
TECHNOLOGY ASSESSMENT METHODOLOGY FOR AQUACULTURE

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Dynamic technologies, like those in aquaculture, call for due recognition of potential human and capital factors that are involved in the industry. Productive utilization of new knowledge is expected to affect the demand and supply of present skills and generate new occupations or employment opportunities not yet identifiable. Besides, the resulting technological pressures will lead to increased interdisciplinary communication.

We are now dealing with economic, sociological, and political consequences of technology. In practice, economic and sociological factors are interdependent. Recognition of these factors and their interplay in the adoption or the expansion process of the technology will help minimize disruption and maximize the positive effect of technology transfer.

The impact of the recent developments in aquaculture technology has been observed to be significant. But their impact on the greater masses in the Third World yet remains to be seen. The major breakthroughs in the aquaculture research, such as in prawn lifecycle or in milkfish spawners, have had no positive impact on the small fish farm. On the contrary, their capital intensive nature have had negative consequence for the small fishfarmer.¹

This brings us to the periphery of technology and change, where technology will be a compelling force for change. Against this backdrop, it is imperative that no planning and policy making in the industry should be done without technology assessment. Therefore, managers are called upon to be aware of technological impact and be sensitive to the need for more precise planning for the future. Technology assessment, therefore, is

about environmental impact of technology adoption and, like technology forecasting, technology assessment is future oriented.

Rationale

It is generally accepted that research resource allocation requires a systematic *pre* (ex ante) evaluation. There is a felt need in the research centers and other development-oriented agencies for more comprehensive assessment of alternative strategies. This state of affairs will continue for a long time because of the lack of satisfactory methodologies of technology assessment.²

SCOPE OF TECHNOLOGY ASSESSMENT

Objectives

The general objective of technology assessment is the systematic examination of the utilization phase of technology, as a component, subsystem or system, and evaluation of implications which include technical accomplishment but extend beyond it.

Specifically, technology assessment is undertaken:

- i. to generate advanced information or warning about potential difficulties and possible risks;
- ii. to highlight the potential benefits of the technology and thus strengthen the technology diffusion and utilization; and
- iii. to enlighten the decision-makers, planners, and policy-makers about the implications of the technology adoption at the community and other subsystem and system levels.

The objectives articulated here lead us to compare and contrast two main concepts that may look alike but are different, namely, 'assessment' and 'evaluation'.

Assessment and Evaluation

In general, assessment focuses on specifying uncertainties, is a key to advanced knowledge or is *ex ante* judgment; evaluation often comes after, focusing on certainties as a key to *post facto* analysis. Assessment must, however, build on and contribute to a firmer understanding of what does happen or on actual outcomes. Assessment, therefore, should have a firm evaluation underpinning without which it will be speculation.

Technology assessment cannot stop at asking about errors of systems. It goes beyond that level because it is a positive science inquiry.

Technology assessment is not synonymous with project feasibility, marketing analysis, social impact, project evaluation or techno-forecasting. But it is highly related to these matters.

Approach

The accelerating pace of aquaculture advancement has highlighted the need to assess the technology, so that the impact of science on society may be not only skillfully developed but also wisely guided, so as to improve the legislative process.

Different approaches to technology assessment are examined. The U.S. Congressional Subcommittee on Science, Research and Development proposes an 'anticipatory and adaptive' approach. The National Academy of Engineering identifies two classes of technology assessment: (1) problem-initiated, and (2) technology-initiated.

The National Academy of Sciences takes still another approach to technology assessment. The ultimate objective is not to fix technology but rather to "conceive ways to discover and repair deficiencies in the processes and institutions by which society puts the tools of science and technology to work.

The eventual results, however, are likely to be displaced in time and space. Further, they may be well-disguised. The

recognition of the fact that the impact of technology innovations is likely to be displaced in time and space contributes to the call for some formal mechanism which will address itself to the problems of the unseen side effects on a continuing basis.

Technology assessment provides the decision-makers with a list of future courses of action backed up by systematic analysis of the consequences. The goal is legislative capability for policy determination in applied science and technology which will be anticipatory and adaptive rather than reactionary and symptomatic.

