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# Utilization of Remote Sensing Data—The Sociological Perspective

## The social aspects and the inadequacy of benefit-cost analyses with regard to remote sensing from satellites are discussed

Abstract: *Remote sensing provides an opportunity to study the ways in which new sources of data enter into decisions related to resource management, the conditions and criteria for acceptance of the new techniques, and the methods by which assessment of their utility is accomplished. This article, based on the ongoing research of an integrated project at the University of California, underscores the social dimensions of technology utilization and assessment, with reliability, specificity, ease of access, and openness among the main desiderata. The point is made that the interface between the technology and the society it is designed to serve is crucial, for upon its nature depend how, whether, when, and by whom the technology will be utilized. How it will be judged is, similarly, seen through the social lens, as the author reviews present reliance on quantitative techniques, such as benefit-cost analyses, and points out their inadequacy.*

Presentation in this journal of the sociological perspective on the usage of remote sensing data may at first glance appear to be an anomaly. On second glance, however, even the most dedicated remote sensing expert will recognize that, ultimately, meaningful application of his work, whether in research or operations, depends on a complex web of social, cultural, economic, and political factors. What he realizes is that implementation of *any* technological advance does not take place in a social vacuum. There exists an important interface between the technology and the society it is designed to serve—between the scientist and the user community. Upon the nature of this interface depend how, whether, when, and by whom the technology will be utilized. In a word, it is at this juncture that its future course is influenced. Thus, when we consider earth-oriented satellites such as LANDSAT (formerly known as the Earth Resources Technology Satellite series), social scientists have a useful role to play. Working in tandem with the remote sensing scientists, they must try to ascertain the social forces impinging on how and where the remotely sensed data can enter decision-making processes and how the data will ultimately affect the outcome of the decisions. This is an area of inquiry that has received relatively little attention, and yet herein may reside the vital link between the "promise" of the technology and its ultimate social significance.

An example will help illustrate some of the lacunae which exist between technological potential and utilization. In a speech before the World Food Conference in Rome on November 5, 1974, Secretary of State Henry Kissinger made the following statement:

> Next year, our space, agriculture, and weather agencies will test advanced satellite techniques for surveying and forecasting important food crops. We will begin in North America and then broaden the project to other parts of the world. To supplement the WMO

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> (World Meteorological Organization) study on climate, we have begun our own analysis of the relationship between climatic patterns and crop yields over a statistically significant period. This is a promising and potentially vital contribution to rational planning of global productions.

Secretary Kissinger's reference was to LACIE (Large Area Crop Inventory Experiment), which is a joint program involving the National Aeronautics and Space Administration, the U.S. Department of Agriculture, and the National Oceanic and Atmospheric Administration.[1] The Secretary's remarks have been interpreted to suggest further expansion of LACIE, beyond the current sample segments in the United States. When the Secretary mentioned testing "advanced satellite techniques," he was still in the realm of the scientific. When, however, he talked of surveying and forecasting "important food crops," he stood at the interface with society, for food crops have clear social connotations; they are important because they feed people. Who gets fed, at what level of sustenance, and what will be the effects quantitatively and qualitatively of a better fed world population—all these are matters of social import about which there is little agreement, as evidenced in the outcome of the Rome Conference. The concept, rational planning, requires scrutiny through a social lens, for it, too, is socially defined. It encompasses history, geography, religion, culture, economics, and politics. "Rational planning" is normative. It implies an improvement over some existing practice, which is part of the "ground truth" that must be analyzed. Rationality is relative, depending on the place and circumstances. A course of action may be "rational" for one person, state, or nation and quite irrational for others. A plan may be economically "rational" and yet socially or politically disastrous. "Rational" is a perishable term; something that may seem "rational" in the short run may be quite irrational over time.

Secretary Kissinger's "rational planning of global production" is laden with even more social implications. The notion assumes the kind of world in which "rational planning of global production" has some possibility of achievement. As one contemplates relations among nations and their stance *vis-a-vis* other vital commodities, as, for example, oil, one cannot but sense the gigantic proportions of this assumption. In fact, one wonders what kind of utopian world view could counteract the earthbound realities of the World Food Conference itself, where the cruel calculus of triage, self-preservation, and nationalism took precedence over humaneness, altruism, and the brotherhood of man. Too, "rational planning of global production" assumes some kind of consensus not only about production but also about distribution, pricing, and even consumption. For this we find no useful models. Even when the technological means to mount a global food watch are achieved, there still remains the need for social wisdom to manage the results.

