THE DEVELOPMENT OF A RISK IDENTIFICATION FRAMEWORK FOR MERGING TECHNOLOGY ASSESSMENT AND ENVIRONMENTAL ASSESSMENT INTO A SYSTEMS APPROACH

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Purpose of Study: The awareness of advancing technologies and their impacts on quality of life has resulted in two separate activities, namely technology assessment and environmental assessment. Technology assessment has assumed a role of evaluating the multi-impacts of new technologies while environmental assessment has assumed a role of evaluating the environmental impacts of existing technologies. This study was intended to provide a framework for merging these two activities into a broad systems approach. The suggested framework utilizes risk as the common denominator for assessing the impacts on the quality of life of new and/or existing technologies. To accomplish this objective it was necessary to present and comparatively analyze representative technology assessment and environmental assessment methodologies.

Findings and Conclusions: Technology assessment methodologies and environmental assessment methodologies indicate a recognition of the potential adverse effects that technologies may have on impact areas. These adverse effects can be termed as risks and identified in the risk identification framework presented in this study. The utilization of this risk identification framework appears to be a potentially beneficial mechanism for merging technology assessment and environmental assessment into a broad systems approach for assessing the quality of life impacts of new and/or existing technologies.

ADVISER'S APPROVAL ______________________

PREFACE

This study is concerned with a comparative analysis of technology assessment and environmental assessment methodologies. The primary objective of the study is to develop a framework for merging the two methodology types into a broad systems approach. This framework utilized a risk concept for identifying the impacts that technologies may have on quality of life.

The author wishes to express his appreciation to his major advisor, Dr. James Jackson, who guided, assisted and encouraged me throughout this study.

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CHAPTER I

STATEMENT OF PURPOSE

Introduction

The 1960's tended to be an awakening decade for many individuals and institutions. Technology was rapidly changing and advancing, and the results of these changes and advances were not always beneficial. The standard of living concept, an economic point of view, was being replaced by the quality of life concept, a non-economic point of view. Quality of life are those characteristics that make life desireable. Rapidly changing technologies were producing threats to quality of life.

During the 1960's two separate activities were undertaken to preserve quality of life. One of these activities involved the increased concern for the impact of existing technologies on the environment. This concern led to the National Environmental Policy Act of 1969. Environmental impact assessment studies and statements were institutionalized with this act. The 1969 environmental act added impetus to the second activity. This activity involved the concern for the impact of new technologies on multi-areas of concern with environment being only one impact area. The second activity was labelled technology assessment.

Since their beginnings these two developments, environmental assessment and technology assessment, have been treated as separate considerations. Environmental assessment studies have for the most part been restricted to the environmental impacts of projects or actions that have dealt exclusively with existing technologies. Technology assessment has assumed a role that is broader in impact area scope but has usually been restricted to new technologies.

These two developments have fostered numerous methodologies for making their assessments. In the case of environmental assessments R. W. L. Andrews[1] has noted three separate changes in the development of these methodologies and their relationship with planning. The methodologies were first structured as processes totally separate from planning. Eventually these assessments became an information source for the planning process. Recently these assessments have been recognized as an inseparable and integral component of planning. The third development of integrating environmental assessment methodologies with planning is important. These changes in development are also believed to be occuring for the technology assessment methodologies. The movement of the two assessment types into the planning process indicates that the methodologies are merging toward a broad systems approach.

Purpose

This first chapter, based upon the discussion presented above, is intended to present the purpose of this study. The overall objective of this study is to provide a framework for the development of a systems approach for assessing the impacts on the quality of life of new and/or existing technologies. This approach virtually combines both environmental assessments and technology assessments.

The approach to be presented will utilize the concept of risk.

In essence risk will become the common demoninator for the assessment analysis. Technologies will be evaluated in terms of possible associated risks resulting from the implementation of these technologies. It is realized that this is only one facet of the overall analysis.

To accomplish this overall objective, several sub-objectives must be fulfilled. These sub-objectives are categorized by chapters in this study. Each chapter is intended to accomplish or provide a framework for accomplishing its related objectives.

Chapter two of this study is intended to briefly present the limited history of technology assessment. Technology assessment is a relatively new concept. Familiarity with its history is hoped to provide a common background for the discussions in the subsequent chapters.

Chapter three involves multi-objectives. The first objective is to examine the impact of technology assessment on different levels of concern. Industry, national, and international levels of concern will be used for this examination. The second objective of this chapter is to compare environmental and technology assessment methodologies. To accomplish this objective several steps are necessary. Methodologies for both assessment types will first be presented. Secondly these methodologies will be evaluated in terms of common criteria. The results of these evaluations will be utilized to compare and contrast the methodologies of the two assessment types.

Chapter four has as its primary objective the analysis of risk and its relationship to an assessment methodology. To accomplish this objective a framework is presented to aid in identifying and measuring risks that are related to the implementation of new and/or existing technologies.

Chapter five presents a summary of the conclusions and findings of this study. Because of the nature of technology assessment, various related fields were involved in this study. In many cases it was necessary to compartmentalize these related fields, as well as areas within these related fields. This compartmentalization provided a means for decomposing numerous considerations into controllable segments. It is recognized that each compartmentalization presented is only a component of a total analysis.

Technology

This study is an attempt to provide a framework for the development of a systems approach for assessing the impacts on the quality of life of new and/or existing technologies. It would seem advantageous to begin this study with a brief description of technology. According to Vice-Admiral H. G. Rickover,[2] technology is tools, techniques, procedures, things; the artefacts fashioned by modern industrial man to increase his powers of mind and body. Technology in broad terms thus involves how things are commonly done or made.

These definitions of Vice-Admiral Rickover tend to assume certain characteristics that are often overlooked in describing technology. Technology is politically, ideologically, and philosophically neutral, but it is not asocial. Technological advances are introduced into society because they affect it. Thus technology for this study consists of tangible products, systems, and processes, the uses of which involve social decisions.[3]

FOOTNOTES

[1] Richard C. Viohl and Kenneth Mason, Environmental Impact Assessment Methodologies: An Annotated Bibliography, Council of Planning Librarians, Exchange Bibliography #691, p. 4.

[2] H. G. Rickover, "A Humanistic Technology," Technology and Society (Reading, 1972), p. 22.

[3] Raymond L. Bisplinghoff, "Foreword," Technology Assessment In A Dynamic Environment (New York, 1973), p. ix.

CHAPTER II

TECHNOLOGY ASSESSMENT - HISTORY AND BACKGROUND

Introduction

Technology assessment is a new phrase that originated in the 1960's and has since gained the increased attention of individuals and organizations both in and out of government. This increased attention has led to a claimed Technology Assessment Movement.

The purpose of this chapter is to review the history of technology assessment and establish a common background for later chapters. This objective can best be achieved by answering five questions. The five questions to be considered are listed below:

1. Why should technology be assessed?
2. What is technology assessment?
3. What was the extent of technology assessment prior to the technology assessment movement?
4. What factors and events led to the technology assessment movement?
5. What progress has been made in the technology assessment movement?

Why Assess Technology ?

Benefits of Technology

Science and technology have contributed numerous benefits to the well-being of man. One merely has to reflect on a few of the comforts that surround man in order to assess the benefits he has received from technology. He is able to communicate over great distances by telephone and travel these distances by various modes of transportation if he desires. Man's life span has lengthened, and numerous diseases eradicated through technological advances in medicine. The basic needs of man such as food, shelter, and clothing are easily and conveniently provided for man in numerous varieties and types through technological advances.

Man has been able to dominate nature by his advances in technology. These advances in technology have become so rapid that technology may soon threaten to dominate man. It would seem that this threat demands methods of protecting man from this rapidly advancing technological creativity.[1]

Costs of Technology

Technology has not always resulted in benefits for man. The accelerated rate of technological change has contributed to a growing population that is rapidly consuming our limited natural resources. Technology has contributed to a deterioration of the social and natural human environment and has threatened the existence of many ecosystems. In essence technology has become a potential threat to man and his well-being. There is an obvious need for an "early warning" system to assess and direct technological advances in order to maximize man's benefits and minimize man's risks.[2]

Individually Affected Impact Areas

Technology as has been stated has provided man with benefits that have improved man's well-being, but these benefits have not been without costs. These costs, which are of primary concern, can be categorized into impact areas.

The categorization of impact areas has differed among the organizations and individuals that have performed technology assessment studies. Five impact areas have been selected from these studies. These impact areas will be used to exemplify the impact that technology has had. These areas are social, environment, economy, technology, and individual.

Social. Technology has often created situations that have led to social changes. These social changes have in some cases affected whole societies. One example of a technological advance that resulted in such a change was the mechanization of agriculture. This agricultural advancement resulted in the movement of millions of rural employees from the land into unexpecting and unprepared cities. The exodus of people from rural areas to cities had a profound effect on the cities, rural areas, and their social structures.[3]

Social changes and impacts are not subject only to "hardware" technologies but also to social technologies. Examples of social technologies that have resulted in unplanned social consequences are the invention of the credit card, the Homestead Act, and the GI mortgages.[4] According to the O.E.C.D., technologies may affect the social impact area through changes in social sub-systems, allocative patterns, and social relationships.[5] Other possible effects of technology on this impact area are changes in the areas of cohesion, invasion of privacy, civil disorder, job motivation, and urban overcrowding. These examples are not intended to cover all possible impacts that technology may have on the social system.[6] Since technology has the potential to profoundly affect changes in man's social system, it seems logical that technology assessment is needed. The nature and form of control then become a part of the political and economic process.

Environment. The examples of the changes that technology has had on man's environment are numerous. Often these changes have been detrimental to man's environment thus potentially threatening man's existence.

The pollution of water and air by the manufacturing and transportation technologies alone has resulted in numerous threats of extinction for many species of wildlife. Such destruction of a total species can result in a disequilibrium in many food webs. Such disequilibrium in the food web of an ecosystem has the potential of altering or eradicating the total ecosystem. Man is a part of an ecosystem and should realize that threats of destruction to other ecosystems are threats to his ecosystem.

There are many other effects that technology may have on environment. A few of these are noise pollution, weather modification, and mutagens introduced into the environment.[7] As with the social impact area, the need for technology assessment is obvious when one is aware of the effects that technology has had and may have on our environment.

Economy. Technology has always been an important influence on the United States economy. Technological advances that result in greater efficiencies in manufacturing may possibly result in decreased product prices, increased consumption, and increased unemployment. There are numerous cases where new technologies such as computers have resulted in the eradication of jobs thus increasing unemployment in the aggregate while increasing productivity and employment in sectors of the economy. Technology can affect the economy by changing economic factors such as the size and distribution of enterprises, income, and production.[8] Once again technological assessment appears to be an apparent need.

Individual. The individual has benefited by technological advances in medical research. Through this research expected life spans of individuals have been increased by the development of antibiotics. The development and use of antibiotics may also have a negative effect. The use of antibiotics has led to the increasing development of resistant strains. The individual presently can expect a longer life time due to this technological advancement, but there is now a potential for this technological progress to possibly negate its benefits by strengthening strains that may reduce man's life span.[9] The individual is not only affected in the health areas by technology, but also in many areas such as work and educational experience and the quality of life.[10] Consequently technologies which so significantly influence the individual should be assessed before they are implemented.

Technology. Technological advances normally result in the replacement of an existing technology, an addition to an existing technology, and/or the creation of newer technologies. The historical evolution of the vacuum tube to the transistor to the integrated circuit is an example of new technologies replacing, adding, and creating other technologies. The changes affected by new technologies on technology include results such as systems of interrelated innovations, technological transfers (horizontal or vertical), legal implications, and new constraints and standards.[11]

Impact Areas Affected in Total

Technological progress normally has an effect on all impact areas, not just one, and the effects are usually highly related. The mechanization of agriculture referred to on page eight affected the economy by increasing unemployment, affected the individual by his involuntary displacement, affected the environment by the increased transformation of wildlife areas into cultivated land, and affected technology by further advancing the agricultural technology scope into genetic and chemical areas. Because technology has the potential to adversely and/or beneficially affect the well-being of man in all the impact areas described above, the need to assess technology should be apparent.

What is Technology Assessment?

It is well known that technology is changing and advancing at a rapid rate. Secondly, it should be apparent that technology has a profound effect on all impact areas related to man, his survival, and his well-being. These two factors have created a need for the assessment of technology and possibly the control of technology. The problem is to determine how, when, and where should technology be assessed and controlled.

It is the intent of this section to present various authoritative opinions on the definition and specifications of technology assessment. These definitions and specifications will be used to develop a definition of technology assessment that will be used throughout this study.

"Technology Assessment" a New Phrase

The description "technology assessment" was first used in 1966 in a report from the Sub-Committee on Science, Research, and Development, of the House Committee on Science and Astronautics. There is some disagreement as to the creator of the phrase. Most historians attribute the phrase to Representative Emilio Q. Daddario, Chairman of this Sub-Committee. Others claim that Phillip B. Yeager, Counsel to the House Committee on Science and Astronautics, created the phrase.[12]

Technology assessment has become a movement thus gaining the interest and support of many individuals and organizations. This interest and support has manifested itself into many definitions of technology assessment.

Technology Assessment - Definitions

A few of the definitions that have been developed since 1966 are provided below.

Congressional Research Service of the American Library of Congress.[13]

> Technology assessment is the process of taking a purposeful look at the consequences of technological change. It includes the primary cost/benefit balance of short-term localized market place economics, but particularily goes beyond these to identify parties

and unanticipated impacts in as broad and long-run a fashion as possible. It is neutral and objective, seeking to enrich the information for management decisions. Both "good" and "bad" side effects are investigated since a missed opportunity for benefits may be detrimental to society just as is an unexpected hazard.

Gabor Strasser, Director of Planning, Columbus Laboratories, Battelle Memorial Institute.[14]

Technology assessment may be defined as a systematic planning and forecasting process that delineates options and costs, encompassing economic as well as environmental and social considerations, that are both external and internal to the program or product in question, with special focus on technology-related "bad" as well as "good" effects.

Vary T. Coates, Senior Staff Scientist and Head of the Technology Assessment Group, Program of Policy Studies in Science and Technology, George Washington University.[15]

Technology assessment is the systematic identification, analysis, and evaluation of the potential impacts of technology on social, economic, environmental, and political systems, institutions, and processes. It is concerned particularly with the second and third order impacts of technological developments; and with the unplanned or unintended consequences, whether beneficial, detrimental, or indeterminate, which may result from the introduction of new technology or from significant changes in the application or level of utilization of existing technologies.

Genevieve J. Knezo, Analyst, Science and Technology, Science Policy Research Division, Congressional Research Service, Library of Congress.[16]

Technology Assessment is defined as the purposeful, timely search for significant unanticipated secondary consequences of applied natural, physical science and development; identifying affected parties; evaluating the social, environmental and cultural impacts; and revealing constructive opportunities,

> with the intent of managing technology more effectively to achieve societal goals.

Donald E. Cunningham and Waller A. Hahn, International Society for Technology Assessment.[17]

> Technology Assessment is a means of developing options to allow society to find ways and means to preserve and improve the quality of life.

The last definition has introduced a concept that will be used for this study. This is the quality of life concept.

Quality of Life

Quality of Life Replaces Standard of Living.[18] Quality of life is a concept that has replaced the once used term, standard of living. Standard of living has lost its impetus, because a relatively high and increasing standard of living, measured in terms of per capita national income or GNP, does not guarantee advances in the overall quality of life.

An example of the standard of living paradox is the middle class professional who earns more income than before, yet breathes polluted air, is delayed in traffic jams, awakened at night by noise, discovers his work is becoming increasingly repetitive, is surrounded by gawdy commercialism, and sees his favorite entertainments discontinued due to overcrowding.

Quality of life is merely those characteristics that make life desireable. Most agree that these characteristics are somewhat universal. Of course certain individuals with specific interests place different importance to these characteristics.

Different Perspectives on Quality of Life.[19] The economist would likely consider the components of quality of life as those aspects that are scarce, costly and in demand such as freedom amid diverse choices, monotony of consumption, and high preference returns on investments of effort.

The sociologist may view quality of life in terms of preferred social relations such as privacy when desired, congeniality of proximate peers, role and class mobility in harmony with one's own and others' preferences and security.

A psychologist may consider quality of life as consisting of opportunities to satisfy self-development, lack of fear of absolute threats, uninhibited by anxieties, and unimpelled to waste time and energy on self-destructive or hostile behaviors.

The ecologist's quality of life may place greater importance on the balanced maintenance of diverse life forms, free from accidental destruction.

Criteria for Quality of Life.[20] The following list of components are considered widely shared criteria for life quality.

1. Aesthetic satisfaction
2. Quiet
3. Privacy
4. Freedom and Diverse Choice
5. Sociability
6. Health
7. Entertainment
8. Physical Safety
9. Employment Security
10. Interesting and Rewarding Work

11. Opportunity for Life - Long Educational Self - Development

Quality of Life and Technology Assessment. Quality of life consists of those components that man desires to maintain and advance. Technology may threaten his present quality of life and future expectations of his quality of life. The assessment of technology is a process designed to aid in protecting man's quality of life.

Unique Factors of Technology Assessment

Technology assessment can be distinguished from other analytical and predictive processes such as long-range planning, technological forecasting, systems analysis, and extrapolation of societal trends. This distinction is based upon five factors that in total are unique to technology assessment. These five specific characteristics of technology assessment are listed below.[21]

1. Multi-order impact
2. Multi-constituency impact
3. Multi-disciplinary approach
4. Iterative process
5. Policy-making tool

Multi-Order Impact. The multi-order impact characteristic stresses the concern for the secondary, tertiary, and higher order impacts of technology. The primary impact of a technology is considered, but technology assessment goes beyond the first level. Unless the higher ordered impacts are considered, important detrimental and/or beneficial consequences may not surface in time to take corrective action for the detrimental impacts or to take advantage of the beneficial impacts.

Multi-Constituency Impact. Technology impacts on more than one individual or group. The mechanization of agriculture affected both the rural individuals and groups, as well as the urban individuals and groups. Technology assessment should incorporate the needs and impacts upon a wide range of individuals and groups.

Multi-Disciplinary Approach. The impact that a technology may have on a group or individual is not limited to one discipline or area. The space technology has affected many areas such as the economy, society, the individual, and man's environment. Technology assessment should take a multi-disciplinary approach in order to evaluate the impact of technology on all areas related to man and his environment.

Iterative Process. Technological change does not occur in a seasonal pattern, nor does the impact of technological change follow a predetermined pattern. Technology assessment is an iterative process. It should involve a continuous study of the interplay between technological change and social change.

Policy-Making Tool. Finally, technology assessment should not be a technical device. It should be a policy-making tool for all four levels of concern, international, national, individual, and industrial. Technology assessment should provide the information necessary for policy-making. The value of technology assessment is in its use as a tool for decision-making and not as a method for assessing technology, although the importance of developing such a method cannot be overlooked.

Technology Assessment - A Normative Definition

Technology has a profound effect on that concept we call the quality of life. In addition, the process of the assessment of a technology involves five distinct features. These considerations are an aid in developing the definition of technology assessment that will be used throughout this study.

Technology assessment is a policy-making tool, iterative in nature and multi-disciplined in approach, for the purpose of evaluating the multi-ordered and multi-constituency impacts of technology on the quality of life.

Forecasting Techniques For Technology Assessment

Technological versus Quantitative Forecasting. Technology assessment, regardless of methodology, involves future predictions. These predictions generally are the forecasts of future technologies and the future impacts on areas such as the environmental, social, and institutional environments. The predictions required in technology assessment do not all have a quantifiable nature and thus cannot all be forecasted by known quantitative techniques. Technological forecasting has provided numerous techniques that can be used to forecast technologies and potential impacts. A brief examination of those techniques that may be used within the methodological frameworks of technology assessment is presented below.

Delphi.[22] Delphi is probably the most lauded and used technological forecasting technique. Delphi consists of a panel of experts who are unknown to each other. These experts respond to a series of questionaires about a situation. Results of each response are analyzed and returned to the experts between rounds of responses. The theory is that the group will achieve a consensus after repetitive responses, and this consensus will approach the "true" answer.

Sprite.[23] Sprite, Sequential Polling and Review of Interacting Teams of Experts, is a modification of Delphi. This technique was first used by Bell Telephone of Canada. Its primary modification is the use of more than one panel of experts. The panels normally differ in their areas of expertise.

S-Curve.[24] S-Curves are characteristic of the pattern followed by the life cycle of most technologies. This curve consists of a slow start, a steep increase, and a maturity plateau.

Historical Analogies.[25] This technique assumes that future technologies or environmental conditions will be similar to the past ones. Once this assumption is made, a future technology or impact is predicted based upon the historic trend of a related technology or impact.

Morphological Research.[26] This forecasting technique is an exploration of all possible future technological discoveries and a systematic analysis of these discoveries to determine their feasibility, costs, and characteristics. Because it encompasses all possibilities concerning a technology, morphological forecasting often provides impacts and alternatives that other methods may miss.

Relevance Trees.[27] The advantage of this method is that normative criteria of desireability can be used to influence the introduction of new technological factors or environmental changes instead of historical pattern extrapolation. This technique presents various inputs and their perceived importance so that a specific achievement is realized. The procedure involves identifying inputs, ranking them according to importance, and the use of importance indexing. The result is information on the desirability of each input.

System Analysis.[28] This procedure analyzes the interrelationships of components within a system and the system's interaction with other systems. This is a step-by-step procedure. Future predictions are made based on the known system inputs and interrelationships.

Analytic Techniques for Technology Assessment

Introduction. Forecasting techniques, as have been established, are required tools for assessing technology. The methodologies of technology assessment also implicitly require analysis techniques. These techniques are used to explore the interaction between technologies, between technologies and impacts, and between impacts. Two analytical techniques are presented below as potential tools to be employed in the methodologies of technology assessment.

Cross-Impact. This technique deals with the exploration between different kinds of events. In terms of technology assessment, events can be new technologies and the potential impacts. This approach, unlike others, explicitly deals with the judgement factor, a basic requirement of most analytical procedures. The normative goal of cross-impact analysis in technology assessment is to test policies that are designed to improve or diminish the probability of certain impacts associated with the assessed technology. The concept behind cross-impact analysis is that the occurence or non-occurence of a possible event or the use of a specific policy may affect the probability of occurence of other events or policies. Interactions and their strengths must be defined or estimated.[29]

The actual acceptance of this technique as a tool for technology assessment has not been firmly established. It is, nonetheless, a tool with a high potential for use in technology assessment. There are modifications of this analytical technique that also may become important in technology assessment. Two of these modifications are the trimatrix[30] and the cross-support analysis.[31]

Cost/Benefit.[32] This technique has been widely acclaimed as a potential analytical technique for technology assessment. The basic concept is quite logical. Technological developments would be analyzed on a total cost versus total benefit basis. The basic analysis is founded on the following equations.

Total Cost = Direct Cost + Indirect Cost (undesireable side-effects)

Total Benefit = Direct Benefit + Indirect Benefit (desirable side-effects)

There is an obvious problem in this approach. As yet the assignment of values to undesirable and desirable side-effects has not been mastered. This value assignment problem is due to the fact that the side-effects occur in areas where quantifiable values as we know them cannot be assigned. A potential solution to this dilemma is in the development of social indicators, and a method for measuring them.

Social Indicators and Technology Assessment.[33] Social indicators are simply defined as non-economic yardsticks of societal performance. This concept developed into a social indicator movement gaining impetus from the Report for the Club of Rome Project. Since that time the OECD among others has undertaken a program to develop social indicators. Their program consists of the selection and definition of social concerns and finally the development of statistical indicators. Their basic study covers seven areas of social concern.