In the problem-initiated category, the assessment is initiated in response to an existing socio-economic problem, such as brackishwater milkfish production, where there is a significant decline in profits today.³ In the technology-initiated category, the assessment is initiated in response to new technological development.

Complexity of the technology-initiated assessment. Whatever any process of assessment might reveal, choices between alternative technologies or supporting systems are essentially economic and political in character; response to assessment almost always requires that decisions be made between competing and conflicting interests and values.

The emphasis is on human behavior and institutions, instead of technology, as the agent of change. The competing and conflicting interests and values do not arise from technology but from economic and political institutions and preferences. The question therefore is not whether something is technologically viable, but rather, if it is politically viable.

The system of participatory technology is defined as the "inclusion of people in the social and technical processes of developing, implementing and regulating the technology." When people advance to a substantial and legitimate participatory role in the technology development and implementation, then participatory technology is in operation.

Different groups view the impact of technology as either beneficial or detrimental, so that reactions and information from all segments of society are necessary for adequate assessment. Spokesmen from many fields should have access to decision-making processes. Participation and representation on a democratic basis should bring together diverse views to be considered in the actions of technology assessment.

Technology assessment begins with an attempt to specify broad social goals before it evaluates alternative development policies in terms of their contributions to those goals and the minimization of unacceptable or undesired trade-offs.

The emphasis of this approach is on the evaluation of alternatives in light of social objectives and not of technological problem areas alone. "Does a technological solution exist?" is basically a non-normative issue. But the question how a technology may operate in a social context is much more a normative and value-laden inquiry.

How should technology be controlled in a democratic society? Who should control it? What should be the goals of its direction? These questions are laden with value judgments. To answer such questions, we have to rely on technology assessment.

What is Technology Assessment

There are many definitions of technology assessment, but so far none has gained universal acceptance. One reason for this state of affairs is the relatively recent development of assessment studies.

In defining technology assessment, David Kiefer says: "Technology assessment is an attempt--still halting and uncertain--to establish an early warning system to control, direct, and, if necessary, restrain technological development so as to maximize the public good while minimizing the public risks. It is, no less, a new approach to allocating scientific resources, setting technological priorities, and seeking more benign alternatives to the technology already at hand."⁴

Joseph Coates thinks that technology assessment involves policy studies designed to systematically explore broad societal impacts resulting from technological introduction, expansion, or modification.⁵

The two foregoing definitions do not in any way imply that the technology to be assessed is a brand-new technology or a technological innovation. It may be a case of traditional technology; it may have existed for generations but is only now emerging with a newly acquired importance in the community.

Coates further specifies the goal of technology assessment: The goal of technology assessment is to examine the risks, the benefits and the consequences implied by a technology and placed in the hands of a decision-maker, who has better information about the possible consequences of alternative actions.

Those in the field of technology assessment seem to agree that the purpose of technology assessment is to anticipate possible consequences of technological change. Such anticipations can be developed into scenarios which identify possible positive and negative consequences, potential trade-offs, and recommended courses of action to maximize the positive aspects of potentially desirable technologies and minimize or eliminate the negative ones.⁶

Principal Attributes of Technology Assessment

There are many definitions of technology assessment; as enumerated by Koppel,⁷ Most share the following attributes:

- 1) A major common analytical concern is the identification, analysis, and evaluation of *higher-order impacts*, the effects of effects. What are the second and third-order consequences of technology transfer? This concern will direct attention to uncovering, analyzing and evaluating unanticipated and unintended probable consequences, both positive and negative.

The 'blue revolution', for example, attempts to locate systematic employment and income effects from utilization of improved aquaculture technologies and complementary inputs.

2) Technological assessment studies tend to be *holistic rather than reductionist*. Problems are defined systematically. The criteria for problem solving are not derived from disciplinary domains but rather from the discernment of significant relatedness, linkage, and interdependence within emerging or existing systems.

