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Methods for Assessing the Socioeconomic Impacts of Large-Scale Resource Developments: Implications for Nuclear Repository Siting

Technical Report

March 1983

Steve H. Murdock

Department of Rural Sociology
Texas A&M University
College Station, Texas 77843

and

F. Larry Leistritz

Department of Agricultural Economics
North Dakota State University
Fargo, North Dakota 58102

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PURPOSE

This report is one of a series of topical papers prepared under subcontract to the Office of Nuclear Waste Isolation (ONWI). The substance of these papers is to provide the U.S. Department of Energy insight into possible approaches to resolve potential social, political, economic, and programmatic issues that may be associated with the development of a nuclear waste repository. The findings and recommendations expressed by each study become inputs to the policy-making process undertaken by the Department of Energy. This does not mean that each recommendation will become policy, but rather they are considered along with other inputs in the policy development process.

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ABSTRACT

The report provides an overview of the major methods presently available for assessing the socioeconomic impacts of large-scale resource developments and includes discussion of the implications and applications of such methods for nuclear waste repository siting. The report:

1. Summarizes conceptual approaches underlying, and methodological alternatives for, the conduct of impact assessments in each substantive area, and then enumerates advantages and disadvantages of each alternative.
2. Describes factors related to the impact assessment process, impact events, and the characteristics of rural areas that affect the magnitude and distribution of impacts and the assessment of impacts in each area.
3. Provides a detailed review of those methodologies actually used in impact assessment for each area, describes advantages and problems encountered in the use of each method, and identifies the frequency of use and the general level of acceptance of each technique.
4. Summarizes the implications of each area of projection for the repository siting process, the applicability of the methods for each area to the special and standard features of repositories, and makes general recommendations concerning specific methods and procedures that should be incorporated in assessments for siting areas.

PREFACE

The siting of nuclear repositories will have significant impacts on the areas in which they are located. These impacts will be particularly pronounced in relation to the socioeconomic conditions of the site areas. These impacts will result both from the fact that they will be relatively large-scale developments employing 1000 or more persons during their construction and operation and will likely be located in rural areas with relatively sparse population bases, and from the fact that such repositories are nuclear facilities subject to the effects that result from public perception of nuclear power and nuclear waste. Impacts that result from the placement of large-scale facilities in rural areas are commonly referred to as standard impacts, while impacts relating to the nuclear characteristics of such projects are referred to as "special" effects.

Although both types of impacts must receive extensive analysis prior to the siting of a facility, standard socioeconomic impacts must receive immediate attention. This emphasis is necessary because of the requirements of the National Environmental Policy Act and because the standard impacts are those that will likely have the most imminent effects on siting areas. The assessment of such effects as they relate to economic, demographic, public service, fiscal and social factors must thus be given concerted attention. Unfortunately, although much attention has been given to the description of such impacts for other large-scale developments (Murdock and Leistritz, 1979), and methods for assessing such impacts are receiving increased attention (Denver Research Institute, 1979), no comprehensive review of available methodologies has been made to assess their utility for nuclear waste repository siting.

The purpose of this effort is thus to provide a comprehensive review of prevailing socioeconomic assessment methods and their implications for assessing the impacts of nuclear repositories. This need is addressed by describing the general features of existing methodologies as they have been used in assessing the impacts of large-scale developments in general and discussing the implications of these methods for the siting process. Such an evaluation, given the similarity of repositories to other large-scale developments in rural areas and the likely siting of repositories in rural areas, is clearly an essential starting point for the socioeconomic analysis of repository siting. Specifically, this effort attempts to:

1. Describe the conceptual and methodological models and modeling alternatives available for assessing the major impacts of large-scale resource developments in relation to:
   - economic impacts
   - demographic impacts
   - public service impacts
   - fiscal impacts
   - social impacts
   - interrelations between economic, demographic, public service, fiscal, and social impacts.
2. Delineate the characteristics of the impact process that affect each of the major types of impacts and the policy considerations and informational needs related to each type of impact.
3. Present the state of the art of impact assessment related to the projection of each of the types of impacts and their integration.
4. Describe the implications and applications of such methods to repository siting.

A consideration of these dimensions forms a basic section in each of the chapters of the work. Thus each of the major substantive chapters dealing with the concepts and methods for projecting the economic, demographic, public service, fiscal, and social impacts of resource developments and the chapter on the integration of these dimensions contains a section on the conceptual basis for and alternative forms of methodological techniques available for use in impact projections as well as an assessment of the relative strengths, weaknesses, and data needs of each method; a section on the factors affecting the nature, magnitude and distribution of such impacts, and the pragmatic informational needs of policy makers in relation to such impacts; a section dealing with the methodological techniques most commonly employed in actual impact projections and the nature of these applications; and a section describing the implications of existing methods and procedures for the repository siting process. In addition, the work presents a separate chapter describing the form of methodologies used in each of several alternative computerized forms of such models which have become of increasing importance in impact projections, and a chapter on the use of assessments in the policy process.

The work is intended to provide an overview of those methods commonly used in the assessment of the socioeconomic impacts of large-scale developments that are likely to be of utility for assessing the socioeconomic impacts of nuclear repositories. It provides a review from which the selection of the most viable methodologies for assessing the impacts of repository siting can be made.

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CHAPTER 1

DIMENSIONS OF IMPACT ASSESSMENT

INTRODUCTION

Any attempt to assess the socioeconomic impacts of resource developments will involve an examination of an extremely broad range of theoretical and methodological considerations that cannot be adequately addressed in a single effort. It is essential then to begin the discussion by clarifying: (1) the rationale behind the work's focus, (2) the specific focus and limitations placed on the effort, (3) the range of conditions and factors likely to significantly alter key impact dimensions, and (4) the basic organization followed in the remainder of the text.

RATIONALE FOR AN EVALUATION OF SOCIOECONOMIC IMPACT ASSESSMENT TECHNIQUES

Preliminary identification of alternative sites for nuclear waste repositories (U.S. Department of Energy, 1980b) indicates that many of these sites may be located in rural areas of the nation. The construction, operation, and maintenance of such facilities will lead to significant socioeconomic impacts for these rural areas. Such facilities may involve from 1400 to 1800 workers during their construction and roughly 900 to 1200 workers during operation (U.S. Department of Energy, 1980a) and are likely to require monitoring for an indefinite period. Although actual sites have not been selected, many of the most geologically acceptable prototype sites (U.S. Department of Energy, 1980b), particularly in the West and Southwest, are in relatively sparsely settled, rural areas with unique social and cultural conditions. For such prototype sites as those in Anderson, Freestone, and Leon Counties in Texas with 1975 populations of 31,244, 11,924 and 8,777, respectively (U.S. Bureau of the Census, 1977); Bienville Parish, Louisiana (1975 population, 16,478); Perry County, Mississippi (1975 population, 9,830); and San Juan County, Utah (1975 population, 11,964), the relative magnitude of the impacts of such a development would be significant. The siting, construction, and operation of nuclear waste repositories may thus involve many factors and are likely to have many impacts that are similar to those for other large development projects that are occurring with increasing frequency in rural areas.

Thus, recent trends toward industrial decentralization have led an increasing number of firms to locate new facilities in rural areas (Summers et al, 1976). Similarly, changes in the nation's energy supply patterns point toward the increasing development of large-scale energy resource extraction and conversion projects in sparsely populated rural areas, particularly in the Western United States (Federal Energy Administration, 1976). These developments present both a promise and a threat to the communities nearby. While new industrial and resource development projects offer the benefits of new jobs and provide a stimulus to the local economy, they also pose the problem of rapid population growth which few rural communities are prepared to handle (Gilmore and Duff, 1975).

The socioeconomic changes occurring during the construction and subsequent operation of large electric generating plants exemplify the paradoxical effects of many types of industrial facilities on rural areas. Such efforts often lead to long-desired increases in local employment and to general economic growth in the area. On the other hand, the total magnitude of economic growth associated with such projects, the rapidity of the fluctuations of such patterns during the lifetime of the project, the public service demands created by growth, and the uncertainty of the timing and specific location of many of the impacts create severe planning problems for local areas.

In sparsely populated rural areas, the construction of electric power plants has sometimes led to a doubling or trebling of population in nearby communities in only a few years with rapid growth beginning as early as the first year of construction. This growth has often fluctuated widely during the development period with rapid growth occurring during the construction phase followed by relative stability during the facility's operation and by rapid population decline during the postoperation phase. Similar patterns of growth have often been associated with the construction of large military installations and reservoirs.

Because public service needs fluctuate with population, local areas often have been faced with the difficult decision of deciding whether to build facilities to meet the anticipated requirements during a project's construction phase and then face the possibility of having substantial excess capacity during the operational phase or to simply attempt to make do during the construction phase and to build to meet the long-term needs resulting from the project. Added to such difficulties is the fact that local officials often must plan with the realization that the demands for new services resulting from a new project are likely to precede the revenues from it (Gilmore et al, 1976; Murdock and Leistritz, 1979) and with the realization that changes in the project's construction schedule or in the settlement patterns of new workers can often negate the expected impacts they might receive (Murdock et al, 1978). Lack of accurate and timely impact projections and effective growth management plans may lead to serious problems for developers as well as for the affected area with unmanaged, boom-type growth leading to costly delays for major projects (Gilmore and Duff, 1975). Given such a decision-making environment, the need for timely projections of the magnitude and location of economic, demographic, fiscal, and other likely impacts of new development projects, and thus the importance of the impact assessment process that produces such information, is apparent.

Socioeconomic impact assessments are also being conducted to meet an increasing number of legislative demands. Federal agencies involved in major development projects are required, by the provisions of the National Environmental Policy Act of 1969 (NEPA), to prepare environmental impact statements in order to ensure that their actions are planned with a full understanding of the consequences (Council on Environmental Quality, 1973). When the impacts of a project are potentially large, a number of other federal agencies with service or resource management responsibilities in the area also may require data from the impact assessments in order to plan their programs.

States have also taken an increasing interest in the impact assessment process, and a number have established environmental and/or facility siting legislation which imposes impact assessment requirements similar to those of NEPA (Murdock and Leistritz, 1979; Auger and Zeller, 1979). Some states have imposed impact assessment, monitoring, and mitigation requirements which go beyond those of NEPA. In addition, many states utilize information from impact assessments not only to assure the viability of affected communities but also to plan their own public service programs.

Private development firms have also had an increasing number of reasons to be vitally concerned with legislation related to the impact assessment process. First, impact assessments are required as a prerequisite for obtaining necessary permits, and inadequacies of impact assessments have led to substantial delays of major projects. Second, development firms are becoming more keenly aware of the need for accurate and timely impact assessments and effective growth management programs as unmanaged boom-type growth can lead to socioeconomic problems which adversely affect worker productivity and project costs (Gilmore and Duff, 1975). Further, in some cases developers may be required to plan for and accept financial responsibility for the mitigation of adverse impacts as a condition for development (Watson, 1977).

Thus for affected areas federal, state, and local governments and the public (such as local officials and their constituents) leaders of community organizations and private entrepreneurs all require information regarding the economic and social changes that will accompany development in order to formulate appropriate responses and to meet legal requirements. The utility and necessity of obtaining such information is apparent.

The legislative requirements and the planning necessity for information on resource development impacts, however, often place heavy demands on the social science analyst who must perform such assessments, on policy and decision makers whose agencies are responsible for the completion of such assessments, and on decision makers who must plan facilities on the basis of these assessments. For each a major task is one of obtaining the expertise necessary to complete and evaluate such assessments.

For the social science analyst the difficulty arises from the fact that impact assessments require an interdisciplinary approach. Economic impacts must be systematically linked with demographic impacts and demographic impacts with fiscal, service, social, and other impacts. Although an individual may have received adequate training in one such area of analysis, he or she will seldom have been cross-trained in all of them. In addition, adequate knowledge of the impact process and impact assessment practices and sensitivity to the informational needs of the policy makers to whom assessments are addressed must be acquired. Academic training seldom provides adequate preparation, and a considerable period of intensive learning is often required before the assessment process can be initiated.

The decision maker is faced with a similar difficulty. If he is responsible for either the production of an assessment or its review or if he must use it in facility planning, he must either obtain the necessary personnel to evaluate the quality of the assessment or increase his own level of expertise to make the evaluation. The use of other personnel to make the evaluation cannot alter the ultimate responsibility that lies with the decision maker, while attempts to increase his own expertise require becoming familiar with such a wide body of scattered literature from so many different disciplines that few decision makers can afford the time and cost expenditures involved.

for the decision maker, as well as the researcher, a long period of training may be necessary.

In addition, the rapidity of the development of the area of impact assessment has often further accentuated the learning problems involved. Demands for timely impact information have led increasingly to the development of computerized socioeconomic impact assessment models (Cluett et al, 1977; Ford, 1976; Hertsgaard et al, 1978; Mountain West Research, Inc., 1978; Monarchi and Taylor, 1977; Reeve et al, 1976; and Stenehjem, 1978). These models all provide a relatively wide range of outputs and do so in a flexible and timely manner. The models, however, differ widely in data input requirements, computational procedures, outputs, and in many other respects. Given the wide diversity of such models and their utility in producing timely and flexible information bases, a careful and systematic comparison of the conceptual and methodological basis of such models is essential, but the information and knowledge bases necessary to make such evaluations are even more extensive than for other assessment methodologies.

Unless a sufficient knowledge base can be obtained, research analysts and decision makers cannot address many of the questions that should be addressed before the assessment process begins, including such questions as:

1. What economic, demographic, public service, fiscal, and social analysis techniques are available for use in impact projections and which are likely to be of greatest utility under a given set of circumstances?
2. What are the factors likely to affect the magnitude, form, and distribution of economic, demographic, public service, fiscal, and social impacts?
3. What are the most frequent informational needs of decision makers in impacted areas?
4. What are the most frequently used assessment methodologies for rural and urban areas?
5. Which of the computerized impact projection methodologies might best meet the decision makers' needs and what are the costs and problems involved with the adaptation of such a model?

In sum, the knowledge base necessary to perform socioeconomic impact assessments and to initiate, monitor, and utilize them is extensive and increasing rapidly. There is a clear need to consolidate our information concerning the assessment process and to expedite the process of obtaining such knowledge by developing a single work which brings together:

1. A discussion of the methodological alternatives for assessing major types of impacts and the conceptual bases, relative strengths and weaknesses, and data base and resource requirements of each alternative.
2. A consideration of factors in the impact process which are likely to affect the nature of each type of socioeconomic impact and the policy and informational needs related to those impacts.
3. A description of the present state of the art of impact assessment and the most frequent forms and types of applications of various methodologies.
4. A consideration of the characteristics and features of the various computerized impact projection models.
5. A discussion of the implications and applications of prevailing methodologies for nuclear repository siting.

This report is an attempt to provide such a work and thus to address the informational needs of decision makers and research analysts who shall be involved in the siting process. It provides a comprehensive introduction to the actual process of socioeconomic impact assessment.

FOCUS OF THE EFFORT

As with any single effort the work must be and is limited in several ways. It examines the assessment of the socioeconomic impacts of resource developments in rural areas and only some of the conceptual, methodological, and policy considerations of computerized and noncomputerized forms of assessment models and techniques. The implications of these limitations for the effort are described below.

Projection of Socioeconomic Impacts

Although a large number of types of impacts are likely to result from resource developments, this work focuses on those related to socioeconomic dimensions and within the socioeconomic realm to those techniques used in the projection of economic, demographic, public service, fiscal, and social dimensions. The discussion also deals specifically with the projection of impacts, events that would not occur were it not for the development being undertaken in the area. Such projections thus inevitably involve projections of two sets of conditions, baseline conditions without the project and impact conditions with the project. Thus both baseline and impact projection techniques for assessing socioeconomic impacts are discussed for each type of impact.

Resource Development in Rural Areas

The term resource development is used very broadly in the analyses and discussion to include the development of any previously undeveloped resource of an area. Although emphasis is given to natural resource developments such as water and energy developments, developments involving new uses of human resources, such as the labor supplies of rural areas for industrial developments, are also considered. Resources then refer to both physical and human resources.

Emphasis is also placed on such developments occurring in rural areas. This reflects the fact that an increasing number of resource developments, including repositories, will be located in rural areas. While assessment principles are similar for urban and rural areas, some differences in techniques are evident. Although references will be made to differences for various types of areas, emphasis will be placed on assessment techniques for rural areas.

Theoretical, Methodological, and Policy Considerations

The emphasis in regard to these key dimensions must clearly be limited because theoretical, methodological, and policy considerations include a very broad range of materials. The theoretical considerations of interest here are limited to the various conceptual approaches that are the bases of methodologies presently in use in impact assessments. The term theoretical is thus used in a very broad sense and refers in many cases to concepts rather than fully developed theoretical bases.

The methodological considerations are restricted to a general discussion of the computational procedures involved in various assessment methodologies, the relative strengths and weaknesses of each methodology, and the data needs and resource costs associated with the use of each methodology. This section of the discussion is more detailed than other parts of the work.

The policy considerations emphasized in the work are the data and projection needs of policy and decision makers rather than the political considerations related to such factors as the need for impact assessments and modes of public participation. The policy focus is on how impact assessments can be made to more directly serve the informational needs of different types of policy and decision makers and what types of projections are of greatest utility for policy makers. The purpose of this part of the discussion is to sensitize the reader to the policy needs related to impact assessments.

Computerized and Noncomputerized Models

Although nearly all of the methodological procedures included in the work involve computer analysis in some form, it was deemed essential to provide a separate discussion of the integrated computerized impact projection models commonly referred to as economic-demographic projection models. The increasing prevalence of these models as well as their widespread utility is likely to result in an increasing role for such models in the assessment process while their complexity is such that they provide unique problems of evaluation. Therefore, a separate chapter is devoted to their comparison and evaluation.

Given the large number of such models, however, not all could be considered in the comparison. Rather attention was restricted to those that consider multiple socioeconomic dimensions, that provide projections at the county or subcounty level, and that provide available sources of documentation sufficient to allow for a systematic comparison. All models are compared on three major dimensions: (1) informational characteristics, including data requirements and specificity of outputs, (2) methodological characteristics, and (3) use characteristics, including flexibility of use, adaptability, and transferability.

The specific models chosen for comparison, their sponsoring organizations and a reference to their model publications are shown below:

1. ATOM 3 Model--State of Arizona (Beckhelm et al, 1975)
2. BOOM 1 Model--Los Alamos National Laboratory (Ford, 1976)
3. BREAM Model--U.S. Bureau of Reclamation (Mountain West Research, Inc., 1978)

4. CLIPS Model--University of Texas (Monts and Bareiss, 1979)
5. CPEIO Model--University of Colorado (Monarchi and Taylor, 1977)
6. HARC Model--Battelle Human Affairs Research Center (Cluett et al, 1977)
7. MULTIREGION Model--Oak Ridge National Laboratory (Olsen et al, 1977)
8. NAVAHO Model--Utah State Planning Coordinator and the Navaho Nation (Reeve et al, 1976)
9. NEW MEXICO Model--University of New Mexico (Brown and Zink, 1977)
10. RED Model--North Dakota Regional Environmental Assessment Program (Hertsgaard et al, 1978; Toman et al, 1979; Leistritz et al, 1979a)
11. SEAM Model--Argonne National Laboratory (Stenehjem et al, 1978)
12. SIMPACT Model--Arthur D. Little, Inc. (Huston, 1979)
13. WEST Model--Denver Research Institute (Denver Research Institute, 1979).

FACTORS AFFECTING SOCIOECONOMIC IMPACTS AND IMPACT ASSESSMENTS

Although each of the major substantive chapters of this work will discuss some of the dimensions affecting its particular type of impacts, it is essential to obtain a broad overview of the total range of socioeconomic dimensions that are likely to affect an impacted area and the interrelationships of these dimensions. The intent of this section then is to provide the reader with a better understanding of the total context of resource development impacts and the factors that must be considered in the impact assessment process.

The list of factors likely to affect impacted areas is extremely complex, and a comprehensive discussion of these is beyond the scope of the present effort (however, see Murdock and Leistritz, 1979). Among the most significant of these dimensions are the factors shown in Table 1.1: (1) characteristics of resource development projects and (2) characteristics of areas where development projects are sited. These categories include factors which are instrumental in determining the nature and extent of a project's socioeconomic effects. Six categories of project effects also are included: (1) characteristics of project work forces, (2) effects of new development projects on the local trade and service sectors and on other basic industries such as agriculture, (3) effects on population growth and the location and characteristics of new populations, (4) effects on public services and community infrastructures,

Table 1.1. Key Economic and Social Impact Dimensions

Item	Key Components	Relationships to Other Impact Dimensions
Causal Forces:		
Project Characteristics	Work force--magnitude, skill level requirements Linkages to other sectors Investment Resource requirements	Strong relationship to all impact dimensions. Relationships to work force characteristics, secondary economic effects, and fiscal effects are especially important.
Site Area Characteristics	Population--size, composition, skill levels Economic structure Public service infrastructure Tax system Unemployment and underemployment Social organization and structure	Strong relationships to all impact dimensions.
Project Effects:		
Work Force Characteristics	Local hire rate Worker demographic characteristics Origins of inmigrants Worker productivity	The major determinant of characteristics of new population. Also influences secondary economic effects and public services.
Characteristics of New Populations	Total population change Population composition Location of population growth	The major determinant of effects on public services and infrastructure. Closely related to secondary economic effects, fiscal effects, and social effects.
Secondary Economic Effects	Indirect and induced employment and income effects Effect of linked industries Effects on local trade and service firms Effects on wage rates and unemployment	Closely related to population effects. Also related to public service, fiscal, and social effects.
Effects on Public Services and Community Infrastructures	Housing Public utilities Quasi-public services (e.g., medical care) Effects on service structures	A major determinant of fiscal effects. Also related to social effects and work force characteristics.
Fiscal Effects	Public sector revenues Public sector costs Timing and jurisdictional distribution of costs and revenues	Related to public service and social effects. Project and site area characteristics strongly influence fiscal effects.
Effects on Social Organization, Values, Attitudes, and Perceptions	Social organization Attitudes Perceptions Values	Related to some degree to all impact dimensions.

(5) effects on public sector costs and revenues, and (6) effects on social organizations, values, attitudes, and perceptions. Although a realistic assessment of the economic, demographic, and social changes likely to occur in impact situations requires a detailed understanding of the interrelationships among the various dimensions, our intent here is only to provide the reader with an initial understanding of the importance of these dimensions and particularly of the importance of their many possible forms of interaction.

Within the two major categories of exogenous or causal forces, a number of key dimensions are particularly important. Among the project characteristics, for example, some key components are work force requirements, linkages of the new development to other local industries, the magnitude and scheduling of the investment in project facilities, and the requirements for various natural resources such as land and water (see Table 1.1). Work force requirements (such as the number of workers needed, the skills which they must possess and the scheduling of labor requirements through the construction and operation phases of the project) are especially important in determining the nature and magnitude of socioeconomic changes associated with the project.

Characteristics of the site area which are particularly important in socioeconomic impact assessment include its population characteristics, economic structure, public service infrastructure, and tax system. Population characteristics which are especially important in impact analysis include not only population size but also age-sex composition, skill levels, and existing levels of underemployment and unemployment.

The six impact categories also include a number of key dimensions. Project work force characteristics are pivotal in determining the nature of impacts associated with a major project. Key dimensions of work force characteristics include the proportion of the workers who are hired locally (that is, those that are established residents of the site area), the origins of the in-migrating workers, the demographic characteristics of workers and their dependents (especially the in-migrants), and worker productivity. Work force characteristics are closely linked to the characteristics of new (that is, in-migrating) populations. Population characteristics of special importance resulting from the project are the magnitude of population change, the rate of that change, the age-sex composition of the new population, and the location of population change within the study area.

Secondary economic effects are likewise important and include indirect and induced employment and income effects, effects on local businesses, changes in local wage rates and unemployment, and linked industry effects. Indirect and induced employment and income effects refer to changes in these economic indicators which result from the project's injection of added purchasing power into the local economy. Expenditures by project workers together with local purchases of supplies and materials set in motion a cycle of spending and respending which is often termed the multiplier process. The result is an increase in sales of local trade and service firms which requires them to hire additional workers and leads to increased incomes for both workers and other resource owners. Linked industry effects refer to the direct stimulus which a project may provide to those industries which supply it with specialized inputs or utilize its outputs.

A new development project may lead to substantial changes in local public services and facilities (infrastructure). Important dimensions of public service impacts include changes in requirements for housing (both number and types of units), for public utilities such as sewer and water, for public services such as education and fire and police protection, and for quasi-public services such as medical care. In addition, the changes in levels and types of public service needs which accompany development often lead to changes in the organization of service delivery systems.

The changes in public service and facility requirements associated with development of a new project typically are reflected in changes in costs incurred by local governments. These changes in public sector costs together with the changes in revenues of local jurisdictions resulting from the new project and associated economic growth constitute the fiscal effects of the project. Key dimensions of these fiscal effects include not only the magnitude of changes in costs and revenues but also their distribution through time and among jurisdictions.

Finally, a major development may lead to a variety of changes in the social structures of the site area. In particular, such developments are likely to alter the way in which persons in rural areas interact with and relate to one another, to change existing organizations and institutions, to change leadership and other status arrangements in rural communities, to decrease the levels of social control and quality of life, and to create possible problems of conflict between new residents and longtime residents in impact areas. Each of these impacts is likely to alter the way of life of the affected communities.

It is, of course, not only the complexity of the individual impact dimensions but also their interrelationships which make impact assessment particularly challenging. Economic impacts, demographic effects, changes in public services, and fiscal impacts are obviously interrelated. In the sections which follow, the more important forms of these interactions are examined.

Project Characteristics

The first two dimensions listed in Table 1.1, project characteristics and site area characteristics, have a pervasive influence on all other impact dimensions. Thus, the characteristics of the resource development project (including population, skill levels, economic structure, public service infrastructure, natural resources, and tax systems) interact to influence virtually all impact dimensions and all phases of the impact process. Project characteristics are particularly important in influencing work force characteristics. Resource development projects differ in their total work force requirements, in the timing of those requirements (particularly the relative magnitude of construction and operational work forces), and in the mix of skill levels required. Skill requirements, in turn, influence a project's ability to utilize local labor and also are instrumental in determining the wage and salary levels of the project workers. The nature of the technology used in the project coupled with the project's construction schedule will determine the size of the peak work force which in turn is a key factor in determining the nature and magnitude of population, public service and fiscal effects.

The project's resource requirements and linkages with other economic sectors are key determinants of secondary economic effects. Development projects differ substantially in their economic linkages both forward (to processors of products and by-products) and backward (to suppliers of inputs). The resource requirements of a given technology such as the use of water and land are primary determinants of effects on other basic sectors such as agriculture. The level of investment in project facilities may be a major factor in determining the local public sector revenues generated by the project. In addition, project characteristics may have other, more subtle, effects. For instance, atmospheric emission from coal conversion plants may change mortality and morbidity patterns of local populations. The aesthetic aspects of the facility, together with the impacts on the physical environment, may affect local residents' perceptions of the project and may alter their basic orientation toward land use. That is, the existing patterns of agricultural dominance and basic agrarian viewpoints may be altered by the emergence of a new major basic industry.

Site Area Characteristics

Characteristics of the site area likewise have an influence that is pervasive across all impact dimensions (see Table 1.1). An area's natural resource base is a major determinant of the feasibility of locating various types of facilities there. Present patterns of resource utilization and ownership in the site area may affect the potential for use of these resources by development firms. For example, lands set aside as National Parks or wilderness areas typically are not available for major development projects.

Site area characteristics may have major effects on a project's work force. The size of the local population, residents' skill levels, and the extent of underemployment and unemployment may determine the proportion of employment needs which can be met by local recruitment. Site area characteristics, including amenities and climate, may influence worker productivity. Gilmore and Duff (1975) indicate that shortages of key services and facilities were major factors leading to declines in construction worker productivity in Sweetwater County, Wyoming. Although the generality of this relationship is challenged by Schulte (1977), it appears that climate does affect worker productivity because certain types of construction activities are severely constrained during the winter months in many northern areas while in areas with more mild climates construction activities can proceed virtually year-round, and peak work force requirements may be smaller.

Site area characteristics may influence the population effects of a new project in several ways. First, as noted previously, they may have a substantial influence on the number of project workers hired locally and, conversely, on the number who will be in-migrants. Second, site area characteristics will have a substantial influence on the residential patterns of in-migrating workers and their families. The number of communities within commuting distance of the project site, the quality of the local transportation networks, and the availability of housing and public and private services in the impact area communities all may influence worker settlement patterns. Finally, the availability of housing and services, together with the degree of

[pop]ulation of the site area, may influence the proportion of the in-migrating [co]nstruction workers who bring their families to the site area.

Site area characteristics also may have a substantial influence on the [s]econdary economic effects of a given project. The area's economic structure [w]ill affect the developing firm's ability to purchase supplies and materials locally and may influence the propensity of project workers to purchase goods and services locally. In addition, present residents' skill levels will affect the availability of workers for certain types of enterprises and thus may enhance or reduce the likelihood that various types of linked industry may develop in the area.

Public service and infrastructure effects of new projects may be substantially influenced by site area characteristics. Any excess capacity present in an area's public infrastructure will affect its ability to absorb new populations and the cost of meeting growing demands for services. The cost of expanding services such as water and sewer may be substantially influenced by the site area's topography and geology. Existing land ownership patterns and topography may influence the availability of land for new housing development. Some impacted communities are surrounded by land owned by the federal government, and this land may not be readily available for development of housing and community facilities.

Fiscal impacts of new resource development projects are influenced quite substantially by site area characteristics. Differences in state and local tax structures can greatly affect the magnitude and timing of revenues derived from a new project and the accompanying population growth and secondary economic activity (Leistritz et al, 1979b; Stinson and Voelker, 1978). In addition, the arrangement of jurisdictional boundaries in relation to the project site and location of workers' residences can in some cases lead to substantial mismatches of project-related revenues and costs.

Finally, areas may differ considerably in the residents' values, attitudes, and preferences toward development, social change, and conservation. The basic characteristics of baseline social groups, of social organizations, and of social structures will determine many of the social effects of a new project. For example, if an area has a substantial number of elderly persons or other persons on fixed incomes in its baseline population, one can expect the baseline population to receive lower levels of benefits from development than if other population characteristics are evident (Albrecht, 1978).

Work Force Characteristics

Project work force characteristics are one of the key dimensions of economic and social impacts and have a substantial influence on other impact dimensions. Some of the major characteristics of interest are the proportion of the workers who are in-migrants to the area, the number and demographic characteristics of their dependents, their wage and salary levels, and their locational origins.

Project work force characteristics have a strong influence on the population effects of a new development. The proportion of the project work force who are in-migrants, together with the demographic characteristics of these migrants, is a major determinant of the population increase associated with a new project (Murdock et al, 1980a). In addition, increased employment opportunities resulting from a new project may lead to increased labor force participation by women and to other indirect population changes such as lower fertility levels. Increased employment opportunities likewise may lead to substantially reduced levels of out-migration from the site area.

Work force characteristics also may be an important determinant of the secondary economic effects of a new project. The propensity of project workers to purchase goods and services locally rather than in distant trade and service centers, together with the wage and salary levels of the project workers, is a major determinant of the indirect and induced employment and income effects of a new industrial project (Tweeten and Brinkman, 1976). In addition, the extent of local hiring by the project may have a major effect on the supply of labor available to local trade and service firms. In some cases, local firms have had difficulty in competing with the high wage levels offered by a new industry.

Work force characteristics also can have an important influence on public service and infrastructure impact dimensions. Local hiring by the firm will affect the labor supply available to local public entities and to firms engaged in construction of housing and public facilities (Gilmore, 1976; Cortese and Jones, 1977). In addition, the demographic characteristics of in-migrating project workers will affect the type of housing they desire (Leholm et al, 1976; Wieland et al, 1977), and workers' salary levels will influence their ability to pay for different forms of housing.

Work force characteristics will also have a bearing on the social effects of a new project. Origins of in-migrating workers may affect the social acceptance and levels of integration of workers' families into the community. Thus, social acceptance and integration may be less difficult to the extent that in-migrants have a regional cultural background similar to that of present area residents. The employment opportunities resulting from a new project may have several effects on local youth. While the new employment opportunities associated with development may lead to the retention of more young adults in impact areas, they also may discourage local youths from acquiring higher levels of education. Further, the higher incidence of wage labor associated with development may increase the formalization of work roles and work-related status differences.

Characteristics of New Populations

Closely related to the characteristics of the new workers are the characteristics of the new populations associated with the development. The size, composition, and settlement patterns of these populations have substantial implications for public service requirements and can be expected to be a major determinant of the social and fiscal effects of a project (Murdock and Leistritz, 1979). Gilmore et al (1975) have provided some general guidelines regarding the relationship between population growth rates and community adjustment problems. These authors indicate that growth rates of more than 10 percent annually are hard to accommodate, and rates of 15 to 20 percent have led to severe difficulties in unmanaged rural growth situations. Others have shown that the availability of planning information and external financial assistance may substantially ease the community adjustment problems associated with a given rate of population growth (Coon et al, 1976; Murdock et al, 1980a).

Population growth associated with a new project, together with the location of that growth, is the key determinant of additional public service and infrastructure requirements. Substantial population growth in a rural community is likely to result not only in increased demands on public services but also in increasing formalization of service structures. The composition of new populations can be expected to affect the mix of service needs experienced. In addition, the composition of these populations (particularly the number of secondary workers in in-migrating households) will affect the labor supply available to local trade and service firms and public service entities. Likewise, the composition of new populations may affect the propensity to spend locally, with single workers and geographical bachelors expected to have smaller local expenditures. The residential location of in-migrating populations will in large measure determine the location of secondary economic impacts.

Socioeconomic characteristics of new populations will affect their perceptions of site area communities and the long-term residents' perceptions of them. Further, the socioeconomic characteristics of new residents may affect their levels of participation in community activities and organizations. Problems of integration of new residents into the community are likely to increase with the magnitude and rate of population growth. In addition, rapid population growth often is associated with substantial increase in rates of crime, juvenile delinquency, and other manifestations of deviant behavior (Gilmore and Duff, 1975; Cortese and Jones, 1977).

Secondary Economic Effects

Another important category of project impacts is its secondary economic effects. The project's purchases of supplies and materials from local firms together with expenditures by project workers typically result in increased business activity and employment in the local trade and service sectors. A major project also may lead to the development of linked industries in the area. These industries may be either backward-linked (i.e., supplying inputs to the project) or forward-linked (i.e., processing products or by-products). The project may have other, less beneficial, effects on local firms. As noted earlier, a major project may lead to substantial increases in local wage rates, and other local employers may have difficulty in recruiting and retaining competent workers. A project also may directly affect other basic industries such as agriculture through competition for such resources as water and land.

Secondary economic effects of a new project may have substantial interactions with several other impact dimensions. Growing indirect and induced employment associated with the project is likely to lead to some in-migration of indirect workers and their dependents. On the other hand, increased job opportunities in local trade and service firms, together with rising wage and salary levels, may lead to increased rates of labor force participation for area residents, particularly for women. Because many rural areas are characterized by relatively low rates of female labor force participation, the potential for increases in local labor supplies from this source appears to be substantial.

The growing demand for labor may alter local patterns of underemployment, unemployment, and income distribution. In addition, the socioeconomic characteristics of in-migrating indirect workers can be expected to affect a variety of impact dimensions.

The growing demand for labor associated with the direct and indirect employment effects of a project may lead to substantial increases in local wage rates and interindustry competition for labor. Changes in the local labor market may have a major impact on the expansion of public services and facilities. All public service entities may be affected by rising wage rates and increased competition for labor (Cortese and Jones, 1977), while additional population growth associated with secondary economic activity will further strain the existing service base.

Secondary economic effects also have a number of social implications. Increased incomes may increase residents' exposure to information on outside areas and their levels of interaction with residents from areas outside the local community, while increased income differentials in an impacted community may lead to increased awareness of social class differences.

Effects of Public Services and Community Infrastructure

Public service and infrastructure effects can be expected to have significant interactions with a number of other impact dimensions. The existing service base of an area may affect its attractiveness as a site for a new project. When several alternative sites are similar in other aspects, those with better developed public services likely will be favored as sites for industrial facilities (Tweeten and Brinkman, 1976). Once construction of a new facility begins, lack of satisfactory housing and services may influence worker productivity and turnover rates. In addition, if an area lacks the necessary services that workers and their families desire, firms may be forced to pay higher wages to compensate for these deficiencies (Mehr and Cummings, 1977). When an area lacks satisfactory housing and public services, some workers may choose not to bring their families with them.

The adequacy of public services and facilities to meet the needs of a growing population also may influence local business investment decisions. If public services are inadequate to meet basic needs and residents feel the local quality of life has been degraded, business may regard the area as unfavorable for new investment (Gilmore, 1976). Uncertainty regarding future economic trends in the area may further discourage expansion of local trade and service firms.

As noted earlier, initial strains on particular types of services may cause shifts to alternative service forms and thus lead to extensive strains on those services. For example, shortages of doctors in Sweetwater County, Wyoming, led many residents to turn to the hospital emergency room as an alternative source of medical care (Gilmore and Duff, 1975). Similarly, an initial shortage of permanent housing may cause substantial increases in mobile home parks. Costs of public services can be expected to affect the cost of new housing units as local governments impose tap fees or other forms of user charges to recover the cost of service expansion. Conversely, the pattern of new housing development can have substantial effects on the costs of providing services. For example, dispersed patterns of housing development may lead to higher costs for school busing, fire protection, and sewer and water services.

If rapid community growth leads to a decrease in the quality and range of services available to the residents, their perceptions of the local quality of life are likely to be lowered (Murdock and Schriner, 1979). Conflicts may arise between new and longtime residents regarding adequacy of present service structures, and poor quality housing and other services may lead to increased strains on family relationships (Murdock et al, 1980b).

Fiscal Effects

Fiscal effects of a new project have substantial interactions with other impact dimensions. The tax structure of an area may influence its attractiveness as a site for a new project. Once a project is under construction, however, local governments may find it necessary to raise tax rates in order to meet growing needs for governmental services. Higher taxes coupled with rising costs of living in the impacted area might then influence some longtime residents to leave the area. High tax rates arising from fiscal deficits during the early years of a project would affect local service firms as well as those in the basic sectors. Agricultural producers may be particularly susceptible to these effects, as their ratio of taxable property to income typically is quite high. Because impacted communities often are constrained in their ability to borrow--by bonding capacity limitations and because additional revenues from a new project often lag behind additional costs--local governments often experience severe cash flow problems during the early years of project construction. These revenue shortfalls may seriously hinder local entities in their efforts to meet growing service needs.

Fiscal problems of impacted communities may become a substantial source of local conflicts. Decisions regarding bond issues and increases in tax rates may lead to conflicts between in-migrants and longtime residents.

Effects on Social Organization, Values, Attitudes, and Perceptions

The social effects of a project also have pervasive interactions with other impact dimensions. Before a project is even initiated, pressure from local groups with negative perceptions of development may lead developers to institute technological modifications (such as additions of scrubbers, precipitators, and other environmental safeguards) to reduce the potential environmental damage from a project. In addition, residents of potential site areas may differ in their opposition or receptiveness to a new project, and these attitudes may influence site selection (Albrecht, 1978).

Residents' attitudes also may influence the employment and population effects of a new project. Aspirations and career patterns of indigenous populations may affect their desire to seek employment. Likewise, increased levels of social disorganization associated with a project lead to increased levels of worker turnover rates among the project workers (Gilmore and Duff, 1975). Residents' perceptions of the desirability of growth may affect their receptiveness to new populations while the preference patterns of nonlocal workers and factors such as the presence of family in the impact area may affect the settlement choices of in-migrants (Weiland et al, 1979). Public views toward growth may influence local attempts to capitalize on new business opportunities associated with development. Family structure and values of local residents may affect the propensity for women and other residents to seek opportunities associated with development (Albrecht, 1978).

The attitudes and preferences of local residents and in-migrants may have substantial effects on public services (Murdock and Schriner, 1979). If in-migrants are characterized by preferences for higher levels of public services than are longtime residents, substantial increases in the overall level of service demands may be experienced. Further, organized action by groups of area residents have sometimes led developers to assist in financing housing and services. Attitudes of fiscal conservatism on the part of longtime residents may hinder the passage of new bond issues, and their perceptions of acceptable tax levels may limit the ability of local governments to raise tax rates.

Finally, the site area's original social structure may have substantial influence on subsequent social effects (Murdock and Schriner, 1978; Murdock, 1979). Thus the initial patterns of dominance and power concentrated in specific groups may affect levels of receptiveness to new groups, and the levels of conflict between new and longtime residents may be affected by interrelationships in baseline social structures. In addition, initial hostile relationships are likely to lead to further increases in conflict and thus further deteriorate new and longtime resident relationships. The actual incidence of such effects, however, requires considerable additional research emphasis.

In summary, these are some of the major factors and their interrelationships that are of obvious importance in impact situations. Many others that are apparent could not be discussed, and still others have not yet been identified. Clearly the identification of these interrelationships and a delineation of their influence on impact situations must be a high priority for future research efforts. Whether implicitly or explicitly, however, these factors and their interactions must be considered in the impact assessment process. The task of assessing such impacts is clearly a formidable one.