1. Personal health and safety
2. Personal development and intellectual and cultural enrichment through learning
3. Occupational development and satisfaction
4. Time and leisure
5. Command over goods and services
6. The physical environment
7. The social environment

Social Indicator Measurement Problems.[34] The social indicator studies and their achievements have yet to reach an impressive result. The definition of social indicators as either societal performance measurements or changes in well-being are still linked to concepts of satisfactions and dissatisfactions. These concepts are termed by economists and mathematicians as welfare, benefits, utility, or utiles. These terms, which are abstract descriptions and values of nonquantitative areas of society, still do not provide a means of measurement of impact area benefits and costs. If measurement and identification of social indicators can be developed, then the cost/benefit analysis technique will likely become an important tool to be used in technology assessment.

What Was The Extent Of Technology Assessment Prior To The Technology Assessment Movement?

The technology assessment movement was not the first time that the impact of technology on society was considered. Groups and individuals have often expressed concern for the consequences of technological innovation. The difference between technology assessment of today and that of the past is in the breadth of the issues considered. Historically, technology assessment was performed but in a much narrower perspective.[35]

Early Technology Assessment[36]

Technology assessment studies are found as far back in history as in ancient Mesopotamia according to R. J. Forbes in Technology In Western Civilization, (1967). He states that "on occasion technical projects were submitted to the scrutiny and advice of learned bodies of priests who formed advisory boards." In addition technology assessment to an extent must have occured when one considers the planning, analysis, debate, and implementation involved in the building of the acqueducts and sewer systems of the ancient city of Rome, or in the extensive land reclamation projects in the Netherlands in the Middle Ages.

Early U.S. Technology Assessment[37]

Examples of assessments of technologies in the past are numerous. The U.S. Congress has a history of concern with ranges of matters that in many cases involve technology assessment. Steam boiler explosions between 1816 and 1848 resulted in 2,563 deaths and 2,097 injuries. The Franklin Institute in 1836 researched the problem and made recommendations that were eventually embodied in the 1852 stringent laws that regulated boiler construction, operation, and inspection.

The railroad industry, a new technology, after the Civil War was used to transport cattle. The initial impact was beneficial until it was discovered that the southern cattle brought a fatal disease to northern cattle. This occurance, in addition to the transmission of hog cholera and trichinosis to animals in Europe from American exports, resulted in Congressional action. A Bureau of Animal Industries was established to investigate, regulate, and prevent the transmission of livestock-carried disease.

These are just a few of the examples of limited assessments of technologies in U.S. history. Numerous agencies and studies have originated from limited technology assessments that have been performed by all branches of government as well as business, civic, and professional organizations.

Fragmentation of Technology Assessment

Prior to the beginning of the technology assessment movement, the process of assessing technology was fragmented. This fragmentation occured for four reasons. First, technology assessment was an unintended result of studies performed by individuals and organizations. Secondly, the assessments were narrow in scope, including only specific individuals or groups and impact areas. Thirdly, the assessment depths were generally shallow, encompassing only primary and secondary levels. Finally, there was no mechanism to combine the various fragmented studies into comprehensive studies.

This fragmentary approach coupled with a number of adverse consequences of technological advances led to increased interest in technology assessment. This movement gained momentum with the increased awareness of the threats that rapid technological changes had produced.

What Factors And Events Led To The Technology Assessment Movement?

Embryonic Growth

The technology assessment movement is said to have begun embryonic growth in 1963 with such events as President Kennedy's statement to the National Academy of Science.[38]

> Every time you scientists make a major invention, we politicians have to invent a new institution to cope with it.

At the same time individuals such as Rachel Carson and Ralph Nader were receiving publicity for their haphazard assessment of various technologies. The threat and fear of adverse effects stemming from nuclear weapon testing, persistent pesticides, nonbiodegradable detergents, smog, thalidomide, automation, the computer revolution, world wide effects of fossil fuel combustion, and the cosmic concerns of planetary contamination increased the interest and awareness in control and planning of technology.[39]

These were obvious factors that pushed technology assessment into embryonic growth. The major impetus was gained through two major factors.[40]

1. The indefatigable effort to establish an Office of Technology Assessment

2. The National Environmental Protection Act (1969)

Office of Technology Assessment

The efforts to establish an Office of Technology Assessment (OTA) were first begun in 1963 by Emilio Q. Daddario, Chairman of the Sub-Committee on Science, Research, and Development, of the House Committee on Science and Astronautics. It is suggested that Daddario's interests were influenced by Charles A. Lindberg, the aviation pioneer, and Dr. Jerome Wiesner, Provost of MIT and scientific advisor to the late President Kennedy. It was not until 1966 that a report from this sub-committee contained the description "Technology Assessment."[41]

1967 Bill HR6698.[42] The first attempt at institutionalizing technology assessment was Bill HR6698 introduced on March 7, 1967. This bill was not intended to result in legislation but was intended to act as a stimulus for further discussion and study. The bill called for the creation of a Technology Assessment Board of five presidentially-appointed members. Their task was to develop a method to identify, assess, publicize, and deal with the implications and effects of technology. This bill resulted in the sub-committee's new duties to explore the scope and process of technology assessment and to examine the possibility of institutionalizing technology assessment. This study lasted over a four year period (1967 - 1970).

Huddle's Monumental Works.[43] In September of 1967 the sub-committee held a technology assessment seminar. This seminar gave rise to a review of the manner of Congressional dealings with technological issues since World War II. The review was performed by F. P. Huddle of the Legislative Research Service (now known as the Congressional Research Service). The original review consisted of fourteen case studies which involved past legislative issues with technological content. Four other case studies were added in 1971.

1970 Bill HR17046.[44] In 1969 the Sub-Committee held hearings on the subject of institutionalizing technology assessment. These hearings were bolstered by the Sub-Committee's four years of study, the works of Huddle, and the independent studies undertaken by the National Academy of Science (Dr. Harvey Brook, Director) and by the National Academy of Engineering (Dr. Chauncey Starr, Chairman). The hearing resulted in Bill HR17046 which was designed to establish an Office of Technology Assessment that would be responsible to the legislative branch of government. Hearings on this bill in May and June of 1970 resulted in a new House Bill HR18469 and a companion Senate bill. These new bills met with delay, and no action was taken.

1972 Public Law 92-484.[45] John W. Davis (Daddario's successor) reintroduced the House Bill as HR10243 in February, 1971. The bill finally passed with amendments on February 8, 1972 by a 256 to 118 roll-call vote. The Senate bill S2302 subsequently passed. On October 13, 1972 the Technology Assessment Act of 1972 was signed by President Nixon (Public Law 92-484).

OTA Structure and Purpose.[46] The Office of Technology Assessment is comprised of a Technology Assessment Board and an Advisory Council. The Technology Assessment Board consists of six senators and six representatives with an equality of parties. The Director of the Board is presently Senator Edward M. Kennedy. The twelve man Advisory Council is comprised of ten public members, the Comptroller General, and the Director of the Congressional Research Service of the Library of Congress. The OTA does not conduct assessments but does contract them out to various research organizations. The initiation of an assessment can be made by the T.A. Board or through the request of a Chairman of a Congressional Committee.

The OTA's ability to institutionalize technology assessment has yet to be tested. Technology assessment in modern terms is a new exploratory area, and the OTA has not really had time to overcome the initiating organizational requirements.

NEPA

A second factor that has added impetus to the technology assessment movement is the National Environmental Policy Act of 1969. This act is intended to set the U.S. on a positive course of environmental management.

102 Statements.[47] The brunt of the act is the requirement that all Federal agencies provide a detailed statement of the environmental impact of every program or reccomendation that may effect the quality of the human environment. This requirement, a result of Section 102(2)(C) of NEPA, has resulted in the 102 Statement. The detailed 102 statement must include the following information.

1. The environmental impact of the proposed action,
2. Any adverse environmental effects which cannot be avoided should the proposal be implemented,
3. Alternatives to the proposed action,
4. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
5. Any irreversible and irretrievable commitments of resources

which would be involved in the proposed action should it be implemented.

NEPA Power.[48] The NEPA has so far been able to maintain if not increase its power to protect citizens' interests in environmental matters. Two landmark cases have strengthened the act and its power. Greene County Planning Board versus Federal Power Commission is one of the cases. In this case the Second Circuit Court ruled on January 17, 1972 that an agency cannot submit an environmental statement drafted by a utility. The agency must draft its own statement. In a second case, Calvert Cliffs Coordinating Committee versus U.S. Atomic Energy Commission, the AEC was charged and found delinquent in their nuclear plant licensing process. This prompted exceedingly high quality impact statements from the AEC and served as a warning to other agencies.

What Progress Has Been Made In The Technology Assessment Movement?

Through various influences, most important being the OTA establishment and the NEPA, technology assessment has become a movement that has encompassed the U.S. and is presently expanding to other nations and international organizations. There have been successful technology assessment studies performed in the U.S. and other countries since the term and modern concept was first introduced in 1966.

Successful Technology Assessment Studies[49]

On December 3, 1970, through the efforts of supporters of the environment, the SST project was rejected in the Senate by a vote of

52-41. The pollution potential from this new technology was the cause of its rejection. In April of 1971 the United Kingdom for similar reasons rejected the idea of an inland site for a new London airport. The argument against the inland airport was an argument against "destructive progress." For the first time according to many authorities, new technologies were rejected on social grounds. All of these factors of the technology assessment movement on a national scale have caused an international growth in the study of technology assessment.

International Organizations

The Club of Rome.[50] In April of 1968 The Club of Rome was formed. This club consisted of a multi-disciplinary group of thirty individuals who have become actively concerned with technology assessment.

International Society for Technology Assessment.[51] Another private organization that has been created from the technology assessment movement is the International Society for Technology Assessment. This organization which was started in March 1972 is a group of scientists who joined with Alvin Toffler, author of Future Shock, to assess the consequences of technology. This organization has begun the publication of a journal, Technology Assessment.

SAINT.[52] In 1972 the General Assembly of SAINT (Salzburg Assembly: Impact of the New Technology) held a conference on "Technology Assessment and Quality of Life." This conference resulted in the publishing of a book, Technology Assessment and Quality of Life.

OECD.[53] The OECD in early 1972 held a three day Seminar on Technology Assessment in Paris. They have since published a book entitled Society and the Assessment of Technology.

Methodology Studies

In addition to specific technology assessment studies that have been undertaken, the seminars and conferences conducted on technology assessment, the resulting publications of these seminars and conferences, and organizations established to promote technology assessment, numerous individuals and groups throughout the world are beginning to establish fundamental methodologies for technology assessment. The U.S. National Academy of Engineering, the Office of Science and Technology and the Mitre Corporation, and the Japanese Ministry of International Trade and Industry have been a few of the early creators of methodological approaches to technology assessment. An analysis of these methodologies will be undertaken in the second chapter of this study.

Conclusion

Man has in the past assessed the impact of technology on certain aspects of his quality of life. The need for such assessments are obvious when it is realized that almost all aspects of man's quality of life have been and may further be influenced by technology.

Technology assessment as an institution, with the broadened considerations that it merits, has just recently reached the awareness stage. Industry, national, and international concerns have begun to develop methodologies for this greatly needed policy-making tool.

This chapter has developed the history and background of technology assessment by answering the questions why should technology be assessed, what is it, and what factors have given impetus to the technology assessment movement.

The next chapter deals with an analysis of assessment methodologies. One specific purpose of Chapter III will be to present, compare, and contrast various methodologies. The impact that technology assessment has on industry, national concerns, and international concerns will also be examined.

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[43]Ibid., p. 36.

[44]Ibid., p. 41.

[45]Ibid., p. 55.

[46]Coates, p. 14.

[47]Medford, pp. 16-17.

[48]Ibid., p. 21.

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CHAPTER III

AN ANALYSIS OF TECHNOLOGY ASSESSMENT

Introduction

The history and background of technology assessment was presented in Chapter II. The rapid changes in technology have had and will continue to have great effects on major impact areas that are important to quality of life. These effects establish the need for technology assessment.

Chapter III is designed first to examine the impacts of technology assessment on three levels of concern, industry, national, and international. Secondly, environmental and technology assessment methodologies will be presented. These methodologies will then be compared and contrasted.

Technology Assessment Impacts

Introduction

The following section deals with the impact that technology assessment has had on three societal levels, namely national, industry, and international. The impact of technology on all three levels has not yet been profound but has for the most part been concentrated on the national level. It has been just recently that industry has begun to feel an impact. The potential impact of technology assessment on the international level is apparent but has not been studied as thoroughly as the other levels.

The impacts will be categorized and presented by their societal levels for this study. This categorization does not imply that the impacts are unique to one level.

Impact on Industry

Introduction.[1] Technology assessment is still in its infancy stage, thus it has not resulted in a major impact on industry. There are a scattering of corporations that are actively performing technology assessment, but most appear to be waiting and speculating on the potentiality of it. Potentiality in terms of technology assessment for corporations has ranged from threats to blessings.

The actual role of technology assessment in industry has not been developed. Its potential as a tool to aid management in current decision-making and in the formulation of long-range plans is recognized by most corporations. This is because most corporations already have some form of technology assessment incorporated into their research and development programs. The assessments that have been made in these programs, however, have been only haphazard partial assessments. Nonetheless, the potential of total assessments if feasible is obvious. Industry in general may be said to be in a holding pattern awaiting policies on technology assessment from the government. The influence of legislation on industry has always been a major factor in industry action.

Pessimistic Attitudes. The arguments against technology assessment requirements for industry have been numerous. Most industries fear that governmental institutionalization of technology assessment will actually be the creation of a new regulating agency. If this does occur, the following results are possible.[2]

1. Technology assessment will have to be incorporated in the early stages of the research-innovation sequence.
2. Propriety data (processes, production volume, and distribution in specific uses) often may be necessary for assessment.
3. Talent will be diverted from new products and processes and profit-increasing management techniques into defensive assessment work.
4. Technology assessment will prove to be expensive to the consumer and if his willingness to take risks or to pay the price of hazard avoidance is not accurately evaluated, he may rebel.

These statements cover a large portion of the fears of industry. The cost of a comprehensive assessment could be beyond profitable continuance of a new innovation. The requirements of talent and information to conduct a comprehensive technology assessment also discourages management. The problem in basic terms is whether or not industry has the ability and the funds to conduct technology assessment.

Many corporations laud technology assessment as highly relevant and potentially useful. They do condition the statement with a fear of technology assessment becoming a self-fullfilling prophesy. Although industry does recognize numerous problems of implementing technology assessment at their level, many also recognize that ignoring technology assessment may be a perilous activity.[3]

Optimistic Attitudes and Views.[4] Not all corporations have developed a pessimistic view of technology assessment. Many view technology assessment for industry as a self-preserving undertaking and a positive guide to research and development. A very interesting argument for industrial technology assessment has been voiced. Traditionally, the invisible hand of the market place has been a guide to decision-making in technology innovation. This mechanism now seems to be inadequate in guiding innovation toward maximum public benefit. Technology assessment could easily become the mechanism to guide and control innovation.

Technology Assessment Studies.[5] Technology assessment has been considered and undertaken by some industrial entities. In June, 1972 the U.S. National Science Foundation surveyed industrial organizations likely to have performed technology assessment studies. From the 475 surveyed corporations (388 from Fortune 500), there were 1,342 claimed technology assessment studies. Further investigation determined that only 36 studies really merited the title technology assessment.

Bell Canada, a subsidiary of American Bell Telephone and Telegraph Company, has been quite active in technology assessment. They have completed a technology assessment of computer-aided instruction in higher education. They are presently in the process of completing two other technology assessment studies, a technology assessment of improved telecommunications and a technology assessment of the impact of satellite communication on isolated Eskimo villages. Another firm, Pilkington Bros. Ltd., a U.S. based flat glass producer, has just recently completed a technology assessment of technology management.

Conclusion. Technology assessment's impact on industry has not yet become profound. The predominant attitude of the industrial sector is a concern that technology assessment will lead to technology harassment and eventually technology arrestment. The impact expected is dependent upon governmental action, the growth of technology assessment as a feasible tool, and the pressures of society. The problems that technology assessment may bring to industry are numerous but so are the potential benefits.[6]

From the limited studies that have been undertaken in industry, technology assessment has been issue and technology-oriented. The use of these assessments has not been publicized, but one would speculate that they have only been used as experiments to develop methodology and to test practicality.

Impact on National Levels[7]

Introduction. Technology assessment was created and first advocated at the national level, namely the U.S. Congress. The impact of technology assessment has consequently been most strongly felt at this level. This strongly felt impact is a logical phenomenon as government entities, the ultimate policy-makers in all societal areas, need the information provided by technology assessments. The national level impact is not unique to the United States. Other countries such as Great Britain and Japan have developed interests and methodologies for technology assessment. The United States, being the spearhead, has felt the greatest national impact from technology assessment. U.S. legislation dealing with technology assessment displays the impact that this concept has had.

Focus of Activity. The focus of activity and discussion of technology assessment has been on governmental decision-making. The establishment of the Office of Technology Assessment and its authorized ability to sponsor technology assessments for Congress is an example of this focus. The establishment of this office resulted in numerous Executive Agencies setting up assessment groups or offices within the agency. These agencies have since produced numerous technology assessments.

Survey of Assessment Studies. A recent survey of 86 offices in the civilian agencies has shown the extent of technology assessment in government. The survey showed that 13% were frequent sponsors and performers of technology assessment, 63% performed some technology assessment, and the remaining 24% performed none. The scope of the studies performed by these agencies was not so impressive. According to Vary T. Coates, who anaylzed 97 technology assessment studies from these agencies, only eleven were comprehensive. These comprehensive studies were usually initiated by Congress or other sources other than the operation agency.

Comprehensive Studies. The comprehensive studies were comparable in several areas. Their average cost was $381,000 and their median cost was $149,000. They normally had four or five disciplines represented in the analysis team. The normal time requirement of the study was 16 months. There were four kinds of recommendations from these studies, and they are presented below.

1. New bases for applied research priorities
2. Specific policy formulations
3. Modification of accepted practices or projects
4. Termination of the projects

The most impressive result of these 11 studies is that they often resulted in administrative or legislative action. The actions included informal but real changes in practices to outright termination of two projects. Examples of these comprehensive projects are listed below.

1. Jamaica Bay - Kennedy Airport Study
2. The Northeast Corridor Transportation Project
3. A Study of Medical, Ethical, Economic, and Psychological Implications of Cardiac Replacement
4. A Study of Snowpack Augmentation (Weather Modification) in the Upper Colorado Valley

Partial Assessments. The remaining studies were of several types. Forty of the studies were partial or narrow assessments. There were normally two disciplines per team and had an average cost of $139,000 if done by an independent research organization. These particular studies averaged about 22 months for completion.

Problem-Oriented Assessments. Fourteen studies were problem-oriented assessments. These studies cost twice as much as the comprehensive studies and took 12 to 18 months. Six disciplines per team were used in these studies.

Environmental Impact Statements. Environmental impact statements accounted for fourteen of the studies. These studies only cost $10,000 and required only three man-months. It was discovered that approximately 200 of these studies are prepared per month.

Future Studies. The final 17 studies are termed future studies (i.e. trends influencing the future levels of utilization of technologies). Two disciplines per team were used, and the costs varied significantly.

Conclusion. Technology assessment has had a greater impact on the national level (U.S. Government) than any other level. Numerous studies have been sponsored and/or performed by governmental agencies. in a few cases these studies have resulted in policy-making decisions by government entities. There does appear to be some uncertainty as to what a technology assessment consists of in regards to the comprehensiveness of the studies. Technology assessment in the U.S. Government appears to be quickly moving to active institutionalization. Other countries are presently starting to follow the lead of the United States. The impact of technology assessment on a national level is expanding and growing quite rapidly.

Impact on International Level

The impact of technology assessment on the international level appears to be minimal. It is obvious, however, that international concerns will ultimately be strongly affected. International entities such as the OECD and others have begun to explore technology assessment. The explorations of the international entities basically involve seminars, conferences, and publications dealing with technology assessment justifications and methodologies.

There have been very few studies concerning internationally applied technology assessments. The available studies take one of two approaches. The first approach is the establishment of a rationale for international cooperation in assessing effects of technology which have a global impact. The second approach consists of the development of alternative institutional arrangements for the conduct of international technology assessments .

Technology Assessment Methodologies

Methodological Approaches[9]

Technology assessment, because it involves a multi-disciplined approach, multi-constituency impacts, and multi-ordered impacts, is a process. A process requires a methodology in order to achieve organization and to subdivide the process into specific operational steps. There are two approaches normally used in methodologies. These approaches are the case study approach and the model building approach.

Case Studies. This approach takes a specific technology and attempts to achieve the objective of the study. It operates very close to the real world and normatively results in a high degree of relevance and practicality. This approach uses systems analysis in order to determine all essential elements of the study and to design solution strategies. The transferability of this approach is limited.

A special type of case study employs the comparative analysis technique. This case study type has potential useage in evaluating assessment studies performed in different countries or by different individuals.

Model Building. This approach attempts to create a general model for overall assessment situations. This model is usually highly transferable but at the cost of being abstract. There is an inherent danger in this approach of using data that fits the model instead of describing reality.

Technology assessment methodologies have been developed by government agencies and departments and private entities. In most cases a methodology is not a unique process that can only be used by the creating entity. The methodologies presented below are intended to display the state of the art.

Office of Science and Technology/Mitre[10]

The most publicized approach to technology assessment is the methodology presented by the OST/Mitre study. This study headed by Gabor Strasser developed a general methodology and applied it to four specific technology assessment pilot studies.

Major Steps in Making a Technology Assessment. The OST/Mitre approach consists of seven basic steps. These steps are general and broad thus allowing for their application to many assessment projects. Each step consists of in depth considerations that are logically ordered to facilitate the assessment. These considerations appear in the form of a generic checklist. The seven basic steps are listed below.

Step 1 Define the Assessment Task

Step 2 Describe Relevant Technologies

Step 3 Develop State-of-Society Assumptions

Step 4 Identify Impact Areas

Step 5 Make Preliminary Impact Analysis

Step 6 Identify Possible Action Options

Step 7 Complete Impact Analysis

Step 1 Define the Assessment Task. This step consists of three basic considerations; the relevant issues and major problems, the scope of inquiry, and the project ground rules. The scope of the study is a matter of great importance. There are two factors that effect the scope of an assessment study. They are breadth and depth. There are three measures of depth, namely major, minor, and none. The breadth of the study consists of seven major headings which are listed below.

1. Range of technologies
2. Range of topics
3. Groups affected
4. Time period analyses
5. Types of impacts
6. Levels of impacts
7. Impacts measurements

Each breadth heading is further subdivided. The subdividions are shown in figure 1.

Step 2 Describe Relevant Technologies. This step involves three basic inquiries; the major technology being assessed, technologies supporting the major technology, and technologies competitive to the major and supporting technologies. This step has resulted in a technology description background statement consisting of six categories of matters that should be addressed. The matters to be addressed are:

1. Physical and functional description
2. Current state of the art
3. Influencing factors
4. Related technologies
5. Future state of the art
6. Uses and applications.

Figure 2 is an example of the Technology Description Background Statement.

Step 3 Develop State-of-Society Assumptions. This step is intended to identify and describe major nontechnological factors that influence the application of the relevant technologies. The importance of

Step 1. Scope of Study

BREADTH OF STUDY	DEPTH TO WHICH STUDY COVERS TOPIC			COMMENT
	MAJOR	MINOR	NONE	
Range of Technologies				
Primary				
Supporting				
Competitive				
Range of Topics				
Technology Forecasts				
State-of-Society Conditions				
Action Options				
Groups Affected				
Beneficiaries				
Sponsors				
Third Parties				
Time Period Analysed				
Extent Retrospective				
Extent Futuristic				
Types of Impacts				
Economic				
Social				
Environment				
Political				
Legal				
Institutional				
Other				
Levels of Impacts				
Primary				
Secondary				
Tertiary				
Etc.				
Impact Measurements				
Qualitative				
Approximate or Precise				
Quantitative				
Approximate or Precise				
Uncertainty				
Analysis				

Source: Jones, M. V. A Technology Assessment Methodology I Some Basic Propositions. Mitre Corporation and Office of Science and Technology, Executive Office of the President, Washington, (June, 1971) p. 40.

