Developing countries today face serious dilemmas regarding introduction of new technologies for development. Their need for a wide variety of technologies is increasing rapidly. Lacking expertise and experience, they find it hard to determine the appropriateness of technological alternatives in terms of cost, quality, scale, degree of sophistication, risk of failure, and environmental risks. Having made certain choices may sometimes compound problems rather than solve them, particularly if the chosen technology happens to be an advanced technology (to be) acquired from abroad, involving high costs and high risks. Criteria and mechanisms for evaluating appropriateness of the needed or chosen technologies before and after their introduction have not been fully developed in most developing countries. This article discusses these issues in light of the contemporary experience of Third World societies and suggests some measures to help incorporate technology assessment in the policy and planning apparatus at various levels.

EVALUATING APPROPRIATE TECHNOLOGY FOR DEVELOPMENT

Before and After

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There was a time not so long ago when the label "appropriate technology" applied only to a technology that was small-scale, locally produced, inexpensive, labor-intensive, energy efficient, nonpolluting, unalienating, and so on. This model of technology was idealized by Gandhi, Mao, the hippies, Schumacher and his "Small is Beautiful" people (Schumacher, 1973), and a lot of others: intellectuals, scientists, environmentalists, and so on.

Despite its Eastern origins, the appropriate technology movement first gained momentum in the West in the sixties and was spurred on in the early seventies by the oil crisis and "Limits to Growth" days of the early seventies (see Meadows, 1972; Clark, 1973; Reddy, 1975). The movement was subsequently exported to some technologically active developing countries where

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left-leaning intellectuals, members of the scientific community, journalists, and politicians embraced it wholeheartedly, romanticized it further, and popularized it locally.[1]

Those were good days for the appropriate technology movement and the people who were in it. These people travelled a lot, spoke a lot, wrote a lot, and had many conferences and lots of fun. Anyone who challenged them was accused of promoting destruction of the environment and cheering on capitalism and technologism.

The extent to which government policy on technology choice in the developing countries was influenced by the ideology of appropriate technology has never been fully determined. The movement did have some impact in that it made the public and the policymakers aware of the exploitative nature and environmental hazards of capital intensive, advanced technologies for which most of the Third World depended upon the more industrialized countries.

The movement also spawned countless programs to develop and implement small-scale, particularly rural and socially relevant, technologies using local resources. Its impact was most pronounced in the energy field. Today, millions of biogas plants, solar energy panels, and windmills in the developing countries owe their origins to the appropriate technology movement.

As the techno-economic-industrial gap between the developed and the developing countries increased, the ideal type of appropriate technology began to lose much of its rationale and emotional appeal in the Third World. Proponents of development there began to suspect the "small is beautiful" formula would guarantee continuing underdevelopment and second-class status in the community of nations.

Fueling this suspicion further was the worldwide push for high technology, particularly in the fields of nuclear energy, electronics, and biotechnology, in which several non-Western developing countries began to play a prominent role. When China and India exploded nuclear devices, and when South Korea, Taiwan, and Singapore followed the Japanese example and jumped into high tech competition and, subsequently, world markets, the Third World lost much of its technological innocence.

These developments heralded a new thinking and a fresh technological strategy for worldwide economic development informed by global events. Growth as a step-wise function and development as a phase-coherent evolutionary process were no longer considered necessary. That nations could actually leapfrog, at least fragmentally, into revolutionary technological change had been empirically demonstrated.

In this changing climate, the ideal type of appropriate technology as proposed by Schumacher and others is no longer considered valid or necessary. Technological appropriateness is determined by the context, that is, socioeconomic needs and goals, environmental constraints and risks, and resource capabilities, including scientific and technological capabilities.[2] This is a classic case of a goal-directed contingency approach to making technology choice decisions whereby an actor (a nation, agency or group) scans the realm of available technological alternatives and chooses the ones that are most desirable and feasible from the point of view of meeting needs and achieving goals rather than being directed by preconceived notions or a predetermined set of parameters. In this approach, quantitative data and its qualitative assessment, opinions of experts and other influentials, and larger political and economic factors play a far more important role than environmental and cultural concerns or the concern for the individual.

This is be no means a foolproof approach and mistakes about the intended and unintended consequences of technologies will continue to be made. Technology assessment before and after technology implementation is suggested as a method to minimize these mistakes (Khan and Rahman, 1985).

If a chosen technology accomplishes what it purported to accomplish, it is considered contextually appropriate provided the context as defined here is fully taken into account. This differs from situation to situation and involves many trade-offs. For instance, if a nation wants to build four-lane intercity highways, thousands of trees and acres of forest and agricultural land will have to be sacrificed. Having made such a decision as an economic and social necessity, the best way to go about building the highways would involve capital-intensive advanced technology.