ORGANIZATION OF THE TEXT

In addition to this introduction, the text consists of six substantive chapters, a chapter comparing various computerized models, a chapter discussing the use of impact assessments in the policy process, and a concluding chapter. Each of the six substantive chapters is devoted to a particular topic, and the chapters are organized in the order that the issues they address are likely to be considered in developing or evaluating an impact assessment system. Within each of these chapters the following topics are examined: (1) the conceptual basis of the alternative methodologies used in the given area of impact assessment as well as the relative strengths and nesses of each alternative and the data and resource requirements for implementing each alternative; (2) the key impact and policy dimensions that are likely to affect the magnitude and distribution of the given type of impact and that must be considered in assessing the specific type of impact; (3) the actual projection methodologies employed in current impact assessments (the state of the art) and in the integration of impact dimensions; and (4) the implications and applications of the techniques given in each assessment area for the siting of repositories.

The chapters are arranged in the following order: Chapter 2 deals with the assessment of economic impacts as measured by changes in employment, income, business activity, and investment. Special emphasis in this chapter is given to examination of the export base and input-output techniques for impact assessment.

Chapter 3 examines demographic impact assessment. The conceptual bases for various assessment techniques are reviewed, and specific techniques for projecting population size, composition, and distribution are examined.

Chapter 4 provides a discussion of public service impact assessment. It addresses the conceptual basis for such assessments, reviews specific projection techniques, and also provides a guide to sources of data concerning public service requirements and standards.

Chapter 5 examines the impacts of major developments on the fiscal structures of local governments. Major conceptual issues are outlined, and alternative assessment techniques are discussed. Special attention is given to assessments of the distribution, among jurisdictions and over time, of the governmental costs and revenues associated with a new project.

Chapter 6 examines the social impact assessment process. Special emphasis is given to describing the place of social assessments in the overall assessment process and to identifying research requirements related to the social assessment process.

Chapter 7 deals with a substantive area closely related to those in the preceding chapters. It examines methods for integrating or interfacing economic, demographic, public service, fiscal, social, and other assessment methodologies.

The next chapter examines a specialized issue. Because of the increasing importance of the computerized forms of impact assessment models, a systematic comparison of these models is useful. Thus Chapter 8 presents a comparison of the basic characteristics and relative strengths and weaknesses of the most widely used computerized models.

Chapter 9 deals with the highly significant topic of the use of impact assessment procedures in the policy process.

The final part of the text presents a brief conclusion which attempts to both summarize some of the major findings of the effort and to point out those areas where additional conceptual and analytical refinement appears necessary.

The topics addressed in the text are broad in scope but inclusive of only some of the many aspects of social and economic impact assessment. They represent, however, very important dimensions of the impact assessment process. It is to these individual dimensions that we now turn our attention.

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CHAPTER 2

ECONOMIC IMPACT ASSESSMENT

The general purpose of economic impact assessment is to measure changes in the level of economic activity which result from a specific action such as the introduction of a new plant into an area. Indicators of economic activity which are frequently used in impact assessments include output (gross receipts or value added), employment, and personal income. Some assessment techniques provide estimates of output by industry, employment by industry or occupation and income distribution by income type or by income level of recipients, while others provide only aggregate measures such as total output, employment, and income. Economic impact analysis thus measures changes in activity levels for the entire economy of the area affected by a new project, including both the private sector and the public (government) sector.[1] Effects on the public sector are frequently subjected to additional, more detailed study which is often referred to as fiscal impact analysis (see Chapter 5).

Economic impact analysis involves estimating the change in economic activity that will result from a new project. A realistic assessment of the impact of a large-scale project, however, typically also requires projection of the level of economic activity which would be expected to prevail in the absence of the project. The results of this projection, often termed a baseline projection, can then be compared with a second projection which assumes development of the project. The difference between the two projections measures the impact of the project (Chalmers and Anderson, 1977). Assessing the impact of a major project thus frequently involves a combination of the techniques often used in regional forecasting and those used in more traditional impact analyses (Richardson, 1972).

The purpose of this chapter is threefold. First, the conceptual bases and methodological alternatives for economic impact assessment are reviewed. Conceptual bases examined include economic base theory, location theory, and central place theory. The review of methodological alternatives places heavy emphasis on export base (economic base) and input-output techniques and includes an evaluation of the strengths and weaknesses, data requirements, and types of outputs associated with each method. Other techniques, including intersectoral flows and econometric models, also are examined but in less detail. Secondly, the characteristics of the impact process which are especially important in determining the economic effects of major projects are discussed, and the information needs of decision makers with respect to economic impacts are described. Finally, the techniques which are typically being employed in economic impact assessments and the ways in which they are applied are examined.

CONCEPTUAL BASES AND METHODOLOGICAL ALTERNATIVES IN ECONOMIC IMPACT ASSESSMENT

Over the past three decades, the factors leading to differing rates of economic growth among regions have received increasing attention. Regional scientists, principally economists and geographers, have developed a number of theoretical concepts which provide the conceptual foundations of economic impact analysis (Richardson, 1973; Tweeten and Brinkman, 1976; Friedman and Alonso, 1964). A number of specific impact assessment techniques or models also have been developed based on these concepts. The purpose of this section is to describe first the conceptual foundations and then the major methodological alternatives for economic impact analysis.

Conceptual Bases

Three concepts of particular relevance to economic analysis are reviewed here. These are the export base (economic base) theory, location theory, and central place theory. Export base concepts underlie all the techniques commonly employed in economic impact assessment. Location theory is important in explaining why firms locate where they do, and it forms the underpinnings for most new firm feasibility studies. In the context of economic impact assessment for major development projects, location theory provides the basis for estimating the potential for development of linked industry on the impact area. Central place theory deals with the hierarchy of interdependence among trade centers. It provides a means to assess the prospective geographic distribution of impacts. Through identification of the threshold or minimum market size necessary to support various types of trade and service activities, it also provides a framework for assessing the likelihood of change in the composition of the local trade and service sectors in response to project development. These, then, are the principal conceptual bases underlying most impact assessment efforts.

Export Base Theory

Export base theory provides the conceptual foundation for all operational impact assessment models (Chalmers and Anderson, 1977; Denver Research Institute, 1979). This theory, which has origins in Keynesian national income and growth model analysis, was originally outlined by Hoyt (1933). More recently, the concept has been thoroughly discussed by Isard (1960), and its applications at the community level are described by Tiebout (1962), among others.[2]

A fundamental concept of the export base theory is that an area's economy can be divided into two general types of economic units. The basic sector is defined as those firms which sell goods and services to markets outside the area. The revenue received by basic sector firms for their exports of goods and services is termed basic income. The remainder of the area's economy consists of those firms which supply goods and services to customers within the area. These firms are referred to as the nonbasic sector or sometimes as residentiary or local trade and service activities.

A second key concept in export base theory is that the level of nonbasic activity in an area is uniquely determined by the level of basic activity, and a given change in the level of basic activity will bring about a predictable change in the level of nonbasic activity. This relationship can be summarized in the following equation:

$$Y = \frac{a - b + X'}{1 - (e - m)} \qquad (2.1)$$

Where: Y = net area product or income

X' = area exports (assumed to be exogenously determined)

e = marginal propensity to spend

m = marginal propensity to import

b = value of imports when $Y = 0$

a = value of expenditures when $Y = 0$.

The values of e, m, a, and b are assumed to be constant in a given area in the short run, although their values may vary substantially among areas. Thus, the level of exports (or basic income) determines the area's total income and output.

The effect of an additional dollar of exports on area income is shown by taking the derivative of Equation 2.1 with respect to X':

$$\frac{dY}{dX'} = \frac{1}{1 - (e-M)} = K \tag{2.2}$$

Because the value of (e-m) is expected to lie between 0 and 1, the value of K in Equation 2.2 is expected to exceed 1. This implies that, if the area's exports increase by one dollar, total area income will increase by more than one dollar because the increase in exports induces additional activity in the nonbasic sectors. This effect is known as the multiplier effect, and K is frequently termed the export multiplier.

The basis for the multiplier effect is the interdependence of the basic and nonbasic sectors of an area's economy. As the basic sector expands, it requires more inputs (for example, labor and supplies). Some of these inputs are purchased from local firms and households. As the firms in the nonbasic sector expand their sales to the basic sector, they too must purchase more inputs. Again, a portion of these inputs comes from other local firms which in turn must purchase more inputs and so on.

Increased wages and salaries paid to labor and management by the basic sector, together with similar payments by the nonbasic sector, lead to increases in the incomes of area households. Some of this additional income is spent locally for goods and services, some is saved, and some leaves the area as payments for imported goods and services (or as additional tax payments to government). To the extent that additional income is spent locally for goods and services, the output of local firms is increased, and additional cycles of input purchases and expenditure result. This cycle of spending and respending within the local economy is the basis for the multiplier effect.

The magnitude of the multiplier effect is determined by the proportion of a given dollar of additional area income which is spent locally. This relationship is often expressed as the marginal propensity to spend locally

Streeten and Brinkman, 1976). Referring to Equation 2.2, the marginal propensity to spend locally is simply the quantity (e-m). High multiplier values are associated with high values of e and low values of m. The value of e can be expected to vary slightly among areas, but the major determinant of the variation in multiplier values is the value of m. The more diversified and self-sufficient the area's economy, the lower will be the value of m and the higher the multiplier. Larger regions, then, tend to have higher multiplier values (Richardson, 1969; Harvey, 1973).

Export base theory is a subset of the general subject of regional income theory (Richardson, 1969). The regional income equation which forms the basis for export base theory is:

$$Y = (E - M) + X' \qquad (2.3)$$

Where: E = expenditures
M = imports
Y and X' are as previously defined.

Equation 2.3 simply states that area income is equal to domestic spending plus exports. Exports are thus treated as the only source of autonomous demand for the area's products. This model can be broadened to include other sources of autonomous demand as in Equation 2.4.

$$Y = C + I + G + X' - M \qquad (2.4)$$

Where: C = consumption expenditures
I = investment expenditures
G = government expenditures
Y, X', and M are as previously defined.

The expanded model includes investment and government expenditures as additional sources of autonomous (that is, determined outside the area) demand for an area's goods and services. Consumption expenditures and imports are generally considered to be determined by the level of local income as in Equations 2.5 and 2.6.

$$C = a + cY \tag{2.5}$$

$$M = b + mY \tag{2.6}$$

Where: a = value of consumption when Y = 0

c = the marginal propensity to consume

b = the value of imports when Y = 0

m = the marginal propensity to import

C, M, and Y are as previously defined.

Tax payments represent a flow (or leakage) of purchasing power from the local economy, and the amount of taxes paid is also treated as a function of area income.

$$T = d + tY \tag{2.7}$$

Where: T = total tax payments

d = the value of tax payments when Y = 0

t = the marginal propensity to tax.

In the expanded model, area income depends on the level of exogenous expenditures (X + I + G) and on the values of the marginal propensities to consume (c), to import (m), and to tax (t). If the values of c, m, and t are taken as predetermined, at least in the short run, a constant multiplier relationship and area income can again be derived (Richardson, 1978; Glickman, 1977).

The model outlined in Equations 2.4 to 2.7 can be further generalized to an interregional trade model with n interdependent regions. In this case exports of a given region are no longer exogenous to the model but rather are determined by the import demands of other regions. While models of this form are conceptually superior to the single region model, such models have never been implemented empirically because of severe data limitations. Economic impact analysts thus typically utilize single region models. The implementation of such models, however, typically follows the expanded definition of exogenous expenditures or basic income (see Equation 2.4). Federal government expenditures, expenditures by tourists and recreationists, and other exogenous consumption and investment expenditures as well as exports are thus considered to be components of the area's basic income (Chalmers and Anderson, 1977; Hertsgaard et al, 1978; Denver Research Institute, 1979).

Numerous authors have examined the strengths and limitations of the export base model.[3] A major conceptual limitation of the model is that it emphasizes changes in external demand for an area's products and completely ignores the factors affecting the area's ability to supply those products (Richardson, 1978; Tweeten and Brinkman, 1976). Some authors are concerned with the model's apparent lack of policy content and particularly with the inability of the single regional model to explain why exports change or what conditions internal or external to the region will be conducive to growth (Tweeten and Brinkman, 1976).

Other limitations of the export base model include the potential for changes in the ratio of basic to nonbasic activity over time and the possibility of lags in the adjustment process. The basic to nonbasic ratio may change over time because of differential rates of change in productivity of the two sectors. For example, rapid productivity increases in the basic sector may allow more nonbasic sector activity to be supported with a given level of employment in the basic sector. In growing regions, furthermore, the basic to nonbasic ratio may change over time because of the import substitution[4] which often accompanies regional growth (Glickman, 1977). Lags in adjustment of nonbasic activity to changes in the level of basic activity also present a problem (Moore, 1955; Stinson, 1978). The export base multiplier provides an estimate of the increase in nonbasic activity which would be expected as a result of a given change in basic activity. It does not, however, provide any insight regarding the time period required for full adjustment to occur. Lags also may present a problem in initially measuring the relationship between basic and nonbasic activity that prevails in a given economy (Glickman, 1977; Gillies and Grigsby, 1956). Despite these limitations, however, the export base model is widely used as the basis for impact analyses.

Location Theory

Location theory is closely related to the concept of comparative advantage and emphasizes the tendency for firms to locate where they can earn the greatest profit on their investment. The conceptual location model based on profit maximization implicitly incorporates both cost and market demand factors. Development of location theory began with the work of Von Thunen in the early 19th century. Major contributors have included Weber (1929), Hotelling (1929), Losch (1940), Greenhut (1956), Moses (1958), Hoover (1971), and Richardson (1978).

Location theory indicates that industry location decisions are guided by the comparative costs of producing, transporting, and marketing a product from plants at various alternative locations. A major factor affecting production costs at alternative sites is the cost of assembling the necessary inputs. When some of the inputs are quite heavy or bulky and hence expensive to transport but the product is less expensive to transport, firms will be encouraged to locate close to the source of the raw material (Weber, 1929). Differences in labor costs, institutional factors such as taxes and insurance, and such special factors as climate all have an influence on location decision (Hoover, 1971).

The cost advantages associated with larger plants or greater utilization of an existing plant must be compared with the increase in transportation and other marketing costs which occur as a firm markets more of its product to distant consumers in order to determine the most advantageous location pattern (Greenhut, 1956). A reduction in transportation costs will encourage a pattern of fewer and larger plants, each serving a larger market area, while an increase in transportation costs will have the opposite effect. Similarly, technological changes which increase the relative cost advantages attainable by large plants will encourage a pattern of few plants and larger market areas.

Industries can be classified according to their general pattern of response to location factors. Those industries which require large quantities of resources or whose transportation costs are quite high tend to locate close to the source of these resources and are termed <u>resource-oriented</u> industries. Industries which require large marketing outlays per dollar of output or whose product is bulky and expensive to transport tend to locate close to major market centers and are termed <u>market-oriented</u> industries. A third group of industries is the <u>footloose</u> industries whose profits do not vary greatly whether they are located close to raw material sources or to market centers.

A final factor to be considered in assessing probable locations for industry is agglomeration economies. These economies are cost savings which are realized when firms locate in proximity to one another. Agglomeration economies fall into two major categories: economies external to the firm but internal to the industry and economies external to the industry. Economies external to the firm but internal to the industry include the ability to support and have access to research and development facilities, the development of a skilled labor pool, the growth of auxiliary industries, and the development of markets for raw materials (Richardson, 1969). The other form of agglomeration economies is economies external to the individual industry. The cost savings which occur when firms from different industries congregate in the same local area are often referred to as urbanization economies (Isard, 1960) or economies of urban concentration (Hoover, 1948). These include access to a larger market; development of pools of managerial talent; presence of specialized commercial, banking, and financial facilities; development of improved transportation and communication facilities; and existence of social, cultural, and leisure facilities. Some observers believe that these agglomeration advantages are even stronger than those internal to an individual industry (Richardson, 1969).[5]

In the context of economic impact assessment for large development projects, location theory is useful as a conceptual basis for assessing the potential for development of linked industry. Export base theory provides the basis for a generalized asessment of the increase in local trade and service activity that would normally be expected to occur in response to a given level of additional basic activity. When a major new industry locates in an area, however, the possibility exists that a series of specialized firms will establish themselves in the area either to supply inputs to the industry or to utilize its products. Firms which supply specialized inputs to the industry are often termed backward-linked while those that utilize its products are often termed forward-linked. Location theory provides a general framework for evaluating the likelihood that new backward- and forward-linked industries will develop as a result of the location of a major facility in a given area.[6]

Central Place Theory

Central place theory attempts to explain the location and development of "central places" (cities, towns, and villages) in terms of functions performed and services provided, not only for the residents in each center but also for the tributary populations surrounding each center.[7] According to this theory, an urban center's primary function is to act as a service center for its hinterland or trade area. The services provided by central places can be ranked into higher and lower orders depending on the minimum market size (sometimes called the demand threshold) required to support the service. Some goods and services can be efficiently supplied only from very large centers while others are more efficiently supplied from smaller centers. Thus, trade and service centers can be classified according to the types of services they provide into a functional hierarchy.[8]

The trade areas of higher order trade centers overlap those of the lower order centers. Residents of a small rural town are likely to purchase some types of goods and services locally but will obtain other, more specialized services from higher order centers. If a new project should bring increased employment and income to the community, the result will be increased levels of trade and service activity not only locally but also in the higher order places.

Central place theory provides a conceptual basis for asessing the potential geographic distribution of the impacts of a new project. If the functional hierarchy of central places in a region can be identified and the rank and market area of each center can be established, the effects of the project on each center can be estimated. The approach that is typically taken is to integrate central place concepts into an export base framework. Thus, the level of nonbasic activity in any central place is assumed to be a function of the level of basic activity in its trade area.[9]

These, then, are the major conceptual bases for economic impact assessment. The next section of this chapter examines the principal forms of empirical models which have been developed to estimate economic impacts.

Methodological Alternatives in Economic Impact Assessment

During the last two decades, interest in regional and urban planning and in small area policy analysis has increased (Tweeten and Brinkman, 1976; Glickman, 1977). The last decade has also been a period in which increasingly rigorous requirements for socioeconomic impact assessments and impact mitigation planning in connection with large-scale development projects have been established (Watson, 1977). These two developments have led to growing interest in techniques for regional economic forecasting and for estimating the localized impacts of new projects. In this section, the major methodological alternatives for economic impact assessment are briefly reviewed. The two principal methodological approaches to economic impact assessment are the export base and input-output techniques. Both of these techniques are reviewed in some detail, including a discussion of each model's basic concepts, its data requirements, the nature of its outputs, and its conceptual and pragmatic strengths and limitations. Several other types of models also have some potential for application in economic impact assessment. These include the intersectoral flows or from-to model, simulation models, econometric models, and interregional models. These models are described more briefly, with emphasis on their general strengths and limitations as tools for localized impact analysis.

Export Base Models

The export base (or economic base) model is one of the earliest empirical models to be employed in economic impact studies. Despite the subsequent development of more complex and detailed techniques, export base models are still used in most impact studies (Chalmers and Anderson, 1977; Denver Research Institute, 1979). A number of variations of the export base model have been developed. The simplest form is based on dividing the total employment of the study area into two components: basic and nonbasic employment.

$$E_t = E_b + E_s \tag{2.8}$$

Where: E_t = total employment
E_b = basic employment
E_s = nonbasic or service employment.

Given the assumption that the proportion of basic to total employment is constant, an employment multiplier, K_1, can be derived:

$$K_1 = \frac{E_t}{E_b} = 1 + \frac{E_s}{E_b} \tag{2.9}$$

To estimate the value of the employment multiplier for a given area, the analyst requires employment data for at least one recent year and a basis for dividing employment into basic and nonbasic categories. Because employment data at the county level is readily available from the U.S. Department of Commerce, the estimation process can be inexpensive and rapid.

The employment multiplier of the form K_1 has been widely criticized because it reflects only the average relationship of basic to total employment in the local economy and because this average relationship may not be a good estimator of the change in total employment which will result from a change in basic employment (Weiss and Gooding, 1968; Lewis, 1976). An alternative formulation of the model, which is sometimes employed to overcome this problem, uses changes in basic and nonbasic employment over a period of time to estimate the mutliplier.[10] This model can be expressed as:

$$\Delta E_t = \Delta E_b + \Delta E_s \qquad (2.10)$$

Where: Δ indicates the change in each variable over the specified time period

E_t, E_b and E_s are as previously defined.

In this model the multiplier, K_2, is:

$$K_2 = \frac{\Delta E_t}{\Delta E_b} = 1 + \frac{\Delta E_s}{\Delta E_b} \qquad (2.11)$$

A number of alternatives exist in the implementation of export base models. The principal alternatives involve the following factors: (1) method of estimating basic and nonbasic employment, (2) unit of measurement (employment or income), and (3) estimation of aggregate or industry-specific multipliers. The implications of these alternatives are examined in the following paragraphs.

Identifying Basic and Nonbasic Employment

The first major decision confronting the analyst is determining the most appropriate procedure for identifying basic and nonbasic employment. Four general approaches have been used to classify employment into basic and nonbasic categories: (1) the assumption approach, (2) the location quotient method, (3) the minimum requirements approach, and (4) the primary data technique. The assumption approach is apparently the most widely used method. Using this method, the analyst identifies certain industries which are assumed to be basic; agriculture, mining, and manufacturing are frequently assumed to be basic. The remainder of the area's employment is thus assumed to be nonbasic. These assumptions, however, may prove to be inaccurate. Some manufacturing, such as printing and publishing and some food processing, may be locally oriented while many financial services, for example insurance and banking, often serve a market larger than the immediate area in which the establishment is located. In regions where tourism and recreation activities are prominent, a number of sectors which are traditionally regarded as nonbasic may be supported in substantial measure by the expenditures of tourists. The proportion of their employment which results from tourist expenditures should properly be classified as basic. If the assumption method results in an underestimate of basic employment, the employment multiplier will be overestimated and subsequent estimates of the impact of a new facility are likely to be too high. Conversely, if basic employment is overestimated, the multiplier value and subsequent impact estimates will be too low.

Attempts to improve the accuracy of employment classification over that resulting from the simple assumption method have resulted in three alternative approaches. The first two, the location quotient and minimum requirements approaches, are statistical methods which compare the area's employment patterns with those of the nation. The third involves using knowledge of the local economic structure, gained either through a survey or by less formal means, to assign each industry's employment between the basic and nonbasic categories.

The location quotient method assigns employment to basic and nonbasic categories by comparing the proportion of the region's employment in a given industry with that observed in some benchmark region, usually the nation. The location quotient is defined as:

$$LQ_i = \frac{E_{ir}}{E_{in}} \Big/ \frac{E_r}{E_n} \qquad (2.12)$$

Where: LQ_i = location quotient for industry i

E_{ir} = employment in industry i in the region under study

E_{in} = employment in industry i in the nation

E_r = total employment in the region

E_n = total employment in the nation.

The location quotient indicates the relative specialization of the region in each industry. A location quotient greater than unity indicates that the region has more than its proportionate share of national employment in that industry. In such cases the excess employment over proportionality is assumed to be export related.[11] The economic base employment multiplier is then computed by estimating basic employment for all industries with location quotients greater than one, summing the export employment of all those industries and dividing this sum into total employment (Isserman, 1977).

The location quotient approach is useful as it takes account of "indirect" exports (that is, firms who sell to other local firms which in turn sell to customers outside the region) as well as direct exports (Tiebout, 1962). This method does, however, have several deficiencies. First, it involves an implicit assumption that consumption patterns and productivity rates are uniform across the nation. Secondly, international exports and imports are ignored. Finally, by assuming that the production of each industry goes first to satisfy local needs and that only excess is exported, the location quotient approach ignores cross-hauling goods. This leads to underestimation of the export base and an overestimate of the multiplier (Leigh, 1970). However, this systematic bias in the multiplier estimates may become less serious as the level of employment disaggregation increases (Levan, 1956; Isserman, 1977).

A second statistical approach to employment classification is the <u>minimum requirements</u> approach (Ullman and Dacey, 1960; Alexandersson, 1956). This technique involves identifying a number of representative areas and calculating each industry's percentage of employment in each area. The smallest percentage of employment found in each industry across the various sample areas is then interpreted as the minimum required to satisfy internal needs. These minimum requirements are then compared to the employment structure of the study area, and employment in any industry which exceeds the minimum requirements is classified as basic.

The minimum requirements technique has many of the same deficiencies associated with the location quotient method. Again national uniformity in consumption patterns and productivity is implicitly assumed (Pratt, 1968). This technique is likely to systematically overestimate basic employment, as the areas with the lower percentage of employment in a given industry may in fact be importing a substantial proportion of their requirements for output from this industry. Finally, the reliability of this technique is reduced as employment is disaggregated into smaller sectors because disaggregation leads to estimates of minimum requirements which approach zero for most sectors (Pratt, 1968).

An evaluation of the estimation error associated with both the location quotient and minimum requirements techniques was undertaken by Greytak (1969). He finds that both techniques result in export estimates which deviate substantially and systematically from those actually observed. While subsequent work by Isserman (1977) demonstrates that the performance of the location quotient technique is improved substantially by disaggregation of industrial sectors, the desirability of specific knowledge about the area under study appears obvious.

The final approach for determining basic employment involves obtaining additional information regarding the composition of the local economy. In some cases a number of firms in each industry may be interviewed to determine the percentage of their sales which are to customers outside the area (Alexander, 1953). This technique can be expected to yield more accurate results than the methods discussed earlier, but the data collection process may become expensive if a large number of firms are involved. The quality of the results is also dependent on the ability of producers to accurately estimate the areal distribution of their customers (Pfister, 1976). Finally, the analyst must attempt to detect indirect exports (Glickman, 1977). The interview technique sometimes can be supplemented with information from secondary sources, such as a state directory of manufacturers, and can be used in conjunction with the location quotient technique.

<u>Employment as a Unit of Measurement</u>. Employment is generally used as the unit of measurement in export base models because employment data are more readily available for small areas than are measures of income, value added, or other potential indicators. In addition, employment is a major target variable for planners and decision makers.[12] Problems arise, however, because employment may not be a very sensitive indicator of general economic expansion caused by technological progress (Glickman, 1977). Thus, output and income may rise relative to employment, especially if the innovations are labor saving. When rates of productivity change are much different for the basic and service sectors, the base service employment ratio may shift substantially. Another problem arises from the fact that basic employment is aggregated for multiplier estimation, and the same multiplier is assumed to be applicable to all basic jobs, no matter which industry they occur in. This practice can lead to misleading results if different basic industries have substantially different wage rates and/or local input purchasing patterns. A unit change in employment in a high-wage industry will generate more total employment and income in the local economy than an equal increment in a low-wage industry, but the aggregate employment multiplier masks this effect.

The problems associated with the use of employment as a measure of economic activity can be largely overcome by substituting income for employment in the export base model.[13] A limitation to the use of income is that reported data at the county level lags the current period by about two years. The use of income has the distinct advantage of accounting for wage rate differentials among industries (Chalmers and Anderson, 1977). Businesses are sometimes reluctant to release wage and salary information, however, and it is frequently difficult to obtain reliable estimates of nonwage income (Denver Research Institute, 1979). The task of dividing nonwage income into basic and nonbasic components is even more difficult.

<u>Estimating Disaggregated Employment Multipliers</u>. Another approach which can be used to overcome the problems posed by differentials in wage rates and input purchase patterns among basic industries is to estimate separate multipliers for each basic industry (Weiss and Gooding, 1968). An excellent example of this approach is provided by Bender (1975). In this analysis, all employment in four specified industries was assumed to be basic, and all employment in the remaining industries was assumed to be nonbasic. Cross-sectional

ta from a large number of counties was used in a regression analysis to estimate separate multipliers for each of the four basic industries. The disaggregated model can be summarized as follows:

$$E_t = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + u \qquad (2.13)$$

Where: E_t = total employment

X_1, X_2, X_3 = employment in three different basic industries

b_1, b_2, b_3 = industry-specific employment multipliers, each of which indicates the change in total employment associated with one unit change in employment in the respective basic industry

u is a stochastic disturbance term.

Strengths and Limitations of Export Base Models. Although the export base model has definite limitations as a general theory to explain regional growth (Richardson, 1973; Tweeten and Brinkman, 1976), it has found widespread use in impact analysis. One reason for the popularity of this model is undoubtedly its simplicity and low cost (Pfister, 1976). The model can be, and generally is, implemented using secondary data exclusively. Further, the necessary computations can be completed in a relatively short time and do not require access to computer facilities. This model, however, provides very limited impact information. In essence, the export base model indicates only the aggregate effect on an area's nonbasic employment (or income) resulting from a given change in basic employment (or income) resulting from a given change in basic employment (or income). Further, in the simpler formulations of the model, all basic employment is assumed to have the same local multiplier effect. Such aggregate models ignore the differences among basic industries in input purchase patterns, wage rates, and worker spending patterns. Refinements of the model alleviate the problems associated with the aggregate employment multiplier either by substituting income for employment in the multiplier analysis or by estimating separate multipliers for each of the area's important basic sectors. These refinements, however, come at the cost of greater data requirements. The export base model, then, provides highly aggregated estimates of economic impacts. Analysts who desire more detailed impact projections, including estimates of effects on individual sectors of the local economy, have often turned to input-output models.

Regional Input-Output Models

Regional input-output models have been utilized extensively in regional impact studies.[14] These models are based on the interdependence of a region's industries and households as suppliers of inputs and purchasers of products. In developing an input-output model for a given region, the regional economy is divided into sectors (groups of similar economic units), and the transactions among the various sectors are estimated. The quantitative estimates of the interdependencies among the various sectors then provide the basis for tracing the multiplier effects of an exogenous shock to the economy in a more detailed manner than do export base models. In general, a regional input-output model can be viewed as a disaggregation of the export base model which allows for consideration of a large number of local industries with varying proportions of basic activity and for consideration of several sources of exogenous demand for the region's products (Richardson, 1971; Romanoff, 1974).

Input-Output Structure and Assumptions.

The basic equation of the input-output model is:

$$X_i = \sum_{j=1}^{n} x_{ij} + Y_i \qquad (2.14)$$

Where: i and $j = 1,2\ldots n$

x_{ij} = the amount of industry i's output required for the production of industry j's output

Y_i = sales to final demand by industry i

X_i = total output of industry i.

Equation 2.14 describes a system of linear equations, one for each industry (or producing sector) of the regional economy. The output of each industry is divided between intermediate products (or interindustry transactions, described by $\sum x_{ij}$) and final products (Y_i). Final products or sales to final demand are generally assumed to consist of sales for consumption, investment, government, and exports.

In order to facilitate empirical implementation of the model, the following assumptions are made:

1. Each industry produces a single, unique product.
2. There are no economies or diseconomies of scale.
3. Each industry has a single production process and no substitution among inputs is possible.

Assumptions 2 and 3 imply a constant relationship between each sector's output level and its input requirements:

$$x_{ij} = a_{ij}X_j \tag{2.15}$$

Where: a_{ij} is the production coefficient specifying the amount of output from industry i needed to produce one unit of the output of industry j, and X_j is the output level of industry j.

By substituting Equation 2.15 into Equation 2.14 we obtain:

$$x_i = \sum_{j=1}^{n} a_{ij}X_j + Y_i \tag{2.16}$$

Equation 2.16 is a system of n linear equations which may be solved for X_i if the values of the a_{ij} and Y_i are known. In matrix notation, Equation 2.16 may be written as:

$$X = AX + Y \tag{2.17}$$

Equation 2.17 can then be solved for the vector X as follows:

$$X = (I - A)^{-1} Y \tag{2.18}$$

Where: X is a vector of output for each industry, X_i ($i = 1,\ldots,n$)

A is a matrix of production coefficients (also called direct requirements coefficients or technical coefficients)

I is an identity matrix

Y is a vector of sales to final demand for each industry

$(I - A)^{-1}$ is a matrix of interdependence coefficients which show the direct and indirect requirements for output from each sector to support one unit of sales to final demand.[15]

Implementation of the input-output model, Equation 2.16 or 2.18, requires independent estimates of the technical coefficients (a_{ij}) and the sales to final demand (Y_i). Given these estimates, the input-output model can be used for both impact analysis and regional forecasting (Richardson, 1972).

Input-Output Multipliers. Impact analysis involves estimating the effect on the regional economy of a specified change in the output of one or more economic sectors. Input-output (I-O) provides a mechanism for estimating the effect of a new project on output, income, and employment for the regional economy as a whole. It can also provide estimates of changes in output and employment for each sector. Final demand, output, income, and employment multipliers derived from the input-output equation system provide useful summary measures of the relationship between expansion or contraction of a given sector and the total change in economic activity created throughout the economy.

The final demand multiplier for a sector measures the change in total output from all sectors resulting from a one dollar change in sales to final demand of products of that sector. The output multiplier for a sector measures the change in total output from all sectors resulting from a one dollar change in the output of that sector (Clark et al, 1974; Roesler et al, 1968). Both final demand and output multipliers can be computed directly from the matrix of interdependence coefficients, and the choice between these two multiplier forms in impact analysis depends primarily on the relative availability of information on sales to final demand versus output for the sector to be analyzed. It is critical, however, that analysts not confuse the two multiplier forms. The income multiplier measures the total change in income (of households) throughout the economy resulting from a one dollar change in income in a given sector.

The employment multiplier, as computed from the I-O model, is defined as the total change in employment due to a one unit change in employment in a given sector. The basic assumption in computing employment multipliers is that there is a linear relationship between employment and output of a sector. Computation of employment multipliers requires an estimate of the direct employment requirement (that is, the man-years of employment per unit of output) for each sector. Given this information, the I-O interdependence coefficients matrix can be used to compute the direct and indirect employment requirements and the employment multiplier for each sector.[16]

A number of factors affect the magnitude of the multipliers estimated from the input-output framework. First, multiplier values may differ substantially from sector to sector because of differences in the linkages of the individual sectors with other sectors of the regional economy. A sector which depends heavily on other local sectors for its inputs will typically have higher multiplier values than one which imports most of its input requirements. Secondly, multiplier values tend to vary directly with the size of the region being studied, for the same reasons discussed earlier in connection with export base models. Finally, input-output multiplier values are affected by the structure of the model itself. In particular, some regional I-O models include households as a producing sector; these models are said to be <u>closed</u> with respect to households. Such models reflect the <u>induced</u> effects of the expansion of a given industry (that is, the additional household consumption which results from the additional income associated with industrial expansion) as well as the <u>indirect</u> effects (arising from additional requirements for production inputs) and the <u>direct</u> effects (that is, the initial direct increase in the industry's output).

Input-output models used in impact assessments for major projects typically are closed with respect to households, although this is not always the case. Multipliers derived from I-O models of this type are termed Type II multipliers to distinguish them from the Type I multipliers which reflect only direct and indirect effects. The income and employment multipliers derived from the closed I-O model are closely analogous to those from export base models. In fact, it has been demonstrated that the export base income multiplier and the consolidated closed I-O multiplier are mathematically identical (Billings, 1969; Garnick, 1970). Both reflect direct, indirect, and induced effects of exogenous changes in demand for a region's output, and both are average rather than marginal multipliers. Further, empirical comparisons of the two multipliers, using similar definitions of basic activity, indicate that their values tend to be similar (Isard and Czamanski, 1965; Garnick, 1970).

Given the conceptual and empirical similarity of the export base and input-output multipliers, the major bases for selecting between the two models are the required level of detail for the analysis, the availability of necessary data, and the time and resources available to the analyst. I-O models clearly provide more detailed impact projections (that is, they show effects on output and employment by sector), and they are more sensitive to differences in input purchasing patterns and salary levels among sectors. These models are capable of extension to allow projection of employment by occupation (Drake et al, 1973; Sherafat et al, 1978), and they can also be employed to project changes in income distribution (Sherafat et al, 1978). Another possible extension of the I-O model is to incorporate coefficients reflecting the resource use and environmental emission per unit of output for each sector. The model can then be utilized to estimate changes in resource utilization and environmental quality associated with the various economic projections and to analyze economic-environmental trade-offs (Isard et al, 1972). However, input-output models also impose substantial data requirements. The data requirements of the input-output model are discussed in the next section.

Data Requirements. The most difficult and time-consuming task in implementing a regional input-output model is developing estimates of the direct requirements coefficients (technical coefficients). These coefficients are frequently estimated using primary data collected through an extensive survey of firms and households in the study area.[17] These data provide a detailed description of the interdependencies among the sectors of the local economy. The time and expense required to prepare input-output tables based entirely on primary data are considerable, however, and may exceed resources available for many impact studies.

In an attempt to reduce costs associated with regional input-output analysis, a number of techniques for developing input-output coefficients totally or partially from secondary sources have been developed. All of these techniques are based on adjusting coefficients already available for some larger area (such as the nation or the state) to approximate the interindustry relationships of the study area. While the regional I-O coefficients thus developed are at best approximations of the true relationships, these adjustment techniques appear to offer the potential for developing coefficients with satisfactory levels of accuracy in a very cost-effective manner (Boster and Martin, 1972).

A substantial number of I-O coefficient adjustment techniques have been developed.[18] Only one of these, the location quotient technique, will be discussed in detail here, however. The rationale for choosing this technique is that it has been widely used and is supported by well-documented and generally available software packages (Mustafa and Jones, 1971).

The location quotient approach is a procedure for comparing the relative importance of an industry's output in a region to that in a larger region (such as the state or the nation). The location quotient (LQ_i) is defined as:

$$LQ_i = \frac{Z_i/Z}{X_i/X} \tag{2.19}$$

Where: Z_i = the regional output of industry i for the base year
X_i = state (or national) output of industry i for the base year
Z = total regional output for the base year
X = total state (or national) output for the base year.

Thus, LQ_i compares the percentage share of the i^{th} sector output of a region with the percentage share of that sector's output of the state or nation. If the region's share is equal to the nation's or state's share, then LQ_i is 1, and the sector in the region is assumed to be just self-sufficient. If the sector of the region produces more than its proportionate share, LQ_i is greater than 1. The sector of the region in this case is assumed to export the surplus production. Similarly, if a sector of the region produces less than its proportionate share, LQ_i is less than 1, and the region is assumed to import the deficit production (Schaffer and Chu, 1968; Jones and Mustafa, 1973).

If LQ_i is 1 or more, all state or national technical coefficients for that sector's row may be used directly to represent the regional technical coefficients. If the LQ_i is less than 1, however, the state or national technical coefficients of the sector's row are reduced proportionately to account for the region's deficit production.

The location quotient technique is subject to criticism because of its assumption of regional self-sufficiency; that is, regional production is used to meet regional needs and only the residual is available for export. The technique assumes that cross-hauling among the regions does not occur and, hence, tends to underestimate regional exports (and imports) and to introduce an upward bias into the regional technical coefficients and output multipliers (Richardson, 1972; Jones et al, 1973). Nevertheless, it represents a very cost-effective approach for developing regional input-output tables when time and budget constraints preclude developing a regional model entirely from primary data.[19]

If input-output models are to be used for baseline and impact projections, another essential data requirement is projections of sales to final demand. There are really two problems: (1) projecting sales to final demand under baseline conditions and (2) projecting changes in sales to final demand associated with a new development project. Developing projections of sales to final demand is a challenging task. Because the issues involved in projecting sales to final demand are similar to those associated with projecting basic employment, however, this subject will be examined in the subsequent section on economic impact assessment techniques.

If projections are being made over a substantial time period, it is also necessary to consider forecasting changes in the I-O technical coefficients. There are at least five reasons why regional input-output coefficients may vary over time: (1) changes in relative prices of inputs, (2) changes in product mix, (3) technological change, (4) economies of scale, and (5) changes in regional trade patterns (Richardson, 1972). There is some evidence, however, that these coefficients may be relatively stable over time, both at the national level (Carter, 1970) and at the regional level (Miernyk, 1968). The major exception may be in rapidly growing regions where import substitution effects may be substantial.

There are several alternative methods of forecasting changes in I-O coefficients at the regional level. Most of these are imperfect, however, and rely heavily on the analyst's judgment (Richardson, 1972). Some of these approaches are: (1) obtain national projections of changes in coefficients and apply them proportionately to the regional coefficients[20]; (2) if two I-O tables are available for the region, compare the coefficients and use this as the basis for forecasting a third table of direct requirements coefficients; and (3) using data from a regional I-O survey, apply the "best practice" technique developed by Miernyk (1968). The use of these techniques may not be feasible in many impact studies, but if long-range forecasts are required, the analyst should at least consider the possibility of changes in the I-O coefficients (Harmstrom and Lund, 1967).

<u>Strengths and Limitations of I-O Models</u>. Like export base models, input-output models have been used extensively in assessing economic impacts at the local, state, and national levels. Criticisms of the I-O model focus mainly on its assumption of constant coefficients (Glickman, 1977; Denver Research Institute, 1979). This criticism is valid, but it should be recognized that the principal alternative model, the export base model, shares this shortcoming. The problems posed by constant coefficients can be overcome, as discussed earlier, but only through substantial effort and at the cost of increased data requirements. Another similarity between the input-output and export base models is that both are equilibrium models, which indicate the estimated secondary economic effects once the local economy has fully adjusted to a change in basic economic activity. Neither model provides an estimate of the time path of adjustment, and this characteristic can pose problems when they are used to assess the impacts of large projects.

In summary, the input-output model provides more detailed impact estimates than the export base model and shares many of that model's basic assumptions. The data collection and analysis requirements associated with I-O models have been the major impediment to their more widespread utilization.