The remarks by Secretary Kissinger at the World Food Conference serve to exemplify the importance of the interface between technology and society and of the peril of neglecting it. Hence, we use it as the introduction to this paper, which is based on research being performed by the Social Sciences Group, related organizationally and functionally to the Remote Sensing Research Program at the University of California, Berkeley, Multi-campus Integrated Project conducted under NASA sponsorship.[2] Participants in the project include such disciplines as hydrology, forestry, geography, agriculture, engineering, economics, and sociology. The Social Sciences Group, working with the others, has been studying the social conditions, environment, and impacts of remote sensing for management of water resources in California. Our specific interest is the utilization aspect of data derived from LANDSAT and subsequent satellites and other remote sensing vehicles. From our research findings we are beginning to derive insights relevant to technology assessment and utilization in general.

Monitoring the earth's resources from space represents a leap into the future technically. The promise is enormous, but the potential can be realized only if implementation occurs and if certain conditions, having to do with proper and full-dimensioned assessment, have been satisfied. These are social problems, and the social scientist must "map the social landscape," much as the remote sensing expert establishes ground truth in order, to ascertain the *why's* and *wherefore's* of application and utilization. Interesting to note in this connection is NASA's official recognition that these aspects of its programs merit study along with the technical.

[1] Allen L. Hammond, "Crop Forecasting from Space: Toward a Global Food Watch", *Science*, 2 May 1975, pp. 434-436.

[2] NASA Grant NGL 05-003-404, "An Integrated Study of Earth Resources in the State of California Using Remote Sensing Techniques."

NASA has long fostered the multidimensional appraisal which only recently, under the rubric "technology assessment,"[3] has become generally recognized as necessary, and, under the mandate of environmental impact assessment, has become a legal requirement.

The focus of the ongoing research by the Integrated Project is California's water resources, central in the life and pattern of development of the region since the days of the Spanish Mission. Vital in the past, water becomes ever more critical because of the uncertain future of a number of factors with which it is intimately related. That many of these are clearly social can be seen in the list of issues selected by the California Department of Water Resources in its attempt to design a framework for future planning. They are as follows:

- shifts in patterns of demography, e.g., lower birth rates and migratory movement of population;
- expanding world agricultural markets, e.g., USSR, China, and the less developed countries;
- more stringent air and water quality standards and regulations;
- changing policies on land management and usage; and
- greater concern for environmental preservation and enhancement.[4]

Another key issue in water policy devolves on its relationship to energy, both with respect to consumption and production, and here the future, near and distant, is uncertain. However the United States achieves some degree of independence from foreign sources, whether through conservation or technological breakthrough, water will play a decisive role both as consumer and producer of energy. Of immediate concern already is the siting of power plants, since the use of coasts has been restricted and inland locations require considerable amounts of fresh cooling water.

The specific objectives of the Social Sciences Group are to identify, define, and refine the user role in the integration of remotely sensed data in water management. This mandate is consistent with and anticipates by some years the observations and recommendations of the prestigious Committee on Remote Sensing for Earth Resources Surveys (CORSPERS). With remarkable economy as to pages, a conspicuous disdain for padding, and no charts and tables, their report and evaluation of remote sensing technology constitute a refreshing antidote to the pseudo-mathematical macrame that dominates most attempts at technology assessment.

> Remotely sensed information ultimately must find its way to a multiplicity of final users. These may be found at all levels in government, private industry, and university groups. For example, the field of water resource management and the issues of land use mapping and land use planning affect many federal, state, and local and private agencies.
>
> The Committee recommends that an institutional communication link be established between resource and environmental data users at the state and local agencies and in private industry with responsible federal agencies.[5]

While the Social Sciences Group may not be able to forge that link, it works toward understanding and establishing the channels of communication which must precede it.

In cooperation with the scientific and technical members of the California Integrated Project, we study the institutions and mechanisms through which water policy decisions in California are made. We therefore concern ourselves with the decision-makers, the ways in which decisions are made, the kinds of decisions that must be made and by whom, and the data used and that which might be potentially useful in making and implementing decisions. Actual and potential receptivity toward new data sources is of special interest; here we assess such matters as (1) the *conditions for receptivity,* i.e., reliability, specificity (readiness of applicability), ease of access, and the like; and (2) the means and methods by which users arrive at decisions about new technologies, especially benefit-cost analyses. By identifying and establishing working rapport with the persons engaged in managing California's water resources, we explore these matters so as ultimately to gain a better understanding of the ways in which remote sensing and related technology might be linked into and made responsive to user needs.