The problem is that many developing countries have opted to build four-lane highways without having many automobiles to travel on them, or without having first provided the basic necessities of food, shelter, and literacy to the masses.

There may be other areas of critical need, for example, energy, for which a developing country need not immediately opt for the most advanced technology. Energy needs can be met in a variety of ways in different sectors. In the domestic sector small, decentralized, individually or collectively owned biogas plants have been quite successful in China, India, Tanzania, and other countries. The cost of these plants is minimal. The fuel is provided by cattle and agriculture refuse. Skill-generating potential for the owner and his or her neighbors is high and the environmental risks are almost nil.

In their haste to modernize and in fear of falling further behind, the developing countries have often shopped around and acquired advanced technologies disregarding their socioeconomic implications and their own incapability to manage them properly (see Ahmad, 1980; Chatel, 1979; Randolph and Koppel, 1982). The advanced nations supplying these technologies cared more for their own commercial and geopolitical interests than for the health and welfare of the technology recipient.[3]

These push and pull factors have combined to create a situation in which technology evaluation before and after its introduction is considered an expensive nuisance by both sides. Technology suppliers have sold abroad countless products: pesticides and drugs, for instance, that they would and could not sell in their own countries. They and their overseas partners have jointly tolerated safety standards much below those enforced in the home country (Shaikh, 1986; Ahmed, Morehouse, and Shaikh, 1982). The Union Carbide pesticide plant in Bhopal was the epitome of such a cooperative international corporate irresponsibility (Bhushan, 1985: 102-116).

TECHNOLOGY ASSESSMENT AND APPROPRIATE TECHNOLOGY

The relationship between TA (technology assessment) and AT (appropriate technology) is obvious: Technology choices must be informed by the results of careful and comprehensive technology assessment. I quote from an earlier study on this subject:

> Comprehensive TA starts with a consideration of social goals for which technologies are to be generated and implemented; and subsequently moves on to take into account all possible implications of the proposed (alternative) technologies—technological, economic, political, sociocultural, environmental, etc. implications—before a choice is made as well as after the technology has been in use for some length of time. The assessment is to be made of the anticipated as well as unanticipated consequences of technologies [Ahmad, 1985: 125].

In this study, a four-phase TA model was presented:

Phase 1: identification and evaluation of social goals (to be achieved through technological interventions)

Phase 2: identification and assessment of feasible technologies

Phase 3: assessment of specific technological alternatives according to a set of criteria—e.g., availability of technology and its socioeconomic costs and benefits, manageability, and environmental risks
Phase 4: post hoc impact analysis over time

Evaluation of social goals as a prerequisite for comprehensive technology assessment often poses serious problems.

Whose goals are these?
How were they chosen?
How can their appropriateness for different sections of society and for society as a whole be determined?

These are basically political questions that would be almost impossible to answer to everyone's satisfaction, particularly in a large, complex, and pluralistic society.

In the developing countries the motor of change is usually the government, however elected or selected. What the government selects as social goals may not satisfy the needs of common people who might not have any say in the matter. TA teams will have to accept these goals as a given and use them as yardsticks to determine the best possible technological alternatives. They can also help clarify the goals and point out the pros and cons for each technological alternative and the conflict of interests it generates as social impacts.

In highly differentiated social structures new technologies have been noted to accentuate inequality further rather than reduce it, while at the same time producing some positive results for society at large. For instance, fishermen along the coast of Maharashtra in India have for centuries caught fish in the Arabian Sea using small boats, hand-woven nets, and a few hired hands. The yield per unit of input has been low, but this mode of fishing has provided subsistence for thousands of fishermen. The State government's Department of Fisheries in recent years has promoted the use of mechanized trawlers imported from abroad. A trawler-based fishing operation yields much bigger catches but it is also a capital-intensive, labor saving, and sea-polluting operation which has driven many traditional and poorer fishermen out of business. So, while there is plenty of fish in the market at higher prices, the rich fishermen have become richer and the poor, poorer.

The same argument holds true in the case of new agricultural technology in most developing countries that have otherwise benefited enormously from it.