Other Economic Impact Models

A number of other models have occasionally been utilized in economic impact assessment or have potential for such application. This section briefly reviews a number of these models, including the intersectoral flows or from-to model, regional simulation models, regional econometric models, and interregional models.

The Intersectoral Flows or From-To Model. The intersectoral flows model combines elements of the input-output and export base models. The concept was introduced by Levan (1961); examples of empirical applications include studies by Hansen et al (1961) and Kalter (1969). The key element of the model is a table showing the distribution of the sales of each local sector to other local sectors, exports, and other forms of final demand. From this table, estimates of (1) direct input requirements and (2) direct and indirect requirements similar to those developed in input-output models can be derived. The direct and indirect requirements coefficients can then be used to derive employment or output multipliers for each local sector (Doeksen and Schreiner, 1974).

The from-to model is clearly a compromise between the export base and input-output models. Unlike the input-output model, the from-to model ignores data on imports. This leads to at least one major advantage and one disadvantage. The advantage is that data requirements of the from-to model are greatly reduced, compared to input-output. The disadvantage is that there is no cross-checking mechanism such as that contained in I-O models (where the rows and columns must balance). The from-to model, then, offers a potential alternative to analysts who desire more detail than is provided by export base models but want to avoid the expense of developing an input-output model.

Simulation Models. Simulation has been defined as the use of a model to represent, over time, the essential characteristics of a system or process under study (Meier et al, 1969). This definition is sufficiently broad to include a wide variety of economic impact models, and in fact all of the computerized socioeconomic impact assessment models referenced in the "Introduction" of this work can be called simulation models. Regional socioeconomic simulation models typically include an economic component or module, utilizing either economic base or input-output techniques, linked with one or more other modules which depict demographic, public services, fiscal, or environmental relationships. The process through which the different components are linked, often with a series of feedback loops, may explicitly incorporate assumptions regarding the time required for economic, demographic, and other adjustments to occur. The early development of regional simulation models was influenced substantially by the pioneering work of Forrester (1961) in systems dynamics and by applications of dynamic simulation concepts in regional analysis by milton et al (1969).[21] The principal strength of regional simulation models is in linking economic impact techniques with models describing other aspects of regional activity (e.g., demographic, fiscal). They should thus be regarded primarily as a mechanism for the integration of economic and other impact assessment techniques and not as an alternative to the economic impact models discussed previously.

Econometric Models. A relatively recent development in regional economic analysis has been a growing interest in regional econometric models. These models are generally based on time series data (that is, observations on the same economic variable on a regular temporal basis). Regression analysis is the principal statistical tool used to estimate the relationships between economic variables. The interest in developing econometric models at the regional level has been fostered in large measure by the development of econometric models for forecasting wages, prices, income, and output at the national level.[22] Regional analysts rapidly perceived the potential for developing regional models which could be linked to these national models and which would use as exogenous variables the forecasts of the latter (Klein, 1969). A number of econometric models have been developed for multistate regions (Crow, 1973; Richter, 1970); for states (Adams et al, 1975); and for substate areas (Fishkind et al, 1978; Glickman, 1977; Hall and Licari, 1974).

The development of regional econometric models has been hampered by substantial data constraints.[23] Whereas national models are typically based on quarterly data, regional models must rely on annual data, and the published data series are often based on short time periods. Scarcity of data has led to model structures which are usually quite simple, relatively static, and lacking in spatial disaggregation (Glickman, 1977). Very few models have been estimated for substate areas, and these have generally been for SMSAs.

While national and regional econometric models are a promising tool for those engaged in regional analysis, it does not appear likely that they will soon replace the more traditional economic impact assessment techniques. Data availability likely will continue to severely limit their application in nonmetropolitan substate areas. State and national econometric models may prove useful, however, in developing regional projections of sales to final demand or basic employment.

Multiregional Models. Regional analysts have long been intrigued by the concept of multiregional or interregional economic models which could explicitly quantify the linkages among the various regions of a nation. Such models would circumvent one of the major problems of single region economic base or input-output models--that being the need for exogenous projections of exports. In a multiregional model, the exports of a given region are determined by the import demands of all other regions. Two forms of multiregional models are of particular interest in the present context. These are multiregional or interregional[24] input-output models and the Harris Multiregional, Multiindustry Forecasting Model.[25]

The theoretical structure of interregional input-output models was first discussed nearly three decades ago by Isard (1951), but little progress was made in applying such models until recent years because of data limitations and computer capacity constraints. Work by Polenske (1969) and Almon (1974) has recently stimulated renewed interest in interregional models, and some progress has been made in adapting the multiregional framework to substate areas. For example, a twelve-region model for the Southwestern United States has recently been implemented, based in large measure on the work of Almon. The model's twelve regions include the seven-state planning districts of New Mexico; the states of Arizona, Colorado, Utah, and Texas; and the rest of the United States (Brown and Zink, 1977). Multiregional I-O models, then, show potential as a tool for regional analysts, but the data requirements of these models and the resources required to implement them are substantially greater than those associated with single region models.

The Harris Multiregion, Multiindustry Forecasting Model is of interest because it has been used extensively in impact analysis by the U.S. Bureau of Land Management (Betters, 1979) and by Resources For the Future (Krutilla et al, 1978). This recursive econometric model is capable of developing annual forecasts at the county level (for all of the 3,111 counties in the United States) for 99 industry sectors, 4 government sectors, and 28 types of construction activity. The model is based on location theory coupled with input-output analysis. The location of the various industries is allowed to shift over time in response to changes in the demand for their products and the price and availability of inputs. The model is described in considerable detail in Harris (1973).and its usefulness in the impact assessment and planning process is evaluated by Betters (1979).

Comparison of Alternative Economic Impact Assessment Methods

The purpose of this section is to provide a brief summary and comparison of the strengths and weaknesses of the alternative economic impact assessment techniques discussed above. The comparison of the major alternatives is summarized in Table 2.1. In examining Table 2.1, it should be noted that all of these models can be criticized on several grounds. All are essentially "static" models which assume fixed relationships between local sectors. This characteristic potentially can be altered in most of the models, but only at the cost of greater data requirements and with willingness to assume that past trends of change in intersectoral relationships will continue. Incorporation of dynamic properties generally is simplest in the export base models. None of the models directly account for the import substitution effects which may accompany regional growth. Likewise, all of these models assume no underemployment of resources (i.e., no excess capacity) in the local economy.

Other limitations shared by all the models compared in Table 2.1 include their lack of mechanisms for estimating the timing and geographic distribution of economic impacts. Problems in estimating the timing of secondary economic effects are endemic to export base and input-output models because these are equilibrium models which estimate the secondary economic effects once the local economy has fully adjusted to a change in basic economic activity. One recent study included an attempt to estimate the time path of adjustment in secondary employment within the export base (disaggregated employment multiplier) framework, but the results were inconclusive (Conopask, 1978). This area is one in which additional analysis is clearly needed.

Export base and input-output models also typically do not provide estimates of the geographic distribution of secondary effects. These models are typically estimated at the county or multicounty study area level and provide estimates of the total secondary effects within the area. One recent study (Chalmers et al, 1977), however, illustrates a method of modifying the export base (income multiplier) model to provide estimates of the distribution of secondary effects among counties in an impact area.

In summary, there is probably no single ideal model for local area economic impact analysis. The choice among models must be determined through a

Table. 2.1. Comparison of Strengths and Weaknesses of Alternative Economic Impact Assessment Techniques

	Alternative Models				
	1. Export Base-Aggregate Employment Multiplier	2. Export Base-Disaggregated Employment Multiplier	3. Export Base-Income Multiplier	4. I-O Location Quotient	5. I-O Primary Data
Major Strengths:	Data are readily available. Resource requirements are modest--less than any other alternative. Can be modified to incorporate timing and geographic distributions of secondary effects. Can provide a labor income multiplier indirectly (through the application of estimated wage rates to the number of jobs in each sector.	Provides for differentiation of multiplier estimates among basic industries. Can provide a labor income multiplier indirectly (through the application of assumed wage rates to number of jobs in each sector). Data is readily available. Can incorporate timing and geographic distribution of secondary effects. Modes resource requirements.	Provides differentiated multiplier estimates. Can provide an employment multiplier indirectly (through the application of assumed wage rates to nonbasic income). Data is readily available. Can incorporate geographic distribution and potential timing of secondary effects. Modest resource requirements.	Provides differentiated multiplier estimates and also accounts for input purchase linkages. Provides estimates of employment, income, and output effects. Identifies incidence of economic impact by sector. Amenable to expansion to examine changes in employment by occupation, resource use, etc. Estimates of activity by sector can be advantageous for subsequent tax calculations.	Provides differentiated multiplier estimates and also accounts for input purchase linkages. Provides estimates of employment, income, and output effects. Identified incidence of economic impact by sector. Amenable to expansion to examine changes in employment by occupation, resource use, etc. Estimates of activity by sector can be advantageous for subsequent tax calculations. Primary data allows possibility of adjusting coefficients over time via "best practice technique".
Major Weakensses:	Does not provide for differentiation of multiplier estimates among basic industries. Employment may be a less sensitive indicator of economic activity than income. Provides only aggregate measures of secondary effects--no distribution by sector.	Employment may be a less sensitive indicator of economic activity than income. Provides only aggregate measures of secondary effects--no distribution by sector.	Income data poses some analytical problems--particularly the division of nonwage income into basic and nonbasic categories. Provides only aggregate measures of secondary effects.	Resource requirements are moderate, but data problems may increase costs in rural areas (because of nondisclosure in secondary sources). Coefficients are acknowledged to be somewhat biased. Does not directly estimate timing or geographic distribution of effects (these can be incorporated through side-calculations).	High data collection and processing costs. Does not directly estimate timing or geographic distribution of effects (these can be incorporated through side-calculations).

balancing of model capabilities and resource requirements. In making this choice, however, it is important that both the nature of the impact process and the information needs of decision makers with respect to impact assessment and mitigation be considered. These topics are discussed in the next section.

FACTORS AFFECTING ECONOMIC IMPACT ASSESSMENTS

In the actual projection of economic impacts, the key factors affecting the results include the nature of the project (including direct employment effects, local input purchase patterns and effects on other basic sectors), characteristics of the site area (including its economic structure and outlook, trade patterns, the skills of its labor force, and the extent of unemployment and/or underemployment) and the interactive effects of project and area characteristics. These causal forces interact through the complex process of regional economic adjustment to determine the nature, magnitude, and distribution of impacts. Developing reliable estimates of these impacts is the goal of economic impact assessment. The purpose of this section is to describe those characteristics of resource development projects which are likely to affect the nature of the impacts experienced and also to discuss the information needs of decision makers relative to economic impacts.

Project Characteristics

The characteristics of the development project are central in determining the nature and extent of all forms of economic impacts. Project characteristics of particular interest include work force (number, skill levels, and timing), investment, input purchase patterns (by sector and by location of suppliers), specific forward linkages to other sectors, and natural resource requirements. Work force characteristics are of obvious importance. Development projects differ in their total work force, in the relationship between construction and permanent work forces, and in the mix of skill levels required for each phase. Skill requirements in turn influence the projects' ability to utilize local labor and also are instrumental in determining the wage and salary levels of project workers (which may in turn affect wage levels in other industries).

A project's resource requirements and linkages with other economic sectors are key determinants of secondary economic effects. Resource and industrial development projects differ substantially in their economic linkages—both forward to processors of their products and by-products and backward to suppliers of inputs. The resource requirements of a given project, such as use of water and land, are primary determinants of effects on other basic sectors, for example, agriculture (Murdock and Leistritz, 1979). The level of investment in project facilities may be a major factor in determining the local public sector revenues generated by the project. The adequacy of local revenues can be expected to influence public sector decisions regarding investment in infrastructure which may in turn affect local business investment decisions (Gilmore, 1976).

Site Area Characteristics

Characteristics of the site area likewise have an influence that is pervasive across virtually all economic impact dimensions. An area's natural resource base, labor force, and level of economic development can have considerable influence on the economic impacts resulting from a given project. An area's natural resource base is a major determinant of the feasibility of locating various types of facilities there, and resource ownership patterns may play a key role in determining the distribution of royalty payments to area residents (Leistritz and Voelker, 1975).

Site area characteristics may greatly affect the composition of a project's work force. The size of the local population, residents' skill levels, and the extent of underemployment and unemployment could determine the proportion of employment needs that could be met by local recruitment. Preliminary estimates of the relationship between local population and local recruitment have been developed by Chalmers (1977) and by Wieland et al (1979). However, more research is needed to quantify the effects of skill levels unemployment and underemployment. Site area characteristics, including amenities and climate, also may influence worker productivity.

Site area characteristics also may greatly influence the secondary economic effects of a given project. The area's economic structure will affect the development firm's ability to purchase supplies and materials locally and also may affect the propensity of project workers to purchase goods and services locally. Areas with more diversified economies and better developed trade and service sectors thus typically experience greater secondary economic effects (Harvey, 1973; Chalmers et al, 1977).

Interactive Effects of Project and Area Characteristics

The economic effects of large-scale developments also result in large part from interactions between the timing of project events, the ability to use local resources, and the characteristics of the local areas. The direct employment effects of a large development project typically occur in two phases: the construction of the facility and its subsequent operation. Construction work-force requirements typically are much greater than operational requirements. Construction of a large electric generating plant, for example, frequently requires a peak construction work force of 1,500 to 3,000, with construction being completed in about five years (Murdock and Leistritz, 1979). Following construction, the facility's permanent operation and maintenance work force will be only a small fraction of the construction work force, perhaps 200 to 300 workers. As a result, the socioeconomic impacts of such facilities are cyclical, being greatest during the construction phase, reducing markedly from construction to operation periods and declining even more dramatically once the operational life of the project has ended.

The extent to which the project's employment requirements are met by local workers plays a key role in determining the magnitude of other economic effects and also other impact dimensions. When most of the workers can be recruited locally, in-migration and local population growth are minimized as are impacts on public services. Other local employers may experience difficulty in retaining skilled employees, however, and local wage rates may increase substantially. The extent to which project construction jobs are filled by inmigrating workers is likely to affect the percentage of project payroll which is spent locally and hence the magnitude of secondary employment and income effects (Mountain West Research, Inc., 1979). The settlement-commuting patterns of the project work force will also influence the geographic distribution of secondary economic effects. Evidence from energy impacted areas in the Western United States indicates that local hiring rates and worker settlement patterns are quite variable among projects (Wieland et al, 1979; Murdock et al, 1978; Chalmers, 1977). This variability poses an analytical challenge for researchers and creates additional uncertainties for decision makers.

Because of the rapid fluctuations in direct employment requirements between project construction and operation phases, the assumptions regarding the timing of increases in indirect employment are of obvious importance to the accuracy of not only the total employment projections but also subsequent projections of population changes and public service requirements. At least three hypotheses have been advanced to explain the response of secondary employment. The first is that lags in employment response are typical and occur because time is required for the the local multiplier process to work itself out and for a new equilibrium to be achieved.[26] The second hypothesis is that, during construction of a large project, secondary employment growth will be further retarded because the economic stimulus is perceived as temporary and because rapidly growing boomtowns are not viewed as attractive sites for new business investments (Gilmore, 1976). Finally, some analysts (Auger et al, 1976; Denver Research Institute, 1979) have hypothesized a "construction accelerator effect" on secondary employment associated with major projects. The rationale for this effect is that a major development will lead to substantial construction of new housing, public facilities, and business structures. Thus, sizeable work forces may be required to build the new facilities and, in addition, these secondary construction activities will have their own multiplier effects on the local trade and service sectors. The result could be major increases in secondary employment during the early years of the project, followed by some reduction in secondary employment levels as the local economy achieves a new equilibrium condition. Efforts to measure the timing of secondary employment growth in impacted rural areas have produced somewhat contradictory results (Conopask, 1978; Thompson et al, 1978; Gilmore and Duff, 1975). More research is clearly needed on this topic, and in the meantime some analysts have resorted to various ad hoc adjustments to stimulate lag effects.

Because a large project may lead to very substantial growth in the affected area (for example, nearby communities could double or triple in population), the potential exists for import substitution and for significant changes in regional trade patterns; and the existing hierarchy of trade centers may be altered. •Impact analysts must take these effects into consideration in developing their projections.

Impact assessments must also take account of the possible effects on other basic sectors resulting from development of the proposed project. Such effects may be the result of direct competition for resources such as land, water, and labor or could possibly result from the effects of air pollution or aesthetic aspects of the project (Murdock and Leistritz, 1979). The aesthetic aspects of a project, together with its impacts on the physical environment could, for example, have negative effects on an area's present recreation and tourism industry.

While most impact assessment efforts have been directed toward evaluating potential effects in terms of estimating overall changes in employment, income, and other indicators for a given area, the distribution of these effects also must be considered. While it appears that local workers who obtain employment will experience substantial income gains and that the effects of most projects will be to increase average per capita income levels (Leistritz et al, 1980a), little is known concerning the effects of large projects on income distribution. Some segments of the local population, such as the elderly, may experience little change in their incomes as a result of development but may experience substantial increases in living costs (Thompson et al, 1978). These persons could be made worse off as a result of development. Analyses to date, however, present only fragmentary, and sometimes conflicting, evidence concerning distributional effects (Reinschmiedt and Jones, 1977; Clemente and Summers, 1973; Summers and Clemente, 1976). More detailed evaluations of the distribution of development-related benefits and costs may be required before the desirability of these developments can be assessed adequately.

Information Needs of Decision Makers

The decision-making environment which exists in a rapidly growing rural community has several specific implications with respect to the information needs of planners and policy makers. First, because many of the necessary decisions must finally be resolved at the local level, projections of changes in population, service needs, and public sector revenues must be provided for individual jurisdictions. This need, in turn, requires that economic impacts also must be projected for individual jurisdictions. Secondly, because the timing of socioeconomic changes is critical in local planning and decision making, annual projections are necessary. The need for annual projections, in turn, requires impact analysts to address questions concerning the time path of economic adjustment. Thirdly, because many local decisions require evaluation of the project's effects in the context of the entire regional economy and its dynamic functioning, impact projections must indicate not only the likely consequences if the project is developed but also the expected future without development. In some cases the principal effect of a new project may be to offset declining employment in other basic economic sectors and to reduce existing excess capacity in the area's public facilities and services, while in others the effect may be to accentuate trends of local growth which are already straining existing facilities.

The nature of the decisions confronting impacted communities appears to indicate a greater need for specificity of impact projections by time period and geographic unit than by economic sector or occupation group. Thus, employment projections clearly must be provided annually and at county or subcounty levels, but projections of employment by industry and occupation often appear less essential. Such disaggregated projections may be important, however, in order to link the economic projections to subsequent projections in the demographic, public service and fiscal areas. Projections of employment by occupational category for example, might be extremely useful in estimating the extent to which employment requirements can be satisfied by the existing population (see Chapter 4) as well as in guiding regional manpower planning and vocational training programs. Likewise, projections of income distribution are very helpful in estimating the types of housing which may be required (Denver Research Institute, 1979), and projections of output or gross business volume by sector are desirable as input to the fiscal impact analysis (see Chapter 6). Finally, disaggregated projections can be very useful in identifying the incidence of project-related benefits and costs among groups in the local population.

A final consideration which affects the information needs of decision makers is the substantial degree of uncertainty often associated with resource development projects. During the planning stages of such projects, uncertainty as to whether the facility will actually materialize, when construction will begin, and whether the project may be developed only to later be abandoned as infeasible increases the complexity of impact management planning (Leistritz et al, 1980b). Uncertainty regarding the potential distribution of impacts at the community level makes the decision-making process even more difficult. Even after project development is under way, changes in construction schedules can lead to substantial increases or decreases in work-force levels and hence in community population school enrollment, and other critical variables. These uncertainties imply that impact assessment cannot be a one-time effort and that impact models should be capable of projecting the implications of a number of development scenarios. These models must also be capable of readily incorporating new information (such as revised work-force schedule) and producing revised projections in a timely manner.

ECONOMIC IMPACT ASSESSMENT TECHNIQUES

The actual preparation of an economic impact assessment involves a number of specific steps. These include: (a) description of the project's characteristics, (b) delineation of the study area, (c) developing baseline projections, and (d) projecting the impacts of development. These steps will be discussed in the sections which follow.

Description of the Project

Before the effects of a new development project can be evaluated, of course, the characteristics of the project which are important in determining its economic impacts must be quantified. These characteristics include work-force requirements, level of capital investment, amount and composition of local input purchases, level and types of output, and natural resource requirements.

The nature of a project's work force is one of the most critical factors determining its socioeconomic impacts. Many assessments conducted in the mid-1970's considered only the size of the peak-year construction work force and permanent work-force requirements (Berkey et al, 1977). Many analysts, however, now attempt to obtain estimates of the size of the work force by year during the construction phase, and some assessments have utilized quarterly work-force projections during the construction period (National Biocentric, Inc., 1977; Woodward-Clyde Consultants, 1975). The work-force requirements during the construction period are sometimes estimated by craft or occupational category in order to facilitate subsequent estimation of local hiring rates (Woodward-Clyde Consultants, 1975; National Biocentric, Inc., 1977;

Chalmers and Anderson, 1977), although the more typical practice is to utilize only total work force (Berkey et al, 1977). Work-force requirements are occasionally disaggregated to occupational categories during the operational phase as well (Division of Business and Economic Research, 1975). The average earnings of the workers during construction and operational phases is frequently estimated, and the income distribution of project workers at each phase is occasionally estimated (Denver Research Institute, 1979; Division of Business and Economic Research, 1975). These estimates of income distribution are often used in subsequent analysis of housing demand.

The capital investment for the new facility as well as its expected output generally must be estimated to enable subsequent calculation of tax revenues (see Chapter 6). In addition, the analyst should attempt to estimate the extent of purchases of supplies and materials which will be made in the impact area. Some analyses have included detailed estimates of local purchases (Auger et al, 1976; Dalsted et al, 1976), but many have simply incorporated the assumption that these purchases will be minimal and, hence, that the only indirect impacts of the project will arise from local expenditures of project payrolls (Chalmers and Anderson, 1977). An exception to this treatment frequently occurs, however, when purchases of a particular type of input are expected to be quite large (for example, purchases of electricity by a synthetic fuel plant). In these cases, the input supply facility may be treated as a linked industry,[27] in which case its expected employment would be added to the basic employment created by the project (Denver Research Institute, 1979). The prospect of <u>linked industry</u> development must be considered on the output side as well. For example, synthetic fuel plants might give rise to fertilizer manufacturing facilities utilizing by-product ammonia. Specific feasibility studies may be required to determine the likelihood that such forward-linked industry will develop in the impact area.

The description of project characteristics also should include a compilation of major resource requirements (such as land required for the plant site or for mining and water required for cooling and other plant operations). This information can be utilized to estimate impacts on other basic industries such as agriculture (Dalsted et al, 1976; Whittlesey, 1978).

Information concerning project characteristics can be derived from several sources. Interviews with officials of the company or agency developing the project are the most frequent source of such information, particularly for project-specific assessments. Analyses which involve a wider region and/or a longer time frame may require that information from developers be supplemented with data from secondary sources. Government and industry publications which provide compilations of development plans may be consulted (U.S. Department of the Interior, 1978; U.S. Department of Energy, 1978; Nielson, 1978), but information from these sources should be cross-checked with that available from local planning officials and industry representatives. Federal and state agencies which have responsibility for permitting or licensing new projects can be a valuable source of information concerning those projects which are scheduled for development in the near future. When specific information regarding the work force requirements and other characteristics of a new project is not available from the developer, secondary sources may be consulted. For example, estimates of manpower requirements for several types of energy facilities are found in Stenehjem and Metzger (1976), while manpower and material requirements for similar types of facilities have been estimated by Stanford Research Institute (1975). Data from such sources also can be used as a check on information obtained from developers.

Delineation of the Study Area

An important decision in any impact assessment is the identification of the study area. Two general considerations affect this choice. First, the study area should approximate an economically self-contained region, as defined by established trade patterns (Chalmers and Anderson, 1977). Second, the definition of the study area should allow detailed analyses of the jurisdictions which will be most seriously impacted by the project (Denver Research Institute, 1979). In order to achieve both of these objectives, some analysts define two impact areas: (1) a regional impact area which approximates a functional economic area or the trade area of a regional wholesale-retail center (Berry, 1973) and (2) a local impact area which includes those jurisdictions where most of the direct employment and population effects of the project will be experienced (Chalmers and Anderson, 1977).[28] When the study area is thus defined at two levels, the usual approach is to provide a summary of economic effects for the regional impact area and more detailed analyses for individual jurisdictions within the local impact area.

The regional impact area is typically defined on the basis of information from secondary sources which identifies regional economic relationships and the trade areas of various centers. BEA Economic Areas (U.S. Department of Commerce, 1977) are sometimes used as the regional impact area. State planning districts or Council of Governments areas provide an alternative basis for defining the regional impact area (Murdock et al, 1979; Hertsgaard et al, 1978; Leholm et al, 1976b).

The local impact area is generally defined in terms of the anticipated residential patterns of in-migrating workers. While the analysis of these settlement patterns is typically qualitative (Berkey et al, 1977), many analysts define the local impact area to include all counties containing communities from which a significant number of construction or permanent workers would commute daily (Chalmers and Anderson, 1977). Data availability usually requires that the local impact area be defined along county lines although it is possible to use census county division or enumeration district boundaries.

In sparsely populated regions where the market area of the wholesale-retail trade centers are quite extensive, the regional impact area will typically be much larger than the local impact area. In more densely settled regions of the country, less difference will exist in the geographic boundaries of the two areas, and in some cases the two areas may coincide.

Baseline Projections

Baseline projections are estimates of the socioeconomic conditions likely to prevail in the impact area if the proposed project is not developed. The first step in developing baseline economic projections for an area is to project the levels of activity for each basic industry over the course of the projection period. These activity levels may be measured in terms of employment, income, output, or sales to final demand with the choice depending on the economic impact assessment technique which is employed. The length of the projection period is frequently determined by the specific planning or assessment guidelines under which the study is being conducted or by specific characteristics of the proposed project (Chalmers and Anderson, 1977).

The economic impact technique which is employed most frequently is the export base employment multiplier (Berkey et al, 1977) technique. When this technique is used, economic trends in the basic sectors are measured by employment. The basis for projecting basic employment is to assess the profitability and growth potential of each industry. Location theory concepts discussed earlier provide a framework to guide this evaluation. Key sources of information include industry experts (for example, persons within the local industry and research economists employed by public and private organizations), state and local planning organizations, and federal agencies. Projections of employment by industry at the national level can be valuable in evaluating those industries whose market is national and can provide insights regarding market forces and productivity trends.[29] Recent employment trends of the various industries in the area also provide some guidance but the analyst should not rely on simple extrapolation of past trends to the exclusion of other procedures and information sources. After projections of basic employment for the area have been developed, the economic base multiplier is applied to the projected basic employment to estimate total employment.

The estimates of employment under baseline conditions are frequently used as the basis for projecting changes in area income and population. Income projections are usually developed by first estimating the average annual wage and salary levels for basic and nonbasic workers. This wage and salary figure may then be adjusted through time using productivity factors.[30] Total wage and salary payments are projected by applying these adjusted wage and salary levels to the projections of basic and nonbasic employment. Other components of personal income (for example, proprietors' income and transfer payments) are then estimated as a function, usually a constant percentage, of wage and salary income. Population effects are typically estimated through the use of assumptions regarding local labor force participation rates and worker demographic characteristics. When local employment requirements exceed the locally available labor force, in-migration is assumed to occur. This topic is discussed in considerable detail in Chapters 3 and 7.

When the export base income multiplier technique is utilized, the projections of basic sector activity are developed in terms of income. The key considerations in projecting basic income are similar to those discussed with respect to basic employment. An additional problem in developing income projections is that it is frequently difficult to obtain reliable data on nonwage income and even more difficult to allocate this type of income into basic and nonbasic components. Once baseline projections of basic income have been developed, the income multiplier is applied to estimate nonbasic income. These income projections may then be used as the basis for employment estimates (by first applying a nonwage income adjustment and then using projected salary levels for basic and nonbasic workers to convert income to employment).

When input-output techniques are utilized, baseline projections of sales to final demand by the various sectors are required. Developing baseline projections of sales to final demand is a challenging task. Many of the considerations outlined earlier with respect to projecting basic employment apply, however. The number of final demand components for which projections are required will differ depending on the specific model structure. National forecasts of rates of growth in output or final demand of various industries can be useful inputs into the regional forecasting process as can the historic performance of the region's major industries. Detailed analyses of the export prospects of the region's individual industries can be valuable if available to the analyst.[31]

Once the final demand projections have been completed, the input-output interdependence coefficients are applied to estimate output by sector for the target years. Projected ratios of output per worker are then frequently applied to develop estimates of future employment for each sector (industry). A further refinement which is sometimes employed is to multiply the vector of employment by industry by a matrix containing the projected occupational distribution in each industry to obtain estimates of employment by occupation for future years.[32]

One of the conclusions that may be reached in the course of projecting the future of the basic sectors is that there are many factors which contribute to uncertainty. A variety of alternative assumptions about the future of certain sectors may appear plausible. Thus, it is often necessary to recognize that there are several possible futures for the area and that more than one baseline projection may be appropriate. In such cases, as many sets of basic sector projections as appear desirable can be constructed, and baseline economic assessments can be carried out for each. It will still be necessary, however, to ultimately choose one of these alternative baselines as the most likely future to which the impacts of the project will be compared.[33]

While some impact assessment efforts have included development of detailed baseline projections for both regional and local impact areas, many assessment reports have drawn their baseline projections exclusively from existing studies (Berkey et al, 1977). This practice may be appropriate if state or regional planning agencies or other groups have recently completed such forecasts and at times may seem necessary in order to conserve project resources. Projections from secondary sources should be carefully evaluated, however, to ensure that their assumptions are appropriate in light of current conditions.

Impact Projections

The purpose of economic impact projections is to estimate the effects of a project on selected economic variables in the affected area. While a number of economic indicators may be considered, those which are most frequently used are employment, income, and output. As noted earlier, it is important that these economic variables be projected in temporal and geographic dimensions which are meaningful to decision makers and that the economic projections be developed in sufficient detail to support subsequent demographic and fiscal analyses.

Secondary economic effects are most frequently estimated using the employment multiplier technique (Berkey, et al, 1977).[34] A variety of approaches are used in estimating employment multipliers, with the most frequent being the assumption method and the location quotient technique (Denver Research Institute, 1979). Income multipliers have been used in a number of studies (Polzin, 1974; TERA Corporation, 1976; Chalmers and Anderson, 1977). Input-output analysis has been employed in a few project-specific assessments (Adcock et al, 1975; Collin et al, 1973; Leholm et al, 1976a,b; Toman et al, 1976) but has been more frequently utilized in regional assessment studies (Roesler et al, 1968; Isard et al, 1976; U.S. Department of the Interior and State of North Dakota, 1978; Auger et al, 1976; Sherafat et al, 1978; Gray et al, 1977) and as a tool for state policy development (Maki et al, 1977).

The types of information reported differ considerably between studies. Estimates of total secondary employment are reported most frequently, often on an annual basis. Changes in income are reported less frequently while only a few studies, usually those utilizing input-output techniques, have reported employment by industry or occupation.

An important issue in evaluating impacts of large projects is how to account for the differences which may exist in multiplier effects between construction and operational periods and, more generally, for the time which may be required for complete economic adjustment to occur. According to Berkey and associates (1977), very few of the environmental assessment reports completed during the mid-1970's for energy development projects considered these timing questions. More recently, however, their importance has been generally recognized (Denver Research Institute, 1979; Mountain West Research, Inc., 1977; Murdock and Leistritz, 1979).

The basic considerations in estimating the timing of secondary economic effects include the following: (1) temporary construction workers may have a lower propensity to consume locally than long-term residents, (2) local businessmen may be unable to immediately expand to meet growing demand and may consider expansion beyond a capacity appropriate to satisfy the level of demand expected during the operational period to be unwise, (3) rapid population growth associated with the project may lead to substantial construction of new housing and public and private facilities which may result in a rapid but short-term growth in secondary employment (sometimes called the accelerator effect), and (4) because the multiplier process involves spending and respending of income, some time is inherently required for full adjustment to occur.[35]

A number of different techniques have been employed to deal with timing effects in impact assessments. Some analysts have examined the proportion of the project work force that is estimated to be in-migrants and assumed that a smaller percentage of these workers' income is spent locally (Mountain West Research, Inc., 1979), thus reducing the magnitude of secondary effects during construction periods. A second approach which is sometimes used in conjunction with the first involves the concept of a ceiling to nonbasic employment growth (Mountain West Research, Inc., 1979). The basis of this concept is that the local trade and service sector will not expand during the construction phase beyond that level of employment which can be sustained during the postconstruction period.[36] A third approach uses a smaller employment multiplier during the construction phase but does not compare the secondary employment levels of the two phases (Briscoe, Maphis, Murray, Lamont, Inc., 1978; Murphy Williams Consultants, Inc., 1978). A fourth approach involves applying a lag factor to all changes in nonbasic employment. Alternative formulations of the lag factor include the following: (1) a three-year lag with one-third of the total estimated employment change occurring each year (Denver Research Institute, 1979); (2) a four-year lag with 71 percent of estimated employment occurring in the first year, 17 percent in the second, percent in the third, and 4 percent in the fourth (Stenehjem and Metzger, 1976); and (3) a quarterly income lag model with respending in each quarter amounting to 59 percent of that in the preceding quarter (TERA Corporation, 1976). The accelerator effect has been incorporated into at least two impact modeling systems (Auger et al, 1976; Denver Research Institute, 1979). The coefficients utilized are acknowledged to be somewhat judgmental, however.

The geographic distribution of secondary economic effects has received less attention than their timing. Within local impact areas, secondary effects are generally assumed to occur in the same community where the direct project workers reside. While differences in the magnitude of multipliers between local and regional impact areas indicate that some secondary effects occur outside the local impact area, few analysts have attempted to estimate the distribution of these effects among jurisdictions. At least three different techniques have been employed to estimate the geographic distribution of secondary effects. Chalmers and his associates (1977) integrated central place concepts into an income multiplier framework to estimate the distribution of secondary income effects among counties in a regional impact area. The RED1 and RED2 models employ the gravity model technique to distribute secondary effects among communities in local and regional impact areas (Leistritz et al, 1979). The third approach, developed by Stenehjem and Metzger (1976), involves use of a linear programming model to allocate workers to places of residence on the basis of commuting distance, housing availability and budget constraints. As is the case for the timing of secondary effects, however, scarcity of data indicating the actual geographic and temporal distribution of secondary effects in rapid growth areas has severely limited attempts to test and refine such models.

The effects of a new project on other basic sectors have been examined in only a few studies (Whittlesey, 1978; Dalsted et al, 1976). The RED1 and RED2 models provide an example of an attempt to explicitly account for such effects. In these models the land used for plant sites, land mined, and land used for residential, transportation, and related purposes is assumed to be removed from agricultural production (Leistritz et al, 1979). The reduction in acreage is translated into a reduction in sales to final demand by the agricultural sectors (assuming that the land taken has an agricultural productivity equal to the average for the regional impact area). The estimated changes in employment, income, and other economic variables are thus net changes (that is, increases resulting from industrial expansion less decreases resulting from reduced agricultural production).

In summary, economic impact analysts have employed a variety of techniques in conducting their studies. A chronological comparison of impact assessments suggests that techniques are becoming more sophisticated and that analysts are giving more attention to simulating the timing of economic effects. Impact assessments have been limited, however, in two major respects. First, many studies have not utilized the more advanced techniques that are available. In fact, some studies have not even considered secondary effects, and many have been limited in their economic evaluation to the estimation of aggregate secondary employment effects. Second, the effort to develop more adequate impact assessment models has been constrained by a scarcity of data reflecting the actual effects of rapid growth in rural areas. Impact studies to date, then, have been more productive in generating hypotheses than in developing verified estimates of key relationships. Future analyses should focus both on synthesizing more comprehensive impact assessment systems and on empirical testing of existing models and relationships.

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

In evaluating the efficacy of alternative techniques for assessing the economic impacts of repository development, the considerations discussed in earlier sections appear to be applicable to repositories as well as to other types of major projects. An additional consideration in the case of repositories, however, is the need for an assessment methodology which not only has the capability of providing detailed impact estimates and displaying sensitivity to differences in project and site area characteristics but also is readily transferable to numerous candidate sites which may be located in several different states. The economic ramifications of the special effects of a nuclear repository are difficult to evaluate in a quantitative manner because they will depend at least as much on residents' perceptions of the hazards associated with the facility as on the objective features of facility design. In the remainder of this section, we will first examine the nature of the special economic effects which may be associated with repository development. Then the implications of economic impact assessment methodology which arise from requirements for transferability will be briefly examined.

Special Economic Effects

The special effects associated with nuclear repository development arise in large measure from the hazardous and long-lived nature of the waste materials and from the fact that the characteristics of these materials, and of the nuclear fuel cycle generally, are relatively unfamiliar to the general public (Willrich and Lester, 1977). The repository and supporting transportation and materials handling facilities are to be designed to minimize the potential for release of hazardous materials (U.S. Department of Energy, 1980). Estimates of the risks associated with these facilities have indicated that these risks are quite low compared to many which are commonly experienced. The public, however, appears to perceive the outcomes which would be associated with a major nuclear waste mishap (potentially severe) to be more important than the estimated probability (very small) of such an event (Hebert et al, 1978). Thus, it appears that the nature and extent of special economic effects of a nuclear repository will be determined at least as much by the perceptions of local residents and the public in general concerning the facility and its associated hazards as by the details of the facility's design and associated objective measures of risk.

After being fully informed about the nature of the facility and the safeguards which have been established to minimize its dangers, they may conclude that the relevant hazards are no more serious than those associated with many industrial or resource development projects. In that case, the special economic effects of the project would likely be minimal. On the other hand, if the facility is perceived to pose a substantial and continuing threat, a number of economic effects may be experienced.

A major potential economic effect is the influence of the project on other basic sectors of the local economy. Land acquisition for the project will lead to restriction of all other activities in an area of about 2,000 acres and to restriction of mining and drilling in a buffer zone of about 8,000 acres (Cluett et al, 1979). Depending on current land use, this could result in displacement of some basic activities such as agriculture or forestry. The likely effects, however, would be relatively minor and would also be readily measurable. Moreover, these effects would not be dissimilar in either nature or magnitude from those associated with large energy resource development projects (Murdock and Leistritz, 1979).

Potentially more serious, however, are the less direct effects of the project on the area's basic economic sectors such as recreation and tourism. If the facility is perceived as a threat, many visitors may cease to patronize local recreational facilities and tourist-oriented establishments. The area could, for example, become much less attractive as a site for residential or second home development with a corresponding decrease in land values.

Development of a repository in a given area also could have the effect of forestalling other types of resource or industrial development. Restrictions on mining or drilling in the immediate site area would, of course, preclude certain types of development activity, but this effect should be negligible as one of the site selection criteria is to avoid areas known to contain valuable minerals (U.S. Department of Energy, 1980). Of greater concern from the standpoint of long-term community development is the possibility that location of a repository in an area will act to discourage new plants or other facilities from locating there, perhaps because of potential difficulty in recruiting workers. Likewise, investment in the local trade and service sectors may be discouraged if the repository is perceived as a negative influence on the area's long-term growth prospects.

Any discussion of the special economic effects of a repository facility is necessarily very speculative. While a variety of possible effects can be identified, the extent to which they will be realized depends both on the physical and environmental characteristics of the site area and on the future course of public perception and attitudes. The extent to which the project will impinge on other basic activities will depend on the present status and potential of the area with respect to those activities. Furthermore, once the repository development is underway, area residents may come to accept it as an established local feature with hazards no greater than those associated with many other developments. Such apparently has been the case for most nuclear power plants and federal experimental facilities, at least until recently. For example, Gamble and associates (1979) report that development of nuclear power plants has had a positive influence on local property values in the Northeastern United States. While recent public opinion surveys suggest that nuclear repositories are regarded as a significant environmental enmity (Maynard et al, 1976), it is possible that they will in time become accepted as a normal feature of our society and of the areas where they are located.

Methodological Considerations

When choosing among alternative techniques for economic impact assessment, it is important to consider both the nature and detail of information provided by alternative approaches and the data collection and analysis costs associated with implementing each. In the context of nuclear repository siting, it appears that the magnitude of impacts may differ considerably among potential sites and also may be quite substantial at some sites (U.S. Department of Energy, 1980). Thus, the technique chosen should be one which is sensitive to differences in site area characteristics and which provides detailed and reliable impact estimates. At the same time, because the methodology may be applied at several sites in different parts of the country, its requirements for local data, and particularly primary data, must not be so extensive that the costs of implementation are unreasonable.

As discussed earlier, economic impact assessment techniques differ substantially in both output characteristics and data requirements. In selecting an approach to be used in the repository siting program, it appears that the primary data input-output approach must be avoided because of its very extensive data requirements and associated costs. At the same time, the aggregate export base employment multiplier approach appears likely to be unacceptable because it does not provide sufficiently detailed impact information. In developing a socioeconomic impact assessment methodology for repository siting, therefore, attention should be focused on three "compromise techniques" which can provide relatively detailed impact information but which can be implemented in a given area within a reasonable time frame and cost. Three approaches appear to meet these criteria:

1. Secondary data I-O models
2. Intersectoral flows models
3. Export base income multipliers.

These techniques again represent a range of capabilities and costs. The secondary data I-O approach provides all the capabilities assocaited with primary data I-O, provided that reliable interdependence coefficients can be estimated from secondary sources. The intersectoral flows model provides less complete impact information (that is, detailed employment projections are provided but output and income effects must be approximated indirectly), and its requirements for local data, while less than those for primary I-O, are still extensive. The income multiplier approach provides no disaggregation of economic effects among sectors, but it can be implemented in a relatively short period using secondary data almost exclusively. In developing the repository siting methodology, it presently appears that the secondary data I-O approach will be the best choice as the principal economic impact assessment technique. The income multiplier approach, however, also will be examined and may be useful as an alternative approach in situations where time and resource limitations preclude the use of an I-O model.