The approach of the Social Sciences Group

[3] A clue to the interest and effort already devoted to the subject can be obtained from reference to the following: Mark A. Shields, *Social Impact Assessment,* A Report Submitted to the U.S. Army Engineer Institute for Water Resources, IWR Paper 74-P6, October, 1974.

[4] State of California, The Resources Agency, Department of Water Resources, *The California Water Plan–Outlook in 1974,* Bulletin No. 160-74, pp. 45ff.

[5] National Academy of Sciences, Commission on Natural Resources, *Remote Sensing for Resource and Environmental Surveys: A Progress Review - 1974,* Washington, D.C., 1974, pp. 38 and 39.

is practical and pragmatic; we seek no dazzling theoretical or methodological breakthroughs. While we engage in no simulation exercises and expect to derive no magic models, we deem it our obligation to draw upon our discipline and experience to examine and evaluate those being offered as justification for courses of action taken or proposed. In addressing the political and socio-economic aspects of water management, we seek to identify the real-life dimensions involved in decision making. In our view, these are the *sine qua non* in public policy formulation and far supersede parochial and doctrinaire considerations.

To identify the decision makers in California water management and to discover the kinds of decisions made is a task not too well or adequately served by reference to formal organization charts or tables. There exist a multitude of separate entities, which include agencies of the state and federal governments, local public bodies of many types, and departments of local governments. There is also the bureaucratic infrastructure, which interacts with appointed boards and commissions and treads a precarious course through the sometimes conflicting jurisdictional levels, to produce a "decision tree" resembling a wild blackberry bush! There is, moreover, the *informal* management structure, where "channels" are bypassed and actions taken with only token reference to "the book." In government as in industry, a great deal is accomplished, or stymied, by this mechanism. Added to this are the wholly personal biases, preferences, prejudices, and predilections of managers. Idiosyncratic, usually unpredictable, and often subliminal, these factors can be crucial in the decision-making process.

These observations should surprise no one who has any familiarity with large scale organizations and, more specifically, with a network of them, such as California's water industry. Who has authority and what are the areas of responsibility reflect a long history in California policy and politics, with economic overtones, legal ramifications, and sociological underpinnings. The huge literature on all these aspects attests to the complexity of water management and warns against too facile reliance on "the decision-maker' as anything but a convenient fiction or "the user community" as something other than a serviceable construct. This caveat is offered because of the tendency on the part of persons who would promote LANDSAT and other technologies to aim at too broad and amorphous a target.

## Conditions for Receptivity

At this point we might offer the axiom, based on observation, that in the case of a new technology, chances for successful transfer appear to be the more favorable the more specific is the application. The reason is clear almost to the point of redundancy: a new technology must prove itself in each instance of use. And the "proof" must show up in a relatively short time and must be fairly tangible. As we shall see later in this paper when we discuss evaluation methods, these conditions explain the popularity of benefit-cost studies of the kind that lend themselves to an assembling of supportive "facts" and thus provide a kind of quick rationale. Ideally, assessment should be conceived of more broadly, embracing many classes of effects that surpass conventional benefit-cost calculations and do so in a longer time frame.

To illustrate the case for specificity, we might point to an ongoing activity of the University of California Remote Sensing Program.[6] This has to do with the use of satellite imagery, in conjunction with appropriate supporting aerial photography, for snow survey work. At present, the California Department of Water Resources conducts a cooperative snow survey and water supply forecasting program, with some fifty agencies and organizations providing personnel and monetary support for field work and collection of data. Snow measurement courses, aerial snow depth markers, and automatic snow sensors are the devices used. While there seems to be a consensus[7,8,9] that the areal extent of snow is a valuable parameter in improved stream flow forecasting, major obstacles have been costs of acquiring data for large areas at the required level of accuracy.

The Remote Sensing Research Program at Berkeley has undertaken the evaluation and

[6] Under NASA Grant NGL 05-003-404, as part of the Integrated Project.

[7] D. Baker, "Remote Sensing of Snow Fields from Earth Satellites," in *International Workshop on Earth Resources Survey Systems,* National Aeronautics and Space Administration, NASA SP-283, May 3-14, 1971.

[8] James C. Barnes and C. J. Bowley, "Satellite Photography for Snow Surveillance in Western Mountains," in *Proceedings of the 37th Annual Meeting of the Western Snow Conference,* Salt Lake City, 1969.