The shortage of fish for local consumption, for example, is only in part a question of fish research. Fish is linked to a number of convergent issues--environmental or water pollution, human settlements, public education and quality of life. The package tends to be indivisible: a change in one subsystem affects the other subsystems. Research investment in aquaculture is a partial response, but there is little reason to believe that the results will be as delimited. The implication of this phenomenon is that aquaculture as well as other technological research agenda need to be developed in close tandem with other forms of social problem-solving.

3) Specification, analysis, and evaluation of the *irreversibilities* courted by alternative technological strategies: 'Irreversibility' here implies the imposition of damaging or undesirable impacts characterized by irrevocable losses. It implies the restriction of future options and the imposition of undesired choices. Environmental impact statements now required in several countries and in development-oriented agencies illustrate this concern. Utilization of biological control, for instance, may court the introduction of unforeseen alteration in existing ecosystems. Assessment study will attempt to specify and evaluate such irreversibilities, preferably before the implementation.

4) Viability of the *technology*: Can technology utilization proceed without incurring a succession of adjustment problems that ultimately undermine the viability of the technology? What complimentary or additional factors will need to be operative to ensure continued achievement of objectives? Assessment involves not only anticipation of external consequences, but anticipation

of capabilities to address future demands emanating from those consequences.

5) Technology assessment is *value and social goal-oriented*. Evaluating impact, sustainability and irreversibility issues are fundamentally a value-analysis problem. Elaborate methodologies have been proposed to subject value-components in technology assessment to explicit identification and quantification.⁸ Technology is viewed here as means rather than end. Besides, the social goal and normative orientation of technology assessment is what distinguishes technology assessment from techno-economic evaluation.

The central assessment concern is not whether a technology will work or even whether it is economically feasible, but rather whether and to what degree a technology is likely to make a significant positive contribution to the realization of some social goal.

6) *Alternatives*: Seeking to identify and evaluate alternatives is a crucial characteristic of technology assessment. This implies that technology assessment is an interactive form of inquiry, a process involving the consideration of micro and macro options and thorough understanding of the impact probabilities of each.

7) *Future-orientedness*. It is not an exercise in forecasting, but an attempt to provide a more comprehensive understanding of critical uncertainties by anticipating the consequences of prospective decisions.

Problems

A broad range of complex problems or questions must be investigated in a technology assessment. The questions with more importance are:

1. What is the present state-of-the-art in the technology?

2. Where does it appear to be going? In what direction?
3. What are the prospects for technological application?
4. What forces might affect potential application?
5. What possible consequences can be anticipated of the application?
6. What are the cost and benefit considerations?
7. What societal interest groups are likely to be affected by the technology adoption?
8. What actions by these vested groups can be anticipated to support their position?

The Trend of Technology Assessment Studies

In order to evaluate in advance the impact of new technologies, scientists are developing a new field of technology assessment. The US National Academy of Sciences proposed legislation to establish a technology assessment board, which would identify social impacts of technologies and their control, or encourage their development.

Technological development arises from a multiplicity of decisions made in industry, government, the market place, and research institutions. It is now the responsibility of development-oriented organizations like SEAFDEC AQD, to decide whether or not expensive programs should be instituted and to weigh possible benefits against detrimental environmental impacts. In short, it is to understand the consequences of the various technological applications.

The social consequences of new technologies are difficult to evaluate or predict. It is in this context that we are to emphasize the use of technology assessment to define the problems, predict future developments, and suggest options for alternative technologies.

Information needed by research and development (R & D) organizations are about (1) potential impact, (2) unavoidable adverse impact, (3) irreversible commitment to resources, (4)

short-term considerations versus long-term resource needs, and (5) alternatives to the proposed action. Probably the best means to direct technology toward humane ends will consist of a combination of many of the methods discussed above, including improved education and information flow; more efficient R & D organization, assessment and planning; and some system of equitable rationing or regulation.

Basic scientific research is an expression of the human traits of curiosity, exploration, and creation. Basic research should not be abandoned but urgent problems now cry out for an expansion of applied research that will offer specific solutions. Man will have to learn to apply wisely and humanely the knowledge he acquires. Furthermore, these urgent problems demand more than technical solutions; they require fundamental changes in human values, and they must be overcome rapidly if man is to survive for more than a few decades.