Figure 1. Scope of Study

Step 2. Technology Description Background Statement

MATTERS ADDRESSED	COVERAGE
1. Physical and Functional Description	What the Technology Embraces Scientific Disciplines Involved Industries Involved Professions and Occupations Involved Products Affected Design-Dimension Data Manufacturing Characteristics Including By-Products
2. Current State of the Art	Current State of the Assessed Technology Current State of Supporting Sciences
3. Influencing Factors	Technical Breakthroughs Needed Technological Factors Affecting Development and Application Economic Factors Affecting Development and Application Institutional Factors Affecting Development and Application
4. Related Technologies	Complementary (Supporting) Technologies
5. Future State of the Art	Timing - Initial Operating Capability Timing - Widespread Applications
6. Uses and Applications	Current and Prospective Industrial vs. Consumer Markets Buyers: Age Groups, Incomes, and Geographic Distribution Marketing Channels Financing

Source: Jones, M. V. A Technology Assessment Methodology. Some Basic Propositions. Mitre Corporation and Office of Science and Technology, Executive Office of the President, Washington, June 1971, p. 46.

Figure 2. Technology Description Background Statement

these factors is their potential to affect the rate and manner that a technology may be applied. The six characteristics are:

1. Values
2. Environment
3. Demography
4. Economic
5. Social
6. Institution.

Figure 3 displays these characteristics and their subdivisions.

Step 4 Identify Impact Areas. The purpose of this step is to ascertain the societal characteristics that will be influenced by the application of the assessed technology. This step involves the same six categories and subdivisions of step 3. The difference between steps 3 and 4 is that step 3 involves identifying the societal factors influenced by a technology, whereas step 4 involves identifying the impact of technology on these societal factors. Figure 3 is also applicable to this step.

Step 5 Make Preliminary Impact Analysis. This step is designed to trace and integrate the process by which an assessed technology makes its societal influences felt. This step is broken down into a key-impact questions list. This breakdown is shown below.

1. Technology
    a. Development
    b. Application
2. Social impact
3. Impact characteristics
    a. Affected group
    b. How affected

Step 3. State-of-Society Assumptions and

Step 4. Identification of Impacts Areas - Major Impact Categories

CATEGORIES	TYPES
Values	Personal Community National Other
Environment	Air Water Open Space Quiet (Noise) Olfactory Weather Sunlight
Demography	Total Major Segments Rates*
Economic	Production Income Employment Prices Trained Manpower Natural Resources Inventory
Social**	National Security Economic Growth Opportunity (Class Relations, Poverty) Health Education Safety (e.g., Crime) Transportation Leisure - Recreation Other Amenities
Institution	Political Legal Administrative Organisation Custom-Tradition Religious

* Migration, population density, birth and death rates, etc.
** Goals and problems

Source: Jones, M. V. A Technology Assessment Methodology. Some Basic Propositions. Mitre Corporation and Office of Science and Technology, Executive Office of the President, Washington, June 1971, p. 67.

Figure 3. State-of-Society Assumptions and Identification of Impacts Areas-Major Impact Categories

c. Likelihood
d. Timing
e. Magnitude
f. Duration
g. Diffusion
h. Source
i. Controllability

Step 6 Identify Possible Action Options. This step provides a framework for comparing action options. Action options are designed to maximize favorable impacts and to minimize unfavorable impacts. This may be the most important step in the methodology. Its purpose is to provide the decision-maker with those options that are available for controlling and managing the impact of technologies. There are two checklists involved in this step. These checklists are seen in Figures 4 and 5.

Step 7 Complete Impact Analysis. This step is intended to integrate the collected information. It consists basically of revising the impact analysis of step 5. There are three basic steps to convert the preliminary analysis to the completed analysis. These steps are compare, integrate, and translate.

Summation. This methodology is based on breaking down large areas of concern into smaller segments and presenting the breakdowns in a logically sequential order. The performance of the assessment does not require strict adherence to the steps. In many instances the steps may be undertaken concurrently. In addition, the categories and generic checklists are only suggestions. Each technology assessment is somewhat unique thus requiring additions and deletions to the presented methodology.

Step 6. Identification of Possible Action Options

a. Types of action options

MAJOR CATEGORIES	CLASSES
Control over R and D Funds	Priority (whether something is funded) Allocation (how much it gets funded) Purpose (funds earmarked as to specific use)
Other Financial Incentive Schemes	Taxes (to discourage use) Tax Deferment or Abatement Subsidies Depreciation and Depletion Allowances Government Grants or Contracts Loans on Favorable Terms Compensation for Damages Off-Peak, Load-Leveling Schemes College Scholarships
Law and Regulations	Legislation Court Decisions, Injunctions, etc. Cease and Desist Orders Licences Monopoly Privileges Mandatory Standards State Police Powers Eminent Domain Inspection Requirements Fines and Punitive Damages Registration and Mandatory Reporting
Exhortation and Indoctrination	Education Publicity Public (e.g., Congressional) Hearings State Technical Services Political Lobbying Propaganda ("Smokey the Bear") Consumerism Conferences, Symposia
Construction and Operation	Drug Treatment Centres Sewage Disposal Plants Traffic (Air and Auto Control Systems) Land Reclamation

Source: Jones, M. V. A Technology Assessment Methodology. Some Basic Propositions. Mitre Corporation and Office of Science and Technology, Executive Office of the President, Washington, June 1971, p. 102.

Figure 4. Identification of Possible Action Options
a. Types of Action Options

Step 6. Identification of Possible Action Options

b. Action option evaluation criteria

CRITERIA	DEFINITION
1. Controllability	1. To what extent is there a consensus that the impact at which the action option is directed <u>can</u> be altered?
2. Worth	2. To what extent is there a consensus that the impact at which the action option is directed <u>should</u> be altered?
3. Priority	3. Granting a consensus relative to paragraph 1 and paragraph 2 above, how high in importance does the specific objective of this action option rank compared with the objectives of other action options?
4. Effectiveness	4. How well would this action option perform? How much would it enhance the specific benefit or reduce the specific problem at which it is directed?
5. Cost (Sponsor)	5. What would be the total financial costs (initial and recurring) of the action option to the funding agencies?
6. Cost (Spillover)	6. What would be the total financial costs to societal groups that are neither sponsoring nor benefiting from this action option?
7. Nonfinancial problems	7. What negative nonfinancial impacts would this action option generate for beneficiaries, sponsors, nonparticipating groups, and society in general?
8. Institutional	8. What political, legal, administrative, etc. obstacles would interfere with the practical implementation of this action option?
9. Uncertainty	9. How much uncertainty exists relative to all of the data inputs regarding this action option? How well documented are its supporting facts relative to benefits, costs, spillover, etc.?

Source: Jones, M. V. <u>A Technology Assessment Methodology</u>. <u>Some Basic Propositions</u>. Mitre Corporation and Office of Science and Technology, Executive Office of the President, Washington, June 1971, p. 104.

Figure 5. Identification of Possible Action Options
b. Action Option Evaluation Criteria

U.S. National Academy of Engineering[11]

One of the first methodologies for the assessment of technology was developed by the U.S. National Academy of Engineering. This methodology follows the basic steps advocated by Representative Daddario's Sub-Committee. The methodology consists of a seven step general approach and is not as comprehensive as the OST/Mitre methodology.

Step 1. The first step is to identify and refine the subject to be assessed. The goal of this step is to identify possible impacts, good and bad, or to connect the effect to a problem-initiated study.

Step 2. The second step involves setting limits to the scope of the study and developing a data base within the confines of the established limits.

Step 3. The third step is to identify alternative strategies. These strategies normatively should solve the selected problems of the technology being assessed.

Step 4. The fourth step is the identification of those groups and individuals that may be affected by the technology. The creators of this methodology recommend the use of social and behavioral scientists to accomplish this step.

Step 5. Step five involves the identification of the impacts on the groups and individuals identified in step four.

Step 6. The sixth step is claimed to be the most difficult. This step requires values to be assigned to the impacts of the technology. The non-quantifiable nature of impacts in terms of costs requires subjective judgements on societal values.

Step 7. Step seven is the comparison of the pros and cons of the alternative strategies. The goal of this step is to determine the most attractive strategies for matching the promises of the technology with the problem selected for application.

<u>Japanese Ministry of International Trade and Industry</u>[12]

The methodology presented by this Japanese governmental entity is intended to emphasize the analysis of technology assessment vice solution seeking. The four step method was designed for use on industries controlled by the Ministry. The steps of this methodology are presented below.

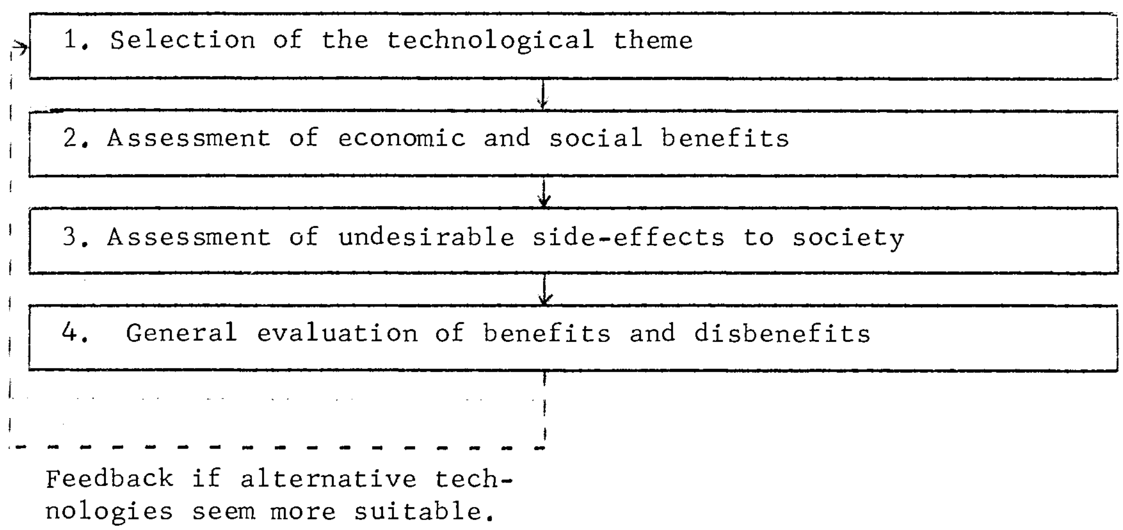


Figure 6. Methodological Approach of the Japanese Ministry of International Trade and Industry

Source: Hetman, Francois. <u>Society and the Assessment of Technology</u>. Paris: OECD, 1973, p. 133.

Step 1. The first step is to select a technological theme from technologies in the development stage and/or expected to enter the development stage. There are four specific criteria for this selection process.

1. Legislative responsibility - Is the technology in the field of the Ministry's responsibility?
2. Feasibility - Can the technology be defined adequately?
3. General Economic Impacts
4. General Social Impacts

Step 2. The second step is the assessment of economic and social benefits. There are six basic criteria for this step.

1. Improvement of labor and social conditions
2. Improvement of the contents of human existence
3. Increase in productivity
4. Competitiveness on international markets
5. Extension of resource base
6. Enhancement of technological standards

Step 3. The third step is to identify any undesireable side-effects to society that might result from the technology. This step consists of four criteria.

1. Points relating to human health and safety
2. Points related to the preservation and maintenance of nature
3. Points related to social mechanisms
4. Points related to the economy

Step 4. Step four is a comparison and analysis of the information collected in steps two and three. This provides the methodology with a cost/benefit analysis approach.

Methodology Used by John Dickey, David Glancy, and Ernest Jennelle[13]

The methodology presented below was employed to assess the solid waste management programs in Fairfax County, Virginia. There are six steps in the assessment methodology. The "claim to fame" of this methodology is its interaction with the decision process. This interaction and the six steps are presented below.

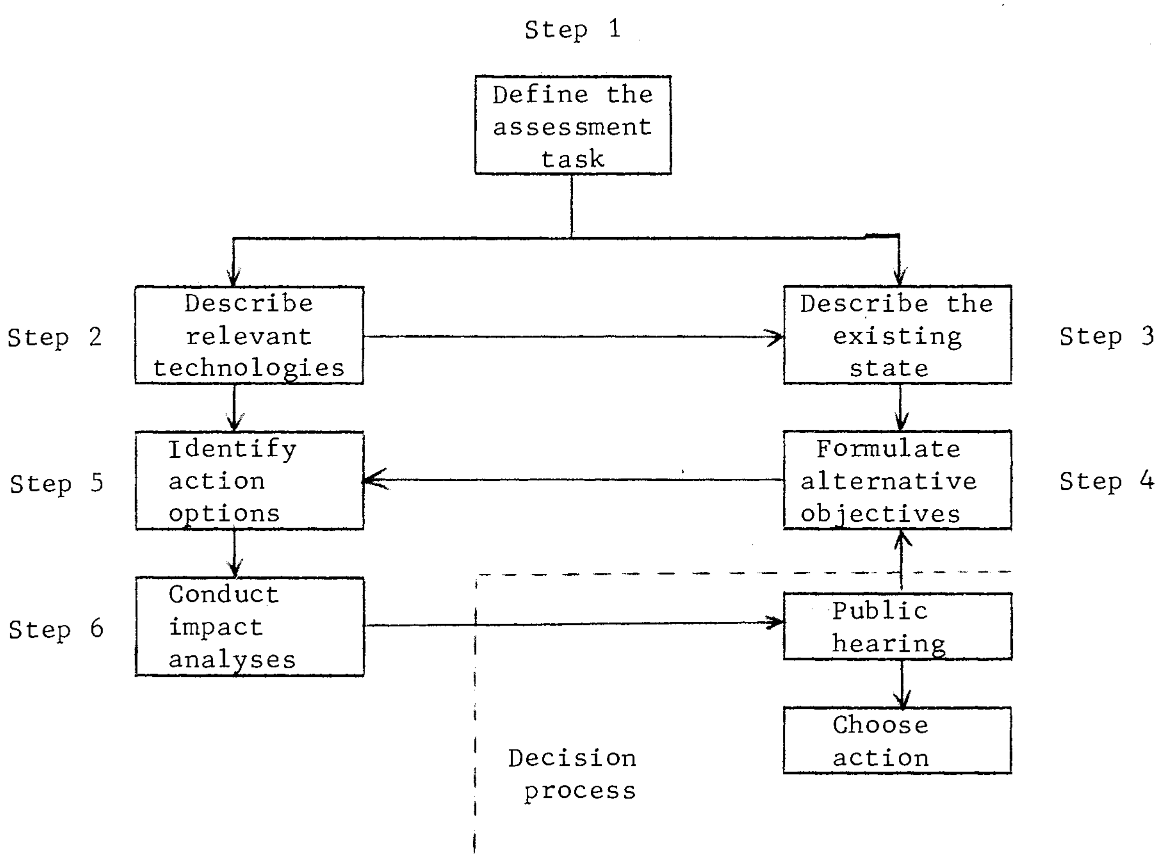


Figure 7.
Six Major Steps in Making a Technology Assessment and its Interaction with the Decision Process

Source: Dickey, John W., David M. Glancy, and Ernst Jennelle. Technology Assessment. Lexington, Mass.: D. C. Heath and Co., 1973.

Step 1. The first step is to define the assessment task. This step is virtually identical to step 1 in the OST/Mitre methodology.

This step is basically designed to define the scope of the study considering the extent, magnitude, and existence of resources constraints. This step in essence attempts to determine the specific system to be analyzed.

Step 2. The second step is to describe the relevant technologies in terms of "hard" which is equipment, materials, etc. and "soft" which is policies, rules, and regulations. Each technology described should include the following information.

1. Capacity
2. Cost
   a. initial
   b. operation
3. Time required to implement
4. Safety and reliability
5. By products
6. Life
   a. economic
   b. functional
7. Flexibility and/or adaptability to change
8. Operator skill required
9. Estimate of social acceptability and/or attitudes of the public

Step 3. The third step is an estimation of the values of individuals affected by and affecting the system. This step includes four subtasks.

1. Define the existing functional subsystems
2. Determine the existing and anticipated use of each subsystem
3. Perform a problem assessment and preliminary impact analysis
4. Develop State-of-Society Assumptions

a. Available resources

b. Constraints (social)

Step 4. Step four is to formulate alternative objectives. This is nothing more than establishing criteria for making selections of action options.

Step 5. Step five is to identify the possible action options. There are three basic design concepts available for this identification step.

Design Concept #1 Minor System Modification

Design Concept #2 System Redesign

Design Concept #3 Combination of #1 and #2

Step 6. The sixth step is to conduct an impact analysis. This step involves estimating every possible consequence of each action option. This step is accomplished by considering the following criteria.

1. Internal system impact
2. Interaction with other systems
3. Effects on various groups or individuals

Environmental Assessment Methodologies

Numerous techniques for evaluating the impact of technologies on the environment have been developed since the passage of the National Environmental Protection Act in 1969. These methodologies, developed out of necessity, provide potential techniques for multi-disciplined technology assessment methodologies. Their potentiality is contingent upon the expansion of these methodologies to encompass impact areas other than the environment. Presented below are a few of the more promising methodologies.

U.S. Geological Survey Methodology - Luna Leopold

The basis of this methodology is a matrix developed by the U.S. Geological Survey entity of the Department of Interior. The horizontal axis of this matrix consists of 100 entries that are actions that may cause environmental impact. Examples of these actions are industrial sites and buildings, highways and bridges, trucking, and spills and leaks. The vertical axis of the matrix consists of 88 entries that are the existing environmental conditions that may be affected. Examples of these entries are water quality, erosion, fish, and scenic views and vistas. The matrix in total provides the potential for 8,800 possible interactions between environmental impact actions and existing environmental conditions. Each square of the matrix signifies one of these interactions and can be evaluated for impact by a technology. Obviously, not all the possible interactions are compatible with a specific technology. Quantification of the interactions is suggested by the methodology that follows.

The analysis of the interactions is based on two factors. The first factor is the magnitude of the impact of an action upon a specific environmental condition. Magnitude in this analysis refers to degree extensiveness. Magnitude is indicated in the left hand corner of each square by the assignment of a value from 1 to 10. The second factor which appears in the lower right hand corner of each square is a weighting of the degree of importance of the interaction of the action and condition, In this sense, degree of importance implies significance and is also indicated by a number from 1 to 10. Only those interactions with significant ratings are evaluated individually. The selection criteria of important interactions to be individually evaluated is judgemental.

This matrix thus provides a method for identifying impacts and summarizing which impacts should be considered. Its breadth and depth allows the assessor a comprehensive review of the variety of interactions that are possible.

Edmunds and Letey Additions[15]

Edmunds and Letey employ the use of the environmental matrix presented above, but are more detailed in their proposed methodology. Their first step involves the use of the environmental matrix. Their second step is to apply environmental analytical techniques to the special impacts that appear to be most adverse in the matrix. They present five substeps to step 2.

The first substep is to construct a materials balance model for the action being considered. This consists of measurements through samples and calculations of all the material inputs and outputs related to the action. The second substep is the development of a dispersion model. Outputs or residuals of the actions being considered would be assessed as to their speed, extent, and mode of dispersion into the environment. The third substep, if the materials concentrations and dispersions have been established, is to construct a market simulation of the ecosystems involved in the actions. This would involve attaching shadow prices to the unpriced values in the ecosystems. These shadow prices are compared with the known tangible costs associated with the actions. The fourth substep is a marginal cost study. In this study estimates of the marginal costs against their marginal returns in terms of environmental quality are made. Substep five is a trade-off analysis. The actual value of certain actions and the biological damage that could result are compared and evaluated.

The third step in the overall assessment is to test the decision criteria. Each of the five substeps above are based on the desire to satisfy a gain in human utility but only with a minimum acceptable loss to the ecosystems. This step is an overview of the results of the substeps in order to arrive at a decision.

Bereano and Others[16]

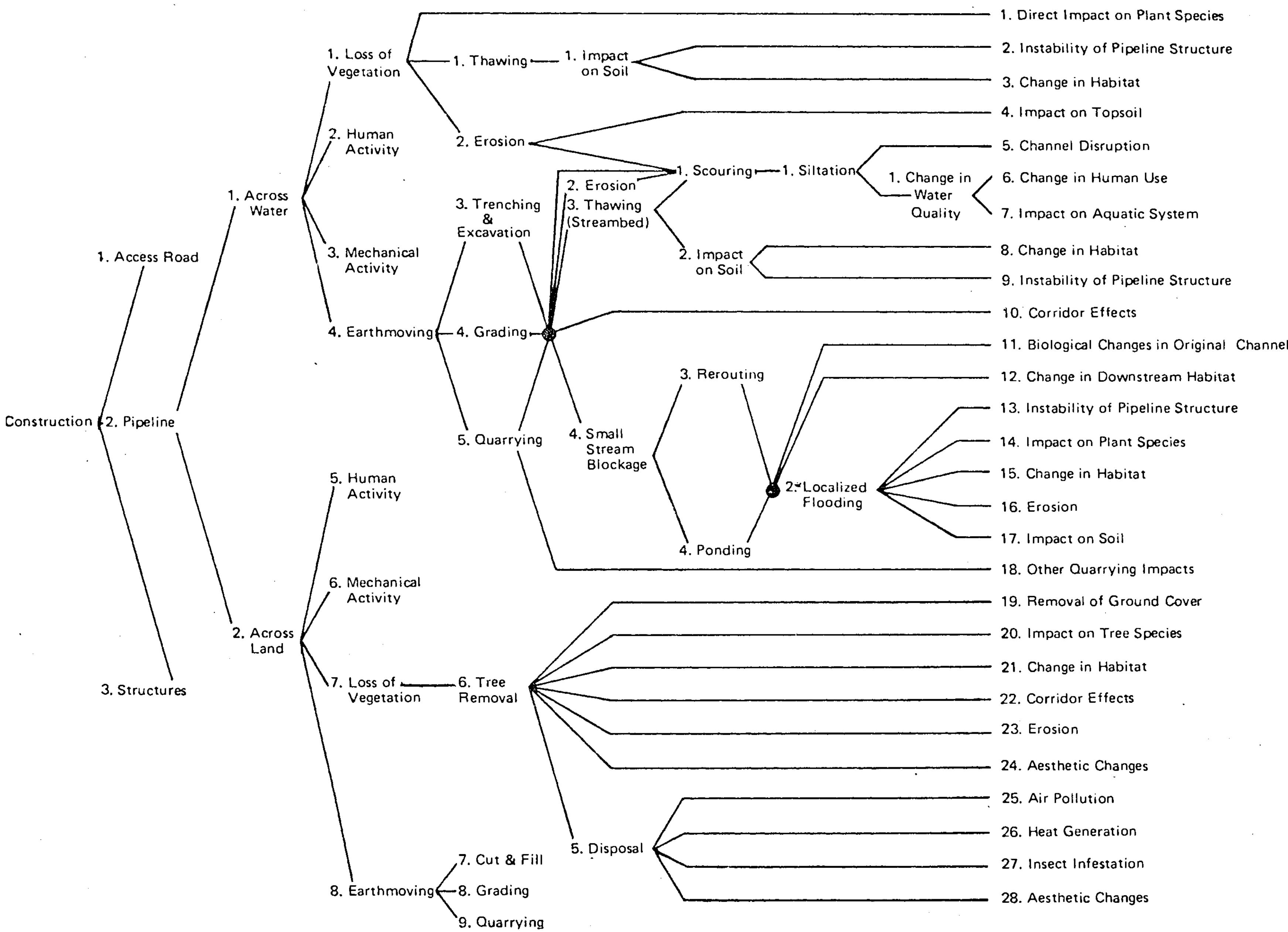
This methodology was developed to provide greater decision-making considerations in the environmental assessment area. It consists of five steps. It is based on a matrix that combines action alternatives and variables (parameters). In addition to the matrix a visual technique known as an "effects chain" is also used. The "effects chain" is a graphic display of all effects flowing from a single starting point.