[9] Charles R. Leaf and Arden D. Haeffner, "A Model for Updating Streamflow Forecasts Based on Areal Snow Cover and a Precipitation Index," in *Proceedings of the 39th Annual Meeting of the Western Snow Conference,* Billings, Montana, 1971.

testing of remote sensing techniques for estimating the areal extent of snow on LANDSAT imagery. Using U-2 and light aircraft photography and ground data as a suitable reference document, the group is developing a technique for interpretation and analyses of satellite imagery designed to provide an estimate of the areal extent of snow over 2.1 million acres (850,000 ha) in the Feather River Watershed. So that there may be confidence in the accuracy of the estimates, supporting interpretation techniques have been devised and statistical procedures applied. The ultimate objective of this demonstration exercise is to explore the cost-effectiveness of LANDSAT data in snow survey work, which contributes to water supply forecasting.[10]

In instances where a new technology is being offered as a potential substitute for and possible improvement over conventional methods, demonstration of reliability is a first priority and *sine qua non*. Another important factor is the time element in availability of the data. If one of the assets of remotely-sensed information and, hence, its advantage over traditional sources is timeliness, then channels for dissemination are essential. The current delivery system is cumbersome; there is a delay of as much as six weeks between receipt of the LANDSAT data and the time they are processed and sent by Goddard Space Center to Sioux Falls, South Dakota. Another two months may pass before the user can get a LANDSAT image from Sioux Falls, or up to four months if a computer tape has been ordered. Potential customers, like watershed managers, and, to a lesser degree, managers of agricultural and range lands, have probably been deterred from using LANDSAT data because of the time lag, since their operations require up-to-date input.

Speed of availability and efficiency of distribution are vital factors in the coupling of any technological innovation to socially useful purposes. This is particularly germane where *information technology* is concerned. Acceptance of LANDSAT and related satellites as a source of information has been further handicapped by another situation, this one peculiar unto itself, *viz.*, LANDSAT's own survival and the uncertainty that, even after convincing demonstrations of its capability, it can assure continuity of data delivery. The CORSPERS Report, mentioned earlier, stressed some of the negative effects of the unsettled future of the satellite program:

> Any user who requires data continuity and suspects that it may not be maintained will be reluctant to forsake his present information sources, even if inferior, to become dependent on remotely-sensed data. Similarly, a user now in the program who subsequently suffers a break in his data continuity may be very difficult to entice back into the program at a later time.[11]

Strongly affecting receptivity toward a technological innovation is *ease of access*, a factor of special importance in information technology because of its predominantly invisible and intangible character. This point concerns not the efficiency of the delivery system, already discussed above, but *openness of access*. Prospective users almost invariably ask about the secrecy associated with gathering and dissemination of LANDSAT data and express relief when they learn that there are no screening procedures, no security regulations, no restrictions on usage of the information. For one brief period in ERTS' history this very policy of openness created a severe problem in its delivery system. When, late in 1973, Eastman Kodak Company ran a series of magazine advertisements exhorting the public to "see your home town from space," the enthusiastic burst of one-time curiosity orders overburdened the facilities of the EROS Data Center and caused further delays for serious users.[12] This little episode illustrates the point that anyone who wants LANDSAT imagery may acquire it. He simply fills out the forms supplied by the EROS Data Center. Instruction sheets are available, as is the Data User's Handbook. Readily-accessible catalogs list offerings and prices. All that is required of the user are such routine items as name, address, zip code, and mode of payment.

Openness of access is stressed here because of a recent budgetary controversy over the future of civilian satellites. According to

[10] Sharp, James M. and R. W. Thomas, "A Cost-Effectiveness Comparison of Existing and LANDSAT-Aided Snow Water Content Estimation Systems", in *Proceedings of the Tenth International Symposium on Remote Sensing of the Environment*, Environmental Research Institute of Michigan, Ann Arbor, October 6-10, 1975.

[11] Committee on Remote Sensing Programs for Earth Resources Surveys (CORSPERS), *Remote Sensing for Resource and Environmental Surveys: A Progress Review, 1974, op. cit.*, p. 22.