Technology assessment as an organized concept is of relatively recent origin. Technology assessment studies, in general, tend to be holistic. If we look at the studies conducted in technology assessment, we can classify them into three: (1) Macro studies where assessment is comprehensive, as depicted by the central questions; (2) Partial studies on selected impact where assessment is about an order of magnitude smaller than macro studies and focus either on depth or on breadth; and (3) Micro studies where assessment is heuristic--they are of a magnitude smaller than partial and are generally based on "brainstorming" group session.

Figure 1 indicates the extent to which such technology studies are generally carried out. Likewise, the analytical parameters and the magnitude of analysis are also given in the same table. The time frame during which the technology assessment studies can be designed and carried out vary considerably, ranging from micro studies, which may be undertaken at the experimental station and could be accomplished in a couple of weeks to macro studies that usually takes much longer time.

CONCEPTUAL FRAMEWORK

Technology assessment spins around the axis of socio-economic policy and institutional system such as aquaculture industry regarding technology utilization. At the macro level, technology assessment in its comprehensive form, no doubt, deals with a complex system.

Procedurally, technology assessment could be conceptualized on a segmented basis, as depicted in Figure I. In the model, six segments are identified and treated as distinct entities with distinct vested interests. In many cases, we can observe that there is an overlapping of functions and some duplication of factors to be considered.

The assumption built into the model is that the technology itself is complex and many vested groups will be involved. Consequently, the technological impact inputs will go beyond the resources and boundaries of any single organization.

Prime impetus for aquaculture technology, for instance, from such sources as science, aquaculture industry, or government. The technology sponsor, intimately involved in vested interest groups, only partially represents society. The ultimate technological results could have reverberations which materially as well as in other respects affect other interest groups.

Undesirable downstream consequences can be avoided or minimized by communication and research. As depicted in the model, each group would approach the problem in the light of its own self-interest. The technologists, for instance, would look at the state-of-the-art technical feasibility and the timeframe for technical accomplishment, ideally in conjunction with alternatives and competing technologies, potential application, and obsolescence. Besides, the technologists would explore the availability of technical resources and possible government interest, as a prelude to requesting government support in the early research and development phases. If industry and not the government is the immediate partner with the technologist, the support decision might be made after consideration of such factors as organizational objectives, profits, costs, existing

products, growth potential, competition, and potential government regulation and/or support. The list of factors to be considered by each vested interest group in Figure I is intended to be representative rather than all-inclusive.

The significant point is that decisions to push technology can be and often are made unilaterally when the prime motivation is provided by either the government, industry, or the technologists; or, the decision can be bilateral, with two of those three interest groups in partnership; or, all three groups may be parties to a trilateral agreement. On the other hand, it has become increasingly apparent that the technologists, government, and industry do not have the right nor sole domain in determining the direction of the technology. Labor and the general public, among others, must be represented and economic factors must be evaluated to provide a more realistic impact analysis. It should be noted, however, that the special interest groups, identified in /Figure 2, are not exhaustive.

TECHNOLOGY ASSESSMENT METHODS

Technology assessment is usually so far-reaching that a sound methodology is needed. Because of the absence of such a methodology, innovation in the area is called for. It appears almost impossible to develop a generally applicable procedure for all types and cases of technology assessment. Some ordered methodology, however, is essential for the technology assessor to attain the end results. Such a methodology will keep him away from being bogged down in a procedural morass.

Here, we can identify seven major steps in making a technology assessment:

1. Define the assessment task;
2. Describe relevant technologies;
3. Develop state-of-society assumption;
4. Identify impact areas;
5. Make preliminary impact analysis;
6. Identify possible action options;

7. Complete impact analysis.

Within this outlined framework, a more detailed structure could be built to support a technological assessment. In a field as new as technology assessment, there are quite a number of fertile possibilities that exist for innovative procedures.

