just happen. The different scientists have to work at it. Their basic task is to minimize human miseries due to poverty.

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