PRE- AND POSTIMPLEMENTATION TECHNOLOGY ASSESSMENT

Technology assessment has generally been carried out as an after-the-fact exercise. This approach is short sighted and costly in the long run. Expensive and often irreversible investments may leave room for only minor changes afterwards. Preimplementation TA can help avoid such pitfalls. On the other hand, nobody has ever forecast correctly the nature and extent of all the intended and unintended consequences of complex technologies in just one shot. In order to be fully understood, they need to be studied after a technology has been operational and diffused for some time. Thus it is advisable to do TA before a choice is made, follow it up after two or three years to study the impacts, and do it again periodically for necessary modifications and upgrading of the technology until it is degraded and is ready to be replaced by a newer one. Post hoc TA will be greatly assisted if the technology management groups are required to maintain a systematic record of the behavior of technology and the technology user systems. Such record keeping is generally lacking in the developing countries (see Chow, Watson, and Chaung, 1983).

INSTITUTIONALIZATION OF TECHNOLOGY ASSESSMENT

The question of who does (or should do) technology assessment has generated much controversy both in the developed and the developing countries. In the United States, the Office of Technology Assessment (OTA) has either directly undertaken or sponsored hundreds of studies since its inception in 1972. Approximately 70% of its work is done by consultants from private firms or universities. Large corporations, as developers and promoters of new technologies, and foundations interested in technology matters also sponsor TA in a similar fashion. Whether technology evaluation by those who have a vested interest in the technology can ever be fair and impartial is arguable. In light of this argument, the role of independent, self-appointed guardians of technology (e.g., Nader's Raiders, Carl Sagan, and so forth) in the technology evaluation process becomes extremely important. However, comparing the reliability of their data and results poses serious problems. Using a similar set of parameters and permutations, different investigators may reach qualitatively different conclusions depending upon their own assumptions, methodologies, and biases. In a pluralistic TA process, one gets the satisfaction of being well informed and hopes that the decision makers, too, are so informed. The conflict on matters concerning science and technology is ultimately resolved not by the methods and expertise of science but by political fiat (e.g., Reagan's Strategic Defense Initiative).

The situation in the developing countries is quite different. There, for better or worse, government is the sponsor and promoter as well as the implementer of almost all large-scale technological change. External lobbies for or against new technologies either do not exist or are very weak at best. Independent scholars and nongovernmental organizations have few resources and/or will to undertake comprehensive technology assessment.

TA, if it is done at all, is done by the government bureaucracy as post hoc rationalization of expert committee recommendations on technology choices. In these countless committees appointed by the government, scientists and engineers, who are usually government servants, evaluate technological alternatives on the basis of their position in the bureaucracy, their expertise, and their experience. Their inputs are considered sufficient data for making sound technological decisions. No further evaluation beyond technical and financial feasibility is undertaken thereafter. These decisions may sometimes be challenged by individuals and groups, but lacking institutional legitimacy and/or political support, they cannot present a serious challenge to the government's decisions.[4]

If TA is to play a role in determining technology choices and evaluating their consequences for the public good in developing countries, it must be institutionalized both within and outside the government. Government ministries, departments of science and technology, research and development agencies, and so on must establish their own technology assessment cells with sufficient autonomy and resources to evaluate independently technologies developed by them or imported from abroad under their authority. The role of these cells should be to sponsor TA studies, not to conduct them.

The actual assessment should be done by interdisciplinary teams of consultants—scientists, engineers, critics, and analysts of technology—drawn from universities, research institutions, and nongovernmental organizations such as scientific associations and private industry, in order to present what Harold Linstone (1984) calls "multiple perspectives" in technology decisions.[5] TA should not be done as an ad hoc, one-shot affair. Following some kind of technology forecasting, it must be built into the policy process as a prerequisite to technology choice.

At the present stage of their development, institutionalization of technology assessment would definitely be a plus point in Third World S&T policy for development. Awareness about TA as an aid to S&T policymaking is growing. Some countries such as India—long before Bhopal—have already taken some concrete steps. The Indian government's Department of Environment and the Department of Science and Technology have conducted and sponsored some important technology evaluation studies (e.g., the Silent Valley Project in the State of Kerala, the Mathura Refinery near the Taj Mahal, deforestation in the Himalayan foothills), although certain areas, such as nuclear energy, continue to be holy cows of Indian science that no one is expected to question (see Sharma, 1987; Bowonder, 1983: 57-89).

Today most Third World S&T policymakers and managers know to some extent what TA is and why it is important. What they don't know is how to do TA from the point of view of its (a) concepts and techniques, (b) institutional location and dynamics, and (c) management and mobilization of the required resources.

Barring a few exceptions, knowledge and expertise about TA is lacking in most of the developing countries. Training with outside help to build the required expertise—for example, familiarity with methods such as operations research, Delphi, cross-impact analysis, scenario construction, and so on, and their applications—would be extremely useful. This expertise cannot be built overnight. But if the developing countries are ever independently to conduct systematic and comprehensive evaluation of the technologies they are acquiring from various sources, they will have to build TA expertise, institutionalize TA, and use it at different levels of science and technology policy.