Joseph Coates, too, acknowledges the inherent difficulties involved in developing a universally applicable procedure or method for technology assessment. He maintains, however, that there are three fundamental conditions which dictate the TA approach: the subject, the budget, and the primary user. He also identifies ten 'modules' of a technology assessment:⁹

1. Definition of the problem, the technology, issue or project to be assessed.
2. Definition of alternative systems to be examined
3. The unfolding of impacts.
4. Evaluation of the significance of impacts.
5. The decision apparatus.
6. Defining options and alternatives.
7. Parties at interest with regard to a particular technology.
8. It is important to recognize and analyze the impacts of variation on the technology under consideration.
9. Exogenous factors should have a prominent place in any technology assessment.
10. One must examine all the above to come to some set of conclusions.

A Matrix Approach

A matrix approach is another possibility in technology assessment. Let us take the example of the country as a whole in illustrating the matrix method. Motivated by national pride and ambition, a developing or emerging country would like to advance along a broad technological front. Motivation and ambition notwithstanding, the avenue providing the most practical path

and greatest potential for success might be the determination of national priorities and selection of specific goals.

Unless realistic priorities are established with a reasonable probability for fulfillment, limited resources can easily be dissipated with few accomplishments. A nation, for instance, may want to increase its fish production through aquaculture, develop a scientific base, educate its population, and establish manufacturing industries. The chances are that it does not have the resources and ability to do all these things simultaneously. Therefore, there is need for decision-making to set attainable priorities. It may be decided that the first priority is to increase aquacultural output, the second major goal could be to improve education, and so forth. Besides, as illustrated in Figure 3, priorities within priorities have to be identified if national goals are to be achieved.

The matrix approach shown could also be modified and adapted to the organizational goals like those of SEAFDEC AQD. Using a matrix, it is possible to get a composite picture for planning purposes; it should also assist in providing insight for checking consistency of objectives, cross-impact analysis, reasonableness of priorities, and synergetic effects.

TECHNOLOGY ASSESSMENT AND MANAGEMENT

The need for assessment of a technology or an impact study is very specific in an international or regional agency committed to development. Such agencies play a crucial but sensitive role in technology transfer in national scene.

Planning, developing technology, innovations, achieving objectives, proper utilization of resources, organizational image-building, product introduction, and legal responsibilities, among other considerations, are responsibilities of the administration of any organization, international or national. These responsibilities have to be properly harnessed for the survival of the organization. The administration should be attuned to possible technological side effects; social and political pressures, and

awareness of legislative developments as they may affect the organization's sphere of operations.

A comprehensive technological assessment involves many disciplines and, among other things, seek a cross-impact analysis of the technology under investigation. Management should be the integrating force, and the extent, direction, emphasis, and dependency on management technology would reflect the nature of the technological problem addressed in the assessment. Many management tools or techniques are much applicable in technology assessment.

Implementation of Technology Assessment

When and how should technology assessment be employed? In its present form and scope, technology assessment is a fresh approach to the technology decision process. In examining the systems model of the aquaculture technology assessment process shown in Figure 2, it is apparent that some degree of technology assessment has been going on for the organization, science, and industry. The role or the contribution of technology assessment is to encourage a more comprehensive examination of the interrelationship of the above-mentioned three interest groups and, ideally, includes functional segments of society, such as the government, in a composite analysis.

As a multifaceted exploration into technology, however, its boundaries appear too large and the complexities too extensive for a single jurisdiction. Technology assessment in aquaculture requires a team effort which could use inputs from those directly involved, as the aquaculture researchers and other support systems of the organization, such as economists, development communication specialists of the research organization, and end-users-fish farmers, the private sector, the government. It also requires support from universities, commercial think-tanks, and nonprofit as well as profit-making organizations.

Cetron¹⁰ presents the idea this way: There are several criteria some in the form of 'catalysts' that must be present in order for a viable technology program to work. Among others

they include (a) a list of qualitative or quantitative goals, needs, or areas of concern; (b) a set of operational societal indicators, namely, social, technological, economic, legal, political, demographic, and so on; (c) a set of analytical skills in the form of tools, methods, and techniques that can be brought to bear on various aspects of the technology assessment problems; and (d) organizational implementation patterns and procedures to provide the institutional framework that must be present in making operational decisions.