[12] Testimony of Senator James Abourezk, Hearings Before the Subcommittee on Space Science and Applications of the Committee on Science and Astronautics, U.S. House of Representatives, Earth Resources Survey System, 93rd Congress, Second Session, October 3, 4, and 9, 1974, p. 83.

the "reliable sources" upon which the press usually draws, especially when a debate has taken place behind closed doors in the Office of Management and Budget, some Government officials maintained the view that military satellites could gather information about natural resources in the course of their other duties, and, perhaps, at a lower cost than and with certain technical advantages over the LANDSAT series.[13] The merits and demerits of military as opposed to civilian hardware are not strictly relevant here. Suffice it to say here that one argument is based on economy. Watchdog agency spokesmen are prone to raise questions about spending more taxpayers' money on space imagery that is of lower resolution that that of military satellites, which will continue to be flown. The counter argument rests on the special characteristics of LANDSAT-type systems, which are said to provide more of the kind of information needed in resource management. Moreover, proponents for the latter point out that follow-on launchings of LANDSAT-type satellites show a substantial decline in cost from the initial large investment in LANDSAT 1 and 2 to the relatively small cost-per-shot. It is clear, then, that we find authorities taking diametrically opposed stands on the technical and financial aspects of the debate.

Our interest being primarily the social factors influencing receptivity toward remotely-sensed information, we view as particularly germane openness of access. For this reason we contrast the reality of the case for LANDSAT data with a hypothetical case involving information from a military satellite. We must dwell in the realm of hypothesis when we discuss the military, because at present only several civilian agencies are permitted to enter the classified facility and use non-secret materials for making specified resource decisions. We even encountered extreme reticence about procedures for gaining access to the data. Other agencies who have sought access reported that there are "no visible mechanisms" for screening clearance and that, if any exist, they are not generally known. As we have just seen, LANDSAT imagery, by contrast, can be ordered like merchandise from a Sears Roebuck catalog.

Before trying to envision present practices for access to data from a military source we should indicate that, despite recommendations alleged to have come from the Office of Management and Budget that the Department of Defense should carry on civilian resource survey work as a sideline, the DOD has not responded publicly. It may be, as one official suggested, that the DOD's historic posture *vis-a-vis* intelligence activity of *any* kind, let alone mapping at home and abroad via satellite or some other "spy-in-the-sky" mode, will prevail. This has been one of categorical denial, even in the face of public disclosure and discussion.[14,15] Despite arguments in favor of economy of operation and against duplication of hardware, the military might very likely opt for steering clear of an expanded civilian service function, so as to maintain its own secrecy and to avoid the inevitable poor public relations that could result when users' requests for data were to be subjected to military screening procedures and, perhaps, denied.

Let us, then, construct our hypothetical case, based on the information we have been able to glean about civilian agencies which have used military sources for their survey data. To begin with, the prospective user must have official clearance. In order to obtain this, he fills out DOD form number 22-R-46, called "Personnel Security Questionnaire." Called for are the following items, among others:

> Names—last, first, middle, present and former, and aliases;
>
> Date and place of birth—self, spouse, former spouse (s), brother, sisters, and children. Also, living relatives of self and spouse not U.S. citizens;
>
> Education; military service, location of Draft Board;
>
> Organizational membership (except labor unions and those in subversive category specified later);
>
> Foreign countries visited or resided in, with length and purpose of stay;
>
> Foreign government, firm, corporation, or person for whom you act or have acted as a representative, official, or employee in the past five years;
>
> References, remarks.

(The following sections of the questionnaire are considered "privileged information between you and the Government.")

[13] David F. Salisbury, "Budget Pinch Threatens Nonmilitary Spacewatch," *The Christian Science Monitor*, January 21, 1975. It may be noted that a proposed third launching was the subject at issue and not LANDSAT 2, which had already been funded at that time.

[14] Ted Greenwood, "Reconnaissance and Arms Control," *Scientific American*, February, 1973, pp. 14-26.

[15] Luther J. Carter, "Strategic Weapons: Verification Keeps Ahead of Arms Control," *Science*, March, 1975, pp. 936 ff.

Arrests—for any violation of any law, regulation, or ordinance—all charges, even if they were dismissed, are to be listed, including traffic violations with a penalty of $25 or over;

Type of discharge, if any, from military service;

Record of security clearance suspended, denied, or revoked;

Mental or nervous disorders; use now or ever of habit-forming drugs; chronic use to excess of alcoholic beverages—with names and addresses of hospitals, clinics, doctors, etc.

Organizational membership in Communist groups, associations which are totalitarian, Fascist, Communistic, or subversive, or which has adopted, or shows, a policy of advocating or approving the commission of acts of force or violence to deny other persons their rights under the Constitution of the United States or "which seeks to alter the form of government of the United States by unconstitutional means."