Step 1. An "effects chain" is developed from the new technology being proposed. An example of an "effects chain" is seen in figure 8. In essence, the "effects chain" is a barnstorming technique to identify the actions to be taken and the impacts of these actions. This "effects chain" provides the parameters and the action alternatives to be studied.

Step 2. The parameters and alternatives are combined to form an effects matrix. The alternative actions are placed on the vertical axis of the matrix, and the parameters are placed on the horizontal axis.

Step 3. This step involves assigning probabilities, utilities,

Figure 8. Effects Chain



Source: Bereano, Phillip, et al. "A Proposed Methodology for Assessing Alternative Technologies." <u>Technology Assessment</u>. 1973.

and importances to the various outcomes described in the effects matrix. Depending on the assessor, this is a possible halting point of the analysis.

Step 4. This step is the computation of a weighted value for each outcome. The computation prescribed is the multiplication of the probability and the utility of each outcome. This also may be a sufficient analysis for the assessor, and thus a decision may be made at this point.

Step 5. Importance is related to utility. This step consists of relating the importance of the action alternatives to the weighted values computed in step 4. This final step coupled with the decision criterion of the assessor completes the analysis.

Environmental Evaluation System[17]

Heirarchical Structure. This is a systematic procedure developed by the Batelle Institute for evaluating environmental impacts. This methodology first involves the construction of a hierarchical structure. This structure provides four different levels of information for use in environmental impact assessments. The four levels of information appear in the structure as shown in figure 9.

The environmental parameters level is very important. Each parameter represents a unit or an aspect of environmental significance worthy of individual consideration. These parameters are estimated in quantitative terms by the fourth level known as environmental measurements. The effects of a technology or development project are then evaluated by a three step procedure. The procedure transforms the parameters into common measures.

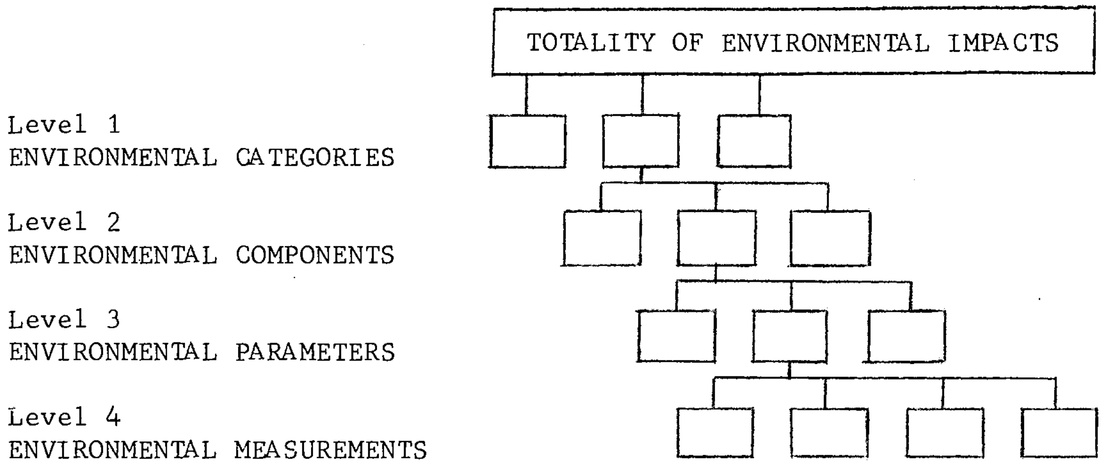


Figure 9. Levels of Information

Source: Hetman, Francois. Society and the Assessment of Technology. Paris: OECD, 1973. p. 283.

Step 1. This step is designed to transform the parameter estimates into a corresponding environmental quality measure (EQ). Environmental quality in this case takes the form of a numerical value between 0 and 1. The value 0 is extremely bad quality, and the value 1 is very good quality.

Step 2. This step assigns a weighted value to all parameters. The weighted value is based on their relative importance. This weighting is assigned in terms of parameter importance units (PIU) and is based on a total of 1,000 PIUs.

Step 3. The desired common unit values for each parameter are calculated in this step. These values are labelled environmental impact units (EIU). The formula for this step is shown below.

$$EIU = PIU \times EQ$$

These EIUs are used to trade-off beneficial environmental impacts with adverse environmental impacts.

Cost - Risk - Benefit Analysis[18]

This methodology was developed by Dennis Tihansky and Harold Kibby. The methodology attempts to merge cost-benefit and risk information, that is quantitative and qualitative value systems, into a single framework. The conceptual framework of this impact analysis is shown in figure 10. Both economic and non-economic factors are represented. Product and service benefits normally can be measured in monetary terms. Many health and ecology risks presently defy quantification. Nonetheless, the omission of these risks could possibly mislead the analysis outcome. These two analyses provide input for the decision making component.

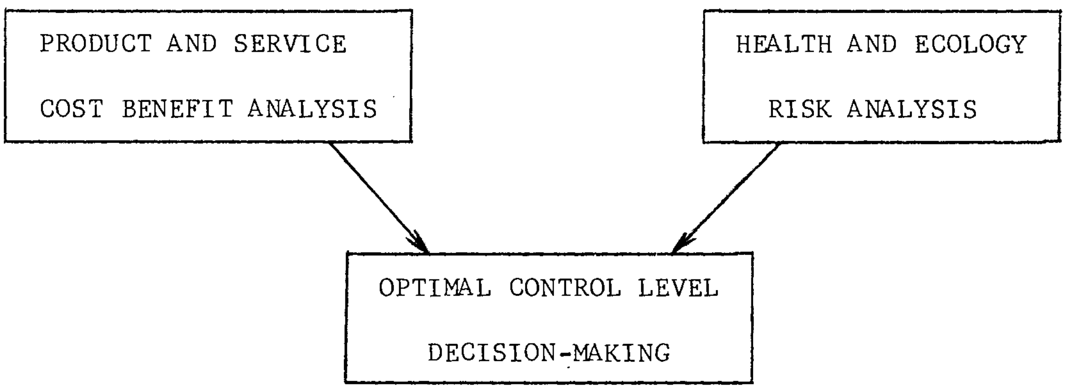


Figure 10. Conceptual Framework for Impact Analysis

Source: Tihansky, Dennis and Harold Kibby. "A Cost-Risk-Benefit Analysis of Toxic Substances." Journal of Environmental Systems. Summer, 1974, p. 120.

Cost-Benefit Analysis. There are six sequential steps in this component. The first step is to preselect all benefit categories, $\alpha_1, \alpha_2, \alpha_3, \ldots$. Step two involves determining the control levels, C_1, C_2, C_3, ... Step 3 is an estimate of the control cost impacts. One impact is graphical and shown in figure 11. At control level C_1, the price of product (or service) α_1 is $P_{1\alpha}$ while at C_2 it becomes $P_{2\alpha}$. As expected, as controls are increased, the costs increase.

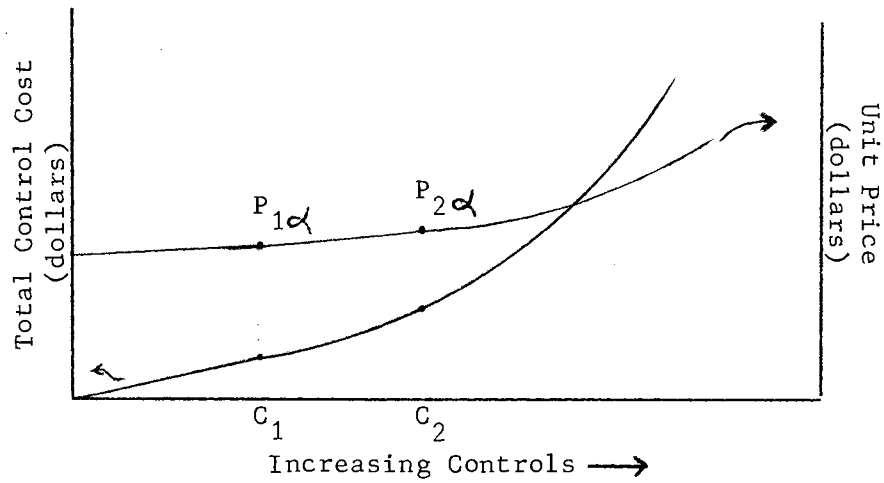


Figure 11. Impact of Various Control Levels on Product or Service Prices.

Source: Tihansky, Dennis and Harold Kibby. "A Cost-Risk-Benefit Analysis of Toxic Substances." Journal of Environmental Systems. Summer, 1974, p. 122.

Step 4 involves estimating the impact of the price increases on the welfare losses to the product consumer. Figure 12 demonstrates this step. The curve in figure 12 is often called a willingness-to-pay curve. If the unit price increases from $P_{1\alpha}$ to $P_{2\alpha}$, there will be those no longer willing to purchase the product or service. The benefit losses from decreased demand are estimated by the area, $XP_{1\alpha}P_{2\alpha}$. Added disbenefits are lost by those paying $P_{2\alpha}$. This loss in benefits is estimated by the area, $XYZP_{2\alpha}P_{1\alpha}$.

Step five involves translating the consumer surplus estimates into a benefit curve. This curve is an estimate of the product benefits plotted against the increasing control costs. It is normally plotted within a confidence band in order to allow for uncertainty.

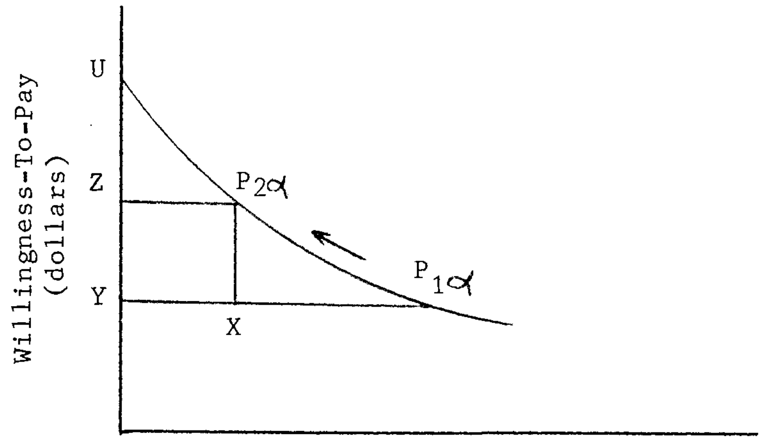


Figure 12. Estimation of Product or Service Benefits for Various Control Levels.

Source: Tihansky, Dennis and Harold Kibby, "A Cost-Risk-Benefit Analysis of Toxic Substances." Journal of Environmental Systems. Summer, 1974, p. 123.

Step six involves combining the benefit curves for each element in the benefit portfolio, α_1, α_2, α_3, . . ., into a single benefit curve, W_b. This would be accomplished by consumer survey techniques.

Risk Analysis. This component of the overall CRB framework also involves six steps. The first step is to list the specific categories of either known or suspected risks, B_1, B_2, B_3, ... This list forms a risk portfolio. Step two is to determine control levels for these risks. These control levels are in essence non-monetary measurements of the risks. These control levels are plotted against environmental quality levels (same measure as control levels) to consummate step 3.

Step four is the claimed crucial step in this analysis. This step relates risk levels to environment quality. Risks in this step must be assessed either in deterministic or probablistic terms over a range of quality levels. Three categories of risk are differentiated in this step. Some risks are economic and can be stated in monetary terms. A second group of risks are non-economic and are quantifiable in non-monetary terms. The third group defy any numerical or physical quantification but can be described in qualitative terms.

The fifth step involves estimating the risk level for each control level. This is graphically shown in figure 13. This provides what is termed as a risk avoidance curve.

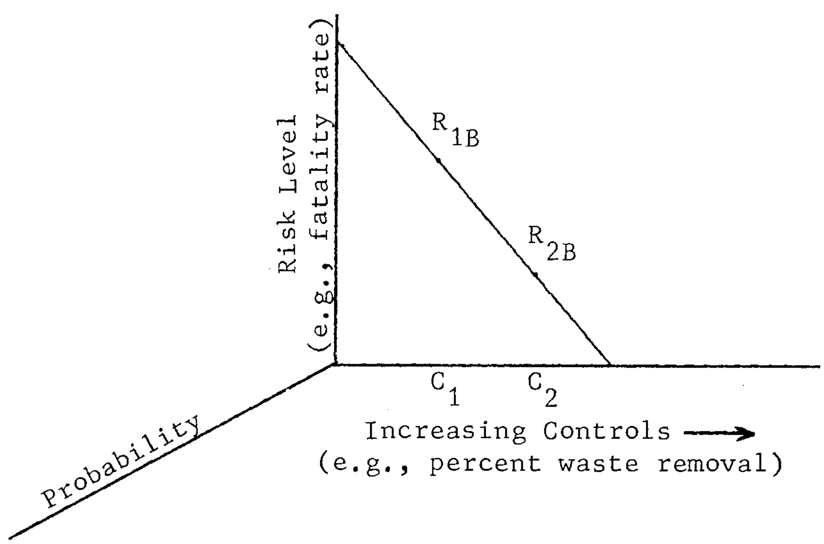


Figure 13. Estimation of Risks at Various Control Levels

Source: Tihansky, Dennis and Harold Kibby. "A Cost-Risk-Benefit Analysis of Toxic Substances." Journal of Environmental Systems. Summer, 1974, p. 127.

Step six transforms the risk avoidance estimates of step 5 into expected economic returns. This is best explained by an example. As the risks of such factors as human accidents, sickness, or fatalities decline, savings in lower medical costs and the like are anticipated. The normally expected curve is shown in figure 14.

Step seven involves deriving W_r which is a function depicting the total economic gains of reducing all risks simultaneously while making controls more stringent. This function forms a willingness-to-pay curve similar to the willingness-to-pay curve in the cost-benefit analysis component of the overall methodology.

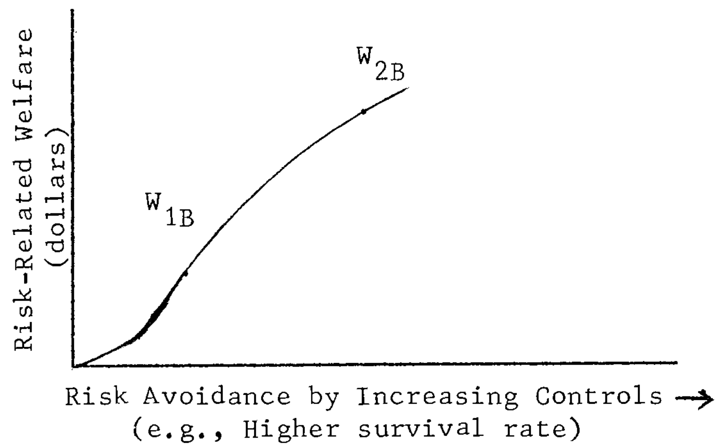


Figure 14. Estimation of Risk Reduction-Welfare at Various Control Levels.

Source: Tihansky, Dennis and Harold Kibby. "A Cost-Risk-Benefit Analysis of Toxic Substances." Journal of Environmental Systems. Summer, 1974, p. 127.

Decision Analysis. This is the third component in the overall methodology. There are numerous methods for using the inputs of the first two components. The desires and limitations of the decision-maker play a great role in the decision analysis to be used. The most straightforward method is to superimpose the willingness-to-pay curves for risks and benefit. Their sum produces a social welfare curve whose optimum can be derived by differential calculus. In summation, this analysis provides the maximum social welfare at the least cost. Figure 15 demonstrates this method in simplified terms.

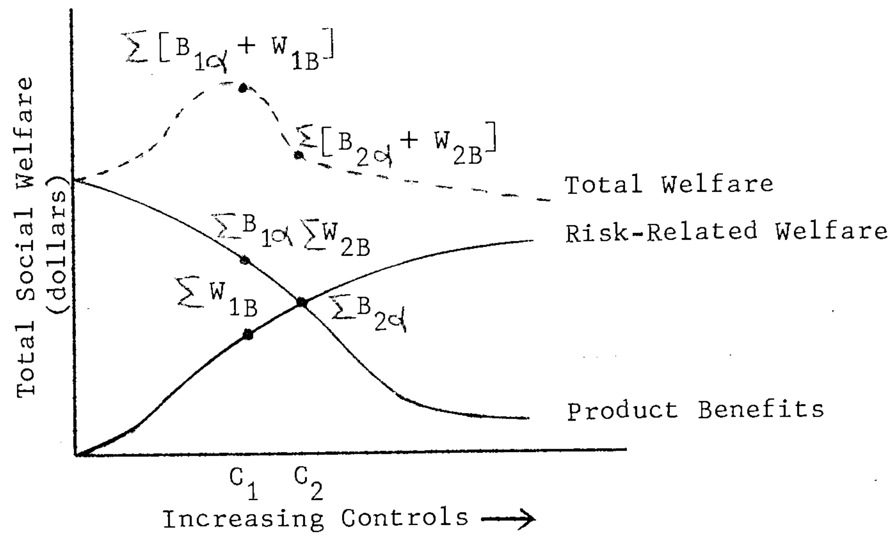


Figure 15. Selection of Optimal Control Level in Risk-Benefit Analysis.

Source: Tihansky, Dennis and Harold Kibby. "A Cost-Risk-Benefit Analysis of Toxic Substances." Journal of Environmental Systems. Summer, 1974, p. 130.

Methodology Assessment Criteria

Many of the methodologies which have been presented, whether technology assessment or environmental assessment oriented, have been applied to specific problems. It is the intent of this section to briefly present the actual applications of these methodologies and to briefly assess these methodologies. This analysis will consequently yield information to be applied to the development of a systems approach for technology assessment. In many cases it may be necessary to use subjective judgement in assessing these methodologies. To reduce the amount of subjective judgement involved in the assessment of methodologies, certain criteria will be applied.

Methodology Criteria

The methodologies to be assessed involve several techniques. The first set of criteria to be used for evaluation and comparing assessment methodologies was proposed by Richard C. Viohl, Jr. and Kenneth G. M. Mason.[19]

1. What kind of technique(s) does it employ?

   descriptive/verbal
   cost/benefit
   matrix
   algorithm
   computer aided (data collection, computation, and statistical analysis)
   computer modeled
   graphic overlay
   remote sensing

2. What are its characteristics?

   specialized training required
   sophisticated equipment required
   funding required
   adaptability to change over time
   universality of application
   comprehensiveness
   level of objectivity
   level of complexity

3. How are alternatives evaluated?

   A. Kinds of impacts considered:

      ecological
      economic
      unquantifiable (e.g. aesthetics)
      negative only, or positive and negative
      primary only, or primary and secondary
      short term only, or short and long term.

   B. Summarizing the alternatives:

      array
      ordinal ranking
      provision for "red flags".

Model Validity Criteria

Some of the methodologies presented in this section employ models. The assessments of these models are facilitated by the model validity criteria suggested by Robert E. Schellenberger.[20] This section is intended to identify and briefly explain these criteria.

There are three types of validity that require attention; Technical validity, operational validity, and dynamic validity.

Technical Validity. This validity consists of four primary components, namely model, data, logic, and predictive validity. Model validity refers to the model's correspondence to the real world. This is judged on the basis of the model's assumptions related to the real world. Data validity is applicable to both raw and structured data. Raw data can be evaluated in terms of accuracy, impartiality, and representativeness. Structured data can be evaluated in terms of comparability and consistency. Logical validity deals with the assurance of a logical progression from model construction to solution. Criteria for this consideration involve mathematical manipulation accuracy and correctness, logical element mixing, and relevant variable omissions. Predictive validity involves the search for errors between actual outcome and the predicted outcome.

Operational Validity. This consideration is an assessment of the divergences found in the technical validity section. A component of operational validity is implementation validity. Implementation validity deals with the question, "What is the probability that the real world will respond as the model indicates?"

Dynamic Validity. This third type of validity attempts to determine if the model will continue to be valid during its life cycle.

This type of validity deals with the model's and the model's components' abilities to be reviewed, updated, and modified.

Technology Assessment Methodology Analysis

Office of Science and Technology/Mitre

This seven step methodology was applied to five specific technology assessment pilot studies.

Pilot Study 1. - Automotive Emissions Control.[21] This study was designed to analyze the role of the automobile as a cause of air pollution. Emission control technology was reviewed for past performance. The study provided an analytical framework to relate the costs expected from reducing automotive-generated air pollution with the costs saved in the resultant improvements in air quality, health, and national welfare.

Pilot Study 2.- Computers - Communications Network.[22] This study evaluated the effects of the large volume of knowledge about computers and communications. Numerous considerations were envolved in this study such as man-machine interaction, technology projections, and security/privacy.

Pilot Study 3. - Industrial Enzymes.[23] The industrial enzyme is a new technological area, consequently this study was more forecasting and process understanding-oriented vice impact-oriented.

Pilot Study 4. - Mariculture.[24] Mariculture or sea farming was assessed as a potential solution to abating the malnourishment problem by its economic stimulation possibilities. In this study, a relevance tree was used as a basic technique for identifying relevant factors. This study provided key parameters for futther cost/effectiveness studies in this area.

Pilot Study 5. - Domestic Waste and Water Pollution.[25] Water pollution was the key impact that was assessed in this study. Two important steps resulted from this study. First, steps were taken toward the development of a dynamic interactive model to relate the factors that affect domestic waste systems. Secondly, potential impacts were shown by the extensive use of a quantitative support model.

Assessment. The Mitre approach utilizes seven steps that are broken down into generic checklists. The basic technique of this methodology is a verbal descriptive technique. The descriptive technique developed by Mitre is quite comprehensive. In order to achieve this comprehensiveness characteristic, a great deal of research is required. This of course indicates a need for funding. The areas of impact considered in this methodology are values, environment, demography, economic, social, and institution. In most cases quantification was not attempted in this methodology. The levels of impacts (primary, secondary, etc.) are limited only by the user of this technique. Impacts are stated in both positive and negative terms. Alternatives are stated in terms of action options that are designed to maximize favorable impacts of a technology and to minimize its unfavorable impacts. The adaptability of this methodology to changes over time and different technologies is really based upon the skills of the user. Because the technique is descriptive, there are potentialities for subjectivity vice objectivity.

U.S. National Academy of Engineering

This approach is quite similar to the Mitre approach and apparently was the forerunner of the Mitre approach. This technique was applied to three experimental studies, the results of which provide very little advantage to us in analyzing the methodology.

Assessment. The technique of this approach is also a verbal descriptive technique. It consists of seven steps with the last step calling for a comparison of pros and cons of alternative strategies. This could imply a simplistic cost-benefit approach, however this methodology does not elaborate on this step. The methodology is comprehensive only if the users of this methodology intend their study to be comprehensive. Unlike the Mitre approach, there are no check-lists with each step. This may tend to create omissions of relevant factors. Adaptability of this methodology is possible. Step six of this procedure calls for a valuation of pros and cons of impacts. This step encourages quantification where possible. Explicit treatment of identifying impact areas is not presented in this methodology. Impacts are assessed in both positive and negative terms, but there is a lack of explicit consideration given to the timing of these impacts. Alternatives are presented as verbal descriptions of possible strategies. The objectivity of this approach is based upon the objectivity of the users.