SOCIAL OBJECTIVES AND TECHNOLOGICAL INNOVATION

In defining technology assessment and initiating studies to perform preliminary analysis of possible policy options in aquaculture, no one can ignore the fact that technological progress and technological innovation play a key role in promoting the economic and social welfare of the nation. The focus here is not on promotion of technology *per se*, but rather on identifying those which serve social objectives via technological innovation.

There are two themes in focus here: (1) stimulating the adoption of socially useful technological innovation, and (2) removing barriers that inhibit the adoption of specially beneficial technology.

The following kinds of questions should be studied in assessing the feasibility of options which might be considered in the short term:

- * Is there evidence of a problem as a consequence of technological innovation?
- * If yes, can the causes of the problem be eliminated or the negative impacts lessened?
- * Is there a set of policy options which can be considered in the short run to overcome the problem or take advantage of an opportunity?
- * What are the pros and cons of the policy options considered?

Long-term options also need to be studied. In fact, they could turn out to be the major purpose of a special section for technology assessment at SEAFDEC AQD.

Policy Options and Criteria

In analyzing the aforementioned problems, it is important to highlight the trade-offs among selected policy options and specified criteria which are employed by policymakers.

The policy options of SEAFDEC AQD, for instance, should address a problem or opportunity which is within the scope of aquaculture industry or sector. Preferably, problem or opportunity should be of long term importance.

The policy options should not foreclose future options or lead to future problems or significant future costs. The policy options should be flexible and alterable without serious problems; they should yield identifiable and measurable progress toward intended objectives in the short term. A measure for evaluating such policy options should be available; if not, it should be developed first.

The policy options should not duplicate existing functions, policies, or programs. They should not conflict with other government policy objectives of equal or greater importance than technological innovation. It should be ensured that the manpower and institutional and technical requirements to implement them are available and some preliminary research completed.

PROSPECTIVE TECHNOLOGY ASSESSMENT STUDIES IN AQUACULTURE

Following are the prospective technology assessment studies in aquaculture that may be conducted at a macro level:

1. Exploring, analyzing, and evaluating the crucial trade-offs and policy issues regarding aquaculture technology research of a research organization like SEAFDEC AQD; such technology

is to be disseminated to and utilized by the end-users in a selected region like Panay Island in the Philippines.

2. Policy issues regarding (a) aquaculture technology generation, (b) technology transfer, and (c) technology support system.

a) *Technology generation* - It will deal with such questions as:

- (i) Are particular aquaculture researches being presently conducted at the organization?
- (ii) What particular funding agencies are providing support for the generation of different aquaculture technologies? What is the amount of funding? What particular research agreements are agreed upon between the research agency and funding agency?
- (iii) What is the present status of these different ongoing researches? Are there problems in implementing the researches or generating the technology such as manpower and expertise?

b) *Technology Transfer* - It will deal with such questions as:

- (i) Who will be the end-users of those technologies being developed?
- (ii) What are the alternative patterns or means by which such technologies being developed (and later verified) could be disseminated to the end-users? What are the alternative means of institutionalizing the utilization of such technologies? What could be the socio-economic impact of the utilization process? What are other possible systems or subsystems that will be affected? And what would be the possible consequences? How will they affect or effect the

policy issues or responses of the research agency as well as the funding agencies?

(iii) What would be the alternative responses or reactions of the subsystems or systems, such as the extension credit, financing, and local political systems, involved in this technology transfer?

c) *Technology support systems* - They will likewise deal with questions such as:

(i) What is the actual role of the funding agencies of these technological researches? What will be the possible participation of the business firms like fish processing, trade, and others in the dissemination and utilization of these technologies?

(ii) What will be the possible participation of local institutions of interest in aquaculture industry like fish farmers' associations and rural banks? What will be the possible participation of the government agencies like the Bureau of Fisheries and Aquatic Resources (BFAR), or the Philippine National Bank (PNB)?