SUMMARY AND CONCLUSIONS

The purpose of this chapter was to review the conceptual bases and methodological alternatives for economic impact assessment, to describe the features of the impact process which influence the information needs of decision makers, and to examine the techniques which are typically applied in impact assessments for large projects and to examine the implications of these methodologies for repository sites. The export base (or economic base) theory is the basis for all economic impact assessments. Location theory and central place concepts also are important in some aspects of impact analysis. The principal methodological alternatives for economic impact assessment include various forms of export base employment or income multiplier models and input-output models. Multiregional models also may be applicable in some situations.

When large projects are located in rural areas, growth may be quite rapid. Because labor requirements may fluctuate both within and between development phases, impacts are likely to be cyclical with employment and incomes increasing rapidly during the project construction period and decreasing somewhat once construction is completed. A substantial decrease in the area's economic activity may later occur when the operational life of the project has ended. The rapid rate at which economic and associated demographic and fiscal changes may occur and the possibility of substantial differences in these effects among individual jurisdictions indicates a need for economic impact assessments to include substantial emphasis on the timing and distribution of impacts. Impact projections also should be presented in a form which allows comparison of future conditions if the project is developed with those likely to prevail if the project were not developed. Finally, impact assessment techniques should allow decision makers to cope effectively with the uncertainties frequently associated with major projects.

The techniques which have been employed in most impact assessments appear rather simplistic. In some cases secondary employment and other indirect economic effects have not even been addressed. In others, impact projections developed using one set of techniques have been compared with baseline projections developed using considerably different approaches and incorporating assumptions which may be invalidated by recent events. Impact assessment practices have emphasized use of the simplest assessment techniques, particularly aggregate employment multipliers, despite their acknowledged limitations. Given the needs of decision makers in impacted areas, it appears that greater attention should be given to assessing the distribution of impacts over time, among jurisdictions and among population groups. Models which take account of interproject differences in salary levels and input purchasing patterns and which provide disaggregated impact projections probably should be utilized more extensively. While data requirements have limited the use of some of these techniques, particularly input-output models, other modeling forms (such as disaggregated employment multipliers and intersectoral flows models) appear to offer substantially greater analytical power with only moderate increases in data requirements.

Economic impact assessment has been limited in another important respect, however. The information base concerning the effects of rapid economic and population growth in rural areas is simply insufficient to allow adequate assessment of many impact dimensions. More extensive longitudinal and comparative analyses of areas experiencing such growth are essential if the quality of impact assessments is to be improved. In summary, then, improving the quality of impact assessments appears to require both more extensive utilization of the more sophisticated analytical systems and greater efforts to determine the nature of actual development effects in order to more accurately calibrate these models. With such improvements, the assessment of the economic impacts of repositories and other large-scale developments will improve substantially.

NOTES

1. It should be noted that, while the techniques of economic impact analysis are most frequently applied in cases where a new project is contemplated, these techniques are also adaptable to the case of reduction or elimination of an enterprise.
2. The volume of literature in this area is large. A comprehensive bibliography, current to 1960, is contained in Isard (1960).
3. In particular, see Richardson (1978), Levan (1956), Tiebout (1962), Garnick (1970), Isard (1960), and Tweeten and Brinkman (1976).
4. Import substitution is the process by which an area develops the capability of producing internally goods and services which formerly were imported.
5. It should also be noted, however, that diseconomies may be associated with high levels of urban concentration. Congestion, air quality degradation, and higher costs for providing certain public services may result from increasing levels of urban concentration and may be reflected in increased tax rates and labor costs for firms in these locations (Tweeten and Brinkman, 1976).
6. An example of the application of location theory principles to the evaluation of linked industry prospects is provided by Gilmore et al (1976). The industrial complex analysis approach developed by Isard (1960) provides an example of the integration of location theory and interindustry economics.
7. The original development of central place theory came primarily from the work of Christaller (1933) and Losch (1940). Subsequent contributions have come from Berry and Garrison (1958), Dacey (1966), Berry (1967), Beckman and McPherson (1970), and Parr et al (1975).
8. For examples of empirical efforts to classify trade and service centers, see Borchert and Adams (1963), Berry (1967), and Voelker et al (1978).
9. For examples of attempts to empirically implement such models, see Chalmers et al (1977) and Bender and Coltrane (1975).
10. A third estimation approach may be feasible if data are available for several time periods. This approach utilizes regression analysis to estimate the coefficients of the equation:

$$E_t = a + bE_b + u$$

Where: b is the multiplier estimate
a is a constant
u is a stochastic disturbance term
E_t and E_b are as previously defined.

This estimation technique is generally considered to be more reliable than the other two but also imposes greater data requirements (Weiss and Gooding, 1968; Pfister, 1976).

11. The proportion of an industry's employment to be assigned to the basic sector is calculated as follows:

$$E_{irb} = E_{ir} \ (LQ_i - 1)/(LQ_i)$$

Where: E_{irb} = basic employment in industry i
E_{ir} and LQ_i are as previously defined.

Thus, for example, if $E_{ir} = 100$ and $LQ_i = 1.6$, 37.5 percent of the employees in sector i would be assigned to the basic sector:

$$E_{irb} = 100 \ (1.6 - 1)/(1.6) = 100 \ (.6)/(1.6) = 37.5.$$

12. This tendency for planners to focus on employment effects and multipliers may not be entirely desirable. For example, some sectors may have substantial income effects but only modest employment effects (Scott and Braschler, 1975). Both effects should be considered in development planning.
13. Examples of the use of income multipliers include studies by Polzin (1974), Scott and Braschler (1975), and Chalmers and Anderson (1977).
14. This section draws heavily on the work of Richardson (1972), Miernyk (1965), and Isard (1960). Pioneering works in input-output analysis include Leontief (1936), Leontief (1941), Evans and Hoffenburg (1952), Chenery (1953), Isard and Kuenne (1953), and Dorfman (1954). Good summaries can be found in Miernyk (1973) and Glickman (1977),

15. For a detailed discussion of the technical and interdependence coefficients and their interpretation, see Miernyk (1965), Doeksen and Schriner (1974), or McKusick et al (1978).
16. For further discussion of input-output multipliers and the details of their calculation, see Miernyk (1965) and Doeksen and Schreiner (1974).
17. For a detailed discussion of the procedures involved in developing input-output coefficients from primary data, see Richardson (1972).
18. For a discussion of the variety of techniques available, see Richardson (1972, Chapter 6). Examples of more recent efforts in this area include Boisvert and Bills (1976) and Mulkey and Hite (1979).
19. For an example of the use of location quotients to develop I-O coefficients for sub-State areas, see Andrews et al (1979).
20. One source of projections of changes in national I-O coefficients is the INFORUM Model. For a detailed discussion of the structure of this model and the procedures used in projecting changes in technical coefficients, see Almon et al (1974).
21. The approaches developed by Hamilton et al (1969) have been incorporated into a number of regional models. For example, see Minshall et al (1974), Carlson and Doll (1976), Battelle (1977), San Diego Comprehensive Planning Organization (1977), and Monts and Bareiss (1979).
22. For example, see Evans and Klein (1968) and McCarthy (1972).
23. For a thorough discussion of this topic, see Glickman (1977, Chapter 2).
24. The terms "interregional model" and "multiregional model" are often used interchangeably. On the other hand, a distinction is sometimes made. In such cases the term "interregional model" refers to the situation where the regions in the model exhaust the system (for example, the components of the national economy), and "multiregional" to a model incorporating any group of interdependent regions, often forming part of the national economy (Richardson, 1972).
25. Another multiregional modeling system which may be of interest to some analysts is MULTIREGION. This model, developed at Oak Ridge National Laboratory, provides employment and population at five-year intervals for 173 BEA economic areas (Olsen et al, 1977). Because the projections are available only at five-year intervals and only

for multicounty areas, however, this model is not described in detail here.

26. Another factor which could contribute to the apparent lag in secondary employment response in some areas is the existence of excess capacity in the local trade and service sectors. That is, existing firms may be able to accommodate substantial increasing business volume before additional hiring or facility expansion is required.
27. Linked industry can be defined as those economic activities which in some cases may be, but in all cases theoretically could be, vertically integrated into the primary resource development project (Denver Research Institute, 1979).
28. Examples of this approach are provided by Booz, Allen, Hamilton, Inc. (1974), Dalsted et al (1976), and U.S. Department of the Interior and State of North Dakota (1978).
29. As discussed previously, a number of national and nationally linked state econometric models have been developed in recent years. Projections developed from these models can be a useful source of insights concerning national trends and their regional implications.
30. For an example of this procedure, see Denver Research Institute (1979).
31. For a detailed discussion of procedures for developing regional forecasts of sales to final demand, see Richardson (1972, Chapter 9).
32. For an example of this approach, see Drake et al (1973).
33. Development of realistic baseline economic projections also requires that changes in the structure of the local economy be taken into account. As service employment apparently is becoming a larger part of the employment mix in many rural areas (Bender, 1980), this factor should be given careful consideration in developing baseline (and impact) projections.
34. It is interesting to note, however, that a survey of Environmental Assessment Reports for energy facility construction projects indicated that the majority did not address secondary employment effects (Berkey et al, 1977).
35. Also, as mentioned previously, excess capacity may exist in the local trade and service sectors, and this could substantially affect the magnitude and timing of secondary employment effects. Comparison

of local output/employment ratios with those for a larger area such as the state or nation provides one method of detecting the existence of excess capacity.

36. This approach also is incorporated in the RED1 Model (Hertsgaard et al, 1978) and the TAMS Model (Murdock et al, 1979).

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CHAPTER 3

DEMOGRAPHIC IMPACT ASSESSMENT

Assessment of the demographic impacts of resource developments represents one of the most important steps in the socioeconomic assessment process. Determining the number and the characteristics of people moving to each geographical entity in the impact area is essential for assessing other population-related impacts such as public service demands, fiscal impacts, and social impacts. In fact, to many planners and decision makers the magnitude of population impacts is synonymous with the magnitude of all impacts. Assessing the size, distribution, and composition of project-related populations is thus of utmost importance and is the major topic of concern in the present chapter. As in the preceding chapter, the discussion first examines conceptual and methodological alternatives in demographic impact assessment, then examines policy and impact process-related factors affecting the choice of alternative methodologies. It then examines the methodologies presently employed in impact assessments and examines the implications of such techniques for repository siting.

CONCEPTUAL BASES AND METHODOLOGICAL ALTERNATIVES IN DEMOGRAPHIC IMPACT ASSESSMENT

The conceptual and methodological alternatives for projecting population change are widely known and numerous excellent works describing specific projection alternatives are available (Shryock and Siegel, 1973; Bogue, 1974; Pittenger, 1976; Morrison, 1971; Irwin, 1977). As a result, our discussion of these techniques will be more limited than discussions in other chapters.

Definition, Distinctions, and Principles

Foremost among the distinctions usually made by demographers in determining population change are those made between population estimates, population projections, and population forecasts. Population estimates refer to population data obtained for periods which fall between dates for which actual population counts are available, such as estimates for 1975 obtained by using

1970 and 1980 census data, or determinations of population for dates that are only a few years past the last population count and for which data on actual counts could hypothetically have been obtained. In other words, estimates refer to data obtained on population levels for past or present periods for which population census data are not available. Estimation procedures do not provide data on future population levels and are thus not applicable to impact assessments that must determine future levels of population. Estimation techniques are thus not examined here. (For an examination of these techniques, see Morrison, 1971.)

Projections, on the other hand, refer to determinations of future population levels. They consist of projections of the future levels of population that will exist in an area if certain sets of assumptions prove to be valid. Thus, projections of the 1990 population for the Western United States, assuming 1970-1980 fertility, mortality, and migration levels continue from 1980 to 1990, would be an example of a population projection. Such projections will be correct if the assumptions on which they are based are correct, and thus they consist of little more than the tracing of the logical consequences of a set of assumptions.

A population forecast also refers to a determination of future population levels. Unlike a projection, however, the term "forecast" has a connotation of certainty, of correctness, of judgment that most demographers wish to avoid. As many scholars point out, this distinction is often recognized only by demographers (Keyfitz, 1972), and the terms forecast and projection are used interchangeably in discussions of demographic assessments.

Whatever the term used, however, it is clear that any projection, estimate, or forecast is likely to vary in accuracy in accordance with the characteristics of the projection area and the projection technique. Shryock and Siegel (1973: 728-729) note several general principles which bear on the accuracy of projections. Perhaps the most important of these is that any projection is only as accurate as the assumptions on which it is based and will only be correct if its assumptions are correct. The assumptions underlying the projections must be critically examined. In addition, they note that population projections are generally more accurate if performed:

(1) For an entire nation or large geographic region than for a small component area or subregion

(2) For total populations than for subpopulations or population subgroups

(3) With data directly related to population change (births, deaths and migration data) rather than using data that provide indirect or symptomatic indicators of population change (automobile registration, housing counts and so on)

(4) For shorter rather than longer periods of time

(5) For areas in which past trends are more likely to continue than new patterns to emerge

(6) For areas undergoing slow rather than rapid change.

As will soon become evident, in areas such as those undergoing rapid change due to resource developments, few of the above factors operate to increase projection accuracy. It is essential, however, to keep each of these distinctions in mind in the evaluation of alternative procedures.

Alternative Techniques

There are numerous alternatives for classifying population projection techniques (Shryock and Siegel, 1975; Morrison, 1971; Pittenger, 1976; Irwin, 1977; Barclay, 1958), but one of the most useful classification schemes is that presented by Irwin (1977). He suggests that projection techniques can be divided into the following types:

(1) Extrapolative, Curve Fitting, and Regression-Based Techniques

(2) Ratio-Based Techniques

(3) Land Use Techniques

(4) Economic-Based Techniques

(5) Cohort Component Techniques.

Although the computational procedures utilized for each of these methods differ, as described below, the rationale and conceptual bases for choosing one or the other of these techniques appear to lie in the factors of data availability, the desire for detail in demographic outputs, and the desire to simulate demographic processes.

Of the five techniques noted previously, the cohort component requires the largest input of data. Data are required on fertility rates, mortality rates, and migration rates, both for present and future periods. The other techniques tend to concentrate on the projection of total populations; thus, detailed data on demographic processes are not required. The data requirements of these techniques then are often less demanding than those for component techniques.

As with other projection processes, however, a lack of detail in inputs also leads to the inability to obtain detailed outputs. Because the cohort component technique usually involves the use of data for specific age-sex groupings (cohorts), its outputs contain a greater degree of detail on demographic structure than is true for other procedures. When detailed data on demographic structure, such as age and sex, are deemed necessary and the necessary input data are available, cohort component techniques are usually selected for use.

Conceptually also, the major distinctions are between cohort component techniques and other projection procedures. Noncomponent techniques tend to use either direct projections of total population or symptomatic indicators of population, such as employment levels, to project population. To many demographic analysts, noncomponent approaches are seen as less acceptable than component techniques because they ignore the basic demographic processes that are known to determine population size--fertility, mortality, and migration. Simulating these processes as a way of determining population should provide more accurate assessments and ones in which the roles of the various processes are more clearly understood. Although there is little indication that cohort component processes are more accurate than noncomponent techniques in actual projections (Ascher, 1978; Bjornstad et al, 1975; Isserman, 1977; Morrison, 1977), their ability to provide detailed age structure data and potential for simulating demographic processes, and hence potential to provide more accurate projections once the effects of the components are correctly understood, has led to their predominant use in demographic projections and in many impact assessments.

In fact, however, the selection of techniques for use in assessments has been too restrictive, and each of the five sets of techniques cited above are appropriate for some aspects of impact assessments and should be given more careful consideration by impact researchers. Each is discussed briefly below.

Extrapolation Techniques

Extrapolation techniques include a wide range of procedures which attempt to predict the path of future population growth on the basis of past trends in total population growth. Included among such techniques are: (1) arithmetic and exponential growth rate techniques, (2) curve fitting techniques including those utilizing polynomial, Gompertz, and logistic curves, and (3) regression-based techniques (linear as well as nonlinear). Basic to all such techniques is the tendency to project only total population size with the use of assumed levels, rates, or trends in growth over time.

The simplest techniques are clearly the arithmetic techniques. These consist of simply taking a level of numerical growth, usually based on past patterns and assuming that it will continue for some period of time. Computationally, this can be expressed as:

$$(P_2 = P_1 + (P_0 - P_1) \qquad (3.1)$$

Where: P_2 = population for projected period

P_1 = population for baseline period

$P_0 - P_1$ = numerical change for known period from P_0 to P_1.

For projections for very short periods of time, this technique may be quite useful. For longer periods, particularly for areas that may show dramatic population changes, such as resource development areas, this technique is likely to be less acceptable.

Slightly more complicated are those procedures involved in exponential projection techniques. These involve using rates of annual or continuous growth. The most basic of these derivations is similar to the compound interest formula used in basic accounting. The formulas for annual and continuous compounding are:

$$\text{Annual} = P_2 = P_1 (1 + r)^t \qquad (3.2)$$

$$\text{Continuous} = P_2 = P_1 e^{rt} \qquad (3.3)$$

Where: P_2 and P_1 are as in Equation 3.1

r = rate of growth per unit of time (t)

t = time period

e = natural log value.

The effect of using this procedure is that population from each previous period of growth (defined by t) is added to the base population before the next period of growth (annually or continuously) is computed. The basic rate used in this procedure is nearly as easy to obtain as the values for arithmetic estimates of change. Given population growth for two known consecutive time periods, the rate of growth can be determined by the following formula in which natural logarithms are used to reduce the tedious nature of the necessary calculations.

$$r = \frac{\text{Log} \dfrac{P_1}{P_0}}{t \text{ Log } e} \qquad (3.4)$$

Where: r = rate of growth for the time period from P_0 to P_1

P_1 = population of the areas at the last formal population count

P_0 = population of area at point preceding P_1

t = number of units of time (usually single years)

e = natural log value.

Determination of the value of t is often done with the value of P_2 set at twice the value of P_1. This provides an assessment of the time necessary to double (the doubling time of) an area's population.

In general, exponential techniques are superior to arithmetic procedures but are still heavily dependent on assumptions about past rates of growth continuing in the future. For projections for short time frames and for areas with relative socioeconomic stability, exponential techniques deserve careful consideration.

Polynomial growth techniques might also be used. They form the basis for many of the curve fitting techniques and, thus, require brief discussion. They involve patterns or trends which, unlike arithmetic techniques, form curves that when graphed are nonlinear in form. Thus, whereas a linear model would be of the form

$$y = A + Bx \qquad (3.5)$$

a polynomial would include one or more additional terms, such as:

$$y = A + Bx + Cx^2 \; . \; . \; . \; Zx^2 \qquad (3.6)$$

and would form a curve rather than a straight line.

Although one might find a given polynomial formula that accurately described the growth of a particular area's population over a given period, such a curve would be unlikely to describe future patterns. Such techniques are seldom used to project population. However, their conceptual and computational procedures form the general basis on which the more generalized curve fitting techniques described below are based.

Among the more generalized curve fitting techniques are the Gompertz and logistic curves which became popular in the work of Pearl and others in the 1920's and 1930's. Each of these two techniques produces a curve that is asymptotic. Thus, both produce an s-shaped curve over time. However, whereas the Gompertz curve is somewhat skewed, the logistic curve provides a smoother curve more closely resembling a normal curve. The formulas for these curves are:

$$\text{Gompertz Curve} = P_2 = KP_1^{r^t} \tag{3.7}$$

$$\text{Logistic Curve} = P2 = \frac{K}{1 + e^{P} + rt} \tag{3.8}$$

Where: P_2 = population for projected period

P_1 = population for baseline period

K = upper asymptote

r = growth rate per unit of time

t = time period over which growth occur.

Although these curves have provided relatively accurate predictions of population for several periods (Ascher, 1978), they are not widely used in present-day projection procedures.

More commonly used are regression-based techniques in which the relationship of various factors to population growth are known and used to predict future population levels. These techniques require establishing a set of factors or independent variables that accurately predict population levels for some past period and assuming that the past relationships between these predictor or independent variables and population levels will persist in the future. Given projections of the future values of the predictor variables, one can then predict future population levels. The nature of the independent-dependent variable relationships are generally assumed to be linear in form, meaning that a straight line jointly determined by the values of the independent variables will predict the rate of change in the dependent variable, population, with a minimum of error. This straight line relationship is referred to as a linear relationship and can be determined computationally in simple and multiple regression forms by the following formulas:

$$\text{Simple regression:} \quad Y = A + B_1X_1 \tag{3.9}$$

$$\text{Multiple regression:} \quad Y = A + B_1X_1 + B_2X_2 + \ldots B_nX_n \tag{3.10}$$

Where: Y = dependent variable

A = origin value

B = slope or amount of change in per unit of change in a given X (X_1, X_2 ... etc.)

X = independent variables.

Projections of population using these formulas may employ such independent variables as size of labor force, income, wage levels, vital rates (births, deaths, and migration), population density, or similar factors as predictor variables. Values for such variables for the future or past periods may be used. If, for example, one had established that in 1980 the relationships between past population levels (1970), per capita income and labor force size were as follows:

$$Y = A + 1.2X_1 + 0.15X_2 + 2.0X_3 \tag{3.11}$$

Where: A = 400

X_1 = 1970 population = 1000

X_2 = 1980 per capita income = \$8,000

X_3 = 1980 labor force size = 600

Y = 1980 population = 4000

one could project 1990 population in the area given 1980 population, projections of 1990 per capita income and 1990 labor force size. If the 1990 projection of per capita income was \$12,000 and the 1990 projection of labor force size was 1200, the Y in 1990 (projected population in 1990) would be:

$$Y_{1990} = 400 + 1.2\ (4000) + 0.15\ (12{,}000) + 2.0\ (1200)$$

$$Y_{1990} = 400 + 4800 + 1800 = 2400$$

$$Y_{1900} = 9400.$$

Regression-based techniques have been widely used for population estimates for periods after the last population count by the Bureau of the Census in methodologies termed ratio correlation techniques (discussed below). Their use is less desirable for projections, however, because they require data on the predictor variables and projections of each predictor variable for the future projection period. In addition, they require assuming that the historical relationships between the independent variables and population (the $B_1 - B_n$ values) will persist throughout the projection period. The assumption of the relationship between predictor variables and the dependent variable being linear may also be problematic. Nonlinear techniques (Isard, 1960) can also be used, but the difficulty in identifying the correct nonlinear relationship to use over future time periods remains a major hindrance to the application of nonlinear techniques.

Whatever the specific form of the extrapolation techniques used, their advantages lie in the fact that they use historical data that are relatively easy to obtain to make projections and consist of generally easy-to-complete computational forms. On the other hand, the dependence on past patterns can also be a major source of error in rapidly changing (impacted) areas. In addition, in some techniques such as the regression-based techniques, data needs, particularly the projections of predictor variables needed to determine future populations, may place considerable data collection demands on the research analyst. Finally, these techniques seldom provide sufficient detail on the demographic characteristics that may be essential for public service and other planning needs. For such methods, then, the data needs can vary from little more than total population figures for two past censuses (arithmetic or exponential techniques) to data on multiple variables for past and future time periods (multiple regression-based methods). These methods may provide adequate short-term projections for past periods and for populations whose compositions are unlikely to alter rapidly over time. These methods, however, should be used carefully and with full knowledge of their limitations.

Ratio-Based Techniques

Ratio techniques consist of procedures in which the population of a subarea is projected on the basis of its proportion of a larger area's projected population. In general, the ratio techniques are subarea techniques that are used in conjunction with other projection procedures. They are frequently used in allocating regional or county populations to municipalities (Murdock et al, 1979; U.S. Census, 1953).

Although the proportion or ratio of the subarea's population to the larger area's population may be assumed to remain constant over time, it is more common to trend the ratio over time (Pickard, 1967).[1] The trends in shares are usually determined by either an extrapolation of baseline patterns or by a regression or similar procedure. When regression techniques are used with the subarea's share serving as the independent variables, the technique is often termed the ratio correlation technique.

Ratio techniques are most widely used in projecting population for subareas of cities and municipal populations from county or regional totals. Their utility as a major projection technique is clearly limited, but their use in subarea analysis is likely to remain extensive.

The advantages of such techniques lie in their relatively limited data requirements and simple computational procedures. Potential disadvantages stem from the need to assume a given ratio or trend in ratios of subarea to area populations over time and from the lack of demographic detail provided by the outputs of such procedures.

Land-Use Techniques

Irwin (1977) delineates two separate types of land-use approaches; these include what he terms: (1) the "saturation" approach in which population projections for an area are limited by the number of housing units that can be built in an area and (2) density methods in which limits are placed on the population in an area on the basis of predetermined levels of population per unit of area. Both techniques are most often used in projections of subarea populations in urban areas (Portland State University, 1975; Genesee-Finger Lakes, 1971; Newling, 1968; Greenberg et al, 1978) and, in such projections, as part of a more comprehensive projection system. As such, these techniques are similar to the ratio techniques in that they are seldom used except as part of more comprehensive procedures.

The "saturation" method is normally used by assuming a standard number of housing units per unit of area and then computing population on the basis of an average number of persons per unit. Among the problems with this method are the determination of the upper limit for housing units per unit of area and the need to obtain recent average household size estimates. For many local areas, for example, the failure to take into account the relatively rapid decline in average persons per household has resulted in inflated population estimates.

The density method may be particularly useful for projecting subarea populations within urban areas undergoing rapid growth. In such areas, extrapolation of past trends may quickly lead to unreasonable population levels. Controls on subarea population levels are essential.

Land-use models are often problematic for use in rural areas because land use is seldom a major limitation on population growth, but land-use considerations should be considered within any impact projection. The advantages of these methods are clearly their utility in limiting the rate of growth in component areas to feasible levels while their disadvantages lie in the difficulty encountered in determining the density limits for housing units for an area and in the lack of demographic detail produced by such procedures. Particularly for rural areas that are not geographically confined, growth limits may be extremely difficult to determine. On the other hand, in some rural areas, topographic features or land ownership by the federal or state government may limit the potential geographical expansion of a jurisdiction (city). In such cases, land-use models may be applicable. In sum, although past use of land-use models has been generally restricted to large urban areas, their possible use in impact assessments for rural areas should be given serious consideration as a potential addition to more widely used techniques.

Economic-Based Techniques

Economic-based techniques, as the name implies, project population on the basis of assumed relationships between economic patterns and population change. As the name also suggests, they tend to be the techniques for population projection most widely used by economists. They have been widely used in the OBERS (Bureau of Economic Analysis, 1974) and National Planning Association (Lee and Hong, 1972) national economic models and are particularly attractive when population growth in an area is expected to result largely from economic development. In addition, as will soon become apparent, they have received widespread use in impact assessments.

The basic methodology of such projections involves using an economic model to determine employment changes and then using either a direct or an indirect method to determine either total population change or the level of change within a key demographic component (usually migration) resulting from the project employment. In the simplest procedure, projections of population are determined by applying a population to employment ratio to the projection of employment. This technique, however, relies on some very simple assumptions. In particular, the assumption of a constant number of persons per employee is often questionable because of the wide variation in dependency rates for rural areas. This technique is, thus, receiving less and less use as a means of population projection.

A more widely used procedure is to match the economic projections of labor demand with projections of labor supply to determine migration levels. In this mode of use, an economic-based technique is usually used in conjunction with a cohort technique (cohort survival technique) that is used to project all but the migration component of the population dimension. Labor supply is usually determined by applying total, age or age-sex specific labor force participation rates to population projections (total, age, or age-sex specific). Labor demand is then matched with labor supply to determine migrating workers. If the labor supply exceeds demand, then workers out-migrate, while if the supply is insufficient to meet demand, then workers are assumed to in-migrate. In-migrating or out-migrating workers are then converted to population estimates by the application of various assumed demographic profiles for migrating workers. In specific application, however, each of the major steps of:

(1) Projecting labor demands over time,
(2) Projecting labor supplies over time,
(3) Matching labor supplies and labor demands,
(4) Determining levels of migration, and
(5) Projecting total population changes accompanying the migration requires a detailed set of procedures and extensive sets of assumptions.

Each of these steps for standard models is briefly reviewed below.

The projection of labor demands is described in detail in the preceding chapter but, in general, an input/output model, an export base model, or some form of shift share analysis is used to project labor demands resulting from economic activity. These techniques are all derived from the basic/nonbasic distinction of theoretical economics and are subject to numerous assumptions about the expected level of given activities required in an area. In general, a national or regional level of activity is taken as a standard, and the growth of the local economy and labor force is assumed to follow the national or regional area's patterns. Given these assumptions, projections of change in employment or productivity over time made via regression or other techniques are used as the basis for projecting economic trends and resulting employment.

The projection of labor supplies usually involves the projection of at least two major dimensions: (1) a baseline or closed population to serve as the base to which employment levels must be applied and (2) the expected levels of labor force participation of persons in the closed population over time. The baseline population is often simply the last population count of persons adjusted for mortality and fertility changes since that count. The levels of labor force participation assumed for the projection period are the key part of this technique, and, if they are in error, the level of migration predicted will be in error. In general, the rates assumed to prevail over time are allowed to vary over time. For local areas, these trends over time are often tied to national projections of labor force participation rates published by the U.S. Bureau of the Census and the Bureau of Labor Statistics. This patterning of local to national rates may be done by calculating a ratio of local to national rates at a known (census) period and then assuming this ratio will be maintained over time or by altering the ratio in a prescribed manner over time. The fixed or projected ratios for each period are then applied to the projections of national participation rates to obtain local rates for use in projecting employed population. This technique can be used with total population labor force participation rates or can be made characteristic specific (that is, age specific or age-sex specific labor force participation rates). Whatever technique is used, however, the participation rate when applied to the baseline or closed population value becomes the major determinant of labor supply. This supply is usually further adjusted by the local level of unemployment or underemployment before being matched with labor demands.

The matching of labor demands and labor supply may involve relatively simple or highly complex procedures. That is, both labor demands and supplies may involve one type of demand and supply or several. In a procedure developed by Hertsgaard et al (1978) and Murdock et al (1979), for example, at least five separate types of demand and supply are used, and supplies are examined with age and sex detail. Whatever the level of complexity, however, the key assumption is that demands that cannot be met by the local population will be met by in-migration while excess supplies will lead to out-migration. A large body of research in economics points to a general relationship between employment and migration (Sjaastad, 1962; Lowry, 1966), but there is some evidence that this relationship is weaker and less pervasive now than at previous periods, and that employment changes are more directly related to in-migration than to out-migration (Greenwood, 1975; Shaw, 1975; Ritchey, 1976).

In recognition of the fact that not all migration behavior is economically motivated, the determination of the level of migration resulting from the matching of labor supplies and demands is often altered by incorporating noneconomic procedures or by adjusting the basic matching or interfacing procedure. For example the OBERS projections maintain three separate population groups: those under 15 years of age, those 15 to 64 years of age, and those 65 years of age and over. Only the under-15 and 15-to-64 age groups' levels of migration are determined by the employment-matching procedure. The age group 65 years of age and older is projected largely on the basis of past trends with little regard for employment patterns. In other procedures, some populations, such as those at military installations, colleges, and universities are treated in "special population" procedures and are exempted from employment matching routines. Finally, some techniques have been developed which allow the labor supply area to exceed labor demands or demands to exceed supplies by predetermined rates, before out-migration or in-migration occurs (Hertsgaard et al, 1978). In sum, then, the step of determining the level of migration resulting from labor market changes has come to use techniques that are increasingly complex and increasingly sensitive to differences in demographic composition.

Given that the matching procedure has been completed and the number of migrating (in- or out-migrating) workers determined, the last step is to convert projections of migrating workers into projections of population. This usually involves simply applying a set of assumed worker-related population characteristics to the projections of the number of in-migrating workers. Though simple computationally, the characteristics assumed for workers (such as family size, dependent characteristics, etc.) will markedly affect the levels of population projected. As with the use of data on average size of households or other similar characteristics in projections, determination of characteristics to be assumed for in-migrating workers must be a careful process.

Economic-based techniques are becoming increasingly popular and are evolving rapidly (American Statistical Association, 1977). Their advantages lie in the fact that, unlike many purely demographic techniques, economic-based techniques allow the economic changes expected to take place in a developing area to be taken into account. Thus, they represent important attempts to integrate factors that are clearly interrelated.

Their weaknesses must also be recognized, however. The number of assumptions on which such projections are based is large. In general, the population projections resulting from these techniques are based on assumptions about economic trends and about the relationships between such trends and population trends. Accurate projections of both economic and demographic factors and their interrelationships are required by such techniques. Since the errors made in assumptions for basic factors at the beginning of such computational procedures may be magnified as the computations proceed (Alonso, 1968), such a large number of sequentially linked assumptions may be problematic. In addition, the data requirements of such models are often extensive. Data on economic and demographic trends such as labor force participation rates, family size, and many other dimensions must be obtained for the projection period. Finally, because they have been developed recently, these techniques have received even less validation than other procedures (see Chapter 8), and it is unclear whether such techniques provide more or less accurate population projections than demographic techniques alone (Kendall, 1977). Economic-based techniques represent an important set of techniques that are worthy of concerted attention but which also require additional analytical verification.

Cohort Component Techniques

Cohort component projection techniques are perhaps the most widely used techniques for determining future population levels. They are often seen as the most complex and sophisticated of the purely demographic techniques and are usually preferred by professional demographers because they involve the direct simulation of the demographic processes of fertility, mortality, and migration that produce changes in population size.

As the name implies, the basic characteristics of these techniques are the use of separate cohorts, persons with one or more common characteristics (usually similar ages, that is, persons born during the same period), and the separate projection of each of the major components of population change--fertility, mortality, and migration--for each of these cohorts. These projections of components for each cohort are then combined in the familiar "demographic bookkeeping equation" (Barclay, 1958; Bogue, 1974) as follows:

$$P_{x+t} = P_x + B_{x+t} - D_{x+t} + M_{x+t} \tag{3.12}$$

Where: P_{x+t} is the population projected at some future date t years hence

P_x is the population at the base year from which the projection starts

B_{x+t} is the number of births that occur during the interval t

D_{x+t} is the number of deaths that occur during the interval t

M_{x+t} is the amount of net migration that takes place during the interval t.

When several cohorts are used, P_{x+t} may be seen as:

$$\overset{Px}{P_{x+t}} = \sum_{i=1}^{n} P_{ci,x+t} \tag{3.13}$$

Where: P_{x+t} is as in Equation 3.12

$P_{ci,\ x+t}$ = population of a given cohort at time x + t and

$$P_{ci,x+t} = P_{ci,x} + B_{ci,x+t} - D_{ci,x+t} + M_{ci,x+t} \tag{3.14}$$

Where: all terms are as in Equation 3.12 but are specific to given cohorts ci.

In general, single-year or five-year age-sex cohorts are used in conjunction with age and sex specific survival rates, fertility rates, and migration rates. The technique is seldom used for geographic areas smaller than counties because of the difficulty of obtaining birth, death, and migration data for areas smaller than counties and because of the widely known problems of applying rates (or percentages) to small population bases (Irwin, 1977). Whatever the geographical level of analysis, however, there are four key steps in the procedure. These are:

(1) The selection of a baseline set of cohorts for the area of study;

(2) The determination of appropriate baseline migration, mortality, and fertility measures for each cohort for the projection period;

(3) The determination of the method for projecting trends in fertility, mortality, and migration rates over the projection period; and

(4) The selection of a computational procedure for applying the rate [from (3)] to the cohorts over the projection period.

Each of these four steps involves consideration of numerous alternatives that are discussed briefly below.

Selection of Baseline Cohorts

The selection of baseline cohorts is usually done by selecting data from the last population census. The data so selected are age and sex cohorts in single or five-year age groups. Of all the data requirements, the baseline cohort data required for the procedure is the most readily available. In addition, the major adjustments to such baseline data that may be necessary (in addition to those noted later) are relatively simple, such as the adjustment of cohort counts for census undercounts.[2]

Determination of Appropriate Baseline Measures

The selection of the appropriate migration, fertility and mortality rates to be used in the projection is the key step in the projection process. The accuracy of the assumptions about these rates and their trends over time (described below) will determine the accuracy of the projections. The selection of these rates involves numerous considerations.

Determination of Mortality Rates

Mortality levels are generally the least problematic to discern because of the ready availability of data on mortality and the relatively slow rate of change in mortality levels over time (at least in developed areas of the world). Life tables for states and other areas are published periodically (for example, see National Center for Health Statistics, 1975), and generally state-level rates can be assumed to be applicable to local areas without biasing the results of the analysis. Given a life table, the mortality measure most often used in the age-sex specific survival rate is one which indicates the probability of persons of a given age living from period (x) to the next (x + t). So considered, the survival rates for any age group can be computed from the number of survivors column of the life table with the following formula:

$$S_{x,x+t} = \frac{L_{x+t}}{L_x} \qquad (3.15)$$

Where: $S_{x,\, x+t}$ = probability of a member of a cohort surviving from the time period x to x + t

L_{x+t} = number of persons in the cohort alive at the end of the period, x + t

L_x = number of persons in the cohort alive at the beginning of the period, x.

These rates are computed for each cohort including the beginning cohort consisting of persons born during the projection period from x to x + t and for persons at the end of their life cycles (for a description of the special procedures necessary to compute survival rates for beginning and end of life cohorts, see Irwin, 1977). The rates so obtained are applied to age and sex cohorts in order to age or survive them to the next projection period. As with the choice of cohorts, either single- or five-year survival rates can be computed.

An alternative to life table-derived survival rates are national census survival rates. As the name indicates, these rates are computed from census data at the national level. National level data are used in order to control for the confounding of mortality and migration factors. Thus, when national data are used, the effect of migration on age groups can be assumed to be negligible because in-migration is a very small percentage of total national population change. To compute these rates, age groups at two consecutive censuses are examined in the following computational form:

$$S_{x,x+t} = \frac{P_{x+t}}{P_x} \qquad (3.16)$$

Where: $S_{x,\,x+t}$ is as in Equation 3.15

P_{x+t} = Population in a given cohort at the second census period

P_x = Population in a given cohort at the first census.

The problem with this method is that the national rates computed are less likely than rates derived from state life tables to reflect local conditions and hence these rates are generally used only when life tables are not available that are applicable for an area.

Determination of Fertility Rates

The methods for determining fertility levels fall into three general categories. These are (1) period-fertility measures, (2) cohort-fertility measures, and (3) marriage-parity-interval progression measures (Shryock and Siegel, 1973).

Period-fertility measures are among the most often used measures of fertility in projections. They involve the use of rates showing the number of births likely to occur to a group of women during the projection period. The rates used most often indicate the number of births per female in the reproductive age groups of the population (usually defined as those women 15 to 44 years of age) and are termed General Fertility Rates (GFR's) and computed as follows:

$$GFR = \frac{B_t}{FP_{t\ 15-44}} \tag{3.17}$$

Where: GFR = general fertility rate

B_t = births during projection period t

$FP_{t\ 15-44}$ = fertility population age 15 to 44 years of age during projection period t.

They may also be made specific to given cohorts (single or five-year cohorts). In such cases they are termed Age-Specific Fertility Rates (ASFR's) and computed as follows:

$$ASFR_i = \frac{{}_iB_t}{{}_iFP_t} \tag{3.18}$$

Where: $ASFR_i$ = age specific fertility rates for females in age group (cohort) i

${}_iB_t$ = births to women in age group i during projection period t

${}_iFP_t$ = female population of age group i during projection period t.

To compute these measures, data are obtained on births (for GFR's) or births by age of mother (for ASFR's) from state health and vital statistics departments or the National Center for Health Statistics and on populations from recent population census. Normally the average number of births for three years centering on a year for which there either was a population count or for which acceptable population figures are available are used. For example, to compute the ASFR for women 15 to 19 in 1980, the following formula would be applied:

$$ASFR_{15-19} = \frac{({}_{15-19}B_{1979} + {}_{15-19}B_{1980} + {}_{15-19}B_{1981})/3}{{}_{15-19}FP_{1980}} \tag{3.19}$$

Where: all values are as in Equation 3.18 but are for women 15 to 19 years of age.

Equation 3.19 thus involves taking the average of the number of births to women 15 to 19 years of age occurring over a three-year period and dividing that average by the number of women 15 to 19 years of age. The use of an average of three years of births is employed in order to reduce the chance of obtaining a numerator that is nonrepresentative of the actual number of births to such age groups. This is essential because of the relatively wide fluctuations in the number of births that occur from year to year in some populations. Such rates are computed for each age group (15 to 44 years of age) given data on births by residence and age of mother and data on the number of females in each age group.

The distinctive characteristics of these rates are that they are rates computed at a given point in time (as for 1980 as shown in Equation 3.19). They do not take into account the fact that the time period covered by a set of projections will involve the fertility experiences of women as they age over the projection period. Rather, these period measures are based on the experience of women at different ages at one point in time.