Japanese Ministry of International Trade and Industry

The actual applications of this methodology have involved only preliminary surveys by this Japanese Ministry. The six known applications involved the following subjects.[26]

1. PCM super multichannel communication system
2. Artificial human organs

3. Iron production with utilization of nuclear reactor

4. Recovery of minerals from the sea-bottom

5. Synthetic wood

6. Off-shore power station

Assessment. The technique of this methodology is primarily a verbal descriptive approach with attention given to benefit-disbenefit evaluation. The descriptive technique involves four steps with check-lists for each step. This provides for greater attention to comprehensiveness. The adaptability of this technique to different areas is demonstrated by its application to diverse subjects, examples of which are listed above. The descriptive approach may reduce this technique's objectivity, depending of course upon the users. Direct attention is given to four impact areas: economic, social, individual, and nature. Quantification is not attempted except in the economic area of impact. Impacts are evaluated descriptively as benefit(+) and disbenefits(-). The time consideration of impacts is ignored in this approach. There is no method presented for summarizing alternatives.

Methodology Used by John Dickey and Others

This methodology was used to assess the solid waste management program in Fairfax County, Virginia. This application was limited by time and resources consequently the iterative feedback process from the public and the formulation of alternative objectives were not carried out to finality.[27]

Assessment. As with the other technology assessment methodologies this approach utilizes a verbal descriptive technique. Six steps with checklists are provided in this methodology. Adaptability to changes and different applications is possible. Objectivity is contingent upon the users. Impact areas are not explicitly designated, but the study that involved the use of this methodology, concentrated on economic impact. Quantification of certain factors was accomplished in the application of this methodology but is not demanded in the methodology. Alternatives are presented in three categories of action options. These categorizations are modification of systems, system redesign, and a combination of the two.

Environmental Assessment Methodology Analysis

U.S. Geological Survey Methodology and the Additions made by Edmunds and Letey

The most widely publicized application of this technique involves a phosphate mining lease request to the Department of the Interior. The study was to assess the environmental impacts of the mining operation.

Assessment. This assessment methodology employed the use of a matrix. The axes are composed of actions that may cause environmental impact and existing environmental conditions that may be affected. Quantification of the interrelationship of the axes components is undertaken. The breadth and depth of the matrix provides for a potentially comprehensive study. Subjective judgement is required for the quantification step of this approach. The impacts considered are entirely environmental. Timing of impacts is not explicitely considered and impacts are designated in negative terms. The weighting procedure provides an ordinal ranking of considerations.

Edmunds and Letey added several steps to the matrix procedure. Two of these steps were the application of environmental engineering models (a materials balance model and a dispersion model.) The application of the model validity criteria cited earlier could be used to assess these models. This assessment of environmental engineering models requires the attention of knowledgeable individuals in the environmental engineering field. In other steps of the Edmunds and Letey additions are requirements for estimations of costs of environmental damage. This procedure is an attempt towards quantification, but requires subjective judgement.

Bereano and Others Methodology

This decision-making methodology was designed to assess alternative technologies. It was specifically applied to alternative pipeline systems for transporting natural gas from the Alaskan fields to access areas.[28]

Assessment. This environmental assessment methodology also employs a matrix technique. The matrix consists of parameters (effects on the environment) and alternative actions. The technique potentially can be applied to other problems and appears to be capable of adapting to changes over time. This flexibility is achieved through the use of an "effects chain". The proper construction of the "effects chain" will allow a study to be comprehensive. The impacts evaluated are strictly environmental. The impacts are stated in negative terms and are quantified. The quantification is accomplished by assigning importance, utilities, and probabilities values to the outcomes derived in the matrix. The assignment of these values require subjective judgement.

Numerical ranking aligns the alternatives. Timing of impacts are not explicitly treated, but may be implied in the value assignment steps.

Environmental Evaluation System

This assessment methodology was developed by the Batelle Institute. It was designed specifically to evaluate the environmental impacts of the U.S. Bureau of Reclamation's water resource developments. The intent of this application was to alert the Burear of Reclamation to sensitive areas in the field of water management.[29]

Assessment. The technique employed in this methodology is an algorithmic procedure. A four level heirarchical structure is first constructed that provides the assessor with environmental parameters. These parameters are quantified in common units by a three step algorithm. Trade-off analysis between beneficial and adverse environmental impacts is then suggested. Adaptability in application and to changes over time is facilitated by the construction of new heirarchical structures. Comprehensiveness is contingent upon the assessor. Impact is limited to environment, but environment in this study was divided into four areas; ecology, environmental pollution, esthetics, and human interest. Quantification is achieved through the assignment of importance and environmental quality values to parameters. This requires subjective judgement. Impacts are stated in positive numerical terms labelled environmental impact units. These impacts may be either beneficial or adverse. Timings of impacts are only implied in the importance valuation. Impacts are categorized by beneficial impacts and adversity impacts and ranked in terms of environmental impact units.

Cost-Risk-Benefit Analysis

This methodology was suggested as applicable to the assessment of the impacts of introducing toxic and hazardous substances into the environment. This methodology concentrates on determining the optimal control level for managing the introduction of these substances into the environment.[30]

Assessment. The techniques employed in this methodology consist of a cost benefit analysis model and a risk analysis model. These two models provide information input for the decision component of this methodology. The methodology was only suggested for application to the study of toxic substances. Adaptability to changes over time and universality of application are potential characteristics. In my opinion the procedure is complex. This complexity may be attributed to the large number of estimates of abstract terms that are required in this methodology. The impacts evaluated are limited to the environment, but the procedures to evaluate these impacts involve social and economic impacts as well. Estimates are required to provide this approach with the quantifiable information sought in this methodology. Timing of impacts are ignored in this methodology. Alternatives are ranked according to dollar values that indicate the individual's willingness-to-pay. These alternatives are stated in negative terms (risk-related welfare) and positive terms (product benefits).

Models Validity Assessments. The two models of this methodology can be assessed for validity in only a limited manner. The methodology has not been applied to an actual problem thus eliminating data, predictive, operational, and dynamic validity tests. Model validity which deals with accurate assumptions and logical validity may be used as criteria in a limited sense.

There are several assumptions made in the formation of the models that are subject to question. It is in my opinion a questionable assumption that the numerous estimates required to derive dollar values for benefits and risks can be made. The mathematic assumptions that involve the use of these estimates do appear to be valid.

The conceptual outcome of the framework presented appears to be the logical outcome that is expected. The mathematical operations that are prescribed also provide backing for the logical validity of these models.

The model validity criteria could not fully be applied to these models. This is due to the non application to a problem of this methodology. The limited assessment however does show the potential value of applying this criteria to assessment models.

Comparison of Technology Assessment and Environmental Assessment Methodologies

All four technology assessment methodologies employed the use of a verbal descriptive technique. The techniques involved steps of varied scopes to systematically evaluate the impacts of a technology. This single technique employment is in vivid contrast to the varied techniques used by the environmental assessment methodologies. These methodologies used matrices and modelling techniques. They too employed systematic step procedures to direct their assessment tasks. One may judge the environmental methodologies as having higher levels of complexity. This judgement is based upon the matrices and modeling techniques used by the environmental assessment methodologies vice the verbal descriptive techniques of the technology assessment methodologies.

The areas of impact for the environmental methodologies were limited for the most part to only the environment. In some cases the consideration of areas of impact was expanded to economics and human interest. This single impact area consideration is contrasted to the multi-disciplined impact areas explicitly dealt with or implied in the technology assessment methodologies.

Both methodology types seemed to be capable of adapting to changes over time and to different applications. Subjective judgements of the assessors were required in both types of methodologies.

The environmental methodologies did not explicitly consider the timing of impacts. This is also true for three of the four technology assessment methodologies. The Mitre approach did give explicit attention to multi-ordered impacts.

In comparing these assessment types a pattern becomes apparent. The environmental assessment methodologies appear to involve more sophisticated techniques. This may be explained by their concentration on one area of impact, environment. Environmental impact assessments have historically been applied to implementation and controlling considerations of existing technologies. The considerations of the methodologies appear to be directed more towards individuals. This may be a justified development as the impact of existing technologies is probably more strongly felt by the individual level of concern.

Technology assessment methodologies are less sophisticated than the environmental methodologies. In this methodology type greater emphasis is placed on multi-areas of impact. In many of these areas very little information has been developed to evaluate impacts.

Technology assessment methodologies have been directed to assessing the impact of new technologies before their implementation. This tends to dictate a role for technology assessment in the guidance of research and development programs. Impact considerations at the early stages of the development of new technologies appear to be more pertinent information for national and industrial levels of concern.

In both methodology types there was a recognition that technologies, whether they are in the development stage or the implementation stage, may have some adverse effects on various areas of concern. These adverse effects were labelled as costs, disbenefits, damages, or adverse parameters. Only in one methodology was a risk concept introduced. A new technology in the development stage or an existing technology being implemented may cause adverse effects to areas of impact. These potentials to cause adverse effects are risks. It would seem possible for an impact assessment methodology to be based upon this risk concept.

Conclusion

This chapter first examined the impact that technology assessment has had on different levels of concern. The largest impact has been on the national level of concern, the originator of this concept. Industry is just now begining to realize its importance and value. All levels of concern are impacted by technology, and these impacts indicate a potential interrelationship between levels of concern. This potential of the interrelationships of levels of concern when considering technology impacts may be a very important issue in assessing technology.

The second section of this chapter presented environmental assessment and technology assessment methodologies. These methodologies were assessed, and these assessments provided criteria for comparing and contrasting the two types of assessment methodologies. Both assessment types recognized the potential for adverse impacts. These potentially adverse impacts could be stated in terms of risks.

Chapter four is designed to provide a framework for identifying risks associated with new and existing technologies. In addition this framework will be developed in such a manner as to indicate the interrelationships of levels of concern.

FOOTNOTES

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[26] Hetman, pp. 132-134.

[27] Dickey, Glancy, and Jennelle, p. xi and p. 93.

[28] Bereano, Callen, Kellner, Olson, Wengenroth, p. 179.

[29] Hetman, p. 281.

[30] Tihansky and Kibby, p. 117.

CHAPTER IV

RISK ANALYSIS

Introduction

Chapter III has demonstrated that different levels of concern are impacted by technologies. The implementation of an existing technology appears to directly impact the individual level of concern while the development of new technologies appear to directly impact the industrial and national levels of concern.

Methodologies have been developed to assess these impacts. These methodologies have been divided into environmental assessments (existing technologies) and technology assessments (new technologies). Both assessment types although differing in their development, techniques, and direction, are becoming integral components of planning.

The assessment of these methodologies has discovered a common factor in both. They attempt to identify potential adverse effects created by technology. These potential adverse effects may be termed as risks to the levels of concern.

This chapter attempts to analyze risk in an impact assessment context. To accomplish this analysis a framework will be presented to facilitate the identification and measurement of risks associated with technology development and implementation. This framework will be developed in such a manner as to provide an analysis of the interrelationships of levels of concern.

Risks

Risks in the context of this study are simply those potential threats to quality of life resulting from the impacts of technologies. Risks to quality of life are not restricted only to the individual level of concern. Risks of this nature are also applicable to the national and industrial levels of concern.

Threats to quality of life are often equated with threats to the environment. Technology assessment has broadened this consideration to include multi-impact areas. Threats to quality of life factors such as family structure and political processes are also possible. Risks are thus applicable to such areas of impact as the social environment, political environment, economic environment, and others.

Timing

Risks are potential threats. Threats in this context implies that this occurance may take place. Of great importance is when will this threat occur?

If we determine that a risk can be associated with a new technology, then timing becomes important. If this adverse occurance is expected to happen instantaneously upon implementation of a technology, then the risk is a very strong consideration in the decision to implement or not implement the technology. On the other hand if the occurance is not expected to happen for twenty years after the technology is implemented, then the risk should assume a lesser role in the decision process. Twenty years may provide enough time to alter the technology to avoid this adverse occurance. Timing is thus an important aspect of risks associated with the development or implementation of technologies.

Threshold. An explanation of the timing of risks may be developed by a threshold concept. Every adverse occurance has a threshold. At some limit of input the adverse occurance will result. To reach this limit, input is required. The input thresholds take two forms, internal cumulative or external cumulative. Internal cumulative thresholds in this context are limits where the inputs are the result of the same technology. External cumulative thresholds are limits where the inputs are the results of different technologies.

A threshold whether internal cumulative or external cumulative may be so small that the time for the threshold to be reached is virtually instantaneous. A threshold may also be so large that a great number of years is required for the cumulation of inputs to approach the threshold.

Thresholds may be known, as in the case of many toxic substances, or unknown. An example of an internal cumulative threshold may shed light on this consideration. Small amounts of arsenic occasionally taken orally normally will not cause death. If however, a larger dose is administered ill-health may occur, and if this larger dose is repeated, a threshold of tolerance is reached, and death occurs.

Risk Identification

Impact Area Categorization

The potential risks of a new or existing technology are easily categorized by the impact areas associated with these risks. An impact area approach will provide the initial categorization and identification technique of risks. The impact areas to be used in this risk identification exercise will be natural environment, physical environment, social environment, political environment, technological environment, and the economic environment.

This initial classification scheme of risks by impact areas emphasizes the multi-disciplined approach necessary for technology assessment. In addition, this scheme provides a starting point for the development of six modified "effects chains". These "effects chains" will be developed in a systematic manner so as to eventually identify the risks associated with technologies.

Levels of Concern Categorization

A second categorization technique that will be combined with the primary technique involves the subdivision of risks by levels of concern. This categorization is based on the premise that some risks associated with one level of concern may not be risks associated with another level of concern.

This categorization is secondary to impact area categorization because there does exist the potential of identical risks between different levels of concern. For this framework of risk identification, three levels of concern will be considered. They are the individual, industry, and the national levels of concern. The framework is of course easily adaptable to including other levels of concern such as the international level.

Initial Categorization Structure

At this point the identification and categorization scheme advocated in this study consists of a primary and secondary categorization. The first categorization is by impact areas. This provides starting points for a modified "effects chain." The second categorization involves levels of concern within each impact area categorization. To begin the identification of risks associated with alternative technologies, we have the following initial framework.

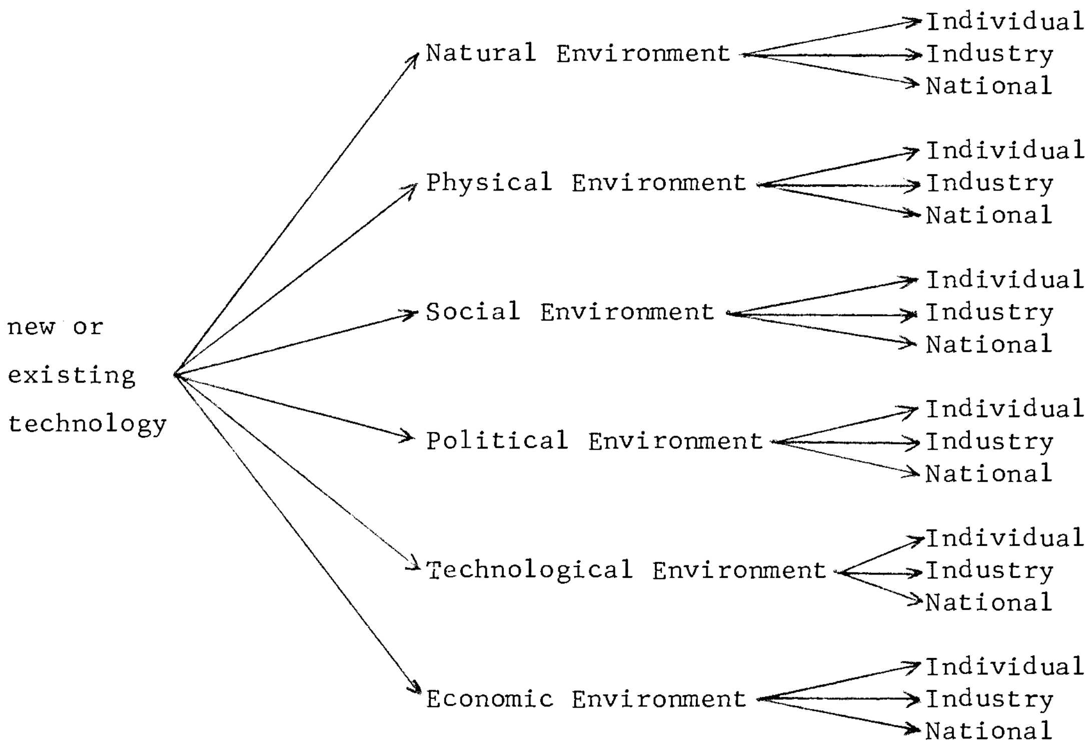


Figure 16. Initial Framework for Identifying Risks

Each technology to be assessed will have this initial starting framework. The risks to be identified in this framework ultimately will be all potential risks of a technology. Thus individual technologies may be assessed on the basis of their potential risks identified through the risk base to be established by this framework.

<u>Levels of Concern Interrelationships</u>

The secondary categorization by levels of concern within each impact area follows a common pattern. The risks associated with the individual level of concern are risks that are also associated with the national and industrial levels of concern. This is due to the fact that individuals comprise both industry and the national level.

Using the same logic, the industrial level of concern risks are also risks associated with the national level of concern. Industries like individuals are entities within the national level.

The reverse of this logic is not applicable to our study. That is, many risks associated with the national level are not risks associated with the industrial or individual level. This is also true for the relationship between industry and individual risks. This means that not all industrial level of concern risks are risks associated with the individual. These levels of concern interrelationships when applied to the risk concept alters the framework in each impact area as follows.

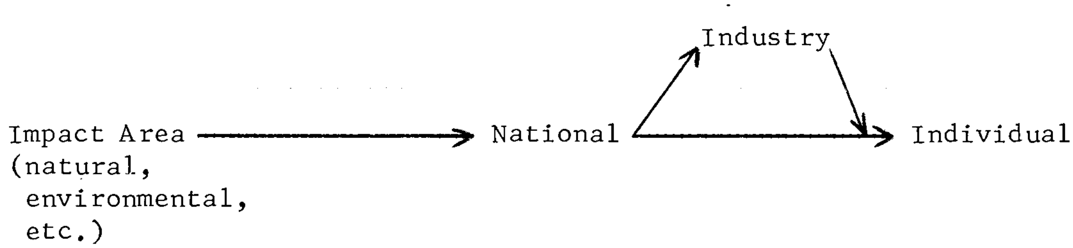


Figure 17. Framework for Levels of Concern Interrelationships

Risk Identification Framework

The risks from an impact area are seen in figures 18 through 20. The identification of risks is accomplished by using the framework presented above. The logic of the framework is based upon the concept of the "effects chain".

Within each impact area, the three levels of concern are considered and interrelated as shown above. The first breakdown eminating from each level of concern is a subdivision of factors related to the specific impact area. For example in Figure 20, Natural Environment-Individual Level of Concern, there is first a subdivision into water quality, air quality, and land quality. The industrial level of concern shown in Figure 19 is subdivided into individual level of concern, anti-pollution control, and public interest (common to national level also). The national level of concern shown in Figure 18 is subdivided into the individual level of concern, the industrial level of concern, anti-pollution policy, and public interest.

The next step in the modified "effects chain" is the breakdown of these subcatorizations. This breakdown is explained as potential "risk to" areas. An example of this breakdown can be seen in Figure 20 under the air quality subcatorization. As can be seen the "risks to" air quality are to human health, to human well-being, to property, and to other life forms.

The final step in identifying risks is the subcategorization that produces the list of actual risks associated with the "risks to" section. To carry on our analysis of Figure 20, the subcategorization air quality has a "risk to" human health. The risks, as can be seen in the figure, are death(LC3R1) and ill-health(LC3R2).

By following this logic throughout Figures 18 through 35, a comprehensive list of risks and categorization of these risks by levels of concern is derived. Figures 21 through 35 are presented in the Appendix of this study.

The framework provided to identify risks is a tool for that purpose and is not intended to suggest that the identified risks are independent. It should be realized that the classification of risks

Figure 18.

Natural Environment-

National Level of Concern

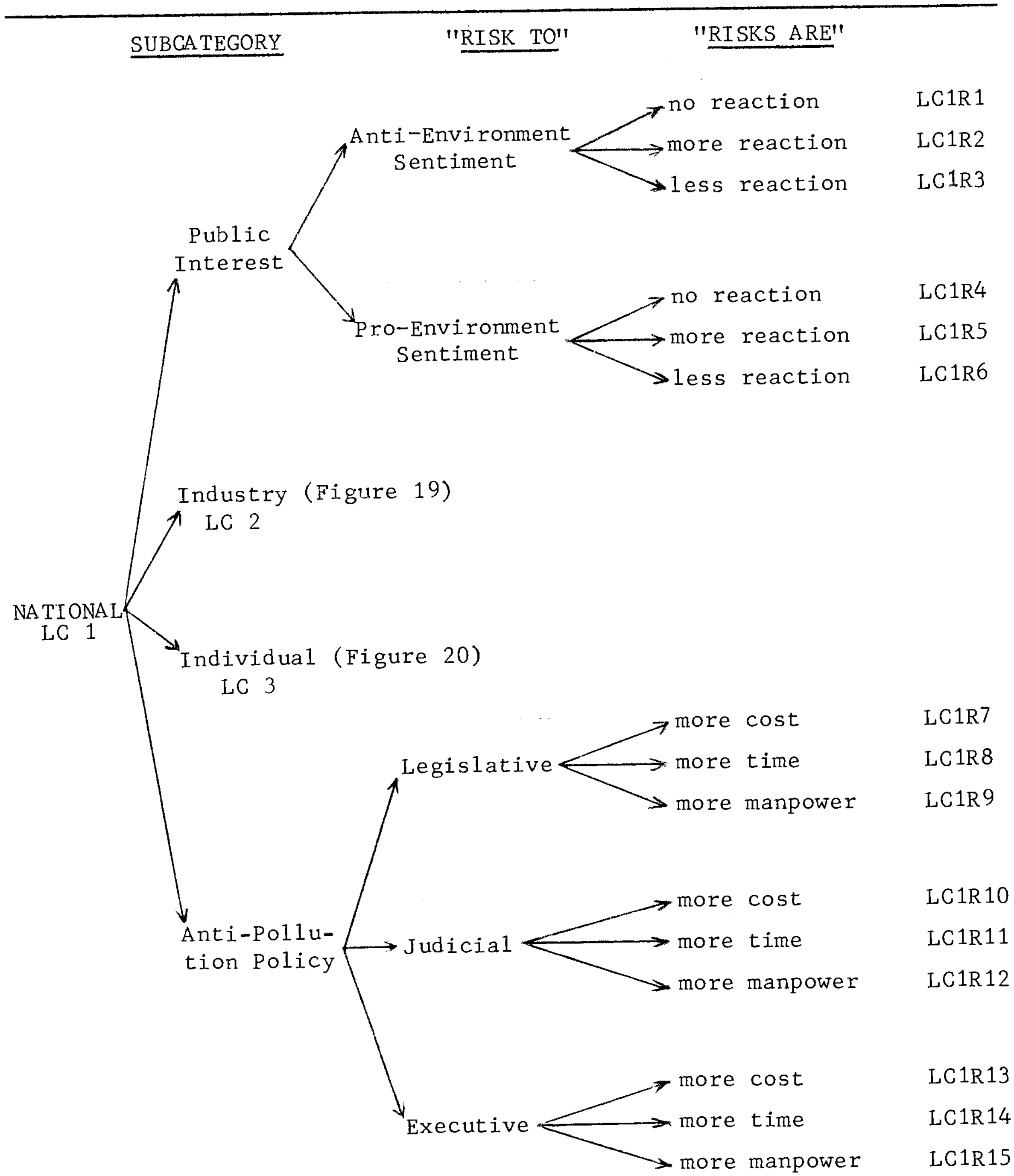


Figure 19.