The forms are submitted along with a card prepared by the Federal Bureau of Investigation (FBI form FD-258) for recording applicants' finger prints. Then, the potential user must establish definitively his "need-to-know"—another DOD requirement, satisfied by submitting his specific information request in terms of the resource decisions to be made. Just how the need-to-know is judged and by whom we could not ascertain. Therefore, we can offer no guidelines on preparing a persuasive case for need. The data are accessible for use only within a classified facility and interpretation is done on the premises; nothing is allowed out of the compound. The data to which the user will ultimately be given access then has to be "presanitized" by the military. In fact, it must be of such nature that it *can* be so shrouded that neither the source nor the accuracy discloses the system which produced it. This is an interesting and important point in light of the generally recognized practice, in professional work, of documenting one's data sources.

Since there exists at present no visible interface with the military, and therefore no mechanism for access, the situation we have described has been reconstructed from interviews with officials who speak from experience. If there are at present different avenues by which access to data from military satellites can be achieved, they are so swathed in secrecy or so obscured by protocol and elaborate procedures as to be virtually impassable. Assuming, as we do, the position that utilization of remote sensing technology is a desirable objective, then axiomatic among conditions for receptivity are ease and freedom of access. On this score, the present situation is as follows: EROS, the present dissemination system, impedes widespread acceptance through inability to deliver data quickly. The military's *ability* to deliver is irrelevant because of the situation just described. It can be said, however, that the situation is not static. The current difficulties are not insurmountable. EROS will probably improve in operational efficiency. The data management system can be altered, with a better flow from the sensing of data to its application by the user.[16] Policy changes may occur in the military. As the state-of-the-art of satellite technology advances and knowledge expands, the rationale for secrecy will decline. If, as we have seen, the Department of Defense can declassify photographs of re-entry vehicles from a Soviet missile,[17] can views of Russian wheat fields be far behind? Moreover, when the global embrace and dimensions of satellite technology are taken into account and its international implications come to the fore, openness will be a distinct asset in overcoming the "super-spy" notion.[18]

## Means and Methods of Assessing New Technologies

In an era when technological progress has been spectacular, social progress seems all the more laggard. The mismatch, while long familiar to anthropologists and sociologists, has a plausible explanation. Nonetheless, the lag can be burdensome to public administrators who are expected to move with the times and yet operate within the same time zone as the public they serve. How to select from the cornucopia of offerings those which will prove useful and beneficial, by whose standards such judgments are to be made, on whose expert advice to rely—these are matters that demand attention if the fruits of science and technology are to be integrated into public policy on a truly informed basis.

Earlier in this paper, we discussed certain conditions influencing the acceptance of remote sensing in particular and new technologies in general. Implicit in all the criteria—specificity, reliability, availability, accessibility, and the like—were elements of technology assessment. When resource managers adopt or reject a technological innova-

[16] Report No. 93-983, Authorizing Appropriations to the National Aeronautics and Space Administration, House of Representatives, 93rd Congress, Second Session, April 10, 1974, pp. 83-84.

[17] Luther J. Carter, *op. cit.*, p. 937.

[18] Donald F. Salisbury, "Satellite Photography: Helping Underdeveloped Countries," *Christian Science Monitor*, January 24, 1975.

tion, they have, presumably, made some kind of assessment. The notion is not new. The Flemish weavers applied it when they gave bad cess to the spinning jenny and hurled their sabots into the looms![19]

What is interesting to us in this context is the re-entry on the national scene of the concept *technology assessment* and its reattribution. For example, in 1969, the National Academy prefaced a report as follows:

> The phrase "technology assessment" was first introduced by Congressman Emilo {*sic*} Q. Daddario, Chairman of the Subcommittee on Science, Research, and Development, to characterize the sociotechnical research that discloses the benefits and risks to society emanating from alternative courses in the development of scientific and technological opportunities.[20]

This statement is as fuzzy as to objective as it is cavalier in its treatment of grammatical and typographical accuracy. Emilio Daddario had, to be sure, polarized attention on the growing scientific and technical content of legislative issues, for he had been concerned that therein lay a capacity for both good and harm. He proposed a program of assessment that would "enable decisions for the public good"[21] through better rapport between Congress and the nation's scientific community.

Daddario's efforts received widespread support for a number of reasons, some of them paradoxical: (1) Faith in science and technology was part of the American credo; therefore society, faced with complex problems, could turn to its scientific and technical reservoir for salvation; and (2) Science and technology were not an unmitigated blessing; in fact, possibly attributable to their skewed development was the "civilizational malaise"[22] of our time. Hence, their possible impacts needed to be scrutinized critically before irreversible commitments were made.