Cohort-fertility measures attempt to overcome the limitation noted above for period measures by attempting to simulate a set of rates that will characterize the actual experiences of a cohort of women as they age through the life cycle. The most used form for simulating these experiences is to choose a set of Age-Specific Fertility Rates (ASFRS) that would result in the average female giving birth to a given number of children by the completion of her reproductive years. Among the "targeted" values often chosen is the level of 2.1 births per female. This number of births is termed the "replacement level of fertility" and is that number of births necessary for the women in a population to replace themselves and their mates taking into account (the .1) that some women will die or not produce children during their reproductive lifetimes. These targeted levels of cohort fertility are the sum of a set of ASFR's for women in each of the reproductive cohorts. This sum (such as the 2.1 noted above) is termed the Total Fertility Rate (TFR) and is denoted by:

$$\text{TFR} = \sum_{i=1}^{n} (\text{ASFR}_i) \qquad (3.20)$$

Where: TFR = total fertility rate

ASFR_i = age specific fertility rate for each cohort i.

The advantage of using such sets of rates is that they allow one to think in terms of family size and other similar concepts that are familiar to a wide range of persons who may use the projections. Although they are often based on the experiences of actual cohorts of women that have completed their child-bearing years, the obvious disadvantage of using these rates is the difficulty encountered in choosing the set of rates that will correctly characterize the experiences of future cohorts of women.

Marriage-parity-interval progression measures refer to the use of sets of sequential probability measures that take into account the probability that women with different marital statuses and completed family sizes will give birth to another child during the projection period. Although this and similar techniques may be more widely used in the future (Pittenger, 1976) and the technique is presently used in some of the U.S. Bureau of the Census Projections (U.S. Bureau of the Census, 1979), it is a relatively complex procedure with extensive data requirements (on women by marital status, age and parity, births by parity, and so on). Marriage-parity-interval-progression procedures have received relatively little use in local area projections and will not be discussed in further detail here. They are, however, worthy of further examination (see Shryock and Siegel, 1973: 789-790) and their use may become more prevalent as the availability of detailed local area data increases.

However fertility rates are determined, the goal at the end of this step of the cohort-component procedure is to have determined a set of fertility rates for each female cohort that can be used to determine the number of births occurring in the population during the projection period. These procedures, then, are ones aimed at providing the Bx + t function in the bookkeeping equation.

Determination of Migration Rates

For local area projections, migration levels are clearly the most difficult demographic processes to predict and the most difficult to obtain current data for when cohort specific values are required. The difficulty is further increased by the fact that migration may involve two different forms with the opposite effects on population change. These are in-migration and out-migration. Any time an area changes from a predominance of one of these patterns to the other (thus changing the M_{x+t} part of Equation 3.12 from a positive to a negative or from a negative to a positive value), the increased potential for error in the projections is evident. Projections of migration are usually the major area of contention in population projections.

Methods for projecting this dimension generally fall into two broad categories: (1) net migration projection procedures and (2) gross migration procedures. Whereas net migration procedures attempt only to discern the net difference between the levels of in- and out-migration in an area, gross migration procedures project in- and out-migration separately.

Net migration procedures usually involve projecting migration using what are termed residual methods. The formula for the residual method of migration is in fact the bookkeeping equation solved for M_{x+t} component or:

$$M_{x+t} = P_{x+t} - P_x - B_{x+t} + D_{x+t} \qquad (3.21)$$

Where: values are as in Equation 3.12.

When these rates are computed for each cohort the equation becomes:

$$_{ci}M_{x+t} = {}_{ci}P_{x+t} - {}_{ci}P_x - {}_{ci}B_{x+t} + {}_{ci}D_{x+t} \qquad (3.22)$$

Where: values are as in Equation 3.14.

In this Equation 3.22 a comparison is made between the number of persons who have survived to the end of the period, x + t, and those who at the end of the period are t years older than at time x. Thus, if ten-year rates were being computed for 1980 for the age group 25 to 29, one would adjust the age group 15 to 19 in 1970 for deaths between 1970 and 1980. These rates can be computed given data on populations by age at two census counts, deaths by age and births (for beginning cohorts) between the two census counts. In addition, useful compilations of such data for past periods have been made available by five-year age and sex cohorts for all counties in the United States by Bowles et al (1965, 1975).

The logic of the residual method does in fact underlie one complete form of population projection developed by Hamilton and Perry (1962). They propose that one simple way to project total populations or cohort populations from one census to another is to compute fertility levels and then to use a residual method to jointly compute the effects of migration and mortality. Their formulation for projecting a cohort from 1980 to 1990 for example would involve the formula:

$$\frac{P^{90}_{x} - P^{80}_{x}}{P^{80}_{x-10} \quad P^{70}_{x-10}} \tag{3.23}$$

Where: P^{90}_{x} = population in age group x in 1990

P^{80}_{x-10} = population in age group x-10 in 1980

P^{80}_{x} = population in age group x in 1980

P^{70}_{x-10} = population in age group x-10 in 1970.

To project P^{90}_{x} the formula then becomes:

$$P^{90}_{x} = \frac{P^{80}_{x-10} * P^{80}_{x}}{P^{70}_{x-10}} \tag{3.24}$$

The ratio shown in Equation 3.23 is thus being assumed (Equation 3.24) to continue for the next projection period. Although this ratio confounds changes resulting from migration with those resulting from mortality, it does provide an appropriate technique for use when the data necessary to separate migration and mortality are not available. It thus provides an alternative method that may be useful in some circumstances.

Gross migration measures are less often used in projections but are somewhat more attractive conceptually because they simulate the behavior of actual individuals. Whereas in-migration and out-migration represent actions of actual individuals, net migration does not, in fact, occur but is rather a statistical creation resulting from a comparison of in- and out-migration. The difficulty with the use of gross migration measures is that the necessary data to determine them are often not available for local areas or when made available are likely to be extremely dated (U.S. Bureau of the Census, 1977). When appropriate data are available, the major mode of projection involves projecting out-migration for each area, usually on the basis of past patterns, and then projecting the pool of out-migrants as in-migrants to each area on the basis of past trends in the ratio of in-migrants in the local area to total in-migrants (Shryock and Siegal, 1973; Irwin, 1977). These methods are not often used below the multiregion level, but clearly require careful consideration.

Although additional procedures for projecting local area migration levels have been suggested (Pittenger, 1974), those discussed here are the main procedures presently in use. Each method places a heavy reliance on the use of assumptions based on past patterns, and unlike mortality or fertility patterns where some theoretical limits can be set, for migration the range of possible values and the reasons for change in direction from in to out or out to in-migration are not well understood.

Methods for Projecting Rates Over Time

Given that a baseline set of mortality, fertility and migration rates has been established, the third major step involves developing procedures for projecting the trends in these rates over time. There are three widely used procedures: (1) continuation of baseline rates, (2) use of targeted rates, and (3) trending of local area rates to the patterns of regional, national, or other "standard" area rates.

Continuation of rates determined for the baseline period may be preferable in many instances, particularly if the area is large, is not changing rapidly, and the projection is for only a short period in the future. For long-term projections, however, and particularly for areas undergoing rapid development, such assumptions are seldom warranted. Increasingly, then, projections using continuations of past trends, particularly when used for relatively small rural areas, are being questioned and used only when projections based on alternative assumptions are also used.

The use of targeted rates for specific periods of targeted levels of change in rates over specific periods are more frequently employed. In using these procedures baseline rates are assumed to reach predetermined rates by certain points in the projection period. Thus, the U.S. Bureau of the Census has historically used rates of fertility that are trended over time to reach a given level (2.1, 2.5, etc. levels of TRF's) by a specific year (U.S. Bureau of the Census, 1979) and have also often used targeted rates for migration, such as assuming in-migration will be negligible by a certain point in time (U.S. Bureau of the Census, 1977).

The choice of rates using this procedure is usually tied to a conceptual perspective on population, such as stable population theory (a stable population being one with a fixed level of births and deaths per year), or to assumptions that local area rates will converge toward those of a larger area, such as the state or the nation. The rates chosen, then, are the targeted levels that will result in a given stable population or that characterize a large area to which local area rates will converge.

As should be evident, this procedure is also dependent on a number of assumptions and requires the analyst to make projections of long-term trends in each of the vital rates and about the time period necessary for an area to reach a given level of fertility, migration, and mortality. The task involved is clearly a difficult one.

The third approach is really a form of the other two in that it involves choosing a standard area after which local rates can be patterned. However, its widespread use requires that it be given special emphasis in this discussion.

In this third approach, the trending of local rates on the basis of larger area rates, the analyst (1) selects a standard population to which to relate the local area, (2) determines the ratio or relationship of the local area rate to the standard population rate, and (3) assumes that the local rate will either maintain a constant ratio or relationship to the standard population rate or changed in a fixed manner over the projection period. Using this procedure, the analyst can make widespread use of projections made by various agencies and groups. Thus, the work of the U.S. Census Bureau on projecting long-term national trends in fertility, mortality, and migration have been used as the "standard" in many local area projections (Tarver and Black, 1966; Murdock and Ostenson, 1976; Hertsgaard et al, 1978). As with the first two procedures discussed, the utility of this technique is dependent on the correctness of the analyst's assumptions about long-term trends in vital rates and about the comparability of local rates to those for other areas. It shares the disadvantages and limitations of the other techniques but provides the researcher with the possibility of using the work of analysts from agencies whose long-term projections and data bases may be superior to his own.

Each of these three techniques for projecting trends in rates over time requires the use of assumptions that are often quite "heroic" in nature, given demographers' present ability to predict mortality, fertility, and migration phenomena. However these trends are projected over time, the population expert should be the first to view his assumptions with skepticism.

Selection of Computational Procedures

Although all cohort component procedures compute their final population values on the basis of the general summation procedure shown in Equation 3.12, several aspects of these procedures require brief consideration. It should be made evident, for example, that few analysts using the cohort component technique feel confident enough of their assumptions about vital rates to suggest that a single set of assumptions will be correct for all areas and periods. As a result, cohort component projections will generally involve making several sets of alternative computations with different assumed rates resulting in several alternative projection series.

In addition, a number of other considerations must be addressed. These considerations relate to adjustments required during the computations and may be most efficiently examined by presenting a standard set of steps used for deriving the values denoted in Equation 3.12. Although a number of analysts provide step-by-step instructions for doing cohort-component procedures (Irwin, 1977; Morrison, 1971; Pittenger, 1976; Barclay, 1958; Tarver and Black, 1966; Shryock and Siegel, 1973; Bogue, 1974), the steps delineated below appear to be the most useful for purposes of our discussion. These steps are:

(1) Adjust the baseline population cohorts for the correct time periods and spatial referents.

(2) Adjust rates of migration, fertility, and mortality making sure that all rates are:

- (a) based on consistent population bases,
- (b) adjusted to consistent time, place, and cohort factors and
- (c) specific to the characteristic details desired in the projections.

(3) Survive baseline population to the end of the population period.

(4) Add or subtract migrants from the baseline population.

(5) Add births to initial cohorts of the baseline population in accordance with sex ratios at birth.

(6) Sum cohorts as desired to obtain total population.

(7) Adjust sum of populations for subareas to population totals for the larger area.

Each of these steps entails adjustments that must be briefly mentioned.

In step one, it is essential to ensure that all data are made consistent in terms of time and place referents. That is, all population values should be adjusted for similar time frames. Population censuses, for example, are for populations as of April 1 of the census years. These figures should either be adjusted to be consistent with the periods for which other data are available, such as calendar years, or other data should be adjusted to be applicable to April 1 of the year. Whatever geographical unit has been chosen for analysis all data must be adjusted to that unit whether by appropriate allocations or other procedures. It is particularly important to make sure that constant boundaries are assumed across time and have been taken into account in any historic data used. Special attention should be given to such factors in urban areas where boundary changes are frequent.

It is essential also in this initial step to consider what provisions, if any, should be made for "special populations". These are populations that are unlikely to be exposed to the same set of demographic processes as the remainder of the population and include such groups as college and university populations, military base populations, Native American populations, and institutional populations. In general, such populations are treated in one of two ways.

One commonly used procedure is simply to separate them from the cohort component procedure and project their total levels for each projection period. For special populations in which the population totals vary little from period to period, in which the age distributions are concentrated, and for which integration with the rest of the population is limited (such as military bases and college populations), this may be an adequate way to project the influence of such groups. For other groups, their distinct demographic rates may be such and their distributions across age groups extensive enough to merit a second procedure -- the development of separate fertility, mortality, and migration rates and the use of separate cohort procedures. For example, Native American populations often have higher mortality and fertility rates than other populations and may merit such attention. In any case, it is in this initial step of determining baseline cohorts that special populations must be designated.

Step two notes that the rates for each component must also be adjusted. These adjustments include not only the same time and place adjustments as for total population bases but also those for cohorts. Whatever the level of detail for which projections are desired--age, sex, ethnicity, and so on--appropriate rates must be developed for each detailed characteristic. In addition, rates must be made consistent with the period of the projection and the size of cohorts. That is, if the projection period is one year and single-year cohorts are to be used, rates must be single year, not five- or ten-year rates, and must be for single-years of age. Pittenger (1976) among others provides readily useable formulas for preparing adjustments of rates to appropriate periods, and Irwin (1977) provides excellent examples of adjusting cohorts to be temporally and areally specific.

Two similar concerns also relate to steps three, four, and five. One of these is the need to adjust the baseline populations to which projected rates are to be applied. For example, if a five-year projection cycle is being used, with five-year age and sex cohorts, parts of at least two different cohorts will be involved in each projection cycle. For example, if the age group of males 15 to 19 in 1980 is to be projected to 1985, the five-year rates should be applied to an average number of persons that are 15-19 during the 1980-1985 period. This will in fact include different parts of different cohorts being exposed to rates for 15 to 19-year olds for different lengths of time. Fifteen-year olds in 1980 will be exposed to the rates for all five years (1980-1984), but 16-year olds will experience such rates for only four years, 17-year olds for only three years, and so on. On the other hand, those 14 years old in 1980 will experience the 15-19-year old rates for four years, those 13 will experience these rates for three years, etc. To adjust these cohorts, an "adjacent cohort" technique (Irwin, 1977) is thus necessary in which an average of the two cohorts is used as the base for projections. These adjustments should occur to all cohorts before component rates are applied. Secondly, it should also be noted in step five that the births produced by adjusted sets of female cohorts must be allocated to each initial sex distribution. This is usually done by taking data on sex ratios at birth, available from most state vital statistics departments, and applying them to the total number of births.

Finally, step seven points out the need to ensure that if relatively large areas with multiple subareas are to be projected, some attempt to control the sum of local area totals to the total of the larger area must be made. If this is not done, the summation of subarea migrants or births may exceed those that are reasonable for the larger area (see Irwin, 1977 and Pittenger, 1976 for further discussion of this problem).

Although the adjustments noted in the seven computational steps are all relatively minor, their omission can lead to serious errors in computations. The computations as well as the assumptions underlying the cohort component procedure may thus be quite complex. Fortunately, however, a number of readily available computer programs for performing such projections are available (Bogue, 1974; U.S. Bureau of the Census, 1976).

Cohort-component procedures are among the most developed techniques available for population projections. Their advantages lie in their ability to simulate demographic processes and in the age, sex, and other detail they provide in outputs. Their disadvantages are equally evident. They have extensive data requirements and rely on a relatively large number of assumptions about each of the major components. Their utility for making projections is thus dependent on their judicious use and the long-term development of an understanding of basic demographic processes.

Conclusions Concerning Projection Alternatives

Each of the major methods discussed, from the extrapolative to the cohort component techniques, provides procedures that are useful under particular sets of circumstances. As such, each represents a set of procedures that may be applicable for making projections of the demographic impacts resulting from resource developments, particularly for making projections of baseline conditions. The choice of the best method under any given set of circumstances will depend on a number of factors that are relatively unique to a given time and place. Data availability, the length of the projection period, and the form of outputs desired are among the key factors. As shall soon be made evident, however, many factors related to impact events and policy considerations must also be considered. Overall, a wide range of potential tools for projecting population are available, but the ones that can be employed under any given set of circumstances are often much more severely restricted.

FACTORS AFFECTING DEMOGRAPHIC IMPACT ASSESSMENTS

The choice of which of the methodologies described above should be used in performing a given impact assessment is affected by a number of factors related to the nature of impact events and the needs of policy makers in impact situations. The purpose of this section is to describe some of those factors that must be considered in the choice of a projection methodology that affect the use of impact projections, and that must be taken into account in the simulation of impact events.

Among those factors that affect demographic impacts and the choice of impact assessment methodologies are several of those noted earlier--the characteristics of the project, the characteristics of the project site area, and the characteristics of in-migrating workers (Murdock and Leistritz, 1979). Thus, such project characteristics as: (1) plant location, (2) direct project employment, (3) indirect/direct worker ratios, (4) length of project phases (construction and operation), (5) levels of local hiring, and (6) the developer's employment policies will all affect the magnitude and distribution of project impacts.

Projects located close to relatively populous areas with large employment bases are likely to draw more of their workers from the local area and are less likely to require the in-migration of new workers. The direct employment requirements of the project obviously play a major role in determining population impacts with projects with larger employment demands leading to higher levels of in-migration and population growth. In addition, projects that lead to higher levels of associated or service employment (indirect or induced employment) will have greater impacts on population growth. At the same time the timing of project phases, specifically the length of the construction and operational phases, will affect the patterns of population change. Thus, in most cases population trends in resource developments follow the trends in employment patterns with project-related population peaking during construction periods and then declining and eventually reaching a relatively stable level during the operational period. Finally, the extent to which local existing residents are hired for project-related employment and the developer's policies toward such hiring will affect population growth. That is, if more local residents are hired, fewer in-migrants will be required to fill project-related employment. Company policies toward training locals may thus have marked effects on the number of locals employed by a facility.

The characteristics of the project site may also affect population growth and its distribution within impacted areas. Among these characteristics (Murdock et al, 1980) are: (1) local labor force skills and availability, (2) the number and characteristics of possible settlement sites and (3) local communities' growth preferences. Clearly the level of local hiring referred to above will, in large part, be a function of the availability of locals for project employment and the skill levels of the population of the local area. The more persons available for project employment and the more compatible their skill levels with those skills required--directly or indirectly--as a result of the project, the fewer in-migrants will be required. At the same time, the number of alternative settlement sites and the characteristics of these sites, particularly their ability to absorb population growth, will affect both relative population impacts for given sites and the distribution of new population between sites. Impact regions with a relatively large number of communities with well-developed service bases will experience less dramatic concentrations of population growth and impacts than those regions with relatively few impact sites and with sites poorly equipped to absorb new growth. Finally, population growth in impact areas may be affected by more subtle factors such as community growth preferences. Although growth in large urban centers is less likely to be affected by such factors, in rural communities the residents' desires for growth are often directly communicated to potential migrants and are thus more effective in inhibiting or promoting growth.

The characteristics of in-migrating workers represent another dimension that must be considered in impact assessments (Chalmers and Anderson, 1977). Since resource development-related population growth is clearly economically created growth, the characteristics of in-migrating workers and their families are key determinants of population growth. Such characteristics as the marital status, average family size, age and sex distribution of workers, spouses, and dependents, and their community service and settlement preferences will affect the total level of population growth in an impacted area, the characteristics of that new population, and its distribution.

Finally, in addition to these dimensions, the legislative mandates of impact assessments and the pragmatic considerations of decision makers also affect the demographic assessment process and the choice of an assessment methodology. Increasingly the guidelines that govern the application of the National Environmental Policy Act (Council on Environmental Quality, 1973; 1978) have established the need to provide assessments that are readily understandable to, and that directly service the informational needs of, decision makers. These guidelines mandate that two separate projection procedures be completed: one for the impact area under baseline conditions, without the project, and one for the impact area with the project in place. Projections that take into account the standard considerations noted in the previous section of this chapter and ones taking the impacts of resource developments into account must be made. In addition, attempts to plan for, manage, and mitigate the impacts of the population growth resulting from a resource development require decision makers such as mayors, city managers, police and fire chiefs, and school superintendents to develop policies applicable to their jurisdictions on the basis of the differences between baseline and impact conditions.

In practice, these conditions have meant that increasing emphasis has been placed on making projections locality- and characteristic-specific under both baseline and impact-related conditions. Projections at the individual community level and for such standard demographic characteristics as age, sex, and race have received increasing emphasis.

When taken as a whole, the factors described above clearly make the task of completing a demographic impact assessment a formidable one. The population analyst must:

(1) Project both baseline and impact population levels in which standard projection assumptions are required.

(2) Project not only the total magnitude and characteristics of that growth but also its distribution and characteristics at the community level.

(3) Make projections that take into account:

  (a) the characteristics of project labor demands and local areas' settlement configurations;

  (b) the workforce as well as the demographic characteristics of the indigenous area's population (that is, availability, skill levels, and so forth);

  (c) the fluctuations likely to appear in various phases of the development project;

  (d) the potential effect of nondemographic factors, such as development policies, community growth perceptions, and service infrastructures; and

  (e) the extent of congruence between local skill levels and the skills required for the development.

(4) Not only assess the demographic characteristics of residents in the area, but also the likely characteristics and settlement preferences of workers and the dependents of workers who will migrate into the area.

In sum, the population analyst doing impact projections must combine the standard and often unsubstantiated assumptions about demographic processes that must be made in standard population projections with the additional assumptions required concerning each of the impact dimensions noted above and the legitimate demands of decision makers for increasing specificity in data outputs.

Clearly, then, an accurate assessment of demographic impacts can only be approximated by existing techniques and knowledge bases. It is a process that, because of its complex nature, requires numerous compromises and simplifying assumptions. It is one, however, that is being completed with increasing frequency, and a description of the state of the art as it is being practiced is essential.

DEMOGRAPHIC IMPACT ASSESSMENT TECHNIQUES

The purpose of this section is to describe the state of the art of demographic impact assessment. That is, given the techniques described in the first section of the chapter and the considerations noted in the last section, we need at this point to examine how these dimensions have been combined in actual assessments.

In general, the projection of baseline and impact-related populations has involved a number of key steps. A description of these steps will delineate the nature of the demographic impact assessment process and point out differences in alternative assessment techniques. These steps include:

(1) Delineation of the impact area.

(2) Projection of baseline population for the impacted region and subregional areas.

(3) Determination of project-related direct and indirect in-migrating workers including consideration of:
   (a) characteristics of required employment;
   (b) characteristics of available employment (unemployment, underemployment, skill levels, and commuting patterns);
   (c) indirect/direct worker ratios

(4) Projections of the geographical distribution (settlement patterns) of in-migrating workers.

(5) Determination of the demographic characteristics of in-migrating workers and their dependents to establish population impacts by site.

Impact Area Delineation

Although the first step, the determination of the impact area, involves considerations in addition to the demographic, it is discussed here because demographic considerations often play a key role in the delineation of the impact area (Finsterbusch and Wolf, 1977). The impact area for socioeconomic purposes is often considered to be that area in which new project-related populations will locate, and the communities placed within the socioeconomic impact area are usually areas within commuting distance of the project site and, hence, likely settlement locations for new workers. The demographic dimension, then, plays a key role in focusing the entire socioeconomic impact assessment effort.

Baseline Projections

The projection of baseline populations in impact assessments normally involves two procedures, a projection of total population at the regional or county level and an allocation or distribution of that population to subareas in the region or county. Surveys of prevailing methodologies (Chalmers and Anderson, 1977; Denver Research Institute, 1979) indicate that several techniques are commonly used to perform these procedures.

Projections of populations at the regional level have tended to use either a single or several separate (one for each of several types of employment) population to employment ratios, a cohort-survival or a cohort-component method. Although use of population-to-employment ratios is decreasing as the need for the detail provided by cohort procedures increases, the use of population to employment ratios is still far more prevalent in baseline demographic assessments than in standard population projections. In part, this prevalence reflects two factors: the tendency for demographic projections in impact assessments to be made as part of the economic portion of such an effort, and secondly the need to use procedures similar to those used in the impact projection procedures which depend on economic assumptions. Unfortunately, however, since population-to-employment ratios do not sufficiently account for differences in population structures (particularly those in age) or changes in those structures, they are likely to lead to substantial errors over long projection periods. Thus, the prevalence of such procedures in impact assessments may not enhance the accuracy of impact projections, and as a result cohort procedures as described above are becoming dominant.

The second major procedure in the projection of baseline population involves the allocation or distribution of populations to subarea units. This is necessary because population projections, whether done by economic-based population/employment ratios or by cohort procedures are seldom performed at the community level. If population projections are made at the regional level (as is usually done when population-to-employment ratios are used), this procedure involves allocations to counties and subsequent allocations to communities within counties or a direct allocation of persons to communities and nonmunicipal areas with a subsequent summing of populations to get county totals. If projections are developed at the county level (as in most component procedures), then county populations are allocated to project community populations and aggregated to get regional totals. These allocations are usually done on the basis of ratioing techniques. That is, ratios or historical trends in ratios of subarea populations to area populations (county/region, city/region, or city/county) are used for these allocations.

Baseline population projections in impact assessments, then, utilize standard techniques, particularly economic-based, ratioing, and cohort techniques. As in the use of these techniques in standard projections, the limitations and assumptions on which they are based must be recognized and taken into account in impact projections.

Impact Projections

Steps three through five are related to the projection of impact populations. Although impact populations might be determined by projecting a total population figure that includes baseline and impact populations and then subtracting baseline projections from the total population figures, the general pattern is to project impact-related populations separately and to obtain total (project + baseline) population by adding baseline and impact projections.

In addition, the impact assessment process as usually practiced makes the assumption that the demographic impacts of a resource development are a function of the number of new persons brought to the area. Assessments of the extent to which such developments lead to the retention of existing persons are seldom made and the effects of such retention are seldom entered into other steps of the assessment process. That is, projections do not contain data on the number of locals retained in the area that would leave if the development did not take place, and the service and other needs of retained persons are usually assumed to be absorbed by existing service bases. Though the failure to develop techniques for projecting levels of population retention largely reflects the difficulty of discerning "those that would leave the area if the project did not take place", such procedures should receive concerted attention by impact methodologies.

Projection of In-Migrating Workers

The most difficult part of the impact projection process is step three. It involves the completion of several procedures and the use of numerous assumptions. This step, the projection of in-migrating workers, is almost the universally accepted starting point for projecting project-related populations. The reasons for the widespread acceptance of this starting point rather than a more purely demographic one are several. First, data on the direct labor requirements of projects are perhaps the most readily accessible of all socioeconomic data on resource developments. Secondly, although migration patterns as a whole are increasingly motivated by noneconomic factors (Long and Hansen, 1979), the migration related to resource developments is largely employment related. Both of these factors suggest the use of employment-related migration as the key to projecting impact-related population. Finally, there simply are few alternatives to the use of employment. No clear linkages between project characteristics, other than employment, such as type of project, project production capacity, or other characteristics have been established. However desirable the development of alternative means for projecting impact populations might appear to be, few viable alternatives have been developed.

The projection of in-migrating workers may involve a relatively simple procedure or a highly complex one, and may involve procedures that are based on economic factors or ones that combine basic economic and demographic procedures. In the simplest and most straightforward procedure, the steps involved as as follows (Murphy and Williams, 1978):

(1) Estimates of direct employment obtained from the developer are multiplied by an employment multiplier (number of indirect workers per direct worker) to obtain estimates of indirect employment.

(2) Given estimates of direct and indirect project employment requirements, estimates of the proportions of these requirements that can be met by the local existing population are made.

(3) Local employment (Step 2) at the project is subtracted from total employment requirements with the resulting difference indicating the number of workers that must migrate into the area as a result of the project.

In this procedure, the key values are the employment multipliers and the local worker ratios. The first of these values can be readily obtained from state or other local economic data (such as an input/output table), and the second has been the focus of a number of studies (Mountain West Research, Inc., 1975, 1977; Leholm et al, 1976; Wieland et al, 1977, 1979) and is readily summarized in several publications (Murphy and Williams, 1978; Bender, 1975; Murdock and Leistritz, 1979).

The advantages of this technique are that it is computationally simple and its data needs are limited to those that are widely available. Its major disadvantage is its neglect of the implications of the site-areas' demographic structure. It entails implicit assumptions that the site-area population is one with an average age structure, skill levels and average levels of labor participation (that is, a population that can obtain a given proportion of the project jobs) which may not be true in many rural areas with a relatively old age structure. It tends to ignore, or at least to confound, multiple factors affecting the nature of employment requirements and the nature of available local employment in determining migrating workers. Even when the procedure is refined by using separate employment multipliers for different industries and separate local employment levels for various kinds of employment (that is, direct, indirect, etc.) for each major project phase (construction and operation) (Murdock et al, 1980b; Murphy and Williams, 1978), such problems still persist. Its use under some circumstances may still be justified, however, if sufficient resources or data are not available to complete projections using more complex procedures.

A somewhat more complex procedure which utilizes more demographic input is also often used (Stenehjem, 1978; Mountain West Research, Inc., 1978). In this procedure, direct employment and indirect employment estimates are derived as noted above, but population projections are used as the basis for determining local labor availability. As noted in the section on economic-based models, the determination of labor force availability is usually computed for such models by applying a set of labor force participation rates to baseline populations that have been projected using cohort component procedures. The advantage of this technique over the one described above, particularly if age-sex specific labor force participation rates are used, is that the population structure of the local area does have an effect, through participation rates, on determining local labor availability. Thus, if a disproportionate part of the population is in age groups with low labor force participation rates (such as very young or very old age groups), a smaller number of available workers will be estimated. The disadvantage of this technique is that appropriate baseline and projected participation rates must be obtained. Although baseline rates are easily obtained from census and other secondary data sources, determining those rates that will prevail during a resource development is more difficult. Even if some general area's (state or regional average) rates are used as targeted values (see Hertsgaard et al, 1978), the assumptions made concerning labor force participation may still be problematic and require careful preliminary analysis. In general, however, this procedure is considered to be a more demographically desirable technique than the one outlined earlier.

Even more elaborate techniques have been applied on some, though infrequent, occasions. Among the more elaborate of these are those of Hertsgaard et al (1978) and Cluett et al (1977). These procedures use different techniques to project different types of employment and to project labor availability and a separate procedure to match employment demands to employment availability. Hertsgaard et al (1978), for example, use an input/output model in conjunction with project employment data to project four types of employment -- baseline, project operational, project construction, and indirect. They also use four sets of age-sex specific employment availability rates (one for each type of employment), that are similar to labor force participation rates but indicate potential rather than actual employment, to project the number of persons that could take each of the four types of required employment. The application of these rates to age-sex cohort data, derived from cohort-component projections, provides four separate labor pools composed of the number of workers by age and sex in the local population available to take each of the four types of project employment.

Given employment needs by type and available labor by type, Hertsgaard et al (1978) then apply a priority schedule which is a set of algorithms for filling each type of required project employment from the four labor pools given certain assumptions about the order with which types of required employment will be filled by available employment. The result of this procedure is the projection of migrating workers with an excess of available employees, after all required employment has been filled, indicating the need for worker out-migration and a deficit indicating the need for in-migration. The final step in this process is the adjustment of the available worker excess on deficit by what is termed an "unallocated" labor pool rate. This rate is a proxy for unemployment and underemployment. The procedures utilized by Cluett et al (1977) are similar but in addition use an algorithm that estimates labor turnover effects on migration levels.

The advantages of these complex procedures are that they simulate most of the major factors known to affect employment-related migration. The Hertsgaard et al (1978) procedure differentiates: (1) types of employment demands that are likely to affect levels of local employment and in-migration; (2) types of labor availability -- the different levels of potential (skills) in the local population for taking different types of employment; (3) the effects of age-sex population characteristics on that availability; and (4) the effects of under- and unemployment. Thus, the procedures are conceptually attractive. Their major disadvantages are that such procedures have extensive data requirements, and many of these data requirements cannot be met by available data. Only extensive primary data collection efforts can address many of these issues (see Wieland et al, 1977), and such effects may be too expensive for use in many assessments.

In sum, then, in the third major step the choice of techniques can range from the relatively simple to the highly complex. The exact choice of technique must depend on the delicate balancing of data availability, and the time and costs involved in altering that availability, with the need to more effectively simulate the conditions actually affecting employment-related migration and the need to consider the effects of population structure on local labor availability. Hopefully, levels of data availability will increase over time and serve to lessen the need for such compromises.

Projections of Settlement Patterns

The fourth step is the projection of the geographical settlement patterns of in-migrating workers. This step may, in fact, be performed with workers or be delayed until after step five and be performed with total population. It is a procedure that parallels the allocation of populations to communities in baseline projections. Unlike that process, however, the focus in impact projections is the distributions of workers in relation to the project site rather than within a geographically delineated county or region. This distribution involves allocating workers to places that may be located in several separate geographical jurisdictions.

It is a vitally important step particularly in its implications for local community planning, for it is in this step that workers are allocated to local areas. Variations in the techniques and assumptions used in this step will largely determine the impacts that are projected for local areas. These distributions can be affected by numerous factors. Workers' housing preferences, service preferences, willingness to commute, and other factors may affect settlement patterns. At best, prevailing methodologies utilize only very broad indicators of these numerous factors in their allocation procedures. Although several techniques are delineated below, the geographical allocation of employment or population is an area in impact assessment requiring concerted empirical attention.

At least three approaches are used with some frequency in the projections of worker distributions in impact assessments. These are (Denver Research Institute, 1979; Chalmers and Anderson, 1977):

(1) Judgmental weighting models

(2) Delphi derived models

(3) Gravity models.

Judgmental weighting models are those models that rely on researchers' or local knowledgeables' qualitative assessments of such factors as available housing and service structures in various communities to differentially weight communities as potential settlement sites (Stenehjem, 1978). Weights are assigned to all communities that are expected to receive workers, and then the weight of each community in relation to the sum of the weights for all communities is used to proportion workers to each community. These techniques have the advantage of providing input of local knowledge into the allocation process but the disadvantages of requiring the collection of such data and of having their accuracy determined by the accuracy of local perceptions.

Delphi techniques refer simply to more concerted and definitive efforts using judgmental techniques. In the delphi technique the sample of persons number of in-migrating workers. More complex techniques use multiple worker-related characteristics including the: (1) percent of workers by age, sex, and marital status; (2) percent of workers with dependents in the area; (3) number of dependents by age and sex; (4) employment status of dependents; and (5) occupational and industrial state of dependents.

The most frequently used computational procedures are as follows:

(1) The age, sex and other characteristics of all migrating workers (direct and indirect) are determined by the application of rates derived from appropriate profiles.

(2) The number of single married workers is determined by the application of percentages in various marital statuses. Single workers are then entered as a part of the population total.

(3) The number of married workers are multiplied by the percent with families in the impact area. Those without families in the area are then entered as part of the population total. Those with families in the area are entered as part of the total population and carried forward for all calculations involving dependents.

(4) The number of spouses accompanying workers is determined by simply adding one spouse per in-migrating worker with a spouse in the region. Spouses are then added to population totals.

(5) The number of children is determined by multiplying the average number of children per married worker with family in the area by the number of these workers. Children are then added into the total population.

(6) Age and sex distributions for spouses and children are obtained by multiplying their numbers by an appropriate age and sex distribution (usually percentages of each sex are determined and then the percentages in each group are applied to the persons of each sex).

(7) The number of employed dependents is obtained by multiplying an average number of additional workers per worker by the number of workers with dependents in the area.

(8) Other characteristics are determined by applications of appropriate rates to the distributions derived from 1-6.

(9) The total number of in- or out-migrating persons by age and sex is obtained by summing: the number of single workers, married workers

without families in the area, married workers with families in the area, spouses, and children across age groups.

These calculations may become quite tedious when age, sex and other detailed characteristics are involved but are not difficult to complete. Although the degree of detail noted above may appear to be more extensive than necessary, because the use of only total family size per worker would provide basic data on total population, the detail provided by the more complex procedures is important for a number of purposes.

Data showing age and sex detail for workers and dependents is important for health and educational planning for development-related concerns such as contractors and real estate firms, and for determining the likely client or customer populations for businesses. Data on marital status and percent of workers bringing dependents to the area can have marked effects on public service estimates and service planning. Thus, in many early impact assessments, inflated projections of in-migrating populations resulted in large part from assuming that the percent of married workers would be equal to the baseline population in the area and that all married workers would bring their families to the area. As the surveys noted above (Mountain West Research, Inc., 1975, 1977; Wieland et al, 1977) indicate, however, workers inmigrating as a result of resource developments are younger and hence less likely to be married than the baseline population in the area, and a substantial proportion of workers will not bring their families to the impact area, particularly during the construction of the project. Accurate assessments of such characteristics are essential.

Projections of the workforce characteristics of dependents are equally important. Since secondary or additional employees in the worker household will be available to take indirect and other employment generated by the project, the number of new secondary workers and households will be reduced by the number of secondary workers in the primary workers' households. The accurate estimation of such secondary workers is essential to avoid inaccurately projecting the number of in-migrating secondary workers.

In sum, then, these and other characteristics of the migrating worker population must be projected both to provide necessary planning information and to increase the overall accuracy of projections.

Conclusions Concerning the State of the Art

The steps delineated above (with some variation) are the major steps generally completed when projecting demographic impacts. It is obvious that these steps involve numerous assumptions about such factors as impact events, baseline conditions, baseline populations, workforce characteristics, and inmigrating population's settlement patterns, preferences, and characteristics. As such, it is obvious that the end product of this assessment is likely to be projections that are approximations of the impacts that will actually occur.

It is essential then that two final admonitions be made in relation to demographic projections. The first of these is that a series of projections should be made in nearly all cases rather than a single set of projections. These series should bracket the likely range of impacts and include a middle series that is the "best guess" projection, a high series that projects the highest likely population, and a low series that presents the lowest likely population projection. It makes little sense, to produce such a large number of series that the range of values from the highest to the lowest projection is so inclusive as to bracket all statistical possibilities. Series produced should all be projections that are feasible under alternative sets of possible circumstances.

Secondly, it may be beneficial to use demographic projections largely as sensitizing mechanisms to assist one in understanding the implications of alternative development scenarios. As such, these projections can be useful for both the planner and the decision maker in demonstrating the implications of alternative policies and in examining potential mitigation measures and the effects of such measures. This use of projections may reflect a more pragmatic evaluation of their potential accuracy and be of as much utility as their use for more exact service planning.

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

As with other socioeconomic dimensions, demographic factors may be affected by both the special and the standard effects of repositories. Although the emphasis in this effort is on the standard effects of repositories, the implications of both special and standard effects for demographic factors and the methodological alternatives most likely to adequately address such effects are described briefly below.

Special Effects

The special effects of repository siting could potentially lead to a decline in population or to a failure for secondary population growth to increase as project-related population increased. That is, if the perceptions of the effects of a repository are such that substantial proportions of the population of an area are motivated to leave the area, then the overall effects on population growth would be negative, leading to overall population decline. This decline could result either from extensive direct out-migration motivated by fear or by the movement of persons as a result of the migration of employment from the area. Although there is little evidence (Herbert et al, 1978; Maynard et al, 1976) to suggest the likelihood of such effects, the possibility of such impacts must be considered within alternative assessment scenarios.

A second possible special effect is related to possible delays or perhaps a complete failure for population growth resulting from service industry growth to occur. If the growth in nonbasic industries that normally accompanies basic industry growth remains outside the area, then secondary population growth will also not occur in the impact area. Since secondary industry growth often results in higher levels of population growth than basic industry growth such an effect would drastically change the population impacts in a siting area. These are only some of the special demographic effects that must be considered in assessing the demographic impacts of repository siting.

Standard Effects

In the absence of effects due to the special characteristics of repositories, the standard demographic effects of repositories are likely to be similar to those for other large-scale developments. Except for a limited number of highly skilled technicians, the labor demands for the construction and operation of such projects are not significantly different than those for other large-scale projects (U.S. Department of Energy, 1980). As a result, the population effects of such projects, in the absence of special effects, should not be significantly different from those for other large projects.

The assessment of standard demographic effects should thus be possible with existing methodologies.

Methodological Considerations

Given the potential special and standard effects of repository siting noted above, the most important methodological considerations appear to involve the use of methodologies that allow for the projection of population decline as well as growth and that allow for potential changes in population through changes in employment-related migration, direct migration, or mortality.

Although any of the five major methodologies described above might be used, these methodological considerations would suggest that a cohort-component method such as those described above (Hertsgaard et al, 1978; Cluett et al, 1979) should be employed. This is clearly suggested by the fact that only such methods allow for direct changes in each of the major demographic processes, including both mortality and migration, and allow for direct and employment-related changes in migration patterns. Clearly, the use of cohort component models seems appropriate for projecting the socioeconomic impacts of repositories as well as other large-scale developments.

Finally, it is essential to use a methodology that allows for easy use in the development of multiple scenarios. This consideration also suggests that methods that have been extensively computerized, such as cohort-component methods (Bogue, 1974), should be employed in assessments of the impacts of repository siting.

In sum, then, the demographic effects of repository siting will include both special and standard effects. Although some possible special effects might lead to population decline or at least retard population growth, these effects as well as standard demographic effects may be assessed with existing methodological alternatives. The alternative most widely used in standard impact assessments of demographic effects, the cohort-component method, appears to be the most useful for assessing the socioeconomic impacts of repository siting as well.