Natural Environment-

Industrial Level of Concern

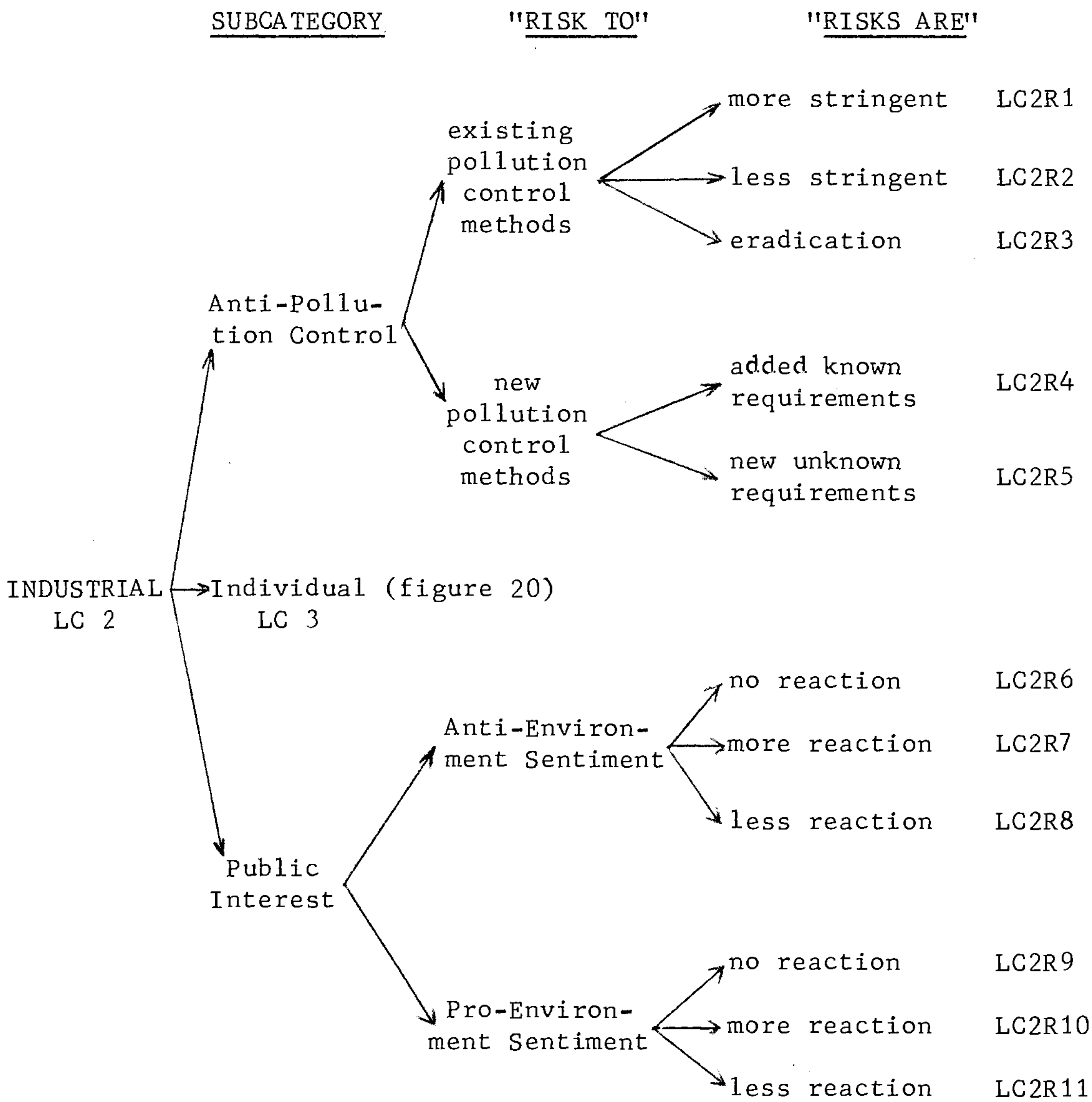
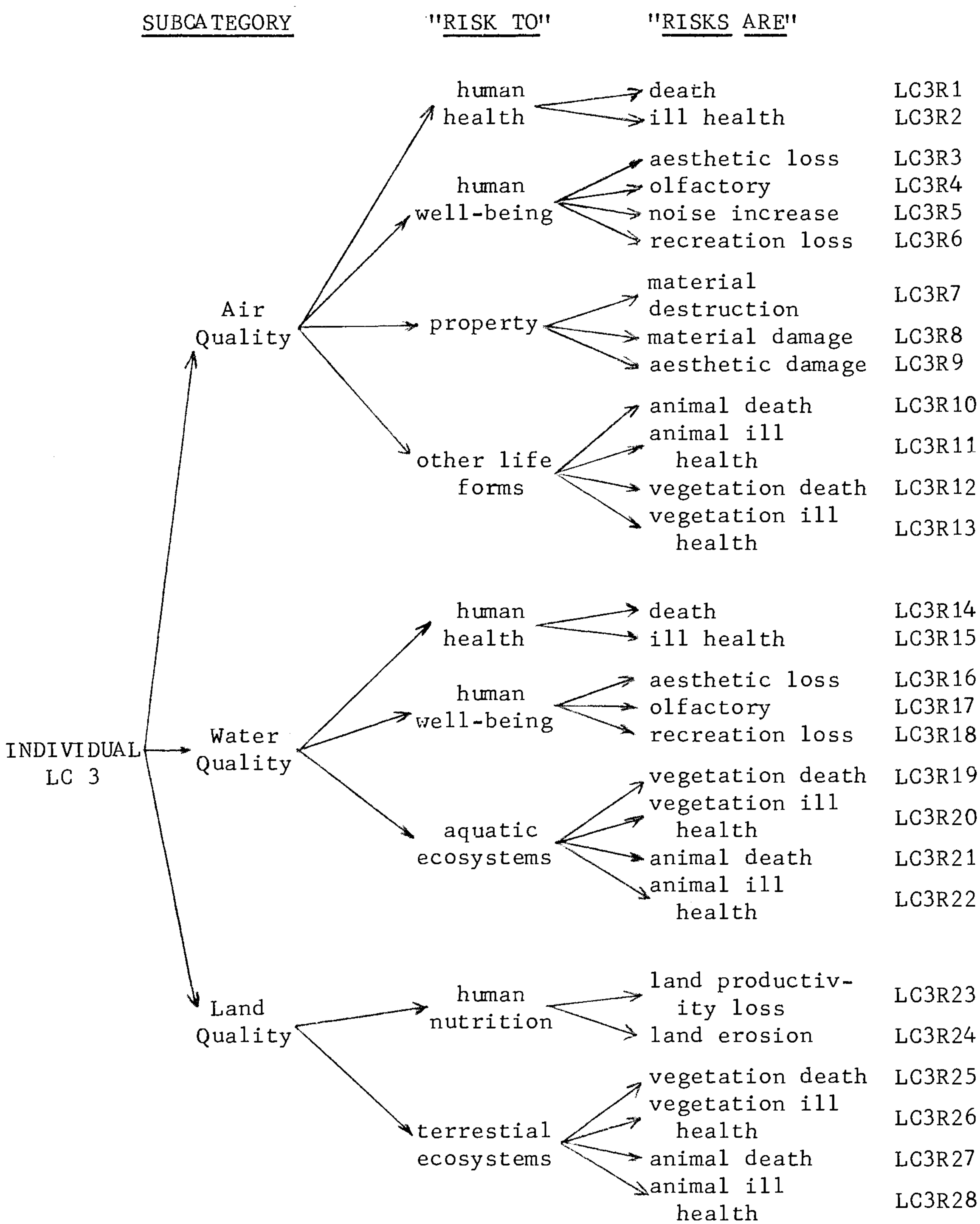


Figure 20.

Natural Environment-

Individual Level of Concern



in this framework by levels of concern is a means of organizing these risks into controllable components.

Identification of Causative Factors of Risks

Figures 18 through 35 have provided a list of risks. Each risk can be measured in terms of what inputs (agents) and quantities of these inputs are necessary to reach the risk threshold. For example, the risk of human death through water quality pollution (Figure 20) may be caused by the following agents:

1. Algal bloom
2. Dissolved oxygen
3. Evaporation
4. Fecal coliforms
5. Pesticides, herbicides, defoliants
6. pH
7. Sediment load
8. Temperature
9. Toxic substances
10. Turbidity
11. Radiation
12. Phosphates.

Each risk has some listing of factors that are causative inputs. It is not the purpose of this study to determine what these factors are for each risk. This objective would require the efforts of experts in many fields.

Technology assessment methods appear to be in need of such factors identification. These factors are necessary for a measurement and a standard to be developed for each risk. This causative agent concept is easily a subcategorization of the risks developed in the "effects chain".

Setting Standards for Causative Agents

Each risk as has been ascertained may reach a threshold level at some point in time after the technology implementation. A technology assessment methodology dealing with risk requires a standard of measure for this threshold concept. If the threat requires 20 units of input a_1 to become a reality, then 20 units of a_1 would be the standard. The task of establishing such standards is also beyond the scope of this study, but is of paramount importance in the technology assessment methodology. Such standards in some cases have been established, but the credibility of these standards are often questioned.

Conclusion

This chapter was designed to analyze the risk concept and its application to technology assessment. Several factors such as risk timing and risk threshold were dealt with. These were discovered to be important factors in the consideration of risks associated with technology.

A framework for identifying these risks in six impacts areas was presented. From this identification, the measurement of these risks becomes a possibility. In addition, this framework has indicated the interrelationships that exists between levels of concern.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of Findings

Assessments have been previously categorized as environmental assessments or technology assessments. Environmental assessments for the most part evaluate the environmental impacts of existing technologies. Technology assessments evaluate multi-disciplined impacts of new technologies. It was the objective of this study to present a framework for merging these two assessment types into a suggested broad systems approach.

A brief history of technology assessment was presented in Chapter II. The study of the history of technology assessment presented important considerations for assessment methodologies. Technology is implemented to affect society, but the effects may be beneficial or costly. Technology affects multi-impact areas such as the social, political, economical, technological, and natural environments. The adverse effects of technology on impact areas have become threats to quality of life. Another important consideration is that these impacts may occur in a multi-ordered manner. Consequently, secondary, tertiary, and higher order impacts are possible and should be considered in an assessment study.

These findings aided in the development of a definition of technology assessment. Technology assessment is a policy-making tool, iterative in nature and multi-disciplined in approach, for the purpose of evaluating the multi-ordered and multi-constituency impacts of technology on the quality of life.

In order to develop a systems approach that merges technology assessment and environmental assessment, it was necessary to present and compare the methodologies of these two assessment types. This task was undertaken in Chapter III. The technology assessment methodologies employed verbal descriptive techniques for evaluating multi-areas of impact while the environmental assessment methodologies employed matrices and modelling for evaluating primarily environmental impacts. Multi-ordered impacts appeared to be the concern of only technology assessment methodologies.

Both methodology types recognized the potential adverse effects that technology may have on impact areas. These potential adverse effects were termed as risks in this study. Risks were consequently defined as potential threats to quality of life resulting from the impacts of technologies. The risk concept was suggested as being the common factor for merging the assessment types into a suggested broad systems approach for evaluating the impacts of technologies.

A suggested framework for identifying all the risks associated with a technology was presented in Chapter IV. This framework provides consideration of six major impact areas: natural environment, physical environment, economic environment, political environment, social environment, and technological environment. The interrelationships of three levels of concern was identified in this framework. Figures 18 through 35 are attempts at utilizing this framework for identifying all the risks associated with technology.

Suggested Research

The risk concept developed in Chapter IV may be a mechanism for developing a systems approach for evaluating the impacts of technologies. This approach could consist of identifying all the possible risks associated with the development of any new technology or with the implementation of any existing technology. Once the risks, such as those in figures 18 through 35, are identified, a risk acceptability value is assigned to each risk. This value from 1 (acceptable) to 10 (unacceptable) indicates the willingness of our society to assume a particular risk.

The identified risks and the risk acceptability values could provide a data base for evaluating specific technologies. The identification of causative factors of risks and the setting of standards for these causative agents could provide inputs for determining what risks are associated with a specific technology. The risks of a specific technology would be identified from the data base of risks. The identification of these risks would also provide acceptability values.

Once the specific risks of a technology are identified, quantification is suggested for evaluating the risks. One suggested technique for quantifying risks is to multiply the risk acceptability value by a probability that indicates the potential of the risk to manifest itself as an actual occurance. This multiplication yields a value that may be termed as a threat value for each risk.

As was ascertained in Chapter IV, risk timing is also an important consideration. To incorporate this consideration involves estimating the amount of time necessary for a risk to potentially become an actual occurance. Plotting the threat value of each risk associated with a technology on a vertical axis and the associated estimated timing consideration of each risk on a horizontal axis may provide a method for evaluating the technology with alternative technologies that have been quantified in the same manner. This suggested approach is one possible method. Further research is required to develop this suggested approach.

The risks identified in Figures 18 through 35 are merely suggested risks. The framework for identifying these risks is the important consideration. This framework is a means to provide the data base of risks associated with technology. The identification of these risks requires further research.

A second area of required further research involves the identification and measurement of the causative factors of the identified risks in the risk data base. These causative factors in many cases may lend themselves to measurement. Through the identification of these factors and a means for measuring these factors, standards for causative agents may be established. Such research would provide added information for determining what risks are associated with specific technologies.

Throughout this study it became apparent that various related fields are involved in technology assessment. This situation led to the compartmentalization of various considerations. It should be realized that compartmentalization was utilized as a tool for analysis and that the components in this study are interdependent.

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A P P E N D I X

Figure 21.

Physical Environment

National Level of Concern

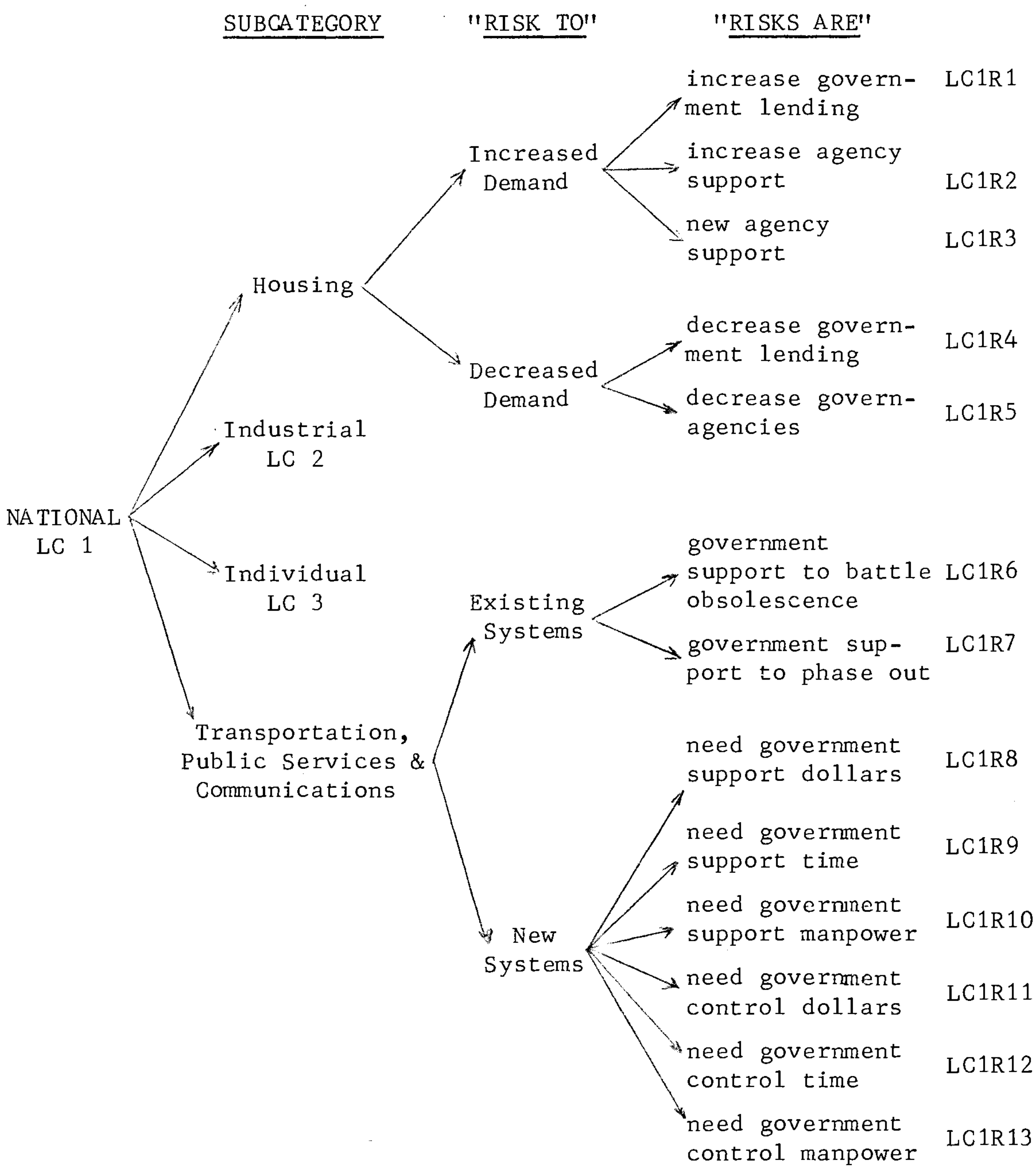

Figure 22.

Physical Environment

Industrial Level of Concern

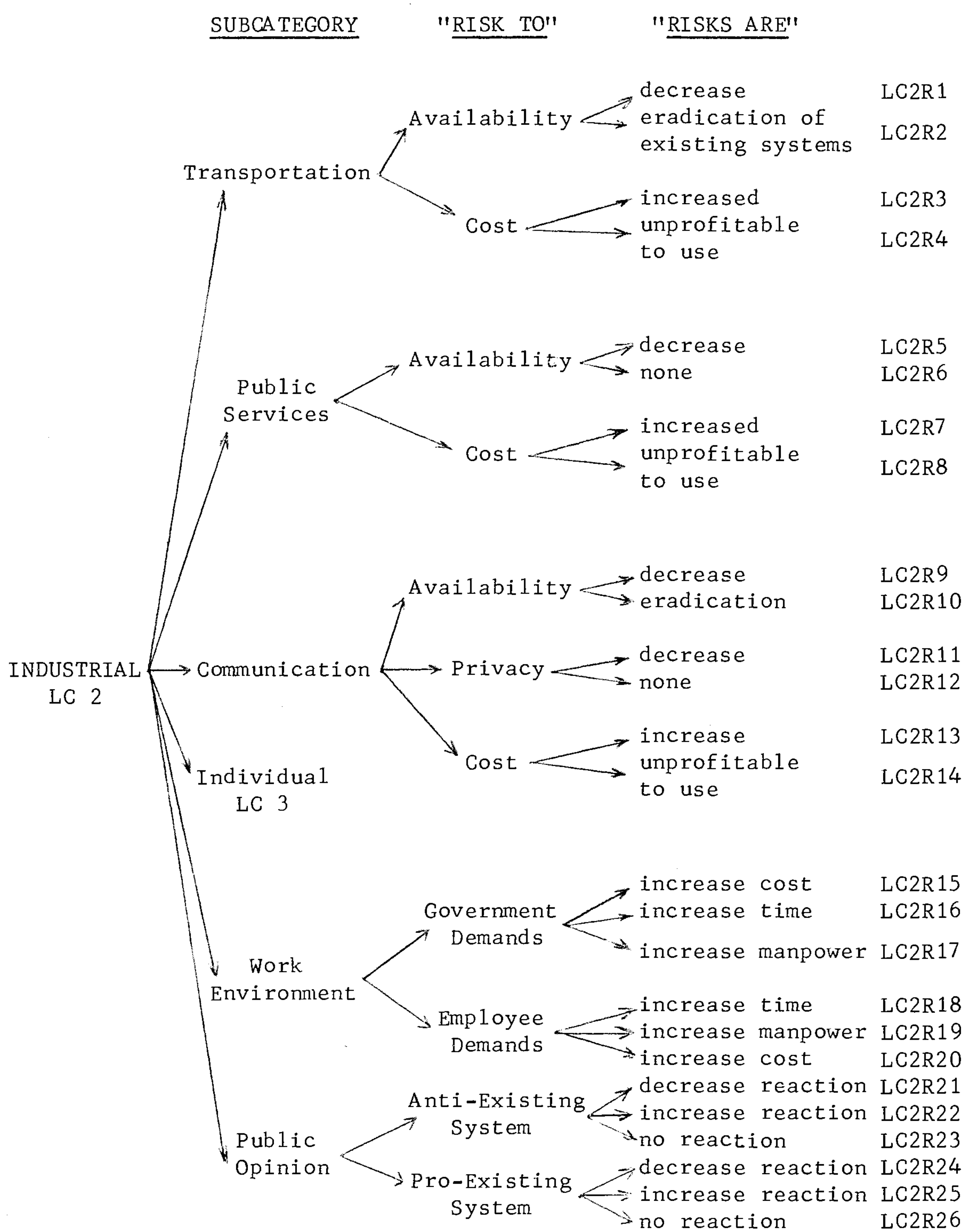

Figure 23.

Physical Environment

Individual Level of Concern

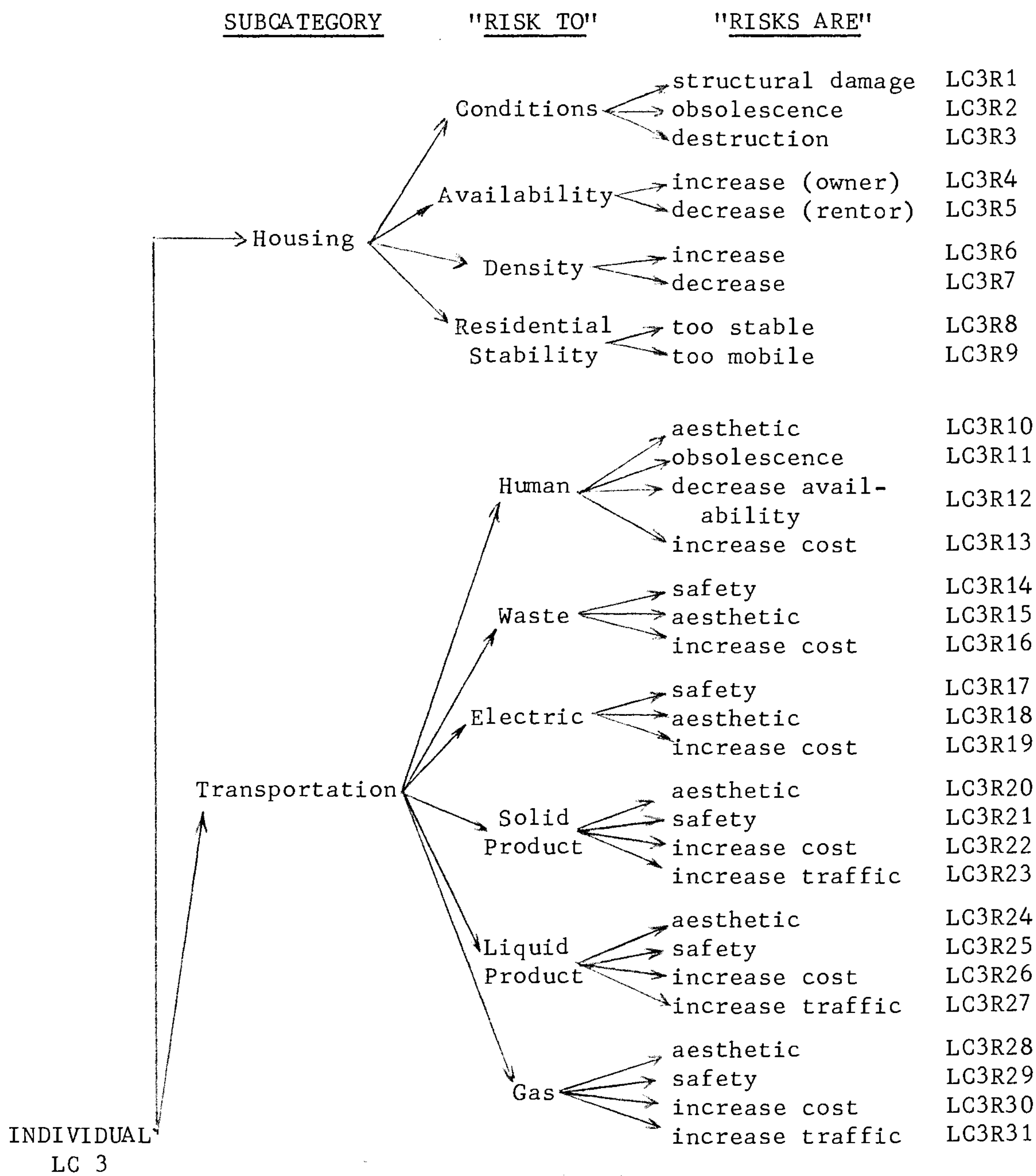

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Figure 23.