Technology assessment was to be rediscovered many more times[23] and, in the process, to undergo considerable institutionalization. Congress held hearings and formed the Office of Technology Assessment; the Department of Commerce set up its own Office of Technology Assessment and Technological Forecasting. Enactment of the National Environmental Policy Act of 1969, with its requirements for environmental impact statements, actually legislated technology assessment. Section 102 of the Act specified that an impact analysis had to be made in the project-approval stage, especially if the course of action under review were of a technological nature. College curricula, built around the theme, blanketed the country, with everything from engineering to political science joined in interdisciplinary effort. Learned societies, national and international, pondered the problems and published papers. New journals on the subject appeared and old ones devoted whole issues to technology assessment and attendant concerns. All these earnest endeavors were abetted, if not inspired, by generous infusions of money from government and foundation sources. Technology assessment had become the gravy train that would attract many riders from a wide range of disciplines, capability, and, deplorably, integrity. During the decade since Daddario "introduced" technology assessment, the term has taken on ubiquitous dimensions and ramifications, among which have been observed the rise and fall of science advisory committees, the growth to epidemic proportions of benefit-cost methodology, and the emergence of technology-predictive tools as part of the futurology kit.

As to the functioning of science advisory committees, the assumption that scientists would "apply the scientific method"[24] and would thus guide the perplexed with objective wisdom proved unwarranted. Science is not without bias and scientists have ideologies. In the orchestration of the advisory process the traditional advise-and-consent was often reversed. *Consent-and-advise* seems to have been the order of procedure, with recognition given to those scientists whose views were known to be consistent with or supportive of those of the current Administration.[25] Many of the nation's emi-

[19] This action did not materially affect the course of the Industrial Revolution, although it did contribute the useful word, ***sabotage,*** to the vocabulary of the worker.

[20] U.S. House of Representatives, Committee on Science and Astronautics, *A Study of Technology Assessment,* July, 1969, p.1.

[21] Statement in U.S. House of Representatives, *Technology Assessment, Seminar,* Proceedings before the Subcommittee on Science Research and Development of the Committee on Science and Astronautics, Nineteenth Congress, First Session, September 21 and 22, 1967, p. 2.

[22] Robert L. Heilbroner, *An Inquiry into the Human Prospect,* New York, W. W. Norton, 1974.

[23] Edward A. Wenk, Jr. " Managing Technology for a Humane Society," *The Trend* (Engineering, University of Washington) Vol. 26, No. 2, April, 1974. p. 5.

[24] Daddario, *op. cit.,* p. 2.

[25] Philip M. Boffey, *The Brain Bank of America;*

nent scientists have avoided the public arena to protect themselves from embroilment in partisan politics. Science advisory committees have sometimes found themselves in the position of the messenger who bears ill tidings. They may not have been beheaded for offering unpopular advice, but they were emasculated. Overall, they served the same purpose as Tevyeh's third stairway[26]—just for show.

Although scientists have been treated like prophets, i.e., without honor, "the scientific method" has been apotheosized. Quite contrary to scientific tenets, however, which call for rigorous definition, the term is now being applied to an eclectic amalgam of techniques derived mainly from operations research and systems analysis and, therefore, basking in a borrowed glory because of their prestigious heritage in defense and space management. Accorded credibility because they are "rational" and "scientific", the tools and analytic procedures have been offered almost evangelically as the way to assess the impacts, present and future, of technology, even though their demonstrated appropriateness for and achievements in public policymaking are dubious.[27]

Prominent among the techniques, benefit-cost analysis has come to represent the primary ingredient, if not the sum total, of the assessment process. Expedient because it yields a quick and quantified answer, the benefit-cost analysis, for all its limitations, is the evaluative tool most commonly utilized here as in other areas of public policy. As such, it is not new, for its origins are in the Flood Control Act of 1936,[28] which authorized the initiation of river and watershed improvements "if the benefits to whomsoever they may accrue are in excess of the estimated costs." Since that early beginning, reliance on benefit-cost analyses by Congress and government agencies at all levels has increased to the point that programs and projects are rarely authorized until a benefit-cost ratio has been calculated.