SUMMARY AND CONCLUSIONS

Summary

The projection of the demographic impacts of a resource development marks an essential step in the assessment process. It provides data that are essential for public service, economic and other planning needs, and in many ways, its magnitude delineates the magnitude of all socioeconomic impacts. Five basic methods are available for general projections of population. These include: (1) extrapolative, (2) ratio-based, (3) land use, (4) economic-based, and (5) cohort component-based techniques. The major differences in these techniques lie in their data requirements, detail of outputs, and their ability to simulate demographic processes. Whereas extrapolative, ratio-based, and land use techniques have relatively limited data requirements, they also provide less detailed outputs than the more data intensive economic and cohort component techniques. Due to its ability to simulate the actual demographic processes that determine population change, cohort-component techniques tend to be the most widely used in general projections and the most preferred by demographers, but economic-based techniques are becoming increasingly popular and are the most widely used in demographic impact assessment.

In selecting a technique for impact assessments, consideration must be given to numerous factors about the project, the project area, and the potential characteristics of in-migrating workers that will affect the magnitude and distribution of demographic impacts. In particular, the labor force requirements of the project and the labor force characteristics of the local population are critical determinants with a greater compatibility between local labor availability and project labor requirements leading to fewer nonlocal employees and fewer in-migrating workers. The characteristics of these workers and their dependents are, in turn, critical in determining the total population-related impacts of the development.

In the present state of the art in demographic impact assessment, almost all analyses utilize either an economic or a cohort procedure for performing baseline projections. Impact projections are made by taking project-related employment demands and either directly projecting population via the use of population-to-employment ratios or by matching such demands with estimates of available employment obtained by applying labor force participation rates to the results of cohort procedures. Workers are then distributed to settlement sites on the basis of judgmental or gravity model techniques and turned into projections of population by applying demographic profiles to estimates of migrating workers. In all cases, these techniques require the use of a wide number of assumptions, and, hence, several series of projections rather than a single series of projections should be used. This use should consist largely of attempts to sensitize the public to the likely range and implications of population impacts.

Conclusions

The assessment of the demographic impacts of resource developments is a highly complex task requiring knowledge of demographic projection techniques, impact assessment processes, impact events and dimensions; data on the characteristics of the resource development project, the characteristics of the impact area population base, the characteristics of migrating workers and their dependents and assumptions; and knowledge about the future trends in each of these factors and in the baseline population of the area. It is unlikely that the trends in all of these factors will be predicted correctly in any given assessment, and thus it is unlikely that any projection will be exactly correct. Unfortunately, the present state of the art does not provide adequate information to indicate the relative effects of errors made in the assumptions for these various factors. The potential errors of demographic impact assessments must be readily acknowledged, and the implications of such errors further evaluated.

At the same time, it is evident that demographic impact projections are essential if the planning needs of impacted areas are to be met. Knowledgeable use of existing techniques and attempts to develop increasingly better simulation techniques and data bases must be the goal of those professional demographers involved in demographic impact projections. The need for the rapid development of better methodologies and data is critical.

For the decision maker using such assessments, the best course appears to be one of caution and skepticism. In evaluating demographic assessments, the decision maker should be careful to discern whether each of the dimensions discussed in this chapter is clearly acknowledged and the assumptions for each clearly stated in the assessment. Although assessments providing such information are not inherently superior in their ability to predict actual impact events than those with less clearly stated assumptions, they are capable of being evaluated--a key factor for the user of an assessment. Assessments that fail to acknowledge or clearly state their assumptions should be given a particularly careful examination. Finally, it is essential, that the user of such assessments remain cognizant not only of the limitations, but also of the utility of such assessments. If cautiously and knowledgeably used, demographic assessments are, with all their potential sources of error, among the best data sources available for use in judging the potential magnitude of the impacts of resource developments and, thus, among the best sources for guiding decision makers in planning for and in evaluating the meaning of resource developments for rural communities.

NOTES

1. When such trending is based on extrapolation of past changes in subareas' shares, it is essential that the totals be controlled to the larger area total. If this is not done, the total sum of shares will exceed 100 percent, and the shares for even single rapidly growing areas may come to exceed 100 percent. To control this phenomenon, an adjustment factor can be determined to apply to each share. This factor can be determined by the formula:

$$AF = \frac{1.0}{\sum_{i=1}^{n} si}$$

Where: AF = Adjustment Factor
n = number of subareas
s_i = share of total area population in subarea i

and then multiplied by each share (s_i) to determine the subarea's adjusted share.

2. However, experts disagree as to whether such adjustments are worthwhile, with some favoring such adjustments (Pittenger, 1976) and others questioning their utility (Irwin, 1977).

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CHAPTER 4

PUBLIC SERVICE IMPACT ASSESSMENT

The projection of the public service impacts of resource developments is a major area of concern in socioeconomic impact assessments (Denver Research Institute, 1979; Murphy/Williams, Consultants, 1978; Chalmers and Anderson, 1977). Changes in the availability and quality of public services are among the most visible and widely noted impacts during any major rural development (Summers et al, 1976; Lonsdale and Seyler, 1979) and have been a topic of much discussion in the impact literature (Gilmore and Duff, 1974; Gilmore et al, 1976; Murdock and Leistritz, 1979). The accurate projection of the magnitude and distribution of public service impacts is of vital concern to governmental decision makers and perhaps no other single set of projections, with the possible exception of fiscal projections, is in greater demand among public decision makers. Accurate projections of service demands during a development are essential because of the lead time necessary to develop and finance public service facilities and in order to prevent the development of excess service capacity. The projection of public service demands is thus a priority area for socioeconomic impact researchers and their clientele.

The projection of such services, however, though clearly essential and often not computationally difficult, requires careful consideration of numerous conceptual and analytical dimensions. A discussion of these factors provides the focus for the remainder of this chapter.

THE CONCEPTUAL BASES AND DIMENSIONS OF PUBLIC SERVICE IMPACT ASSESSMENTS

As with other areas in impact assessment the projection of public services utilizes conceptual bases that are relatively poorly developed and is an area for which prevailing practices rather than alternative theoretical perspectives have determined accepted techniques. In addition, it is an area in which the dimensions analyzed are both extensive and complex.

Conceptual Approaches

Although the techniques employed vary substantially from one assessment to another, most reflect one of several basic approaches. These approaches are similar to those described by Burchell and Listokin (1978) for fiscal analysis, and their basic delineation is one that can be usefully employed in the discussion in this chapter. These approaches, as outlined by Burchell and Listokin (1978), include: (1) approaches that project service demands for new population only, utilizing averages per unit of new population and either national, statewide, or local service standards and (2) approaches that attempt to take existing services into account and project new service requirements on the basis of marginal demands (that is, demands above those that can be met by existing service bases).

Average Unit Approaches

Perhaps the most widely used approach is that which projects service needs on the basis of new population only. The assumptions underlying this approach are that existing service bases should reflect existing demands and that no excess capacity is present in existing service bases. These premises significantly simplify the projection process. They reduce the information required on existing services, which may be particularly difficult to collect in rural areas, and require only a simple application of a set of standard rates to projections of new population to project service demands.

The utility of this approach is limited by the fact that public services seldom reflect a true market system (Day, 1968; Jones and Murdock, 1978). That is, supply and demand considerations seldom operate in the absence of social and political considerations. In addition, in rural areas certain services are required (medical care units) because of the severity of a problem for those experiencing it rather than because of the magnitude of the demand. As a result some services in rural areas may have significant excess capacity. The utility of this approach thus varies with the extent to which market factors operate within a service area. For services such as housing and private recreational facilities, the use of this approach is less problematic than areas, such as medical and educational services, where the significance of the need may be such as to make market processes less applicable.

The approach is one that is relatively easy to apply but which is difficult to use in many instances where service bases are not determined by market activities. The use of the approach, however, is likely to remain dominant until the necessary data to assess the levels of services in rural areas improve substantially.

Marginal Approaches

The second major approach is one which attempts to take baseline conditions into account by projecting service requirements beyond those that can be provided by existing service structures. The marginal new services required are thus projected taking full account of existing service bases.

The potential sources of error underlying the premises in this approach stem from the fact that the adequacy of existing services may be nearly impossible to measure. Secondary data on rural services are often extremely limited and the costs involved in the collection of primary data are often prohibitive. Thus the adequacy of many services may be largely a function of citizen perception and extremely difficult to quantify, service demands may partially reflect the degree of formalization of existing structures, and the acquisition of primary data may require interviews with service personnel in each community. In sum, whereas the average unit approach is often problematic because it fails to take existing service bases into account, the marginal approach often fails because of insufficient data on service adequacy and availability in rural areas.

Standard Selection

Whichever of the two approaches described above is chosen, however, another conceptual dilemma must be addressed before service projections can be completed. This is the need to select a set of standards for projecting the service demands that will accompany new population. Again, two major conceptual approaches appear to underlie existing practices. These are: (1) the use of local or comparative area service levels or (2) the use of generalized standards.

Local Standards

The use of local or comparable area's service standards, as the name implies, assumes that new persons moving to an area will use and demand services at the same level as existing residents. The validity of this premise determines the validity of using local standards and is highly variable, depending on existing service bases in an area and the type of service under consideration. If existing service bases are deficient, new residents are unlikely to be satisfied with existing services. The extent to which such dissatisfaction is expressed will vary by type of service, however. Water, sewer, and similar services may be technically inadequate but these deficiencies are often not directly evident, and requirements for new services beyond existing service levels may not be recognized. On the other hand, for services such as education and law enforcement, existing deficiencies are more likely to be directly experienced, dissatisfaction openly expressed, and new standards demanded. The use of local standards requires careful preliminary analysis, including a comparison of such standards to the minimum standards required.

General Standards

The use of general standards, such as those for the nation, a region, or a state, is based on the premise that new residents are likely to bring demands typical of populations in other areas rather than of the population of the local area. New populations may have few of the same characteristics as local populations, may have shared few experiences similar to those of local residents and thus may be unlikely to perceive or demand similar levels of service. Whereas general medical care may seem adequate to existing residents, new residents may demand more specialized services. In large part, then, the utility of employing general standards versus local standards depends on the disparity between local residents' and new residents' service demands and on the likely influence of new residents in changing local service demands. When substantial disparities exist and new residents exert a sufficient level of influence, the premises underlying the use of general standards are clearly supported. However, at the present state of knowledge, the validity of the premises underlying the use of alternative standards has not been adequately examined. As a result, the use of both local and general standards seems likely to continue.

Dimensions of Public Service Projections

The range of dimensions included within public service projections is often broad, including projections of service demands related to:

1. Housing
2. Education
3. Medical and mental health

4. Law enforcement
5. Fire protection
6. Water supplies
7. Water treatment
8. Solid waste disposal
9. Transportation
10. Social welfare
11. Libraries
12. Recreation.

Although the methods for projecting these services will be discussed in detail in the following sections, it is essential to briefly delineate the dimensions usually considered under each of these service areas. For all services it is essential to note that significant impact dimensions, such as differences in construction and operational phases of projects, site area, project, and other characteristics, must be carefully considered in projections of service impacts.

The projection of housing services normally includes an examination of both the number and type of units required. Because different types of housing have different effects on local revenues and on long-term community growth, projections of housing without consideration of housing types are seldom merited. Thus, most projections of housing demands include projections of single family, multifamily, and mobile home units (Hertsgaard et al, 1978) and some include projections of temporary forms of housing as well (Ford, 1976).

Projections of educational services usually include projections of the number of students and their resultant demands on educational personnel and facilities (Murphy/Williams, Consultants, 1978; Chalmers and Anderson, 1977). Such projections will usually include estimates of the number of primary and secondary students, the number of teachers, the number of support and administrative personnel, and the amount of classroom space (square feet) required.

The projection of medical and other health services is especially difficult because medical services are often centralized in regional clinics and hospitals. In general, in the projection of medical services more attention is given to the location of such services than in other service areas. Projections in this area may include a wide range of factors including patient days and occupancy rates (Murdock et al, 1979) but tend to concentrate on such personnel and facility items as the number of doctors, nurses, psychiatrists, and hospital beds required to serve the in-migrating population.

Law enforcement and fire protection service projections also concentrate on personnel, equipment, and facility requirements, although attempts to project the number of offenses and similar occurrences to which such services must respond are sometimes made (Murdock et al, 1979). In most cases, however, these projections predict the number of law enforcement or firemen required, equipment requirements (numbers of police cars and so on), and facility requirements (square feet of floor space per officer, number of jail cells, and so on).

Water supply and treatment service projections usually concentrate on required capacity measured in gallons per capita or per population unit (such as 1000 persons). Such projections seldom consider the size of the functional units necessary for the efficient operation of such facilities. That is, increments in such services are usually made by adding functional units (for example, a new water treatment facility with a specified gallon per day capacity) rather than as per capita increments. In nearly all cases, however, such projections consider only incremental service demands.

Solid waste disposal is usually considered in terms of landfill area required and the unit of projection is usually acres. Again, such projections seldom consider the actual functional units required for the effective management of landfill operations. In addition, these projections usually include projections of service personnel and equipment (for example, garbage trucks and bulldozers) required.

Projections of transportation needs are often absent from projections for rural areas because such services are often not being used at capacity levels and because the actual level of new demand resulting from new populations is difficult to predict. When such projections are made, miles of new highway construction are usually the unit of output.

Projections of social services include a wider range of phenomena than any other service area, and there is little agreement on those social services that should be projected in impact assessments. Levels of delinquency, social worker case loads, number of families receiving aid to dependent children, and the number of social workers may be included in such projections. Unlike other projection areas, the focus tends to be on service needs rather than on the personnel and facilities required to meet such needs. Thus, projections of rates of occurrence are performed more often than projections of personnel or facilities. These projections seldom deal with a sufficient number of social service dimensions and are generally less complete and less adequately performed than projections in other public service dimensions.

Library services are projected less often than other services and are often perceived as less critical than many of the other services noted above. When such projections are completed, the factors normally projected are the number of volumes and floor space required per unit of population.

Projections of recreational services tend to concentrate on outdoor recreation because of the tendency for indoor recreation to be provided under private auspices. In addition, although extensive analyses have been done to determine outdoor recreational demands for various population units, the levels of services for indoor recreation are less well known. When projections of recreational services are made, the items most often projected are acres of open, park, playground, and campground space required per unit of population.

The alternative approaches and dimensions of service projections noted above reveal the extensive range of expertise and data required to properly describe and project public service demands resulting from a resource development. Whether local services are taken into account and local service standards applied or projections based only on new populations and general standards are employed, the projection of service demands requires the impact researcher to carefully examine the premises underlying the approach used and the level of detail and range of services to be projected. Conceptually and pragmatically, then, public service projections, though often seen as relatively straightforward (because of the ready availability of population-based standards), clearly require careful analyses of and extensive information on present and new populations' service requirements, if they are to be done adequately and accurately.

FACTORS AFFECTING PUBLIC SERVICE PROJECTIONS

The projection of public services requires a careful consideration not only of total service demands but also of other dimensions of service delivery and service usage in impacted rural areas. Foremost among the factors affecting the utility and accuracy of public service projections are an area's:

1. Predevelopment service levels
2. Distribution of services
3. Quality of services
4. Service delivery system

5. Perceptions of and satisfaction with local services bases
6. Service variability.

Each of these factors is described briefly below.

Level of Services

One of the most obvious factors affecting the level of new services required to meet the demands of new populations is the predevelopment service level in the site area. Although an exhaustive listing of local services in rural areas in the nation is not readily available (Murdock and Leistritz, 1979), it is evident that many services in rural areas are inadequate. Rural populations have lower levels of nearly all forms of health services (U.S. Department of Health, Education and Welfare, 1979), and rural educational services are clearly less comprehensive than those in urban areas (U.S. Bureau of the Census, 1979). In fact, in terms of nearly all nonenvironmental dimensions, the quality of life in rural areas lags behind that for more urban areas (Ross et al, 1979).

The level of local services must thus be carefully considered in public service projections in rural areas. Although some services may have excess capacity (such as medical or educational facilities), most will not, and assessments must carefully determine the adequacy of existing services prior to either using local standards as a means for projecting new service needs or accepting the sufficiency of existing services. It is essential that service projections be able to project existing service inadequacy or excess capacity and that the potential significance of new demands for existing service bases be adequately examined.

Service Distribution

It is also essential to recognize that public services are often not appropriately located geographically to meet the increased demands resulting from a resource development, even when total service levels in the site are sufficient to meet the increased demands. Thus, impact assessments must describe the location of service bases in relation to the location of the expected growth. In many rural areas, for example, social service, mental health, and similar services are provided only in regional trade centers and may be inaccessible to rural populations that are several hours' driving distance from such centers. In addition, because service areas are often formally defined, persons whose normal trade patterns involve one trade center may find that their area of residence falls in the service area of another trade (council of government, health system agency) center. Inaccessibility may effectively negate the availability of services. Before an assessment can be interpreted as indicating service adequacy or inadequacy, the question of accessibility must be addressed.

Quality of Services

Equally significant is the question of service quality. The existence of the appropriate number of service units does not ensure that the quality of services is adequate to meet either existent or projected demands. Although assessing service quality is extremely difficult, service quality requires careful consideration because of the potential problems that may be encountered if only quantitative assessments are made. Assessments of the age, education, training of service personnel, and the conditions of plant and equipment should be completed. If medical personnel are nearing retirement, police officers lack training in firearm usage, or firemen have little formal training, then the use of numbers of existing personnel as indicators of service adequacy may lead to underestimates of service needs, while the existence of extensive expertise may partially offset numerically lower service levels.

The Service Delivery System

Another factor affecting service projections is the need to take the characteristics of the existing service delivery system into account. The form and management of service delivery in rural areas differs substantially from that in urban areas. Delivery systems are often less formalized and fixed management structures and routines (such as daily routes for garbage collection) may not be included in existing systems. In rapidly growing areas, such as areas being impacted by resource development, more formalization may be necessary to meet increased demands. Although it is extremely difficult to assess such dimensions, it is essential to assess not only whether the level of existing services is sufficient but also to determine whether the delivery system and the management structure for that system are properly organized to deliver the services necessary to meet increased demand.

Service Perceptions and Satisfaction

The adequacy of a given level of services is seldom simply a function of the level of services. It is, in large part, a function of residents' perceptions. Levels of services may be differently perceived such that a relatively large number of persons in one area will perceive such service levels as sufficient to meet their needs while in another area, or for other groups in the same area, the same level of services is deemed to be inadequate (Christenson, 1976; Gessaman et al, 1978; Murdock and Schriner, 1978). Perceived levels of dissatisfaction often increase with increased levels of growth (Summers et al, 1976) and expectations rise dramatically. Thus, although the prediction of trends in service perceptions is extremely difficult, such changes should be considered.

Service Variability

Finally, it should be recognized that the projection of service demands, though usually reported in a single part on an impact assessment and performed by only a few members of an assessment team is, in fact, a multifaceted area of analysis. It is an area in which a broad range of dimensions unique to each service area should be examined and in which specialized knowledge of each type of service should be obtained. Service projections involve not one but several substantive areas and should involve specialists from numerous substantive fields. Thus, the delivery of medical services is clearly different than the delivery of water and sewer services, and law enforcement, fire protection, and other public services differ from housing and recreational services which are largely privately financed and managed. It is unlikely that any assessment effort can obtain the resources necessary to involve specialists from each service area; recognition of the limited knowledge base upon which most service projections are made and of the relatively simplistic nature of this base in relation to the complexity of each service area is essential.

The need to consider the factors noted above, coupled with the breadth of service dimensions and complexity of premises underlying service projections clearly point to the need for care in performing service projections. If service projections are to be useful for infrastructure planning and development, they must be completed with full recognition of the complexity of the task being attempted and of the limitations inherent in the use of prevailing methods and conceptual bases.

METHODS FOR PUBLIC SERVICE IMPACT ASSESSMENT

The actual processes used in assessing public service impacts, like those used in other assessment procedures described in earlier chapters, fail to attain many of the characteristics desired for such projections. Few adequately assess service distributions, service delivery systems or provide other detail required to fully characterize the complexity of each service area. Despite such weaknesses, the techniques used have received relatively widespread acceptance. The techniques actually employed are described briefly below.

The techniques employed in making public service projections involve the completion of three major assessment processes. The description of these processes--(1) the description of baseline services, (2) the selection of a standard for use in projecting service demands, and (3) the projection of service demands--provides an organizing mechanism around which alternative methods can be described. Thus, the steps in each process, data sources used in each process, alternative methods that can be employed, and the relative advantages and disadvantages of each method are described below for each of the three assessment processes.

Description of Baseline Services

As with all assessment processes, the first major step involves a description of baseline service levels. To complete such descriptions, secondary, primary, or a combination of secondary and primary data collection methods can be employed.

Secondary data methods are nearly always employed, even when primary data collection methods are also used. The utility of this approach varies by service area. Data on housing are readily available from the census of housing for each decade. For years between census periods, data from periodic national surveys (such as the Annual Housing Survey) can be obtained and local surveys have often been performed by local planning agencies and similar groups.

For educational services, data can be obtained on average daily attendance, and number of personnel from state departments of education and nationwide educational data are available from the U.S. Department of Education.

Data on law enforcement and fire services are more difficult to obtain but some data are usually available from the state fire marshal and state police or other state law enforcement agencies. In most cases, however, definitive local data on police and fire services in rural areas are only available by collecting primary data in local areas.

Data on medical services, though available at the national, regional, or state level (Department of Health, Education and Welfare, 1979), are seldom available on a regular basis for communities in rural areas and must be obtained from primary data collection efforts. Data on water supplies, water treatment, and solid waste disposal are often available from the state health department but these services may require extensive primary data collection and updating of secondary data.

Data on transportation services are usually available from the state highway department, data on social service agencies from social service agencies, and data on library services from the state library or library association. Finally, data on outdoor recreation are usually available from state recreational associations, but data on indoor recreation facilities are seldom available except through primary data collection.

Overall, secondary data can be most readily used for baseline descriptions of housing, education, and social services, with less certainty for law enforcement, fire, water and waste, transportation, and library services, but they are seldom sufficient for characterizing medical and indoor recreational services. In addition, secondary data seldom allow one to adequately assess service needs. Data on service personnel and facilities and on service usage and occurrences (for example, crime data) may be available, but data seldom indicate areal levels of need for medical, educational, social, or other services. Needs assessment data thus form a logical, but seldom available, counterpart to secondary data in assessment efforts.

The advantages of secondary data are evident. They are relatively easy to obtain, though often difficult to physically locate. They are less costly to collect and more likely to have been collected for multiple areas using a common set of procedures and guidelines than is possible with primary data.

The disadvantages are in the variable quality of such data from one service area to another, and the tendency for secondary data to be somewhat dated and to have low levels of reliability for small areas.

Primary data collection methods are usually used to expand, update, and validate secondary data. When primary data collection methods are used they require contact with officials in each service area. Although mail, telephone, or other forms of noncontact surveys are often used, personal surveys are the most reliable form for such data collection efforts.

Primary data methods have the clear advantage of providing comprehensive and current data that are generally well validated, though in some rural areas the part-time nature of service personnel may limit their knowledge bases concerning many services. These methods are also quite costly to complete and require extensive time and personnel resources. Because of such cost considerations, primary data cannot be used in many assessment efforts.

Finally, it should be noted that the optimum and most widely used method for collecting data on baseline service conditions involves collecting as much data as possible through secondary means and then updating, validating, and expanding these data through primary methods. Such combined methods are usually the most desirable and efficient method for obtaining the data necessary to describe baseline services.

Whatever method is used to describe baseline conditions, the accurate description of such conditions is essential to the assessment process. If such descriptions are incomplete or inaccurate, projected service impacts will be inadequate for effective facility and service planning.

Selecting a Standard

Although the selection of a standard to be used for projecting service demands is largely a decision-making step rather than a procedure step, it is perhaps the most vital step in projecting service demands. It involves the selection of rates of service usage per unit of population and thus, as with other projection methods, the accuracy of these rates (and the assumptions underlying them) will determine the accuracy of the projections. In general, the rates used are derived from one of several alternatives. These alternatives involve the use of:

1. Predevelopment local service levels,

2. Comparable area service levels, and

3. General usage and engineering standards and estimates.

Each of these alternatives is briefly described below.

The use of local service levels is widely accepted in service projections. The use of these standards represents the most conservative projection approach. Such standards are clearly applicable to the impact area, and their use has the advantage of ready availability and relatively high credibility with decision makers. The disadvantages of the use of local standards are that, for a variety of reasons described above, they may reflect already insufficient service bases and may not accurately reflect the impacts of new service demands.

Another method for selecting service standards is to analyze the service demands that have occurred in similar areas during developments. Such case study or comparable area methods (see Burchell and Listokin, 1978) have several advantages. They avoid both the assumption that predevelopment service levels will prevail during resource developments and the use of general rates that may be derived from areas that are significantly different than the impact area. The difficulties entailed in the selection of such standards are twofold. First, finding an area with predevelopment service levels similar to the impact area may be difficult. Secondly, because of the lack of adequate data on actual service changes that have resulted from development events, establishing standards that accurately reflect actual service changes may be nearly impossible. The method is used relatively sparingly, but its use is likely to increase as data on larger numbers of impacted areas accumulate.

The third type of standards is those that are most often selected. Several sets of such standards have received widespread use. Table 4.1 presents data on three widely used sets of rates. The data in the table indicate the nature of such standards and their variability. Thus, it is evident that such population-based ratios are likely to vary widely from one source to another and should be used with caution. The advantages of such standards lie in their widespread usage and acceptance, their ease of application, and their grounding in analytical analyses. The disadvantages of such standards are equally evident. They are unlikely to be applicable to many areas, particularly rural areas that are dissimilar to the areas for which they were developed; they do not reflect existing service bases in the impact area, and

Table 4.1. Public Facility Standards from Selected Sources, by Service Area

Services	Source: THK Associates	Source: Powder River Basin Capital Facilities Study	Source: Real Estate Research Corporation[a]
Education:			
Personnel		18.2 students/1 teacher	Elementary--30-32/class Secondary--30-35/class
Plant	Elementary--74 square feet/student Junior High--90 square feet/student Senior High--108 square feet/student 1 elementary school--800 students 1 Junior High school--1,200 students 1 High school--1,800 students	Number of acres/1,000 population: Elementary--3.25 (urban), 2.20 (rural) Junior High--2.08 (urban), 1.40 (rural) Senior High--3.28 (urban), 2.20 (rural) Number of schools/1,000 population Elementary--.2558 Junior High--.0825 Senior High--.0810	Elementary--90 square feet/student High School--150 square feet/student .48 elementary students/household .22 high school students/household
Recreation:			
Playground	1.5 AC*/1,000 population	1.5 AC/1,000 population	3.9 AC/1,000 dwellings
Neighborhood parks	2.0 AC/1,000 population	8.5 AC/1,000 population	3.3 AC/1,000 dwellings
Play field	1.5 AC/1,000 population	1.5 AC/1,000 population	
Community park	3.5 AC/1,000 population	--	--
District park	2.0 AC/1,000 population	2.0 AC/1,000 population	--
Baseball field	1/1,800 population	1/6,000 population	--
Swimming pool	1/25,000 population	--	--
Tennis court	1/2,000 population	1/2,000 population	--
Golf course	1/50,000 population	1/25,000 population	--
Ice skating rink	1/25,000 population	--	--
Community building	1/30,000 population	1/25,000 population	--
Regional park	--	15.0 AC/1,000 population	--
Basketball court	--	2 AC/1,000 population	--
Sports field picnic areas	--	1.5 AC/1,000 population	--
Softball field	--	1/3,000 population	--
Wading pool	--	1/5,000 population	--
25-yard outside pool	--	1/10,000 population	--
50-yard outside pool	--	1/20,000 population	--
Indoor pool	--	1/25,000 population	--
Football field	--	1/25,000 population	--
Community open space	--	--	--
Library:			
Plant	.7 square feet/capita	Minimum: 2,000 square feet	1.0 square feet/capita
Equipment	2.5 volumes/capita	10,000 volumes	Minimum 15,000-20,000 volumes

Table 4.1. (Continued)

Services	Source		
	THK Associates	Powder River Basin Capital Facilities Study	Real Estate Research Corporation[a]
Medical:			
Personnel	--	.75-1.25 doctors/1,000 population	--
Plant	4 beds/1,000 population	--	4.0-4.5 beds/1,000 population 75-80 percent occupancy
Social welfare services:	--	--	.5 social workers/1,000 population
Fire:			
Plant	1 station/10,000 population	--	5,120 square feet
Personnel	--	--	2/1,000 dwelling unit or equivalent volunteers
Equipment	1 truck/10,000 population 1 pumper/10,000 population	Pumping capacity of 2,000-2,500 gallons/minute 1 fire truck	2 pumpers 1 staff car 1 ambulance 1,000 gallons/minute for 4 hours duration/1,000 population
Police:			
Plant	1 station/12,500 population	100 square feet per officer	22.5 square feet/officer
Personnel		2 officers/1,000 population	1.5 officers/1,000 population
Equipment	1 vehicle/2,500 population	1/2-2/3 car/1,000 population	1 vehicle/1,000 dwelling units
Water:			
Supply		180 gpd[b]	150 gpd[b]
Treatment	2.5 average gallons/day	168 gpd[b]	150 gpd[b]/persons to operate sewer plant

*AC signifies acre.

(a) Standards shown are those for dependent outlying communities with less than 10,000 rural population.

(b) Gallons per day per capita.

Sources: THK Associates--John S. Gilmore, Robert E. Giltner, Dean C. Coddington, and Mary K. Duff, Factors Influencing an Area's Ability to Absorb a Large-Scale Commercial Coal-Processing Complex (Washington, D.C.: Energy Research and Development Administration, 1975); Powder River Basin--Intermountain Planners and Wirth-Berger Associates, Powder River Basin Capital Facilities Study (Cheyenne; Wyoming Department of Economic Planning and Development, 1974); and Real Estate Research--Erik J. Stenchjom and James E. Metzger, A Framework for Projecting Employment and Population Changes Accompanying Energy Development (Argonne, Ill.: Argonne National Laboratory, 1976).

they only occasionally (Real Estate Research, 1976) reflect the functional unit thresholds for various services.

In assessing the relative advantages and disadvantages of each type of standard, it is essential to note that there has been relatively little systematic assessment of the relative reliability and validity of any set of standards used in impact assessments. Thus, which sets of standards (local, general, and so on) provide the most accurate assessments under any given set of circumstances is not clear. Such assessments are critical, and until they have been completed the selection of standards will remain less exact than desired. The selection of standards for use in the projection process must be done with full realization of the limitations entailed in the selection process.

Projections of Service Impacts

Given an adequate description of baseline conditions and a set of standards for projecting service demands, the projection of service impacts is a relatively simple process. It consists of procedures for applying the selected standards to projections of new project-related population. The population-based standards employed in such projections may be either per capita or per population unit rates (i.e., rates per 1000 population). The standards shown in Table 4.1 are typical of these rates.

Given these rates, the projection of service needs consists of the straightforward process of applying the selected rates to projections of new population. For example, given a projected new population of 10,000 persons and using the THK Associates estimates in Table 4.1, the projections of new service needs would include projected requirements for 15 acres of playgrounds (1.5 acres per 1,000 population multiplied by 10,000 new population), 7,000 square feet of library space (0.7 sq. feet per capita multiplied by 10,000 persons), 40 new hospital beds (4 beds per 1,000 population multiplied by 10,000 persons), 1 new fire station (1 station per 10,000 population), and 4 new police vehicles (1 vehicle per 2,500 population multiplied by 10,000 persons).

The only variation in the application of these rates results from the use of average versus marginal approaches. When an average-usage approach is employed, the projected values are reported in an unadjusted form (that is, as noted above). If a marginal approach is used, the values projected are adjusted (upward or downward) to reflect existing service deficiencies or excess capacity. Occasional variations may be made in these procedures to adjust for unique areal characteristics or to more adequately reflect service thresholds, that is, to reflect the minimum facilities required to provide a given level of services. In nearly all cases, however, the general procedure outlined above is that employed for service projections.

The procedures utilized are easy to compute and are easy to use in a variety of geographic settings. Their disadvantages lie in the fact that they are based on standards that have not been adequately verified, they fail to provide adequate assessments of needs other than personnel and facility requirements, and they seldom adequately account for distributional and quality differentials. These projection techniques thus clearly require additional refinement and further analysis of their validity and reliability.

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

Public service provisions and assessments may potentially be affected by the special and standard effects of repository siting. In this section, as in similar sections of preceding chapters, some of these effects and their implications for the public service assessment process are discussed.

Special Effects

Among the special efforts of repositories on public services are the additional demands likely to be placed on transportation, health and safety maintenance and monitoring, and for emergency preparedness services as a result of the potential danger resulting from the radioactivity of the substances to be stored at repository sites. Although the cost dimensions related to such factors are discussed in Chapter 5, the personnel and facility dimensions are of concern here.

It is apparent that few rural areas have personnel adequately trained in the procedures necessary for transporting or securing nuclear waste and nuclear waste sites. In addition, most rural areas do not have widely known emergency evacuation plans and few personnel have been trained in such procedures. Finally, few health agencies in such areas are capable of providing the specialized types of services that might be necessary to diagnose and properly treat cases of radiation exposure. Clearly, services in these areas will have to be expanded, personnel given additional training, and additional personnel employed to address such specialized needs.

Standard Effects

The standard impacts of such facilities on public services should be similar to those for other large-scale developments. That is, since service needs are population dependent, the demand for such service needs should be determined by the level of population at the project. Although the population effects may vary with the special effects of such projects (see Chapter 3), the level of project-related population will still be the major determinant of service requirements.

Methodological Considerations

The assessment of the public service impacts of nuclear repository siting will require expansion of the normal range of public service projections and an expansion of the considerations normally given to other public service areas. Thus, projections in the areas of emergency preparedness, nuclear medicine, nuclear waste transportation, and community-related facility site security should be added to the standard range of services projected. At the same time, projections of general medical, transportation, and public services should be expanded to include the special effects of repositories on standard service dimensions. The major methodological considerations thus appear to result from the need to expand the range and dimensions of services that are to be projected.

Available methodologies, however, with the types of additions noted above, seem capable of providing the necessary projections for public services for repository sites. The recommended methodologies should entail the use of marginal approaches with extensive assessments of baseline service dimensions. The use of such approaches with the types of additions noted above should allow for adequate assessments of the public service impacts resulting from nuclear repository siting.

SUMMARY AND CONCLUSIONS

The projection of public services requires consideration of alternative conceptual approaches and numerous service dimensions. These projections may include or exclude consideration of predevelopment service bases and may include a wide range of widely diverse services. Service projections require adequate assessment not only of quantitative service dimensions, but also consideration of the distribution of services, the quality of services, the nature of the delivery system, service perceptions and satisfaction, and the variability that exists between various types of services. Finally, the process of projecting public services requires the completion of an adequate description of baseline service levels, the selection of a set of standards for use in the projection process and the application of these standards to projections of new populations. Secondary or primary data approaches are usually used to describe baseline conditions, standards are derived from local, comparative, or general sources, and the projection process is usually straightforward, involving the application of selected standards to projections of new population. Whatever the form of projection technique employed, it is evident that the projection of public services, when properly performed, is a highly complex process requiring broad-based expertise and extensive analyses of numerous areally specific socioeconomic and service delivery dimensions.

The assessment of the public service requirements resulting from resource developments requires extensive additional analysis of key premises and methodologies. Until these premises and methodologies have been adequately analyzed, the validity and reliability of service projections cannot be established. Research needs related to several dimensions of public services are thus evident.

One such area is the need for a comparable data base on service levels for all rural areas in the nation. Although quantitative needs can be assessed on a local area basis, there is no single national source of comparable data on service availability, quality, and distribution in rural areas. A data source showing quantitative service levels for small areas is essential if truly comparative analysis of the service changes resulting from developments are to be completed.

Equally important is the requirement for additional needs assessments in impact areas. These assessments are commonly completed for service planning, but seldom appear as part of impact assessments. They usually include assessments of both quantitative and qualitative service dimensions, and thus provide a more holistic basis for public service analyses than is usually provided by impact assessments. The inclusion of needs assessments in the impact process should receive careful consideration as a means of increasing the utility of the public service assessment process.

Related to the needs noted above is the development of methodologies that ensure the systematic inclusion of service distribution, service quality, and service delivery system dimensions in the assessment process. At present these factors enter largely as qualifiers in the descriptive phase of public service projections but are seldom used to adjust or otherwise modify the projection process. Both qualitative and quantitative methods for including such dimensions in the assessment process should be pursued.

There is also a clear need for critical analyses of the utility of various service standards. The simple availability of existing standards has, in fact, been the major reason for their use. Most standards in use have not been thoroughly analyzed in terms of either their validity or reliability. A critical examination of the sources for these standards reveals that they are derived from relatively few areas of the nation, and these areas are unlike many of the areas to which they have been applied. Analyses of service changes in impacted areas must be made to determine what levels of demand have actually been experienced as a result of resource developments. Only when such analyses have been completed can one assess when the use of local, general, or some other service standard is appropriate.

It is also necessary to more fully integrate service management and engineering considerations and research issues into the service assessment process. Most present projection techniques assume a linear relationship between population increase and service requirements. As with public costs, however, the validity of such assumptions requires extensive analysis (Lansford, 1980). In addition, it is essential that thresholds related to the management efficiency and engineering feasibility of alternative service units and thresholds be more fully included in service assessments. Increases in management personnel requirements and the minimum levels of demand necessary to merit the construction of certain facilities must be integrated into the formal projection process. Such considerations have been integrated into fiscal assessment processes, but they must be more effectively integrated into the service projection process.

Although the time and cost considerations involved in the impact assessment process will clearly lead to the continued use of averaging approaches, it appears necessary to argue for the use of marginal rather than averaging approaches. Existing service levels in impact areas simply cannot be ignored if an assessment is to be complete and useful to planners and decision makers. Research to develop techniques that more adequately use marginal approaches is thus essential.

Finally, the most evident need related to the assessment of public services, as well as for other impact dimensions, is simply the need for more comprehensive data on the actual public service impacts that have occurred in rural areas as a result of resource developments. Such data must be collected and subjected to careful comparative and longitudinal analyses to discern the actual changes in service demands that occur as an area develops. Until such data and the results of its analysis are available, there will be little agreement on which alternative techniques should be used in assessment efforts. As with the assessment process as a whole, then, the assessment of service impacts requires increased long-term research and analysis efforts.

The assessment of service impacts is often seen as one of the least complicated steps in the socioeconomic assessment process, but this assumption is true only in relation to the numerical computation of service demands. To effectively understand and project the service demands of a major resource development requires an extensive base of research and analytical information. As with other parts of the assessment process, the assessment of public services must be refined so that its accuracy, reliability, and validity can be assured, and its use for critical planning and decision-making processes fully justified.

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CHAPTER 5

FISCAL IMPACT ANALYSIS

The purpose of fiscal impact analysis is to project the changes in costs and revenues of governmental units which are likely to occur in response to a development project. The governmental units of primary interest are those local jurisdictions which may experience substantial changes in population and/or service demands as a result of the project (Muller, 1975). In some cases, the effect of major projects on state tax revenues and expenditures also may be evaluated (Krutilla et al, 1978; Leholm et al, 1976a; Stinson and Voelker, 1978; Toman et al, 1977), but such analyses are often for the purpose of identifying resources which could be used for local impact assistance programs (Leistritz et al, 1979b). Some early analyses considered only the direct effects of the project (that is, the additional tax revenue produced by the plant and the added public service costs directly attributable to the plant and its workers).[1] This approach ignores tax revenues from workers' residences and other property and also neglects both the revenues and costs which may result from the secondary (indirect and induced) effects of the project. Because the secondary effects of a project can be quite important in determining its total fiscal implications (Hirsch, 1964), most recent analyses attempt to account for both direct and secondary effects.[2] In summary, then, the primary objective of fiscal impact studies is to determine whether new development projects will directly and indirectly generate enough new local revenues to pay for the added public services they will require (Muller, 1975).

Fiscal impact analysis is sometimes confused with other evaluative techniques, particularly cost-benefit and cost-effectiveness analysis. The basic difference in these approaches is the scope of the analysis. <u>Fiscal impact analysis</u>, also often called <u>cost-revenue analysis</u> (Burchell and Listokin, 1978), focuses exclusively on the <u>public sector</u> costs and revenues associated with a particular development project or form of growth. The results of such an analysis is typically a statement of net surplus or deficit (usually measured in dollars but sometimes in service units or manpower). The key feature of fiscal impact analysis, then, is that it focuses exclusively on the revenues received and costs incurred by <u>governmental units</u>. <u>Cost-effectiveness</u>

analysis focuses on the cost of providing selected services, or more broadly, of achieving selected objectives. This technique emphasizes determining the least cost approach to achieving a given objective and typically considers a range of alternative actions within the constraint of a fixed level of resources (Burchell and Listokin, 1978). Cost-benefit analysis is the broadest of the three techniques and involves comparison of both tangible and intangible costs and benefits of a project. The cost and benefits considered include not only the expenditures and revenues of public sector entities but also benefits and cost experienced by private businesses and individuals, including both tangible benefits and costs.