Physical Environment

Individual Level of Concern Continued

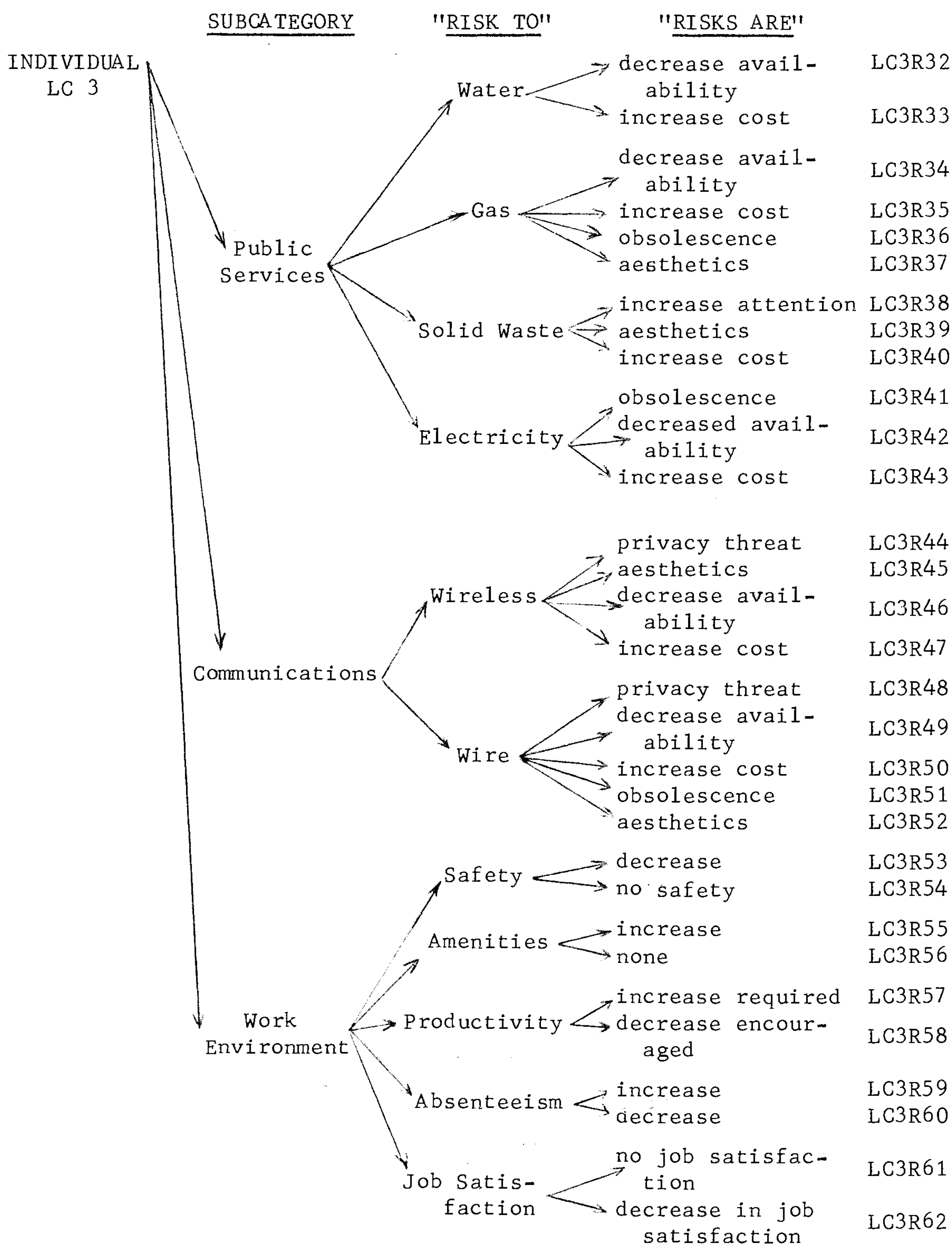


Figure 24.

Social Environment

National Level of Concern

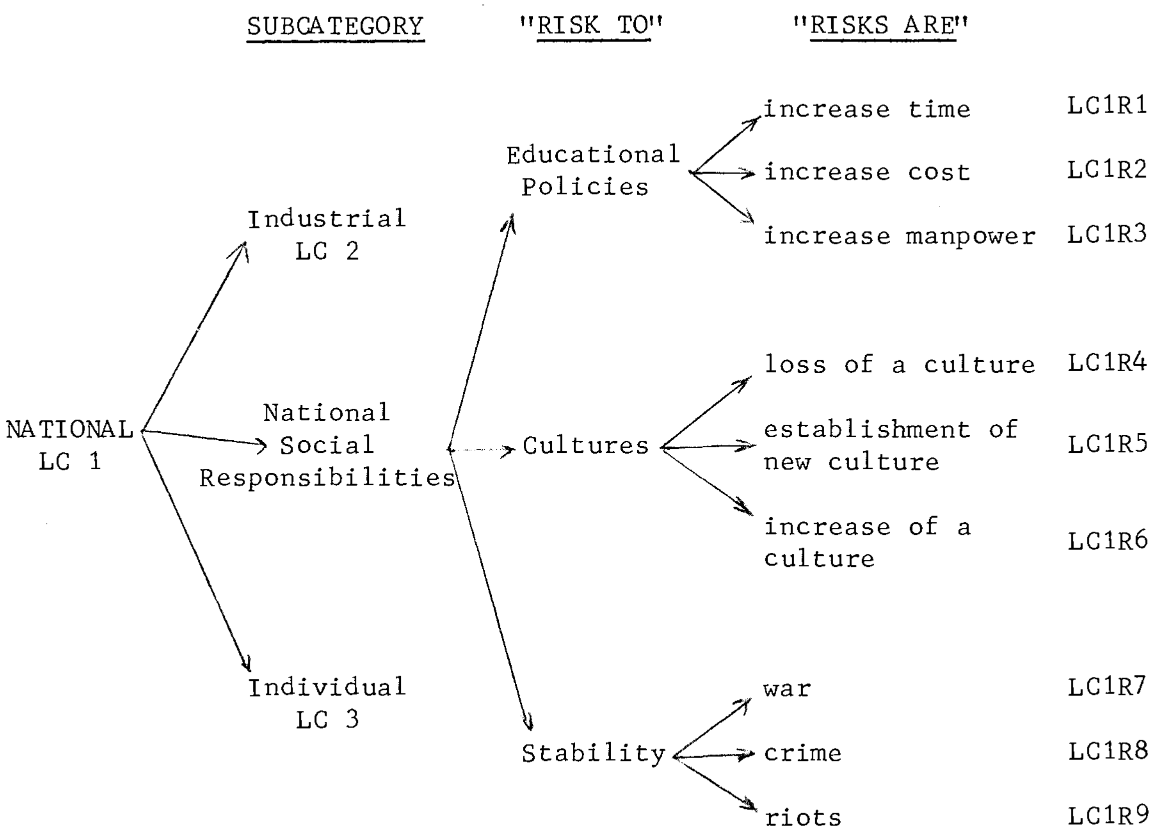


Figure 25.

Social Environment

Industrial Level of Concern

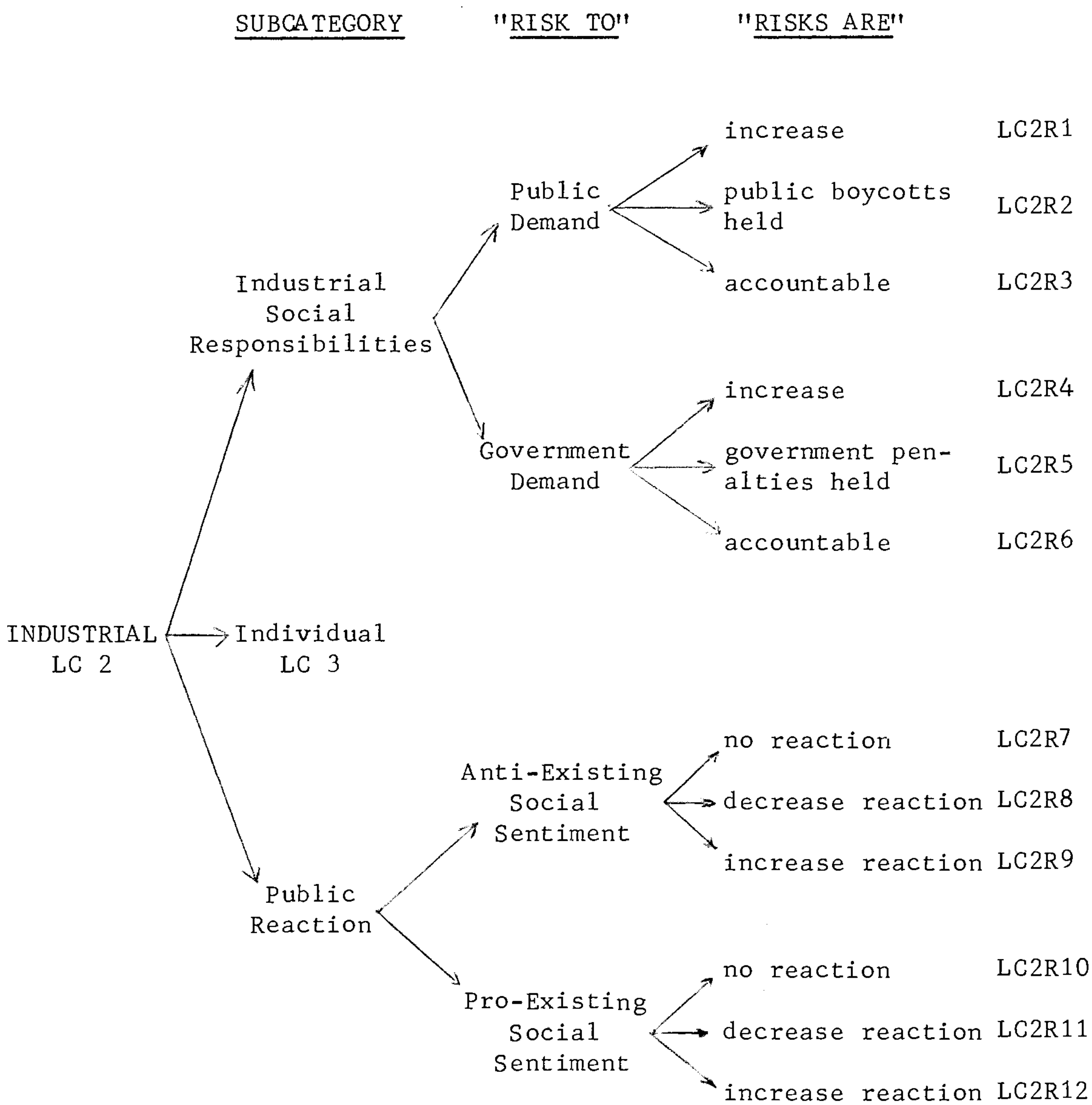


Figure 26.

Social Environment

Individual Level of Concern

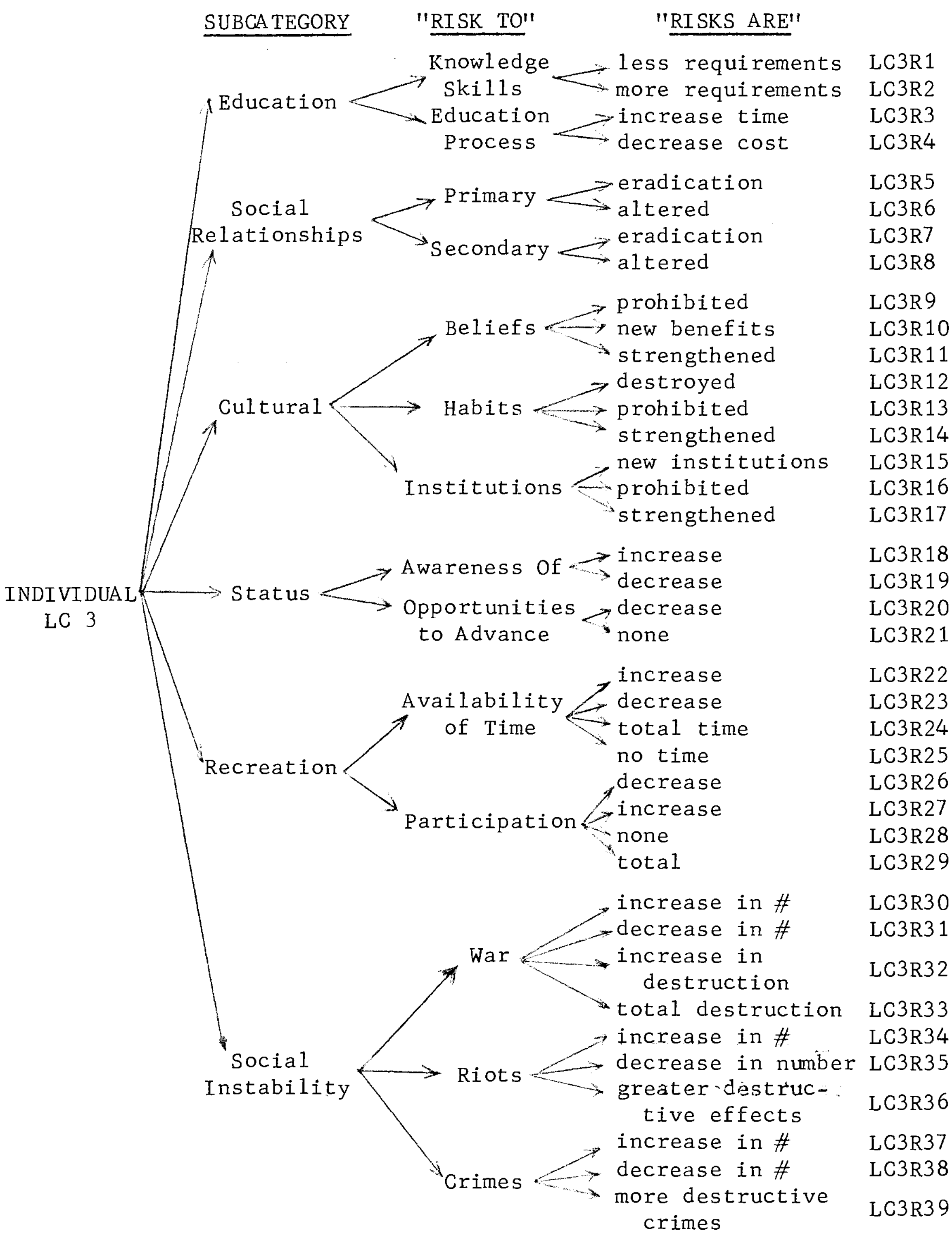


Figure 27.

Political Environment

National Level of Concern

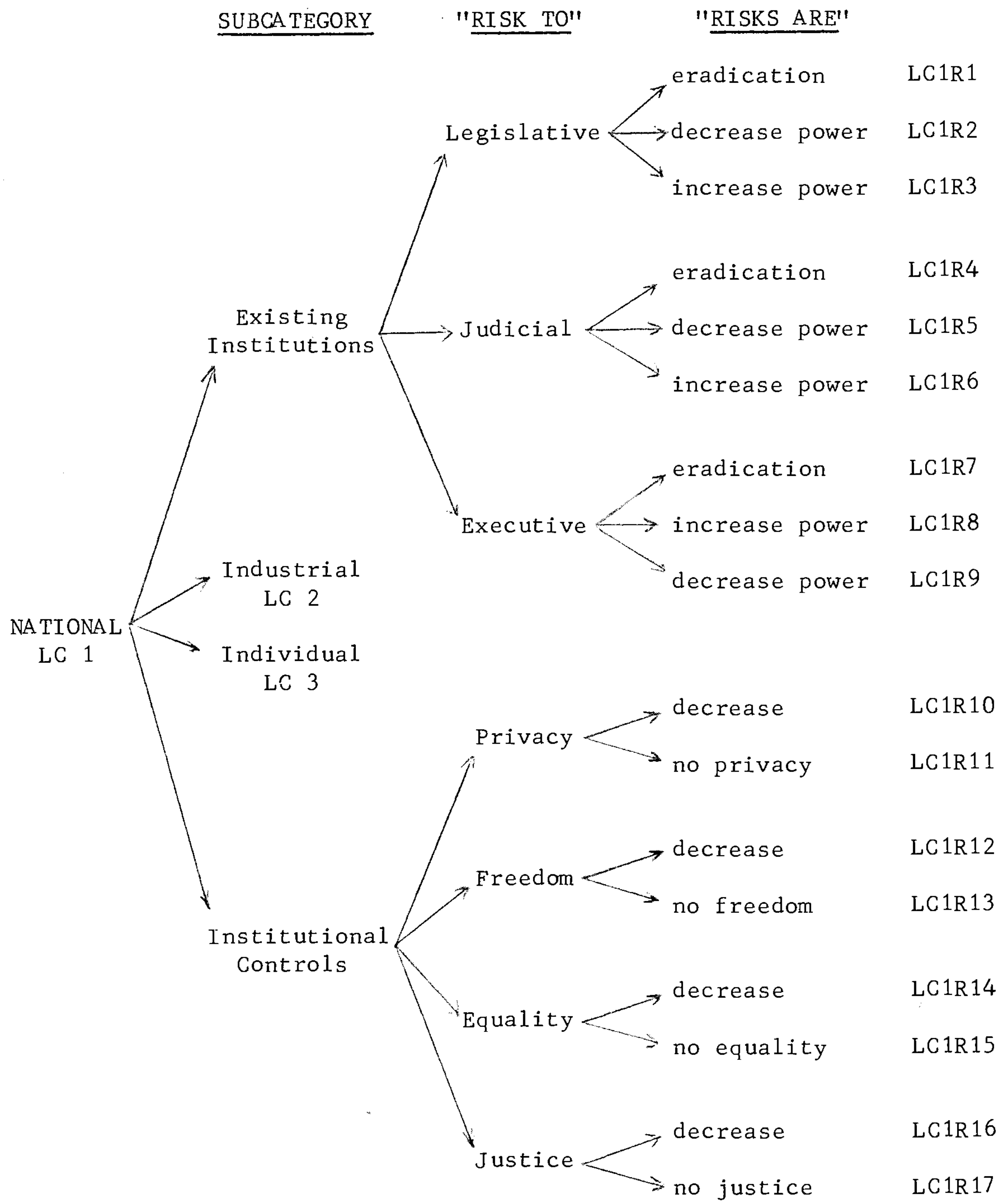


Figure 28.

Political Environment

Industrial Level of Concern

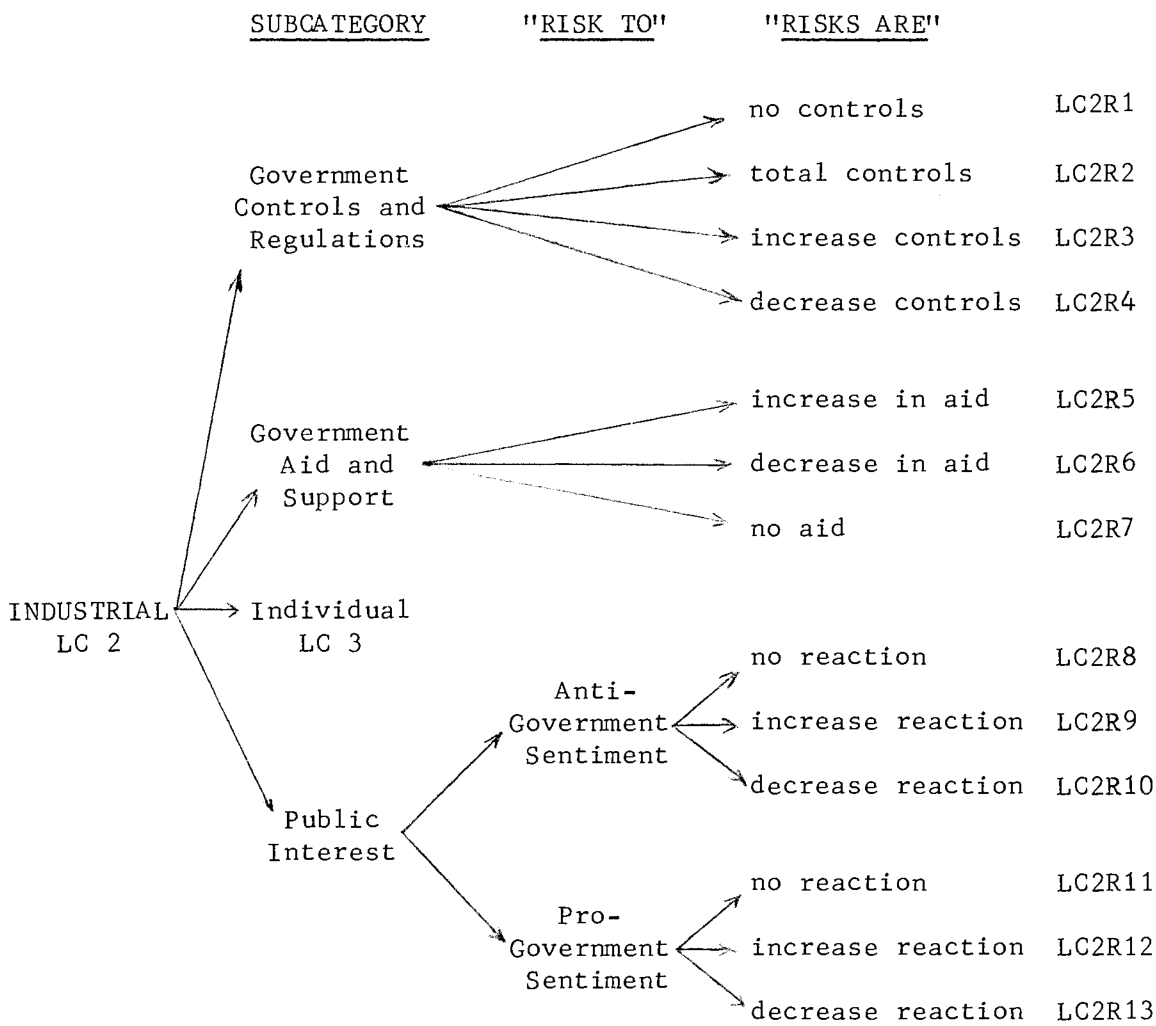


Figure 29.