As experience has grown, however, some disenchantment has set in. Economists have pointed out the limitations, and criticism has focused on use of the techniques in the management of water resources.[29] The General Accounting Office conducted a survey of a number of federal bureaus and agencies which used benefit-cost analyses in project justification and summarized the criticisms as follows: (1) benefits were not computed in a consistent manner; (2) benefits were not based on an analysis of conditions with and without the project; (3) benefit computations were not adequately supported; and (4) project costs and induced costs were not fully considered in the benefit-cost determinations.[30]

Hanke's analysis of the Bureau of Reclamation's benefit-cost analysis reveals discrepancies in estimated costs and benefits sufficient to have altered radically the decisions about projects. The tools of economics lead, in these instances, to very divergent conclusions. And this will always be so, because, as he says "analysis is filled with both disputes over basic assumptions and widely divergent choices as to the 'correct' solutions to difficult issues such as level of interest rates, the value of wildlife, the effect of government programs on agricultural markets, and the impacts of political and administrative expedients." As Hanke so correctly points out, "although benefit-cost analysis can enlighten us on these issues, it does not provide us with an unambiguous technical solution to public expenditure decisions. In spite of years of refinement in the theory of benefit-cost analysis, no one has succeded in making it impartial or indisputable."[31]

Remote sensing is being subjected to these forms of assessment; benefit-cost analyses are used as means to justifying the continued development and operation of LANDSAT-type satellites as well as to the adoption of

*An Inquiry into the Politics of Science*, New York, McGraw-Hill, 1975.

[26] *Fiddler on the Roof*, musical by Sheldon Harnick and Jerry Bach, book by Joseph Stein, based on short stories of Sholom Aleichem.

[27] Ida R. Hoos, *Systems Analysis in Public Policy*, Berkeley, University of California Press, 1974.

[28] U.S. Statutes-At-Large 1510 (1936).

[29] For example, Otto Eckstein, Water Resources Development: *The Economics of Project Evaluation*, Cambridge, Mass., Harvard University Press, 1958.

J. Hirshleifer, J. deHaven, and J. Milliman, *Water Supply: Economics, Technology, and Policy*, Chicago, Illinois, University of Chicago Press, 1960.

N. McKean, *Efficiency in Government through Systems Analysis: With Emphasis on Water Development*, New York, John Wiley, 1958. Steve H. Hanke, "Benefit-Cost Reconsidered: An Evaluation of the Mid-State Project," *Water Resources Research*, Vol. 10, No. 5, October, 1974, pp. 898-908.

[30] Comptroller General of the United States, *Improvements Needed in Making Benefit-Cost Analyses for Federal Water Resources Projects*, Report to the Congress, September 20, 1974, p. 12.

[31] Hanke, *Op. cit.*, pp. 906-7.

remotely sensed data for specific resource management applications. Unfortunately, both types of evaluations have evoked exercises assigned merely to dazzle Congress or cover the law. Manipulation of costs; unsubstantiated assumptions of benefits; arbitrariness of selection of variables, objectives, and criteria; doubtful credibility of "facts"; built-in advocacy have all contributed to demonstrations of technical virtuosity. As guideposts to "rational" decision-making, the benefit-cost figures produced were highly questionable. They are more likely to satisfy a point of view or discharge a consultant's contract obligations quickly and neatly than to serve a social need.

The outlook is not altogether bleak, however. The Comptroller General's report[32] suggests that the era of cavalier treatment of the assessment process by obedient consultants and accommodating academics may be coming to an end. In the case of LANDSAT and related satellites, to predicate estimation of the value ultimately to be derived from the data on patently flimsy calculations is to court embarrassment at the review stage. Congress and funding agencies, once prone to gullibility so long as the benefit-cost format was used and numbers plugged in, are becoming more sophisticated. They recognize that a wary public will not accept a numbers game in the form of an econometric model of dubious validity or an absurdly precise benefit-cost ratio when long-range and intangible desiderata are at stake. More persuasive and credible than analyses conjured up as proof of capability or potential of LANDSAT-type technology are such evaluations as that performed by the National Academy of Sciences' Committee on Remote Sensing for Earth Resources Surveys (CORSPERS), whose work was mentioned earlier in this paper.[33] Needed are reviews, comprehensive in scope and searching in depth, with less dependence on the knee-jerk reflex of benefit-cost calculations and more concern for the larger dimensions and real-life proportions of technology assessment, which is, in the final analysis, an inherently social process.

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[32] *Op. cit.*

[33] *Remote Sensing for Resource and Environmental Surveys: A Progress Review - 1974, op. cit.*

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