(iii) Is there a baseline study conducted in the projected target area? Are there sufficient socioeconomic and ecological data available for evaluation of the technological innovation in the community? In the absence of such study and data, can a macro-study be conducted in randomly selected municipalities per province? If that, too, is not possible for some reasons or other, what probable disadvantages would the organization as well as the technological innovation face in the

light of socio-economic observations
and general milieu?

3. Evolving recommendations concerning policy options on the effective management of new technological advances preferably at the technology generation if not at verification levels.

Assessment Procedure

In the absence of an all-purpose technology assessment methodology, a study could be structured around a simple overall procedure consisting of three phases, namely, (a) preparatory, (b) policy analysis, and (c) validation.

1) Preparatory Phase. The objectives of this phase are:

(a) to review the existing literature and practices about the various forms of aquaculture technology applied on particular fish species and the area of the study; (b) to identify the most crucial technological and institutional uncertainties linked to probable policy-specific impacts; and (c) to indicate what additional data and analyses will be needed in order to define the thrusts of the next phase. The activities in this phase include: (i) initial information gathering, (ii) formation of a steering committee for the project, (iii) in-house consultation meeting to clarify issues and practices, and (iv) identifying the prospective participants in the project.

2) Policy Analysis Phase. The objectives are: (a) to describe technical, socio-economic, and policy-institutional future based on alternative assumption about the future in the study area; (b) to identify the probable future implication of aquaculture technologies with emphasis on possible unplanned and higher order institutional and policy effects; and (c) to identify and compare possible policy alternatives related to aquaculture technology development in the region with emphasis on costs, benefits, uncertainties, and risks likely to be involved.

The activities in this phase include: (i) data consolidation, through interaction with collaborating individuals and institutions; (ii) intensive analysis of data consolidated; and (iii) preparation of the final report.

3) Validation Phase. The objectives are: (a) evaluate and review the assessment against the initial question and assumption which generated the assessment framework; (b) to discuss the implications of the assessment; and (c) to develop a plan for monitoring the impact, tracking the assumptions that underline the assessment.

Activities of this final phase of the project are: (i) panel discussion meeting of involved research staffs, experts, and government officials who are involved in planning and implementation of the regional and national aquaculture industry development; and (ii) completion and publication of the report.

Expected Results

The main result of this technology assessment study will be improved information for decision-making of research administration, policy-makers and technology-support-system managers. The second significant result is the demonstration that policy and institutional analyses can form the core of a comprehensive assessment. Added to these is the experience in conducting technology assessment that would generate methodological insights to technology assessment per se.

Analytical Parameters

Figure 1. Classification matrix of TA Studies

Technical efficiency Economic Feasibility Safety risks Public Policy options	All relevant impact domains Only selected impact domains	2nd & higher order effects (i.e., unintended, unanticipated synergistic, cumulative) Only 1st order effects (1. e., intended impacts)	All key parties at interest (i.e. bankers, consumers, industry, youth) Only particular parties at interest)	Effects on all relevant system (ex. health, transportation, communication, education, legal)
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Macro TA - What is the state of the art of the technology? (Comprehensive)

- Are there better micro and macro alternatives to achieve the objective?
- What are the potential 2nd and higher order impacts and consequences?
- How will these impacts and consequences interact with each other?
- How will these impacts and consequences interact with each other?
- Who are the parties at interest and how will they be affected?
- Who are the decision makers and What is the potential for public Policy to avert/minimize undesirable impacts and/or enhance desirable impacts?

1 1 1 1 x x x x

Partial TA (about an order of magnitude smaller than macro, and focus either depth/breadth)

Selected impact (same problem as above, but only selected impact and consequence domains are included)

3 3 2 1 x x

Micro TA (... smaller than partial and are
(Heutiric) generally based on "brainstorming"
group session.