The distinguishing features of the three techniques can be illustrated by a hypothetical example of their application to a large-scale synthetic fuel facility. A fiscal impact analysis would evaluate the likely effect of the project on the tax revenues and costs of nearby school districts, municipalities, counties, and perhaps the state government. A cost-effectiveness analysis might be employed to determine the least costly means of providing public service, such as emergency medical care, at desired levels. A cost-benefit analysis would include evaluation of not only the public sector costs and revenues considered in the fiscal impact analysis but also private sector costs and benefits. These private sector costs and benefits would include the direct and secondary effects of the project on incomes of area residents and also environmental and quality of life effects such as increased air pollution, congestion, and visual impacts.[3]

The purpose of this chapter is fourfold. First, the conceptual bases and methodological alternatives for fiscal impact assessment are reviewed. Second, the characteristics of the impact process which are especially important in determining the fiscal effects of major projects are examined, and the information needs of decision makers with respect to fiscal impacts are described. Third, we examine the techniques which are typically employed in fiscal impact assessments. Finally, the implications for nuclear repository siting are discussed.

CONCEPTUAL BASES AND METHODOLOGICAL ALTERNATIVES IN FISCAL IMPACT ASSESSMENT

Fiscal impact analysis had its origins in the 1950's as a number of studies were undertaken to statistically predict municipal expenditures.[4]

The cost functions or multipliers thus derived were employed in studies to determine whether certain types of housing development "pay their own way" in terms of costs and revenues to local governments.[5] While early fiscal impact studies tended to focus on the implications of alternative types of housing development or alternative residential growth patterns, a few studies examined the impacts of industrial development on local government finances (Hirsch, 1961; Loewenstein, 1963; Kee, 1968; Garrison, 1970). During the 1970's there has been a substantial increase in fiscal impact analyses in both urban and rural settings. In the urban context, the growing interest in fiscal impact analyses arose in large part from concern that some types of land uses may have adverse fiscal effects (Muller, 1975). In rural areas, fiscal impact studies have become more frequent as a result of industrial decentralization (Youde and Huettig, 1971; Shaffer and Tweeten, 1974; Morse and Hushak, 1979). Many communities have offered tax concessions or other inducements to encourage industries to locate in their area, but there is growing awareness that careful analysis of the fiscal implications of rural industrialization is needed if these programs are to bring the desired results (Tweeten and Brinkman, 1976; Wilson, et al, 1979; Morse and Gerard, 1980).

Analysis of the fiscal impacts of large-scale development projects has received increasing attention since the enactment of the National Environmental Policy Act of 1969 (NEPA). During the first few years following the enactment of NEPA, environmental impact statements often gave only limited attention to economic and social impacts. Court decisions coupled with pressure from local and state officials, however, have led to more thorough treatment of economic and social impact considerations (Watson, 1977). The fiscal impacts of new developments have received special attention because these effects are readily perceived by local officials and are believed to be amenable to mitigation efforts. Recent decisions by the Nuclear Regulatory Commission and the Federal Power Commission have established the precedent that firms developing new power plants may be required to compensate local governments for additional expenditures resulting from the project (Watson, 1977). A number of states have enacted legislation governing the siting of major industrial facilities (Rapp, 1976; Auger et al, 1978; Auger and Zeller, 1979). The state siting authorities thus created often have been authorized to include requirements for fiscal impact mitigation as conditions in the siting permits they grant.[6] Finally, local officials may use their zoning power as the basis for negotiation with development firms.[7]

The growing interest in fiscal impact assessment in both rural and urban contexts has led to an increasing number of such studies.[8] These efforts have resulted in a more intensive examination of the conceptual basis for fiscal studies and also in the development of a number of specific methods of fiscal impact analysis. In this section, we describe first the theoretical foundations and then the methodological alternatives for fiscal impact assessment.

Conceptual Bases for Fiscal Impact Assessment

Key concepts in the estimation of public sector costs and revenues include the basic economic principles of demand and supply. These concepts were developed primarily with reference to private sector goods and services, however, and their application to public sector services is limited by a number of conceptual and practical obstacles.

Demand for a particular good or service is traditionally defined as a schedule describing the quantities of the product which will be purchased by consumers at various alternative prices. With very few exceptions, larger quantities will be purchased at lower prices. Consumers will differ in their demand schedules for a given product because of difference in their incomes and in their tastes and preferences. A consumer's demand schedule may change over time, then, with changes in income, in prices of other goods, and in preferences for particular products. The horizontal summation of the individual demand curves of all consumers in a given market gives the market demand schedule.

The supply of a given product is similarly defined as the schedule of quantities of the goods that producers will place on the market at various alternative prices. The typical relationship is that greater quantities will be supplied at higher prices. The nature of the supply function is in turn determined by the nature of the production function for the product. In the private sector, the prices and quantity exchanged for a given product are determined by the intersection of the supply and demand schedules (that is, the price level at which the quantity consumers wish to purchase is equal to the quantity producers will supply).[9] However, when this conceptual framework is applied to public sector services, a number of conceptual and practical difficulties arise.

Services provided by local governments have a number of unique characteristics which pose difficulties in applying the traditional supply and demand concepts in a straightforward manner. These characteristics relate to both the nature of the services produced by local governments and the environment in which governmental decisions are made. Public services are typically characterized by one or a combination of the following characteristics: public or collective good, natural monopolies, externalities, and merit goods. It is the presence of these features which has led certain services to be provided by the public sector rather than by the private sector. Public or collective goods refer to products characterized by joint consumption (that is, consumption by one individual does not reduce consumption by anyone else). National defense and local fire and police protection are examples of this phenomenon. These services are not well-suited to provision by the private sector as many persons who benefit from the service likely would not be willing to share in its cost.[10]

Natural monopolies exist when the conditions for supplying a given service are such that a given market can be supplied most efficiently by a single producing entity. Local sewer and water services are examples of this situation as are electric and gas utilities.[11] When natural monopolies are present, the service is sometimes provided directly by a governmental entity; but often a private firm is authorized to supply the market, subject to governmental regulation of its rates and the nature of its services.

Some services are characterized by external benefits (that is, benefits which accrue to others besides those who directly consume the service). Education is an example of this type of service. These services are typically provided by governmental entities because private enterprise would tend to produce a smaller than optimum quantity of the service (because private producers could not capture the full social benefits of their product).

Merit goods are those which society deems essential for the well-being of persons who will not or cannot purchase them in the market. For example, innoculation for disease and milk for school lunches are sometimes provided by the public sector at no charge to consumers.

In summary, services provided by the public sector typically differ in certain key characteristics from those provided by private sector entities. These characteristics in turn complicate the task of projecting the service requirements and costs associated with growth. The environment in which public service decisions are made also differs from that found in markets for private sector goods. Government agencies establish levels of services to be provided and taxes to be levied subject to both external and local constraints. For some services, such as education and welfare, minimum standards are established by outside authority and the community supposedly meets these standards, generally with outside financial support (Tweeten and Brinkman, 1976). Similarly, state statutory or constitutional provisions typically establish minimum and maximum levels for tax rates and assessment ratios and limit debt issues to a specified fraction of the local tax base. Within the framework established by these external restrictions, local officials are further constrained in their decisions by voters' perceptions of "acceptable" levels of taxation and "desirable" levels of services.[12]

Individuals in a community can be expected to differ in the level of services they desire and in the level of costs they are willing to incur. Further, the distribution of benefits and costs associated with a particular service is generally not uniform over all members of the community. A combination of the desire of individuals to maximize benefits from public services relative to costs and their inability singularly to have a significant effect on the outcome of collective decisions provides an incentive for the formation of groups with mutual interest. The central goal of such special interest groups is to influence officials to provide a set of services from which the members of the group receive benefits in excess of their costs (Jones and Murdock, 1979). Local officials, then, can be viewed as balancing the desires of their constituents for adequate services against their need to limit expenditures to a level deemed acceptable by those constituents.[13]

Demand For Public Services

Demand analysis requires a thorough understanding of the characteristics of the various public services. If demand schedules are to be estimated for specific public services, meaningful output measures are essential (Hirsch, 1973). Output should be measured in terms of the number of basic output units of specified quality characteristics provided per unit of time. Very few of the public services provided by local governments, however, has basic output units with well-defined physical characteristics (water delivery and solid waste disposal are obvious exceptions). Measuring the output of many public services is quite difficult, and defining and measuring the quality of that output is even more difficult (Hirsch, 1973). In the abstract, one can view a basic service unit for many public services as having numerous quality dimensions which should be incorporated into a demand analysis. Because of the great difficulty in developing empirical measures of public service output quantity and quality, however, demand functions for many public services are difficult to estimate.[14]

In the context of assessing the impacts of a large-scale project, the lack of empirical estimates of the factors affecting the demand for public services poses a serious problem. There is reason to believe that the economic and demographic changes which accompany a large-scale development will lead to substantial shifts in the demand for various services (Auger et al, 1978; Gilmore and Duff, 1975). There is little basis, however, for estimating the extent of these changes in service demands in a given impact situation.

Another factor which complicates the analysis of public service provision is the public budgeting process. As discussed earlier, local officials attempt to balance the revenues and expenditures of their jurisdictions within a set of external and local constraints. Changes in local residents' preferences with regard to services are reflected in this process only indirectly. Changes in factors affecting local residents' demand for services (for example, per capita incomes, demographic characteristics of in-migrants) may have less direct influence in public budgeting decision than changes in factors influencing public fiscal capacity (for example, property tax base, intergovernmental transfers). Thus, analysts typically find that measures of local fiscal capacity are more effective in explaining intercommunity differences in levels of public expenditures than are variables which should affect the demand for services (Pidot, 1969).

Supply and Cost of Services

The nature of the supply schedule for a public service depends on the characteristics of the production function for the service and on the prices (or supply schedules) of the major inputs (that is, labor, capital, and management). The production function describes the relationship between various combinations of physical inputs and levels of output. From this production function, costs functions can be derived which describe the relationship between output level and cost per unit of output.[15] Such cost functions provide the basis for the supply function for the service.

The costs associated wtih providing public services can be categorized into operating and capital costs. Capital costs refer to those costs associated with resources which have a useful life of several years (for example, a building), while operating costs refer to payments for resources which are completely used within the current year (for example, labor and fuel). In order to provide a realistic estimate of the cost of providing a service, capital costs should be prorated over the useful life of the capital good.[16]

Public service costs can also be expressed in terms of average costs and marginal costs. The average cost of providing a given service for a given time period is computed by simply dividing the total cost (operating costs plus the prorated share of capital costs per year) of providing the service by the number of units of output. The marginal cost of providing a service is the cost of providing one additional unit of the service. Marginal costs may differ greatly from average costs for certain services and under some conditions. Some factors which can lead to divergence of marginal and average costs are the presence of excess capacity in existing capital facilities, the existence of threshold effects for certain services, and the presence of economies or diseconomies of scale.

If excess capacity is present in a community's capital facilities, the marginal cost of providing additional services may be substantially less than the average cost. This effect is particularly important for those services for which capital costs make up a substantial percentage of total costs (for example, water and wastewater services).

Threshold effects refer to the fact that basic changes in the type of service facilities required tend to occur when certain population levels are reached. For example, a growing community may need to begin mechanical treatment of sewage and/or may find a change from volunteer to full-time firemen to be desirable. When such threshold levels of population or service load are reached, the marginal costs of providing additional services may be substantial.

Economies of scale are said to exist when larger quantities of a service can be provided at a lower cost per unit. Recent analyses suggest that economies of scale are present for most services in small communities (with populations less than, say, 20,000). The most substantial economies are typically associated with services which are capital intensive (for example, water and sewer). Conversely, diseconomies of scale are frequently observed in very large cities.[17]

Given the conceptual model discussed above, it would appear that the most appropriate approach to fiscal impact analysis would include developing empirical estimates of the demand and supply functions for each type of service. These functions would then provide a basis for estimating changes in service output and cost associated with a new development. Unfortunately, the problems inherent in measuring public service outputs have caused most analysts to seek a simpler approach which avoids output measures and deals directly with the cost of services (Denver Research Institute, 1979; Burchell and Listokin, 1978). This approach does, however, require some simplification of behavioral assumptions and tends to eliminate the distinction between forces affecting supply and those affecting demand (Margolis, 1968).

Fiscal impact analysts also typically utilize simplifying assumptions in dealing with the public budgeting process. In general, it is recognized that tax rates and governmental expenditures are jointly determined by a number of factors including community preferences and local tax base. Further, in the short run, fiscal capacity rather than need is the most significant determinant of expenditure levels.[18] Analysts then must choose between approaches which include predicted revenues as a major determinant of costs or those which base cost estimates on a constant level of services (Denver Research Institute, 1979). The former approach leads to projections of changes in the level of services which can be supported while the latter provides estimates of fiscal deficits or surpluses resulting from a project. Since fiscal surpluses and deficits provide a more concise measure and one which is more amenable to discounting, most analysts assume a constant level of services, often in conjunction with an assumption of constant tax rates.[19]

Methodological Alternatives in Fiscal Impact Assessment

In this section, the major methodological alternatives for revenue and cost estimation are examined. Methods for revenue estimation are discussed first, followed by alternative approaches to cost estimation.

Revenue Estimation Methods

Revenue sources of local governments can be broadly classified as own-source revenues (that is, those taxes and charges assessed and collected directly by the local jurisdictions) and intergovernmental transfers (that is, funds received from state and federal levels). Own-source revenues can be further classified according to their primary determinants into those based on property valuation (for example, ad valorem property taxes), those based on income or sales (for example local or sales taxes), those based on the level of production of some industry (for example, severance or gross production taxes), and those based largely on changes in population. The techniques which are most appropriate for estimating revenues for these sources will differ depending on the revenue source (Burchell and Listokin, 1978; Denver Research Institute, 1979).

Several general factors must be kept in mind when estimating changes in local revenues. An adequate estimation technique must include a mechanism for estimating the change in tax base, a method for estimating (or assumptions concerning) the effective tax rate, and a means of estimating the timing of revenue collections. Estimates of changes in the relevant tax bases (for example, property value and income) are frequently derived from the economic and demographic impact assessment models discussed in previous chapters. Tax rates are frequently assumed to remain at their current levels.[20] Estimating the assessment ratios which will apply to new industrial and residential property is frequently a complex task; this topic is discussed later in connection with specific property tax estimation techniques. Finally, estimating the timing of revenue changes requires careful attention to the prevailing taxation and revenue distribution practices. Frequently substantial time lags exist between an initial increase in tax base or population and receipt of additional revenues resulting from this change.

Property Tax Estimation

The property tax is by far the most common form of local taxation, accounting for more than half of the own-source revenues of municipal governments and more than 85 percent of own-source revenues of school districts in 1972 (Burchell and Listokin, 1978). The property tax base in a particular state may consist of both real property (land and structures) and personal property. Real property, however, typically represents the bulk of the tax base.

Estimating changes in property taxes involves first estimating changes in the tax base. Major components of the change in local tax base resulting from a new project include the taxable value of the project facilities, of additional business and commercial property resulting from the project, and of new or improved residential property. Determining the taxable value of project facilities requires careful analysis of relevant state statutes and administrative guidelines together with detailed information concerning the investment in project facilities. Statutes and administrative practices may differ not only from state to state but from industry to industry and from county to county in cases where local assessors are responsible for valuing the new facilities (Denver Research Institute, 1979).

Changes in the value of business and commercial property may be estimated as a function of estimated changes in local income or sales (Toman et al, 1977). Changes in the value of residential property may be estimated as a function of the changes in population or local income (Morse and Gerard, 1980; Krutilla et al, 1978), but some analysts believe that more precise estimates can be developed through estimating the composition of new residential development. This approach involves estimating the number of new housing units by type during the various phases of the project's life (particularly distinguishing construction and operation phases) and then estimating the typical values of each type of unit. Types of housing typically include single family housing, multifamily permanent units, and mobile homes (Denver Research Institute, 1979; Toman et al, 1977). An important consideration which is sometimes overlooked, however, is that population growth is likely to lead to substantial increases in the value and assessed valuation of existing residential and nonresidential property (Weber and Goldman, 1979). The relative elasticities of the assessed valuations of residential and nonresidential property with respect to population growth will affect the distribution of tax burdens among classes of property owners (Buchanan and Weber, 1979). Further, the extent to which these changes in assessed valuation of existing property are taken into account may have a substantial effect on revenue projections.

The possibility that a new project may lead to losses of tax revenue from certain sources must also be considered. This issue is particularly relevant if the new project is to be publicly owned and hence exempt from local taxes.[21] Likewise, a new mining project may reduce the long-term productive capacity of the mined land for agricultural purposes and hence reduce its anticipated taxable value. These effects should be included in the analysis in order to obtain a complete assessment of the fiscal implications of such projects (Toman et al, 1977).

Estimating the assessment ratio which will apply to new property is often a complex task. Some studies have assumed that statutory ratios of assessment to market value will be implemented. The statutory ratio, however, is almost always higher than the effective assessment ratio (that is, the actual relationship between assessed and market values), and so this approach will generally lead to overestimation of actual tax revenues. In order to estimate the effective assessment ratio, some have utilized the results of published analyses of sales to valuation ratios. Others have collected primary data on sales and assessed values for each jurisdiction being analyzed and/or have interviewed local assessors (Denver Research Institute, 1979). These approaches may, however, lead to underestimation of the effective valuation ratio for new property. The effective ratio is typically lower for older units than for new property. A sample drawn on a strictly random basis is likely to include a high proportion of older units and thus to provide an estimated assessment ratio lower than that likely to apply to new units. A selective sample including only relatively new units may be the best approach to approximating the effective assessment ratio for impact analysis.

Income and Sales Tax Estimation

In many states there is a recent trend toward diversification of local governments' revenue sources with reduced dependence on property taxes (Burchell and Listokin, 1978). This trend is particularly evident for municipalities, and sales and income taxes are two revenue sources which are being utilized increasingly.

Estimation of income and sales tax revenues involves application of the prevailing tax rates to the estimated change in taxable income or sales. Income and sales estimates can typically be derived from the economic impact analysis models described earlier (in Chapter 2). Income estimates, for example, can be obtained directly from input-output models or from export base models utilizing income multipliers. Alternatively, given estimates of project-related direct and indirect employment, income estimates can be derived through application of average wage and salary levels to the number of workers by type. Estimates of local sales can be estimated as a function of the change in local income.

Production and Severance Taxes

Taxes based on the production of specific types of facilities are being utilized increasingly as a source of state and local revenue, particularly in connection with mining projects. In 1978, twenty-nine states had some form of special tax on minerals extraction (Stinson, 1978). These taxes are usually either gross production taxes (levied as a percentage of the value of the product) or severance taxes (levied as a fixed sum per physical unit of output). In some cases severance or gross production taxes are levied in lieu of ad valorem property taxes, but often they are applied in addition to these local property taxes (Stinson, 1978). The division of the revenues from these special minerals' taxes between state and local levels of government also differs substantially among states. In some states, all revenues from special minerals' taxes accrue to the state treasury, but several states use severance tax receipts as the basis for substantial programs to assist local governments in rapid growth areas.[22]

Estimation of local government revenues from special minerals' taxes requires a detailed understanding of the state's taxation and distribution formulas together with estimates of the facility's production (and in some cases the price of the product) over time. Production estimates generally are easily obtained from the firm developing the facility, but the price estimates may be more difficult. Generalized projections of product prices are usually available at the industry level, however, if project-specific estimates are unobtainable.

Population-Related Taxes and Charges

A number of local taxes and charges are perhaps most easily estimated as a function of population. These include per capita taxes, fees and permits (such as for building or occupancy), and user charges for water, sewer, and sanitation services (Burchell and Listokin, 1978). While it may be possible to develop more accurate and detailed formulas for projecting some of these revenues, simple per capita rates are frequently applied. Alternatively, user charges may be estimated as a function of the number of new households in the jurisdiction, but the number of households is, in turn, usually estimated as a function of population. Particularly if these items account for a relatively minor share of total revenues, simple per capita approaches are often employed.[23]

Intergovernmental Transfers

Intergovernmental revenues are often more difficult to project than own-source funds. These difficulties arise because the allocation formulas are frequently complicated, eligibility for certain forms of assistance changes as local wealth or other indicators change, and frequently overall community effects must be considered (Burchell and Listokin, 1978). For instance, state school aid is usually inversely related to local wealth, and so a new project that significantly affects the local tax base would affect the level of state assistance not only for the new students associated with the specific project, but also for all other students in the locality. In such situations, the analyst must take account of this overall net change if he is to obtain a realistic estimate of the effect of the project on the community (Burchell and Listokin, 1978).

Intergovernmental transfer programs which provide substantial revenues to local jurisdictions include state educational transfers, redistribution of state-collected sales and income taxes, redistribution of state-levied motor fuel, alcohol, and tobacco taxes, and the federal revenue-sharing program. Educational transfers and federal revenue sharing typically have some of the most complex distribution formulas, and a detailed simulation subroutine may be required to accurately reflect changes in these revenue sources (Stinson and Voelker, 1978). Because educational transfers often account for a substantial proportion of school district revenues, considerable attention should be devoted to accurately projecting this revenue source (Denver Research Institute, 1979).

To summarize, revenue estimation methods tend to be very similar in their general approach. They differ primarily in the degree of detail employed in estimating the various revenue components. The greatest variability is usually found in the methods used to estimate property tax revenues and intergovernmental transfers. Because the relationships and formulas involved are frequently complex, but generally capable of determination, revenue forecasting is an area where greater analytical effort can be expected to provide more reliable results. In addition, greater attention probably should be given to utility user charges and hook-up fees as these are potentially important policy tools for local officials.

Cost Estimation Methods

A number of approaches can be employed in estimating the community service costs associated with growth. These methods can be categorized by the nature of the cost estimates they provide into average cost and marginal cost approaches. The average cost approaches include the per capita expenditures method, the use of community service standards, and the use of cost functions derived from cross-sectional regression analysis. Marginal cost approaches include the case study method, comparable city analysis, and economic-engineering methods. These alternative approaches are discussed in the following sections.

Per Capita Expenditures Method

The per capita expenditure method is the most widely used of the average cost techniques and is based on the assumption that the average costs of providing services to current users are a reasonable approximation of the costs to provide services to future users (Burchell and Listokin, 1978). Using this approach, the additional expenditures of a local jurisdiction are computed as the product of the present per capita expenditure and the number of new residents. The major strength of this approach is that it can be applied quickly and relatively inexpensively as it involves very simple calculations and utilizes readily available, historical, local data. The principal weakness of the technique is that it assumes no excess capacity exists in local services, no economies of scale prevail, and no significant threshold effects are to be considered. It also does not allow for the possibility of changes in expenditures per capita as a result of changes in income or other socioeconomic characteristics.

The per capita expenditure method has a number of variations which involve different methods for calculating or adjusting the per capita expenditure multiplier. Some analysts adjust the historic per capita expenditure figures judgmentally to account for the effects of changes in income, economies of scale, and other factors in order to arrive at an impact multiplier

(Denver Research Institute, 1979). The major problem with this approach is its reliance on the judgment of the analyst. If in-depth interviews with local officials are used as the basis for the adjustments, this approach becomes very similar to the case study approach discussed in a subsequent section.

Another approach to estimating the per capita multiplier is to utilize data from a number of jurisdictions. The multiplier may then be derived as a simple or weighted average of the per capita expenditures of the various jurisdictions or through a regression of expenditures on population and perhaps other variables. As more variables are added to the regression, this approach becomes a cross-sectional regression analysis, discussed in a subsequent section.

Service-Standard Method

The service-standard method, another average-costing technique, involves developing estimates by service category of the manpower, equipment, and capital facility requirements associated with a particular level of population growth. Given the estimates of manpower and facilities required, cost estimates can be developed. The standards (for example, police officers per 1000 population) can be developed from several sources including the community's current public service personnel and facilities, standards recommended by state agencies or interest groups, or average relationships derived from data from state agencies, the U.S. Census of Governments, or other secondary sources.

The service standards approach has many of the same strengths and limitations that were discussed with respect to the per capita expenditure approach. If current local practices are used as the basis for developing standards, the approach should produce the same results as the per capita expenditure approach. Perhaps the principal strength of the service standards approach is the fact that its outputs (for example, personnel requirements by service area) are provided in a form which is quite useful to local planners and decision makers. Further, the two-step nature of the cost-estimation process (that is, estimate resource requirements, then estimate costs) provides an opportunity for the analyst to take explicit account of changing labor market conditions and inflation in developing the cost estimates.

Finally, the service-standards method can serve as a useful adjunct to the case study approach, discussed subsequently.

Cross-Sectional Regression Methods

In cross-sectional analysis, expenditures for each service are compared for different communities with data for the same year. Regression analysis allows an examination of the relationship between expenditures per capita and community population, the rate of population growth, income levels, age distribution, educational levels, and other socioeconomic characteristics. The development of a predictive formula by use of regression analysis allows the projection of expenditures given local data on each of the independent variables. While such expenditure functions are frequently criticized as lacking an explicit supply and demand framework or behavioral model, a similar criticism could also be made for the estimation methods discussed previously. Because the objective of fiscal impact analysis is to estimate changes in expenditures and revenue resulting from growth and not to estimate cost functions per se, however, the identification problem is not a major concern. Essentially, this approach allows a systematic exploration of the correlation of expenditure growth with a large number of variables (Morse and Gerard, 1980).

A major strength of the cross-sectional regression approach is its ability to include a large number of variables which may influence local expenditures. The expenditure function which is estimated, however, is a generalized function based on average relationships across a large number of jurisdictions. For this reason some analysts feel that these functions are better suited to regional analysis and to exploration of general trends than to projecting expenditures for a particular jurisdiction (Denver Research Institute, 1979).[24]

Case Study Method

The case study method is a marginal cost approach which may be particularly well-suited to cases in which existing services and facilities may be significantly under- or overutilized (Burchell and Listokin, 1978). Under these conditions, the average cost of providing services to present users may not accurately measure the costs of providing services to new residents. This method relies primarily on in-depth interviews with officials of local service departments to determine what additional personnel and equipment each department will require to meet the needs created by the proposed development.

A major advantage of this approach is that it encourages participation by service department personnel in the estimation of growth impacts. It allows consideration of such local factors as existing excess capacity (or conversely, current overutilization of facilities), threshold effects, economies of scale, and any other unique circumstances which may be present. The major problem with this method is judging the accuracy of local officials' responses. In some cases, officials' responses may be influenced by political and budgeting considerations, and this may lead to either over- or underestimates of actual expenditure requirements. Further, local officials may not always be well-equipped to evaluate potential needs and associated expenditure requirements. For example, if a small rural community is located near the site of a large industrial project, its population could double or triple in just a few years (Gilmore et al, 1976; Murdock and Leistritz, 1979).

Under these conditions, local officials may have difficulty in estimating additional service requirements as the magnitude of anticipated population growth and the resulting changes in service needs are outside the range of their experience.

Community service standards developed from secondary sources may be quite useful as a supplement to the case study approach. Thus, Burchell and Listokin (1978) suggest estimating the number of additional personnel required based on service standards and comparing these estimates with those obtained from local officials. If the two sets of estimates diverge substantially, the officials may be reinterviewed to determine the reasons for the differences.

The case study approach has been used extensively in recent years (Morse, 1978; Muller, 1976; Denver Research Institute, 1979) and may be particularly applicable to impact analysis for large projects in rural areas. It does, however, require considerably more time and effort than some of the average cost techniques described earlier.

Comparable City Method

The comparable city method, another marginal cost procedure, is employed in situations similar to those in which the case study method is used. This method involves use of expenditure ratios calculated by population size and growth rate and is sensitive to economies and diseconomies of scale as well as to expenditure variations which are a function of both the direction and pace of growth (Burchell and Listokin, 1978). It is among the most recent of the fiscal impact analysis methods and has received widespread application only since the mid-1970's.

The cornerstone of this procedure is a set of expenditure multipliers for communities of different sizes and growth rates. These multipliers are typically calculated using data from the U.S. Census of Governments.[25] To apply the comparable city method, the analyst first determines (using the results of the demographic impact assessment) the future population of the community and its estimated growth rate during the impact period. The community's growth rate since the latest census is also computed. Then two sets of multipliers are employed to estimate the additional expenditures associated with growth. The current multipliers are those applicable to the community without the growth stimulus while the future multipliers are those applicable to the community after growth. The difference in cost estimates from the two sets of multipliers provides an estimate of the costs of growth.[26]

Economic-Engineering Method

The economic-engineering method may be quite useful in fiscal impact projections. The essence of this approach is to develop a production function for the service in question by specifying the physical inputs required and attaching a cost to each input (Isard and Coughlin, 1958; Mackey, 1977). The economic-engineering approach can be applied either to develop generalized estimates of service production functions (for example, by size of city) or to develop community-specific estimates based on the design and capacity of present facilities and the amount of anticipated growth. The community-specific approach can be very useful as it can provide not only very realistic estimates of additional costs but also can suggest the likely timing of those costs (Denver Research Institute, 1979). Recent examples of application of the economic-engineering approach include studies by Mackey (1977) and Schmidt et al (1978).

To summarize, a number of distinct techniques can be employed in estimating the local expenditure effects of a new project. Each of these techniques has both advantages and disadvantages. The strengths and weaknesses of the different expenditure estimation techniques are summarized in Table 5.1.

Table 5.1. Comparison of Strengths and Weaknesses of Alternative Expenditure Estimation Techniques

	Alternative Models					
	1. Per Capita Expenditure Method	2. Service Standard Method	3. Cross-Sectional Regression Method	4. Case Study Method	5. Comparable City Method	6. Economic-Engineering Method
Major Strengths:	Can be applied quickly and inexpensively. Uses readily available data. Use of local data may enhance credibility of results to local officials.	Application is relatively quick and inexpensive. Form of output (requirements for personnel, equipment and capital facilities) may be particularly useful to local officials. Assumptions about changes in costs of resources (e.g., labor) can be readily incorporated. Can be a useful supplement to other approaches such as the case study approach.	Allows a systematic analysis of the relationship between expenditures and a number of socio-economic variables (e.g., income population, population gorwth rate, population age distribution).	Encourages participation of local officials in estimation of growth impacts. Allows consideration of local factors such as excess capacity, throshold effects, and economies of scale. Provides marginal cost estimates.	Provides expenditure estimates which are sensitive to economies and diseconomies of scale and to the direction and rate of population growth.	Provides expenditure estimates which take account of economies of scale, present capacity of local facilities, threshold effects, and local resource costs. Timing of capital expenditures can be estimated using this method.
Major Weaknesses:	Ignores under- or over-utilization of present service facilities. Economies or diseconomies of scale are not considered. Threshold effects are not considered. Changes in demand for services stemming from changes in income or other socioeconomic characteristics are not considered.	Has many of the same weaknesses of other average costing methods (for example, the per capita expenditure method). If local service ratios are used as standards, the results will be the same as those from the per capita expenditure approach. If national or regional standards are used, the results may appear unrealistic to local officials.	Because cost functions are estimated from data for a large number of jurisdictions, they may not reflect unique local conditions.	It may be difficult to judge the accuracy of local officials' estimates. Time and effort required is considerably greater than for some other techniques (particularly 1 and 2)	Like the regression approach, the expenditure estimates developed via this approach may not reflect unique local conditions.	Time and effort required is considerably greater than for most other techniques.

Two contrasts can be observed in examining Table 5.1. The first is between the average costing techniques (methods 1, 2, and 3) and the marginal costing techniques (methods 4, 5, and 6). The second major difference among the techniques is the extent to which they rely on localized data. Those techniques which rely heavily on localized data (particularly methods 1 and 4) may be the most accurate in projecting expenditures over long time periods or when very substantial community growth occurs.

FACTORS AFFECTING FISCAL IMPACT ASSESSMENTS

The fiscal implications of a new project are determined by the interaction of a number of factors including project characteristics (for example, the magnitude of investment and the size and scheduling of the work force) and site area characteristics (for example, state and local tax structures and the capacity of existing service delivery systems) and by the nature of the economic and demographic effects resulting from the project. Further, because the fiscal impacts of a project are of considerable interest both to local officials and their constituents and to developers, decision makers will seek to use the results of the assessment both to form judgments concerning the desirability of the proposed development and to design growth-management programs. The fiscal impact assessment should, therefore, be designed to produce projections in the form which will be most useful to these policy makers. The purpose of this section is to summarize the major determinants of the effects of a new project on the revenues and costs of local governments and to describe the information needs of decision makers relative to fiscal impacts.

Factors Affecting Changes in Revenues

The effect of a new project on local government revenues is determined in large measure by the characteristics of the project and its work force, by the extent of secondary economic activity resulting from the project, and by institutional factors, particularly the state and local tax structure. Project characteristics which have a very substantial influence on local revenues include the taxable value of the facilities and the earnings of the work force. Projects which include a substantial amount of taxable property can add quite significantly to the tax base of the host jurisdictions (Kee, 1968; Purdey et al, 1977). Likewise, workers whose earnings are relatively high can afford residences with higher taxable values. The extent of secondary economic activity which accompanies the project will also affect the revenues of local governments. If the secondary effects of the project lead to substantial increases in the sales of local firms, local jurisdictions may experinece increased revenues either directly through local sales and income taxes or indirectly through increases in business property values.

The state and local tax structure can be expected to have a substantial effect on the revenues that local jurisdictions receive from a project. Some states allow municipalities to levy sales or income taxes which are generally more responsive to growth than are property taxes. Property tax assessment and collection practices differ among states with some states taxing major industrial facilities at the state level. The time required for new property to appear on the tax rolls also differs among states. Finally, some states provide special forms of financial assistance to rapidly growing communities.[27]

Factors Affecting Changes in Costs

The effect of a development on local government costs is determined by the interplay of a number of factors, the most important of which are the extent of local population growth associated with the project and the extent of excess capacity in local public service infrastructure. The greater the population growth associated with a project, other things equal, the greater will be the associated increase in local government costs. Measures which minimize project-related in-migration, such as recruitment and training of local workers, will also tend to lessen the costs borne by local governments. The extent of excess capacity in local public facilities is also a major consideration. Recent estimates of the capital investment in local facilities required in energy-impacted communities of the Rocky Mountain and Great Plains states have ranged from $3,000 to $6,000 per capita in 1975 dollars (Gilmore et al, 1976; Murphy, 1975; Toman et al, 1978). Schools, water and sewer facilities, and streets and roads were estimated to account for the bulk of the capital costs. It is apparent, then, that a community with some excess capacity in its local facilities will experience much lower costs than one whose facilities are being utilized at capacity.

The preferences of local residents can be an important determinant of local public service costs. For example, Gilmore and his associates (1976) identified substantial differences in service quality and per capita service expenditures among communities with similar populations. These differences were attributed primarily to differing preferences and a resulting willingness in some communities to pay higher costs for better quality services. Differences in preferences regarding public services between project-related in-migrants and long-term community residents can be a source of conflict in rapid growth areas (Auger et al, 1978; Gilmore et al, 1976). Threshold effects can cause substantial increases in the costs of certain services. Likewise, local topographic and geologic conditions can have a substantial influence on the cost of expanding water and sewer systems.

While factors which determine the magnitude of the changes in costs and revenues which ultimately result from development of a new project are important, the timing of these changes and their distribution among affected jurisdictions are perhaps even more significant. A review of selected case studies provides insight into the local fiscal implications of large-scale projects.[28] The general conclusion from these analyses was that the total revenues accruing to local governments over a life of a project generally equal or exceed the total project-related governmental costs.[29] However, virtually all case studies revealed financial problems for at least some jurisdictions because of the temporal and jurisdictional distribution of costs and revenues. Two major dimensions, then, emerge as the source of local fiscal problems. These are the timing of additional project-related revenues in relation to additional costs and the distribution of costs and revenues among the local jurisdictions.

Factors Affecting Temporal and Jurisdictional Distribution of Impacts

The problem of cost and revenue timing, frequently referred to as the "front end financing problem", arises because, although new demands for public service and facilities begin early in the project construction period, many of the revenues associated with the project are not available until the construction phase is completed and production begins. Project facilities often do not appear on local tax rolls until construction is completed, and construction populations typically live in temporary housing with low taxable values.

new population will be faced with especially severe fiscal problems. Even when the facility and its support population are located within the same county and school district, affected municipalities may experience difficulties as the project facilities are almost invariably located outside city corporate limits and hence do not contribute to the minicipal tax base.

The jurisdictional distribution of project-related revenues and costs will be affected in large measure by the settlement patterns of the in-migrating project-related population and by the state tax structure. Methods for estimating settlement patterns were discussed in Chapter 3. Aspects of state tax structure which may have a substantial influence on the jurisdictional distribution of project revenues include local sales and income taxes, state redistribution of severance or gross production taxes, and the ability to create special tax districts which allow municipalities or school districts to tax the project facilities.

When the project-related revenues accruing to a jurisdiction are less than project-related costs, local officials have three basic alternatives. First, if the cash flow problem is expected to be only temporary, the jurisdiction may be able to obtain the funds needed to offset the revenue shortfall through bonding or loans. A number of institutional factors may limit the ability of local governments in impacted areas to obtain funds from these sources, however. These factors include constitutional and statutory debt limits, amortization schedules, and limitations on interest rate ceilings. Further, uncertainty regarding the nature and extent of impacts which may actually be experienced frequently leads to reluctance on the part of local residents to incur long-term obligations and to an unwillingness on the part of lenders to make funds available.[32]

If sufficient funds cannot be obtained through various forms of borrowing, the local officials' options are reduced to two: (1) to increase rates of local taxes and user charges or (2) to reduce the level of services provided. Under either of these alternatives, equity issues are apparent as long-term residents of the area may be forced to bear part of the costs associated with the new project, either through higher taxes or reduced services.[33]

In summary, the intertemporal and interjurisdictional distribution of project-related costs and revenues are extremely important aspects of the fiscal impacts of large-scale projects. Accurate assessment of these dimensions requires reliable estimates of the timing and distribution of the economic and demographic impacts of these projects. Above all, however, a thorough understanding of state and local tax structures and policies is essential to accurate estimation of the timing and jurisdictional distribution of project-related costs and revenues.

Information Needs of Decision Makers

The decision-making environment associated with the fiscal impacts of large projects has a number of implications with respect to the information needs of decision makers. First, because many of the important decisions must be made by local officials or sometimes by state agencies acting on their behalf, projections of changes in costs and revenues must be provided for individual jurisdictions. Second, because the timing of changes in costs and revenues may be as important as their ultimate magnitude, revenue and expenditure projections should be presented annually at least through the period of project construction and into the operational phase until costs and revenues become relatively stable. Third, because future levels of revenues and expenditures without development may be quite different from current levels, the impact assessment should include specific consideration of the future without development (Weber and Goldman, 1979).

The nature of the decisions confronting local officials indicates a need for fiscal impact assessments to provide estimates of effects on individual revenue and expenditure components (Markusen, 1978a). More importantly, impact assessment models should be capable of simulating the likely effects of specific local decisions (for example, changes in user charge rates or alternative schedules for construction of capital intensive facilities). As in other aspects of impact assessment, it is important to give attention to those factors which can be affected by local decision makers and not merely to the dimensions which can be most easily measured (Murdock and Leistritz, 1979).

Finally, because the implications of development for local residents are always a central question in fiscal impact assessment, careful consideration should be given to the format for presenting the results. Projected revenue and expenditure changes clearly should be reported for individual jurisdictions on an annual basis. In addition, however, summary measures may prove useful to indicate the overall effects of a project (over its expected life) on a given jurisdiction and to demonstrate the implications of the project in terms of changes in the fiscal burden on a typical local household.

FISCAL IMPACT ASSESSMENT TECHNIQUES

In the actual preparation of fiscal impact assessments, there is considerable variation not only in the techniques which are employed but also in the types of costs and revenues which are considered, in the treatment of costs and revenue timing, and in the formats in which the results are presented. In this section the techniques commonly employed in revenue estimation, in cost estimation, and in evaluating the timing of revenues and expenditures are described. Before examining these specific aspects, however, it should be noted that fiscal impact analysis is typically one of the weakest sections in environmental statements (Chalmers and Anderson, 1977). Many statements do not even address fiscal effects and others treat this topic only with very brief qualitative statements (Berkey et al, 1977).

When fiscal effects are addressed, the analysis often covers only a few of the relevant categories of revenues and costs. For example, the revenue analysis may include only property taxes, and perhaps only those increased property tax revenues which can be attributed directly to project facilities. Local government costs are treated in quantitative terms even less frequently than are revenues (Berkey et al, 1977), and, as with revenues, the analysis frequently is limited to only a few services. Public service costs are most frequently projected from present per capita expenditure levels, and capital and operating costs often are not separated (Weber and Goldman, 1979).

The treatment of the distribution of impacts over time and among jurisdictions also is quite variable. Some analyses present only an estimate of the average annual governmental costs and revenues resulting from a project (Shaffer and Tweeten, 1974; Wilson et al, 1979). These analyses provide useful information, but by failing to trace the time path of changes in costs and revenues, they also may omit important information. Other studies have presented annual estimates of the aggregate changes in costs and revenues for all affected local units of government (Leholm et al, 1976a). These studies provide a useful overview of the distribution of project-related costs and revenues over time but do not indicate their distribution among jurisdictions. Only a few analyses have provided annual estimates of costs and revenues for individual local jurisdictions (Hayen and Watts, 1975; Gilmore et al, 1976; Toman et al, 1978).

In overview, then, the treatment of fiscal impacts in environmental statements and similar studies typically has serious limitations. In the following sections we will examine the practices employed in those studies which have attempted a reasonably comprehensive assessment of fiscal effects.