Political Environment

Individual Level of Concern

INDIVIDUAL LC 3

SUBCATEGORY	"RISK TO"	"RISKS ARE"	
Freedom	Of Religion	prohibited	LC3R1
		restriction	LC3R2
	Of Speech	prohibited	LC3R3
		restriction	LC3R4
	To Assemble	prohibited	LC3R5
		restriction	LC3R6
	To Bear Arms	prohibited	LC3R7
		allowed	LC3R8
		restricted	LC3R9
	To A Trial	prohibited	LC3R10
		restricted	LC3R11
	From Seizure	decreased	LC3R12
		total seizure allowed	LC3R13
Individual Equality	Minority Discrimination	increased	LC3R14
		total	LC3R15
	Majority Discrimination	increased	LC3R16
		total	LC3R17
Individual Participation	Electoral Participation	discouraged	LC3R18
		prohibited	LC3R19
	Nonelectoral Participation	discouraged	LC3R20
		prohibited	LC3R21
Government Responsiveness	Public Demand	no response	LC3R22
		total response	LC3R23
		undesired response	LC3R24
	Information	no information	LC3R25
		restricted information	LC3R26
		unlimited disclosure	LC3R27
Privacy	Conscious	decrease physical privacy	LC3R28
		decrease information privacy	LC3R29
		no privacy	LC3R30
	Subconscious	techniques to extract subconscious information	LC3R31
		partial extraction	LC3R32

Figure 30.

Economic Environment

National Level of Concern

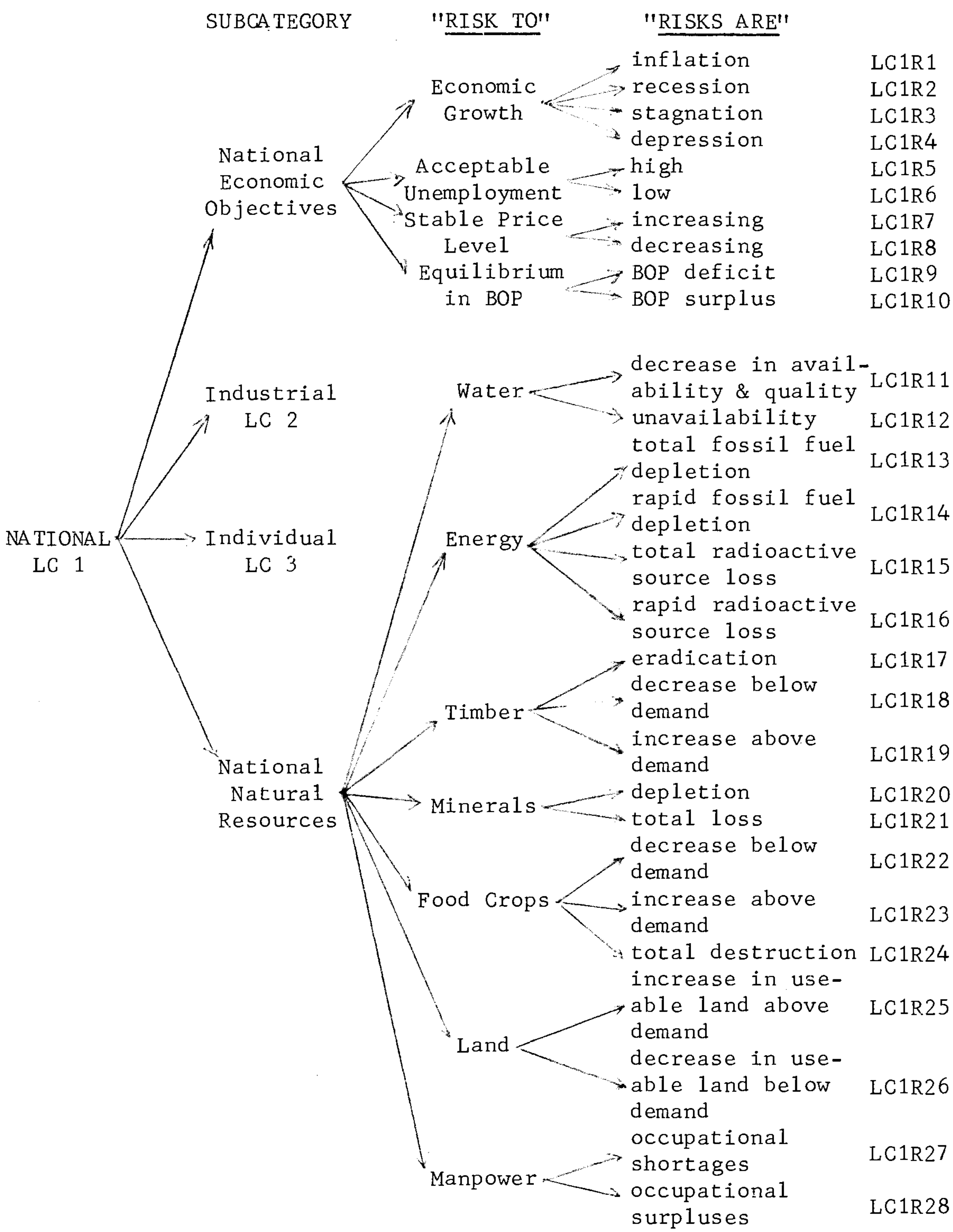


Figure 31.

Economic Environment

Industrial Level of Concern

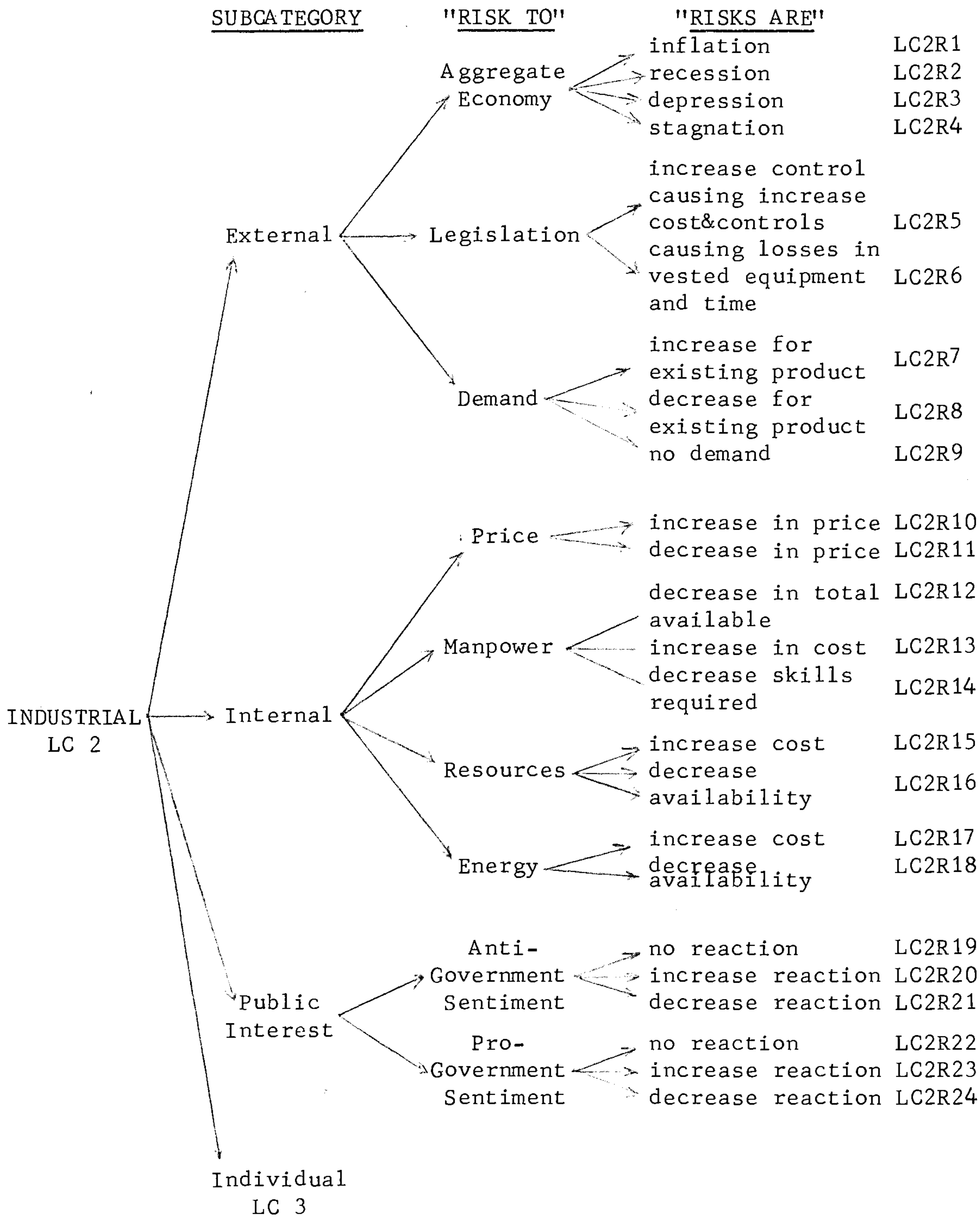


Figure 32.

Economic Environment

Individual Level of Concern

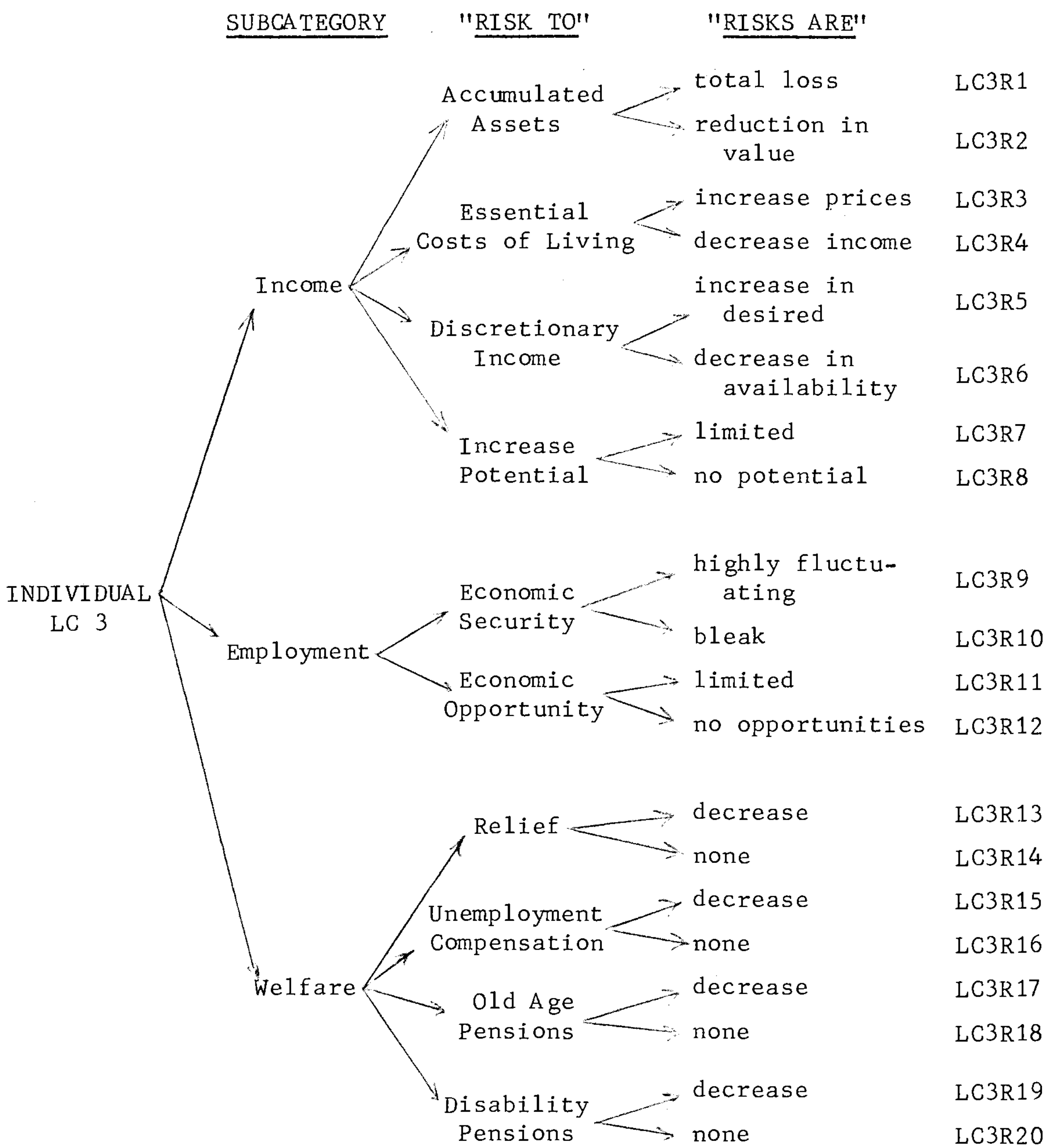


Figure 33.

Technological Environment

National Level of Concern

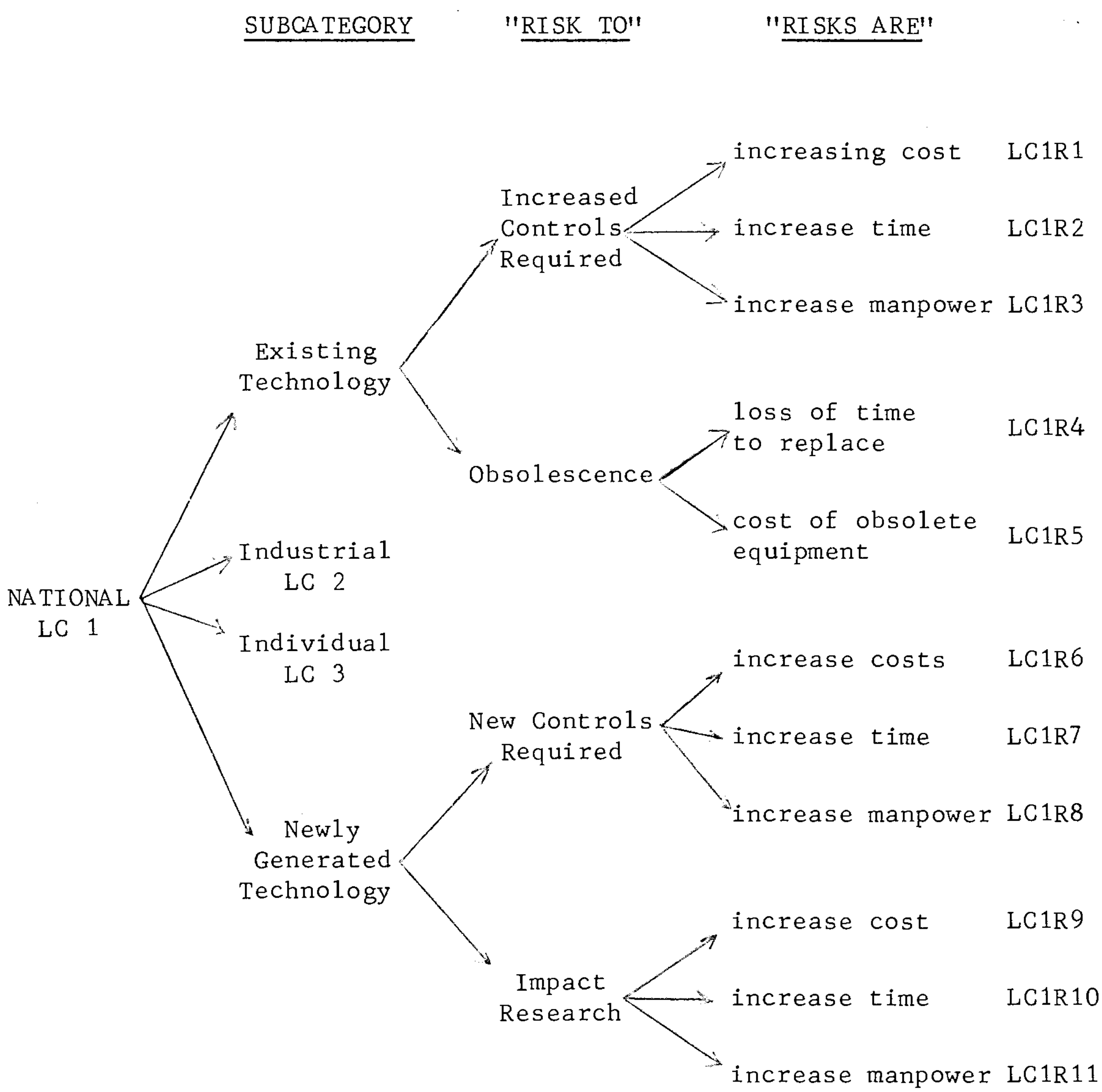


Figure 34.

Technological Environment

Industrial Level of Concern

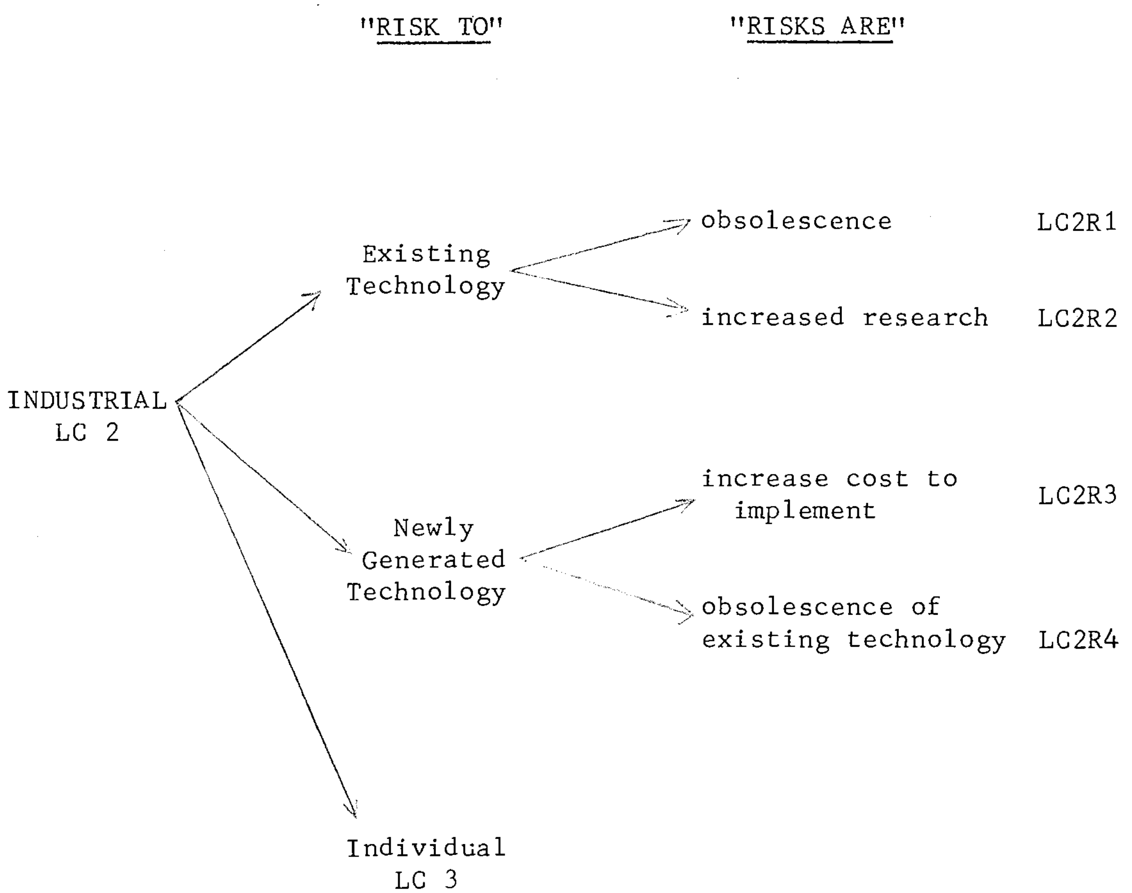
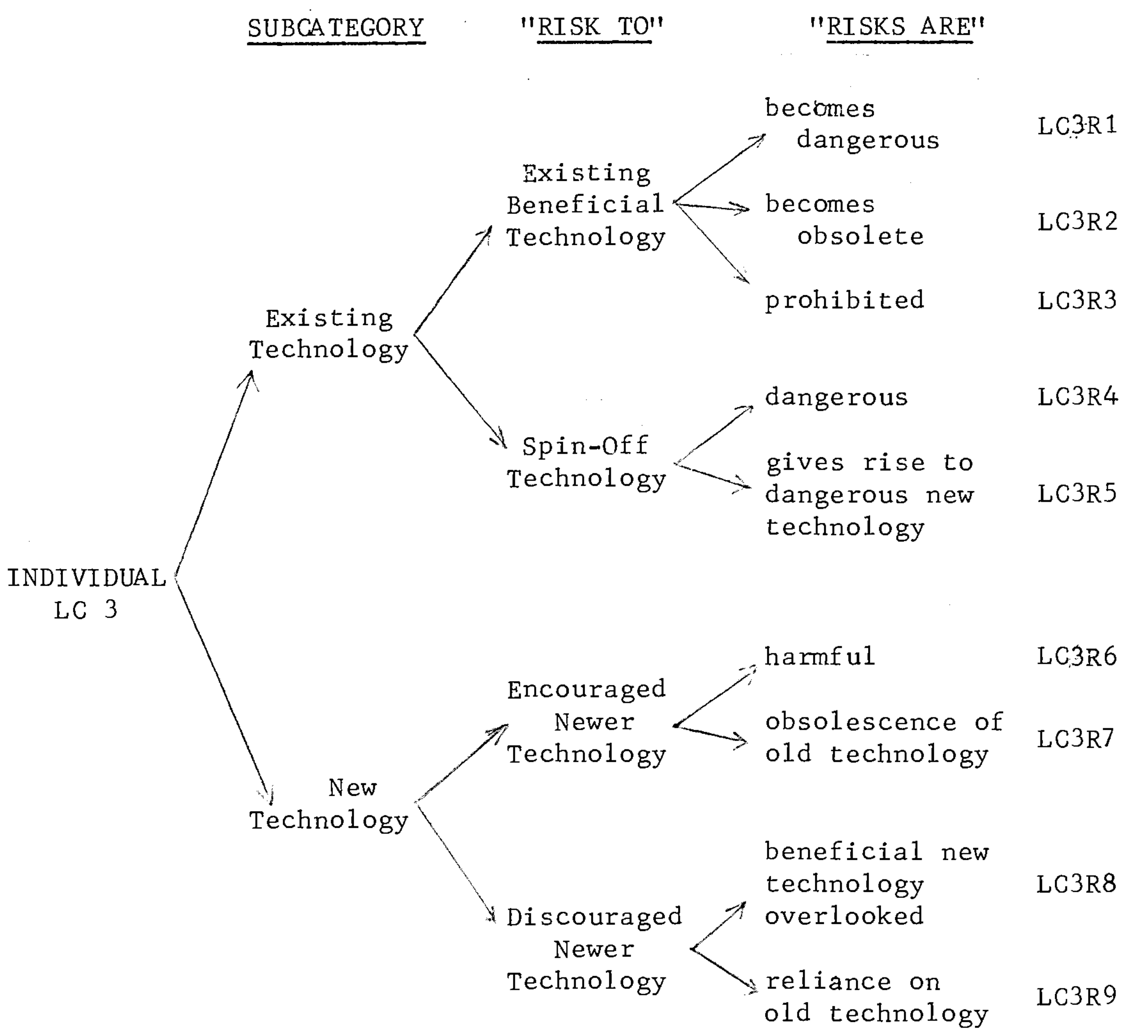


Figure 35.

Technological Environment

Individual Level of Concern



VITA

Gary Wayne Watson

Candidate for the Degree of

Master of Business Administration

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Major Field: Business Administration

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