4 4 4 4 x x x x

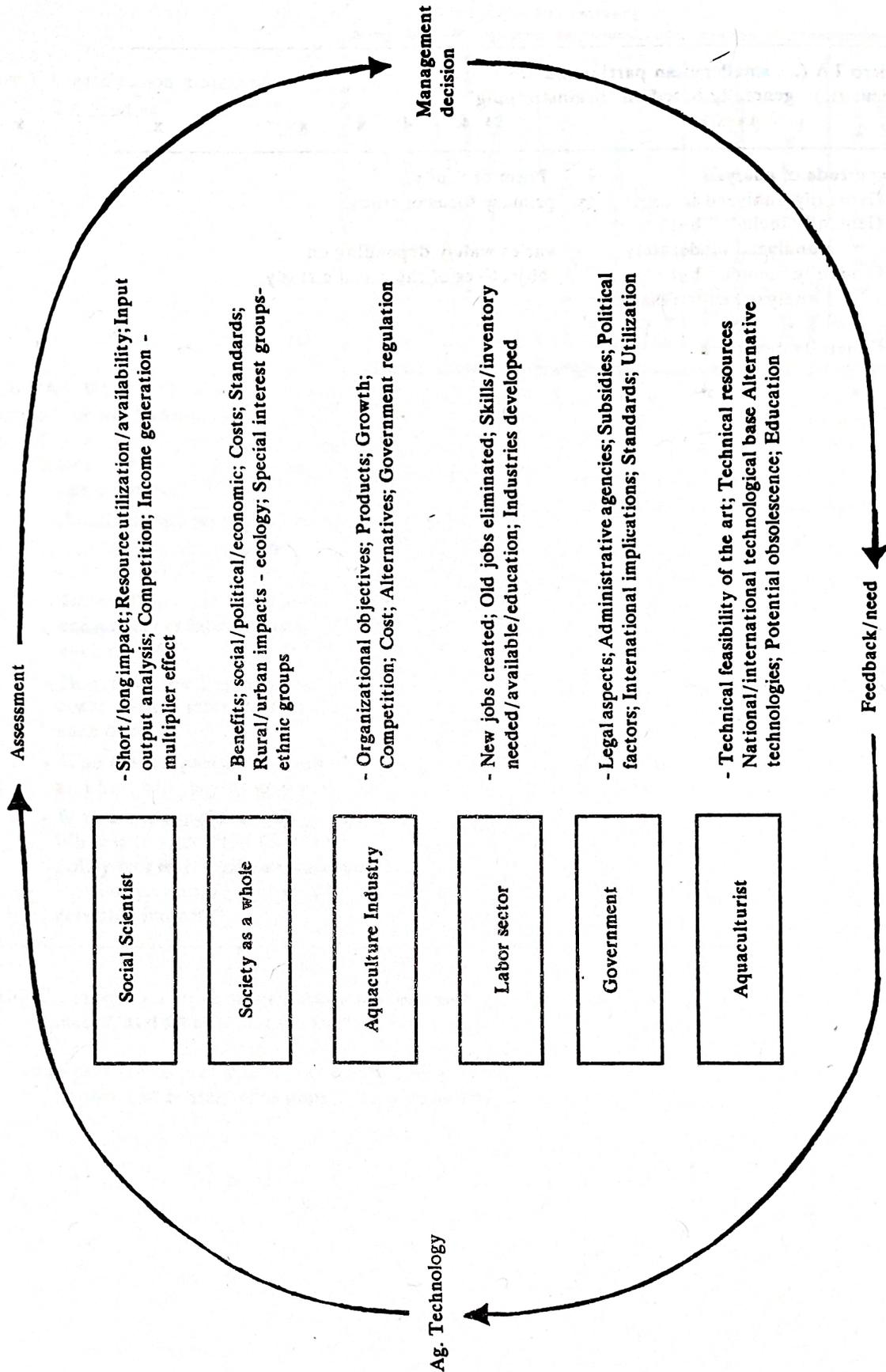
Magnitude of analysis

- 1. Generally analyzed in depth
- 2. Generally included but analyzed moderately
- 3. Generally included but analyzed superficially
- 4. Generally depthless

Form of Study:

- x primary focus of study
- varies widely depending on objectives of the specific study

Figure 2. Aquaculture Technology Assessment Process: A Systems Model



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4. David M. Kiefer, "Technology Assessment" *Chemical Engineering News*, Vol. 48 (October 5, 1970).

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