It should, however, be noted that even where assessment capabilities do exist, TA may still not be done. Or, if it is done, the results may neither be made public nor used by the government. The reasons for this may be technical, social, political, and/or economic. Necessary data to do comprehensive technology assessment may be difficult or impossible to obtain. Government and industry, as sponsors of technology, may worry about TA causing unfavorable public reaction to the proposed technologies, forcing them into a less preferable, often costlier, course of action. TA may be considered an expensive and time-consuming exercise that produces controversial findings at best, causing confusion and delay. Government machinery may prove incompetent to implement TA recommendations and bring about necessary change in its preplanned strategy. These difficulties can be overcome only if the government is convinced of the importance of TA as an aid to making better and more sensible technology choices.

CONCLUDING REMARKS

While technology assessment is proposed as a useful method in technology choice decisions in the developing countries, it is not to be taken as the last word in resolving technological dilemmas or avoiding technological failures. Much of the initial euphoria about TA has subsided internationally due primarily to three reasons:

(1) Environmental concerns have been institutionalized at various levels of technology decision making and implementation.
(2) Global competition has intensified technology push and pull everywhere.
(3) Technology assessment has not delivered as much as it had promised.

So, for instance, while nobody in the United States today expects the Office of Technology Assessment to utter the last word in matters concerning science and technology and their social and environmental consequences, the OTA is still a very active and influential organization in its role as adviser to the Congress on technology related issues. Despite its many failures, TA continues to be conducted by many people at many places for different technologies, for whatever it is worth.

NOTES

1. For a global mapping of the appropriate technology movement, see Jequier and Blanc (1983).
2. For further comments on the changing definition of appropriate technology, see Ahmad (1985: 326-325).
3. Some details regarding this aspect of international technology transfer are provided by Shaikh (1986).
4. For details on a sustained effort to counter India's nuclear policy, see Sharma (1984).
5. Linstone's multiple perspectives consist of T (technical), O (organizational/social), and P (personal/individual).

REFERENCES

AHMAD, A. (1980) "Technology assessment: The state of the art in India." J. of Scientific and Industrial Research 39 (March): 125-131.

AHMAD, A. (1985) "Building indigenous capacity in advanced technologies," in Third World Foundation for Social and Economic Studies (ed.) Third World Affairs. London: Author.

AHMED, K., W. MOREHOUSE, and R. SHAIKH (1982) "A poisonous trade." Development Forum (January/February).

BHUSHAN, B. (1985) "Bhopal: what really happened?" (Special Report 1). Business India (February 25-March 10): 102-116.

BOWONDER, B. (1983) "Environmental risk in developing countries," pp. 57-89 in T. O. Riordan and R. K. Turner (eds.) Progress in Resource Management and Environmental Planning, Vol. 4. New York: John Wiley.

CHATEL, B. H. (1979) "Technology assessment and developing countries." Technological Forecasting and Social Change 13 (April): 203-211.

CHOW, J. C., J. G. WATSON, and C. Y. CHAUNG (1983) "Air pollution in the republic of China (Taiwan). Air Pollution Control Assn. J. 33 (August): 768-770.

CLARK, R. (1973) "Technology for an alternative society." New Scientist (January 11).

JEQUIER, N. and G. BLANC (1983) The World of Appropriate Technology. Paris: OECD.

KHAN, M. U. and A. RAHMAN (1985) "Problems of technology development in the Third World." J. of Scientific and Industrial Research 44 (December): 631-634.

LINSTONE, H. A. (1984) "Futures research report card—Quantity: A; Quality: C; and Impact: F." Futures (August): 397-400.

MEADOWS, J. L. (1972) The Limits to Growth. New York: New York Univ. Press.

RANDOLPH, R. H. and B. KOPPEL (1982) "Technology assessment in Asia: status and prospects." Technological Forecasting and Social Change 22 (December): 363-384.

REDDY, A.K.N. (1975) "Alternative technology: a viewpoint from India." Social Studies of Sci. 5: 331-342.

SCHUMACHER, E. F. (1973) Small is Beautiful. London: Bond & Briggs.

SHAIKH, R. A. (1986) "The dilemmas of advanced technology for the Third World." Technology Rev. 89 (April): 57-66.

SHARMA, D. [ed.] (1984) Atomic Power: Myth and Reality. New Delhi: Committee for a Sane Nuclear Policy.

SHARMA, D. (1987) "Sociology of nuclear disaster reporting." Media Monitor (March-April).

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