Revenue Estimation Techniques

The techniques employed in revenue estimation, unlike more general approaches, exhibit more variability in the types of revenue included and in the degree of detail incorporated in the estimation process. Property tax is the revenue source which is most frequently included. Property tax revenues from project facilities are usually based on the capital investment in the proposed facility and are often coupled with information concerning the assessment practices applied to similar projects in the same area (Chalmers and Anderson, 1977).[34] Most studies have used current tax rates.

Property taxes from other sources, such as residential and commercial property, are frequently assumed to be proportional to population growth (Division of Business and Economic Research, 1975; Hayen and Watts, 1975). Other analysts have attempted more detailed evaluations involving estimation of the increased value of commercial property, based on changes in local income or sales, and estimation of residential property values, based on the estimated number and characteristics of in-migrants (Colony Development Operation, 1974; Leholm et al, 1976c; Denver Research Institute, 1979). Residential property value estimation frequently involves estimating the composition of new residential development, often differentiating between construction and operation phases, and applying estimates of the assessed value of each type of housing unit. Types of housing typically include at least permanent housing and mobile homes (Colony Development Operation, 1974), but permanent housing is sometimes subdivided into single family and multifamily permanent units (Denver Research Institute, 1979; Toman et al, 1977). Only a few studies have considered possible losses of tax revenues as a result of displacement of other activities by the new project (TERA Corporation, 1976; Toman et al, 1977).

Other revenue categories, such as income and sales taxes, user charges, and various fees are typically estimated using per capita rates (Chalmers and Anderson, 1977). Some analysts, however, utilize estimates of local income or sales in projecting income and sales tax receipts. Few analysts have considered the possible use of locally established fees and user charges as fiscal management tools (Weber and Goldman, 1979), although others have assumed that user charges will be established at rates sufficient to cover the amortized costs of specific facilities.[35]

Production and severance taxes and royalty payments are frequently estimated where applicable. Statutory tax rates and established lease terms generally are the basis for these estimates (Chalmers and Anderson, 1977).

Intergovernmental transfers are usually estimated on a per capita basis if they are even considered. As noted earlier, however, distribution formulas for such transfer programs are frequently complex and simple per capita estimation techniques may be inappropriate in some cases. Nevertheless, analysts have employed detailed simulation routines to estimate certain transfer payments, particularly education transfers (Stinson and Voelker, 1978). More effort in this area appears desirable.

Few analysts have developed explicit projections of revenues and expenditures for the baseline (i.e., without development) situation. Some, however, have projected the fiscal implications of alternative development scenarios (Gilmore et al, 1976; Toman et al, 1978), and several studies indicate that capacities of existing facilities and current expansion plans were considered (Hayen and Watts, 1975; National Biocentric Inc., 1977). Other studies, especially those which included a number of jurisdictions, have frequently incorporated the assumption that no excess capacity exists in community facilities.[36] Justifications for this assumption have included the following: (1) existing excess capacity is insignificant when compared to the needs resulting from the project, (2) excess capacity is sometimes difficult to determine; local and state officials, for example, may provide substantially different estimates of the capacity of a given facility (such as, a school), and (3) the assumption of no excess capacity should lead to estimates of the maximum costs likely to be incurred by a given jurisdiction.

Cost Estimation Techniques

While a variety of techniques have been employed to estimate local government costs, the per capita expenditure approach is clearly dominant in impact assessment reports (Chalmers and Anderson, 1977). The per capita expenditure factors are usually developed from local data, although regional averages are occasionally employed (Hayen and Watts, 1975; Stenehjem, 1978). The degree of aggregation in the cost analysis varies substantially with some studies projecting only total costs for a given jurisdiction (Colony Development Operation, 1974; Ford, 1976), while others provide a detailed breakdown of costs by service category (Leholm et al, 1976c; Gilmore et al, 1976).

The service-standard method appears to rank second with respect to frequency of use. Service standards typically are drawn from state guidelines or from national studies.[37] Case studies are sometimes utilized as the principal cost analysis technique (Morse, 1978), and they are often used as an adjunct to the per capita or service standards approaches (Denver Research Institute, 1979).

Economic-engineering and cross-sectional studies have been utilized only rarely in preparing fiscal assessments. Use of the economic-engineering technique has been limited primarily by its high cost. When this technique has been employed, it has usually been used to develop generalized estimates of facility costs by size or jurisdiction rather than to develop community-specific estimates.[38] Cross-sectional studies have been limited by two factors. First, local cost data available from secondary sources are frequently unreliable because of inconsistencies in accounting practices.[39] Second, because cost functions developed through cross-sectional analysis reflect average relationships across a number of jurisdictions, some analysts are reluctant to employ them in near-term analyses for specific jurisdictions. Cross-sectional analysis has been employed most frequently in estimating operating cost functions. These functions may have their greatest applicability in regional analyses.[40]

Estimation of Cost and Revenue Timing

Few studies have provided detailed explanations of the assumptions they employ with respect to cost and revenue timing. In general, however, it appears that most analysts who estimate annual changes in costs and revenues assume that costs will be incurred in the same year that project-related inmigration occurs. Substantial time lags may be associated with the receipt of most new revenue sources. The greatest delays are associated with property taxes and severance or production taxes.[41] Furthermore, the timing of revenues can be expected to vary substantially among states based on variations in assessment and collection practices. Thus, most analysts who have attempted to deal realistically with timing factors have tailored their assumptions to the tax laws of a specific state.[42]

Because large-scale projects frequently result in substantial differences in the cost-revenue balance both among jurisdictions and over time, some thought must be given to selection of the most appropriate format for presenting the results of a fiscal impact study. Typically, the projections of costs by type and revenues by type are presented annually for each of the affected jurisdictions. The subtraction of total costs from total revenues gives an estimate of the net fiscal balance for each jurisdiction for each year. These projections often reveal a pattern of net fiscal deficits for most jurisdictions during the project's construction period. Further, they often reveal that the long-term fiscal outlook is much brighter for some jurisdictions than for others. Under these conditions, summary measures may prove useful to indicate the overall effects of a project (over its expected life) on a given jurisdiction and to demonstrate the implications of the project from the perspective of a typical local resident.

Comparison of a stream of costs and benefits over time is typically accomplished through discounting the stream of annual values to a single discounted present value. The formula for deriving discounted present value is:

$$PV = \frac{NR_1}{1 + r} + \frac{NR_2}{(1 + r)^2} + \ . \ . \ . + \frac{NR_n}{(1 + r)^n}$$

Where: PV = discounted present value

NR = net revenue for each year (1, 2,...n)

r = discount rate

n = number of years in planning horizon.

The discount rate employed should be an approximation of the social rate of time preference.[43] Often the interest rate which public agencies/departments/organizations must pay for borrowed money is used as the discount rate. If the present value of the future stream of annual net fiscal balances is positive, it indicates that the positive fiscal balances occurring during the project's period of operation are sufficient to offset the negative balances occurring during the project's construction period. Taking the social rate of time preference into account, an analyst or local decision maker could infer the project is a fiscal asset to the jurisdiction in question if the long-term net fiscal balance for the project's construction and operational periods is positive. A negative fiscal balance would have opposite implications.

Discounted present value has been employed in a number of analyses including those by Gilmore et al (1976) and Leholm et al (1976a). In both of these studies, the discount rates employed were approximately equal to the interest rates which the local governments in question were paying for borrowed funds.[44]

As noted earlier, the fiscal outlook is likely to be much more favorable for some local jurisdictions (e.g., counties) than for others (e.g., municipalities).' Because the consequences of either adverse or favorable fiscal impacts ultimately are experienced by local residents (through changes in either tax rates and user charges or changes in levels of services) and because each local resident is typically a taxpayer in several jurisdictions (i.e., a county, a school district, and often a municipality), a summary measure which indicates the aggregate change in fiscal burden on a typical household may be useful. Such an aggregate measure is utilized by Gilmore et al (1976). Their index of fiscal burdens reflects the overall influence of a project on a typical household in the impact area, based on the present value of the stream of tax and user charge payments required from the household by each relevant local jurisdiction in order to maintain governmental services at their preproject levels (interpreted as maintenance of preproject levels of per capita or per pupil expenditure). This present value of future burdens is then compared to the present value of a constant payment at the preproject level to form the index. A value for this index which exceeds 1 (or 100 percent) indicates that a typical household will have to pay more taxes in user charges to maintain existing service levels.[45]

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

As is the case with other impact categories, evaluating the potential fiscal impacts of the development of a nuclear waste repository will involve consideration of both standard and special effects. Evaluation of the standard fiscal effects of repository siting will involve the same general considerations outlined above with respect to evaluating other types of large development projects. In addition, certain special fiscal effects of nuclear repository development may result from the unique characteristics of the facility, which may lead to additional service requirements and costs for local and state governments. A further consideration in evaluating the fiscal implications of repositories is that these facilities will be located on federal reservations and hence will be exempt from local property taxes. Analysis of the effects of this tax-exempt status and of the precedents and procedures governing federal payments to jurisdictions affected by such facilities will be required.

In evaluating the methodological alternatives for fiscal assessment of repository development, the special requirements of the waste isolation program also must be kept in mind. One important requirement of the waste isolation program is for a fiscal assessment methodology which is readily transferable between candidate sites located in different states. In addition, the methodology must be responsive to the needs of its key users, which will include the federal agency which develops the facility and the local officials whose jurisdictions are affected by that development.

In the remainder of this section we will examine the special fiscal effects which may be associated with repository development. Then the implications for fiscal impact assessment methodology which arise from the requirements of the waste isolation program will be briefly examined.

Special Fiscal Effects

The special fiscal effects associated with nuclear repository development will arise primarily from the hazardous nature of the waste materials and from public perceptions of the risks involved in their transportation and storage. The properties of the waste materials have been discussed at length (U.S. Department of Energy, 1980; Willrich and Lester, 1977) as have alternatives for their transportation, handling, and final isolation (U.S. Department of Energy, 1980; Battelle Pacific Northwest Laboratory, 1976). The public concerns and policy issues associated with the waste isolation program have been treated in some detail (Nealy and Radford, 1978; Hebert et al, 1978; Cluett et al, 1979) and will not be discussed further here.

Special fiscal effects may be experienced if the unique nature of the repository program leads to additional costs for state and local governments, beyond those normally associated with large-scale development projects. Examples of the types of activities which might lead to such costs include development of evacuation plans for the site area and provision of special mental health services for area residents. As with other categories of special effects, any discussion at this point is necessarily highly speculative. During the impact assessments for candidate sites, however, an effort should be made to identify potential special fiscal effects and, to the extent possible, estimate their magnitude. This information will be valuable in developing mitigation plans.

Fiscal impact assessment for nuclear repositories also must include consideration of the fact that the facilities will be federal property and hence tax-exempt. Evaluation of the statutes and administrative precedents governing payments-in-lieu-of-taxes and other forms of federal assistance to communities affected by such facilities will be important as input to the fiscal assessment and also may be valuable in formulating impact mitigation/community development strategies.

Methodological Considerations

When alternative approaches to fiscal impact assessment are evaluated, it is always important to consider the context within which these tools will be applied. In the case of nuclear repository analysis, two considerations appear to be particularly important. First, the methodology may be applied to a number of candidate sites located in several different states. This will necessitate creation of an analytical system which is sufficiently flexible to accommodate key features of the taxation systems of several different states. Second, the modeling system must address the questions which are important to key user groups and provide information in a form which is useful to them. In this case the key users of the system will include both the federal agency which develops the repository and the local officials who must respond to its effects.

The requirement for system transferability among sites in several states constitutes a substantial challenge in model development. Taxation/revenue distribution systems differ substantially among states, and most fiscal impact models developed to date have been designed to simulate the fiscal relationships of one particular state. An early task in developing the fiscal assessment methodology will be to assess the feasibility of developing a generalized revenue-expenditure simulation model which can be readily tailored to correspond to the taxation system of any given state. Such generality is likely to entail some loss of detail, however, and a careful trade-off analysis will be required to discern the most appropriate compromise between these two objectives.

The expenditure side of the fiscal analysis also will require compromise between the desire for community-specific cost estimates and the need for rapid and low cost transferability. The desire for a system which is easily transferable suggests that heavy reliance be placed on national and regional service standards and associated cost coefficients. On the other hand, the need for cost estimates which are specific to the conditions existing in a given community suggests that techniques which depend heavily on local data be employed. Again, a trade-off analysis will be required. One possibility is to develop a cost-estimation module utilizing only secondary data for initial analyses, but with the option of refining the cost estimates for a given site at a later time when local data are available.

Designing the fiscal assessment methodology also will require careful attention to user needs. In particular, the model should be capable of responding to the decision variables which are relevant to key users. Thus, the developing agency will likely be interested in evaluating the relative severity of impacts that may be anticipated at alternative project sites and the effects of various construction management strategies (for example, scheduling of construction activities, extent of local hiring) on the magnitude and distribution of impacts. Local officials naturally will be most interested in the implications of development for their specific jurisdictions. They also are likely to be interested in the prospective effects of alternative local growth management strategies (for example, alternative rates for utility user fees and hook-up charges, infrastructure investment options and local zoning alternatives) on the various impact categories. Both groups will be interested in the likely effects of alternative federal impact assistance programs. These, then, are among the key considerations in designing the fiscal impact assessment component of the socioeconomic impact assessment methodology for the nuclear repository program.

SUMMARY AND CONCLUSIONS

The purpose of this chapter was to review the conceptual bases and methodological alternatives for fiscal impact assessment, to describe the features of the impact process which influence the information needs of decision makers, and to examine the techniques which are typically applied in fiscal impact assessments for large projects. The basic concepts of demand, supply, and cost theory provide the basis for fiscal impact analysis. Difficulty in measuring the output of public services, however, usually leads to a number of simplifying assumptions when fiscal impact models are implemented.

The principal methodological alternatives for revenue estimation are to either assume that revenues will be directly proportional to population or to employ more detailed models which involve first estimating the change in the relevant tax base and then applying an appropriate tax rate. Revenue estimation methods tend to differ primarily, then, in the level of detail rather than in a basic form of analysis. It is generally agreed that more detailed analyses which reflect the unique characteristics of the state's tax system will provide more reliable estimates of the magnitude and especially the timing of revenue changes.

Six general approaches may be employed in cost estimation: (1) per capita expenditures, (2) service standards, (3) cross-sectional analysis, (4) case studies, (5) comparable city analysis, and (6) the economic-engineering approach. The first three methods can be classified as average cost approaches and the latter three as marginal cost approaches. In general, marginal cost approaches can be expected to be more reliable if the services being analyzed are subject to substantial economies of scale or threshold effects, or if excess capacity is likely to exist. Average cost approaches, on the other hand, have the advantage of being quicker and less expensive to employ.

Several features of the impact process are particularly important in determining the information needs of decision makers and hence in influencing the selection of assessment methods. First, because growth may be both extensive and rapid, demands for local government services also may increase rapidly. Further, the project-related needs for expanded facilities and services may occur as much as several years in advance of the receipt of significant amounts of project-related revenues. Local officials are thus confronted with a number of management decisions relating to alternative strategies for service provision and financing. To be most useful to these decision makers, fiscal impact assessments should, at a minimum, indicate the likely timing of changes in service demands, costs, and revenues. To be of maximum utility to local officials and planners, fiscal impact models should be capable of simulating the effects of different growth management options, both in terms of changes in the magnitude and timing of different categories of costs and revenues and in terms of the distribution of costs and benefits among specific groups in the local population.

A second important factor affecting information needs is that the fiscal implications of a given project can differ greatly among local jurisdictions because of both the settlement patterns of the in-migrating population and the interjurisdictional distribution of project-related revenues. Fiscal assessment techniques should be sensitive to these factors and must provide jurisdiction-specific projections if they are to be useful to local officials. A third consideration is that fiscal impacts are extremely sensitive to a variety of project-specific and site-specific factors. Assessment models must be designed to reflect the effects of such factors. Finally, because considerable uncertainty frequently is associated with the magnitude, timing, and distribution of the economic and demographic effects of a major project as well as with key fiscal parameters, fiscal assessment models should be designed to allow decision makers to cope with these uncertainties through sensitivity analyses and related techniques.

The techniques which have been employed in the fiscal impact segments of most environmental assessment reports have been quite variable. Many of these reports have addressed fiscal effects only qualitatively while others have examined only a few selected revenue and cost categories (Berkey et al, 1977; Chalmers and Anderson, 1977). There are indications that this situation is changing, particularly for projects which are likely to result in substantial changes in local population and service requirements. Assessments for projects of this type now frequently involve annual projections of costs and revenues by type, sometimes for several jurisdictions (Murray, 1980; Denver Research Institute, 1979). Because fiscal impact assessment methods have been developed primarily in connection with environmental assessments and other applied studies, there is little difference between the state of the art in this area and the techniques employed in the more sophisticated assessments. There is, however, a high degree of variability in the scope and detail of fiscal assessments, and many assessments appear to use rather simplistic techniques.

Future assessments should give greater attention to analyzing the effects of specific local decisions regarding alternative approaches to service provision and financing. The distribution of impacts among groups of local residents (such as long-term residents versus newcomers and residential versus nonresidential property owners) also should receive greater attention. Finally, as in the case with other impact categories, more extensive studies of areas experiencing rapid growth are needed before some aspects of the fiscal effects of such growth can be adequately evaluated.

NOTES

1. For examples of analyses of this type, see Garrison (1970) and Loewenstein (1963).

2. For examples of analyses of this type, see Gilmore et al (1976), Toman et al (1977), Drutilla et al (1978), and Leistritz et al (1979b). While a recent work (Burchell and Listokin, 1978, p. 2) recommends projecting direct effects only, these authors refer primarily to studies of residential development.

3. Attempts to quantify the environmental/quality of life benefits and costs are one of the major challenges associated with cost-benefit analysis. For a thorough discussion of cost-benefit analysis, see Mishan (1971). For a recent example of the application of cost-benefit techniques to a resource development problem, see Randall et al (1978).

4. For a summary of this early work, see Mace (1961).

5. For example, see Mace and Wicker (1968).

6. For example, in Wyoming a siting permit granted for construction of an electric generating plant included conditions which required the developer to provide housing for the construction workers and to provide loan guarantees to assist local governments in financing needed public facilities (Auger et al, 1978).

7. For example, negotiations between Skagit County, Washington, and the Puget Sound Power and Light Company led to an agreement whereby the company pays a set amount to the school district per new student brought in by the construction of the project (Myhra, 1976).

8. For extensive bibliography of fiscal impact studies, primarily in urban areas, see Burchell and Listokin (1978). For reviews of studies which focus on rural areas, see Murray (1980) and Murdock and Leistritz (1979).

9. Good basic expositions of demand and supply theory are provided in most introductory economics texts; see, for example, McConnell (1969). An extensive discussion of the application of these concepts to public services is provided by Hirsch (1973).

10. It can be argued, however, that police and fire protection are not perfect examples of public goods. Consumption of these services in some sense occurs when decisions are made regarding the location of police and fire stations and the design of police patrol patterns. Further, the rapid growth of the security industry suggests that police protection can be provided by the private sector, at least for those individuals who desire more of this service than the public is willing to provide.

11. It is recognized, however, that water and sewer services may be provided individually, particularly in very small towns and rural areas.

12. For additional discussion, see Maxwell (1969), Groves and Bish (1973), and Weber (1979).

13. For further discussion of these factors, see Inman (1979), Deacon (1978), and Niskanen (1971).

14. It should be recognized, however, that the outputs of many services are measurable in quantitative terms. Emergency service output can be measured in response time, parks and recreation facilities in carrying capacity, and streets and roads in terms of maximum weights and throughput capacity. The difficulty for the researcher is that these managerial/engineering measures are not normally collected as secondary statistics, and such information is thus difficult and costly to obtain.

15. For detailed discussion of production and cost functions as they relate to public services, see Hirsch (1973) and Tweeten and Brinkman (1976).

16. Public services also can be usefully classified according to the relative importance of capital and operating (usually primarily labor) expenditures in their overall cost structure. Some services thus can be classified as capital-intensive (e.g., water and sewer) and others as labor-intensive (e.g., police and social services).

17. For extensive discussions of economies of size in public services, see Tweeten and Brinkman (1976), Gabler (1974), and Shapiro (1963).

18. See, for example, Pidot (1969), Scott (1972), and Bahl (1968).

19. For recent attempts to deal more explicitly with the local fiscal decision-making process, see Kirlin and Brown (1979) and Weber and Goldman (1979).

20. When tax rates are assumed to remain at their current levels, the result of the fiscal impact analysis is usually a statement of the net fiscal balance (surplus or deficit) resulting from the project. A projected fiscal deficit is interpreted as an indication that the affected jurisdiction will not be able to maintain both its existing (preproject) service levels and current tax rates, except perhaps through borrowing. A projected surplus has the opposite interpretation. Some analysts then utilize the projected net fiscal balance as the basis for determining the effect of development on tax rates, particularly for local property taxes. For discussion of this approach and the effects of alternative assumptions on the conclusions, see Weber and Goldman (1979).

21. It should be noted, however, that such projects are often accompanied by some form of transfer payment, often termed "payments in lieu of taxes" or "impact payments", to offset at least in part the additional costs imposed on local governments (Markusen, 1978b).

22. For a thorough review of state special minerals taxes, see Stinson (1978).

23. It should be noted, however, that user charges and hook-up fees are important variables in local growth management strategies. Because these fees can be established by the local government and because their incidence (particularly for hook-up charges) is primarily on new residents, they can be a useful tool for local officials who wish to shift the added costs associated with growth to the new residents (Weber, 1978).

24. Recent applications of the technique include Burchell and Listokin (1978, Chapter 7) and Toman et al (1977).

25. For examples of such multipliers for both operating and capital expenditures, see Burchell and Listokin (1978, pp. 103-108).

26. For a detailed discussion of the procedures of the comparable city approach, see Burchell and Listokin (1978, Chapter 5).

27. For analysis of variations in state tax structures and their implications for local fiscal impact analysis, see Stinson and Voelker (1978) and Leistritz et al (1979b).

28. Studies reviewed included both case studies of specific projects or areas (Gray et al, 1977; Krutilla et al, 1978; Leholm et al, 1978c; Toman et al, 1978; Luken et al, 1977; Purdy et al, 1977; Shurcliff, 1977; Shields et al, 1979) and comparative analyses covering a number of impacted areas (Gilmore et al, 1976; Stinson and Voelker, 1978; and Murdock and Leistritz, 1979).

29. This conclusion may not hold, however, for large public projects whose facilities are exempt from local property taxes unless compensating payments in lieu of taxes are provided.

30. Another factor which can contribute to the lag of local revenues is the administrative capacity of local jurisdictions to add new taxable property to their tax base. In rapid growth situations, the available personnel (often a single and perhaps part-time assessor) may

not be able to assess new property and reevaluate old property as rapidly as would be desirable.

31. An excellent theoretical discussion of community investment strategies is provided by Cummings and Schulze (1978). For preliminary estimates of benefits attributable to infrastructure investments in boomtowns, see Cummings and Mehr (1977).

32. For a more detailed discussion of these factors, see Gilmore et al (1976), Auger et al (1978) and Murdock and Leistritz (1979).

33. It should be noted, however, that through judicious use of mechanisms such as user charges and hook-up fees, local officials may be able to shift substantial portions of the project-related costs to new residents. For additional discussion and examples, see Gilmore et al (1976) and Weber (1979).

34. For examples of these approaches, see Colony Development Operation (1974), Hayen and Watts (1975), BBC Associates (1975), and Leholm et al (1976c).

35. For example, see Toman et al (1977) and Leistritz et al (1979a).

36. For example, see Leholm et al (1976c) and Toman et al (1978).

37. A source which has been used extensively is Real Estate Research Corporation (1976).

38. For example, see Leholm et al (1976c).

39. Major concerns include lack of consistency in separation of expenditures by function and failure to separate capital and operating costs. For further discussion, see Denver Research Institute (1979).

40. For example, see Toman et al (1978).

41. For a detailed discussion, see Lamont et al (1974).

42. For example, see Hertsgaard et al (1978).

43. For a detailed discussion of the rationale behind the discounting procedure and alternative measures of the social rate of time preference, see Mishan (1976) and Sugden and Williams (1979).

44. A discount rate of 7.5 percent was used by Gilmore et al (1976) while Leholm et al (1976a) used a discount rate of 7 percent.

45. For further discussion of this index and its application, see Gilmore et al (1976, pp. 49-50).

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CHAPTER 6

SOCIAL IMPACT ASSESSMENT

The assessment of the social impacts of resource developments is an often neglected and ill-defined area of impact assessment. Social assessments are often not completed at all, and when performed, they tend to be reported in only a few short paragraphs in an otherwise comprehensive impact statement. Equally problematic is the fact that social impacts are often defined as "non-quantitative" or "unmeasurable" types of impacts and as a residual category including all factors not included in economic, demographic, public service, and fiscal impact assessments. They are seen as the assessment research performed by sociologists or as consisting only of analyses of public service needs and demands. The limitation of social assessments to such uses is unfortunate because it deflects analyses from many of the critical social issues that surround resource developments.

In addition, many types of social impacts, such as changes in interaction patterns, social organization, social structures, social institutions, and social perceptions, are of vital importance in the project development process. Formal and informal group organizations are, for example, the major focus of social actions both for and against various kinds of developments. Understanding of the dynamics and the issues around which social groups and social movements are formed is a major focus of analysis in the sociology of social movements and the sociology of organizations, and it is clearly of central importance in the process of project development and completion.

Prevailing social structures and institutions affect the process of project development and are affected by developments. Key groups in the social structure, such as land owners, merchants, and new residents, respond to one another on the basis of social interaction patterns that may be altered significantly as a result of developments. Changes in structural patterns and in the relative dominance of groups within such patterns alter the way of life in an area and often create conflicts between various groups as the relative importance of various activities is changed. At the same time, patterns of disorganization may arise as standard social alignments and controls dissipate. Rates of divorce, delinquency, and drug and alcohol abuse may increase, and the need for more formal controls over such behavior may increase dramatically.

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Thus, it is obvious that many of the most publicized issues and those of greatest general interest in the initiation of a resource development and its ongoing process toward completion are social in nature, as are many of the effects of such projects. Acceptance or rejection of project proposals, opposition to project siting and litigation often have their roots in concerns about the effects of projects on community life or ways of life, on people's relations with one another, and on how residents perceive and feel about their communities and the project-related changes and new residents likely to result from the development. Although economic effects, such as increased incomes and employment opportunities, are the most often noted positive impacts of development, social factors, such as increased rates of crime, divorce, and other forms of conflict are the most often cited negative factors leading to project opposition (Murdock and Leistritz, 1979). Both in terms of the public and legislative obligations to assess impacts that are of critical importance to residents of impacted areas and in terms of instrumental concerns related to project development, social impacts require careful assessment and consideration.

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CONCEPTUAL BASES AND METHODOLOGICAL ALTERNATIVES IN SOCIAL IMPACT ASSESSMENT

Although the significance of social impacts is often acknowledged, the utility of attempting to assess them is not (Chalmers and Anderson, 1977). In part, the difficulty in assessing social impacts has resulted from this having been poorly defined initially. Thus, before attempting to delineate the major approaches in social impact assessment, it is necessary to more clearly define the subject matter of social impact assessments.

The term social generally refers to the processes and products of human interaction. Social impacts can thus be defined as impacts that affect the patterns of interaction, the formal and informal relationships resulting from such interactions, and the perceptions of such relationships among various groups in a social setting (or system) (Popenoe, 1980; Goodman and Marx, 1978). Although such a definition still includes a broad range of subject matter, it avoids the tendency to see the analyses of social impacts as a residual process. Rather, it focuses analyses on four broadly accepted areas of social phenomena. These are:

1. Processes of interaction
2. Social organizations and social structures
3. Social institutions
4. Social perceptions and attitudes.

The first area of analysis examines the forms of interaction between members of social groups that are attempting to adjust to various environmental, economic, and social conditions. Processes such as conflict, consensus, accommodation, and cooperation are often the focus of discussion. Such analysis concentrates on the interaction of individuals within groups and with one another. The emphasis is on the initiation of interaction patterns, on the first steps in the formation of social groups, and on the norms, values, and beliefs that underlie such group structures. In social impact assessments, analyses of this kind have examined the formation of interest groups, particularly those involving new residents and the interactions between new and longtime residents. The analyses of interactional dimensions is seldom given anything but passing attention in actual assessment efforts.

The second of these four areas is concerned with patterns of interactions that have become more formalized in identifiable entities, such as informal and formal groups and organizations. It is also concerned with such groupings as social classes, with stratification systems and patterns of social dominance, with patterns of community leadership and with other phenomena related to the formation or dissolution of relationships within and between groups. Such analyses in impact assessments and related research areas thus focus on the origin of various proponent and opposition groups, on the effects of development on civic and other community groups, on existing community leadership and power groups (i.e., farmers, businessmen, etc.), and on special groups such as the elderly, those on fixed income, and minorities. In its broadest dimensions, this area of analysis may even consider impacts on the total community structure or on the well-being of the total area.

The third area of analysis is concerned with the effects of project development on more focused areas of interactions surrounding given sets of activities, such as earning a living, governance, family life, religion, and training and education. These regularized sets of activities are ones of paramount importance in nearly every social setting and are referred to as social institutions. In all assessments, impacts on these institutions must be carefully considered. For example, the effects of project development on educational quality, on family dimensions such as divorce, child rearing, delinquency, and similar factors, as well as the effects of the project on churches and church groups are of concern in assessment efforts (Schriner et al, 1976).

The final area of analysis affects and is affected by each of the others. This is the general area of social perceptions and attitudes--how members of groups come to perceive themselves, their groups, characteristics of their communities, and possible changes in their communities. In impact assessments, this area of analyses includes attempts to measure community and service satisfaction, perceptions of the environment, and community growth and development preferences (Selbyg, 1978; Lopreato and Blisset, 1978; Freudenburg, 1979).

In sum, then, it is essential to understand the context and meaning of the term social impacts. These impacts include effects on: (1) the processes by which people interact to form groups, (2) the structures or patterns of interaction resulting from such interactions, both generally (social structures and organizations), and in the relation to specific functions (social institutions), and (3) the perceptions of these processes, structures, and institutions. Social assessment research thus involves analyses of the effects of these social factors on the development process and the effects of the development process on these factors.

The wide range of phenomena that are included under the heading of social impacts reflect equally broad conceptual and methodological bases. The conceptual bases include a broad range of perspectives on social interaction and social phenomena. Although it is not possible to delineate even the basic aspects of or sufficient detail on any of these approaches, it is essential to provide some familiarity with several basic approaches to social phenomena to provide a more complete context for understanding different types of social assessments and the various roles sociologists play in the assessment process.

Conceptual Approaches

Theoretical development in the area of social assessment has been extremely limited (Murdock, 1979), and few impact assessment or research efforts acknowledge that a particular conceptual approach underlies the effort. Since certain paradigms and viewpoints inevitably underlie any research effort (Kuhn, 1962), it is possible from an examination of social assessment efforts to discern the conceptual bases underlying such efforts. When this is done, characteristics reflecting at least four major theoretical bases appear with some frequency. Because the interpretation of assessment data is often affected by which of these theoretical bases underlie the researcher's perspective, it is essential to briefly discuss each of these theoretical approaches. These theoretical perspectives include:

1. The symbolic interactionist perspective
2. The conflict perspective
3. The functionalist perspective
4. The human ecological perspective.

The Symbolic Interactionist Perspective

The symbolic interactionist perspective emphasizes the analysis of the actual processes of interaction, of how persons come to understand and to perceive themselves and others, and how processes of interaction form different types of patterns. Taking its emphasis from the work of such sociologists as Mead (1934), Simmel (1950), Cooley (1909), Blumer (1969; 1980), and others, the interactionist perspective emphasizes ongoing group actions and interactions and the mutual effects of individuals and groups on each other. One major emphasis, then, is on the fluid, ever-changing nature of social phenomena.

A second major emphasis is on the individual, both as the individual affects and is affected by group membership. The individual's perceptions and actions are seen as having substantial effects on group characteristics and, in turn, as being affected by group characteristics. The perspective emphasizes what is often termed a social-psychological perspective in sociology.

In the analysis of social impacts, such an emphasis is particularly evident in those works that stress: (1) the relatively unique nature of the impacts of each project (Gold, 1974; Cortese and Jones, 1977), (2) the need to establish social impacts by directly observing the patterns of interactions between groups, such as new and longtime resident groups, and (3) the effects of developments on individual behavior and individual perceptions (i.e., delinquency, drunkenness, depression, etc.). It is perhaps the most individualistic perspective used in assessment activities.

The Conflict Perspective

The conflict perspective on social life traces its origins to the works of Marx (Avineri, 1970), Dahrendorf (1959), Coser (1967), and similar theorists. From the conflict perspective, life involves a struggle for control of limited resources. Individuals come together to form interest groups to more effectively compete for resources. The most important social process is conflict and conflict is assumed to underlie nearly every phenomenon. The major groups between which conflict occurs include social classes and economic ownership groups.

In assessment research, this perspective is evident in those efforts which attempt to identify interest groups who are likely to take different stands on development issues and in those efforts that concentrate on the conflicts between new and longtime residents (Massey, 1978). This emphasis is also evident in efforts that examine impacts from a relative costs and benefits perspective (Fitzsimmons et al, 1975; Finsterbusch, 1977). In most cases, such analyses emphasize the potential conflict that may occur between various interest groups during a development.

The Functionalist Perspective

The functionalist perspective is usually associated with the work of classic social theorists, such as Durkheim (1933), and more recent theorists such as Parsons (1951) and Merton (1968). Under this perspective, members of populations are viewed as coming together to form social groups in order to more effectively and efficiently perform certain essential functions. These functions include both those necessary for basic survival and those related to the maintenance of social interaction and group cohesion. In its most elaborated form (Parsons, 1951) society is seen as a system in which such basic elements as culture, individual personalities, and societal factors interactively determine the nature of the social system. These factors seek to perform such functions as adaptation (to the physical and other dimensions of the environment), goal attainment (the meeting of basic social and individual goals), integration (the maintenance of patterns of key interdependencies), and latent pattern maintenance (the maintenance of total societal patterns). Processes of interaction and social structures and institutions are examined in terms of their roles in maintaining such functions.

In impact research, such emphases are evident in those analyses that examine the effects of project development activities on key functions or institutions. In fact, a majority of the research on the social effects of the process of modernization, urbanization, economic development, and industrialization (Appelbaum, 1970; Carnes and Friesma, 1974), which are often used in assessment efforts as the theoretical bases for predicting the social patterns that will evolve during a development, utilizes a functionalistic perspective. Other reflections of such emphases are analyses of the impact-related changes in social patterns that result from an area's change in economic functions and efforts that emphasize the importance of changes in groups' positions and purposes within the area's social system.

Human Ecological Perspective

A perspective that is not widely used in the discipline of sociology as a whole, but which has received increasing use in environmental sociology and impact assessment is that of human ecology (Catton and Dunlap, 1978; Murdock, 1979; Olsen et al, 1977). Based on the historic work of Malthus (1798), Durkheim (1933), and more recently elaborated by Hawley (1950), Duncan and Schnore (1959), Duncan (1964), Micklin (1953), and others, human ecology takes man's need to adapt to an ever-changing environment as the central human problem. This adaptive process is seen as inevitably leading, through the use of various types of group interdependencies (such as commensalistic and symbiotic relationships), to given types of social interaction-based organizational arrangements. Heuristically, the key components of these processes have been termed the POET variables of population, organization, environment, and technology. These four factors encompass nearly all social and demographic phenomena as well as technologies and physical environmental factors that affect such phenomena. It is thus perhaps the most holistic perspective used in social analysis and the one that emphasizes a wide range of nonsocial as well as social determinants of human behavior.

In impact assessment, the ecological perspective has been suggested as a useful framework from which impact events can be seen as involving changes in population and social organizational factors resulting from the application of technology to various environmental resource bases (Murdock, 1979). In addition, it has been used as a means for conceptually organizing various types of impacts (Olsen et al, 1977). Substantively, it is reflected in those analyses that concentrate on large-scale social structural changes related to different patterns of resource usage and technologies, those efforts that view impacts as resulting largely from changes in population factors and those which emphasize the effects of differences in project, areal, and other characteristics on the magnitude and distribution of impacts (Krannich, 1978).

These four perspectives, then, form bases for many of the assessment efforts that have been completed. It is clear, however, that a more concerted and definitive use of these and other perspectives is essential if adequate conceptual bases are to be developed for impact assessments and research efforts.

Methodological Alternatives

The methodological approaches used in impact assessment reflect those widely used in the social sciences, generally, as well as approaches that have received renewed development within the area of assessment research. Of the most widely used social science methodologies, only the experimental approach has received little use in assessment research. However, the comparative techniques and principles so essential in experimental designs have been employed (Thompson et al, 1978; Murdock and Schriner, 1978). The major approaches used in assessment efforts include:

1. Secondary data methods
2. Survey methods, including
   a. sample surveys
   b. expert-opinion surveys (delphi-surveys)
3. Participant observation methods
4. Unobtrusive research methods.

Each of these methods has played an important role in different impact assessment efforts, and their major techniques and the advantages and disadvantages of each are described briefly below.

Secondary Data Methods

Secondary data methods involve the use of existing data, collected for other purposes, to anticipate the magnitude and distribution of social impacts. The data so used include those from such agencies as the U.S. Bureau of the Census, the National Center for Health Statistics, the U.S. Department of Agriculture, the Federal Bureau of Investigation, the Department of Health, Education and Welfare, and from such state and local sources as state health departments, state social service agencies and similar entities.

Such data are extremely important for the description of baseline conditions in an impact area. As such, they provide information that is absolutely essential for the projection of impacts. They are particularly useful in providing a base of historical information on the social, demographic, and cultural context within which project-related social changes occur.

Secondary data methods, however, do not provide a sufficient set of data for completing a comprehensive social assessment. Such methods seldom provide data on social processes, informal organizations, social relationships, social structures and institutions, or residents' attitudes and perceptions. In addition, secondary data are often dated by the time of their publication and unavailable for areas smaller than counties. As a result, secondary data methods must be used in conjunction with other social assessment methods.

Survey Methods

Survey methodologies consist of the direct solicitation of information from individuals via personal interview, mail, or telephone administered questionnaires. A survey methodology is usually selected when data are not available from secondary sources and when individual or household information is essential. Surveys are often used when perceptual and attitudinal information on impacts or patterns of service usage in impact areas are required. Due to the widespread use of surveys for political and opinion polling, the basic dimensions of surveys are well known. Because of the importance of surveys for the collection of social data, however, it is appropriate to briefly outline the major steps in a survey. The discussion of these steps will also serve to indicate those aspects of survey methods that require careful and critical evaluation.

Although the survey process can be divided into numerous steps, it is convenient to consider six steps as essential in any survey effort. In addition to those steps necessary in the use of any research method (such as the decision concerning which dimensions or research questions should be addressed and the choice of the form of analysis to be used), surveys require that special attention be given to the following steps:

1. Selection of the type and form of survey to be used
2. Sample design, including:
   a. sampling frame selection
   b. sample selection
3. Questionnaire or interview design
4. Questionnaire pretesting
5. Questionnaire administration
6. Response analysis.

The first of these steps occurs after the decision to use a survey has been made. It requires selection of self-administered versus interviewer-administered or assisted surveys. The most common type of self-administered questionnaire is the mail survey. It has clear advantages in terms of costs and ease of administration, but, in general, response rates are lower than for interviewer-assisted questionnaires and its use requires extensive efforts to ensure that an adequate, up-to-date mailing list has been obtained. Mail survey techniques have become increasingly sophisticated in recent years (Dillman, 1978; Dillman et al, 1974); Heberlein and Baumgartner, 1978; Carpenter, 1977), and were used as the major form of data collection even for the relatively complex long form in the 1980 census. Mail surveys remain a useful option in impact analysis.

Interviewer-administered or assisted surveys include both the increasingly popular telephone surveys and personal interviews. Telephone surveys have become popular because of their cost advantages over personal interviews and because of the more extensive level of respondent contact they provide in comparison to mail surveys. Their major limitations result from the fact that some households may not have telephones and even those that do may choose to have unlisted numbers. Recent evidence (Groves and Kahn, 1979), however, suggests that such surveys are generally quite representative, and the use of computer-generated random-digit dialing codes ensures that even unlisted numbers are included in the sampling frame.

Personal interviews are clearly the most desirable in terms of obtaining complete and in-depth information. Points of uncertainty in questionnaire items can be clarified and unclear responses probed to ensure clarity.

Personal interviews are relatively expensive, however, with costs of several hundred dollars per interview not being uncommon for a complex survey. These costs result from the need for extensive interviewer training as well as interviewer salary, travel, and similar costs.

The type of survey selected will depend on the nature of the information required and on time and cost considerations. If in-depth information is required on a controversial topic, or if one is relatively uncertain of the critical issues related to a particular dimension, personal interviews may be necessary. On the other hand, if the subject matter is not controversial and consists largely of responses describing past behavior, then either a mail or a telephone survey may be sufficient. The selection of the form of survey to be used must be made after careful consideration of the subject matter requiring assessment and an evaluation of resource availability.

In addition to the choice of the type of survey to be used, consideration should be given to the selection of the form of survey to be employed. That is, it must be determined whether it will consist of a fixed set of questions structured in a given order (referred to as a structured form), consist only of a list of the broad dimensions to be queried without any fixed question format (referred to as an unstructured survey form), or follow a course between these two extremes, taking a semistructured form. In general, when the context to be assessed is well-defined, a more structured survey form is desirable because one can be more certain that responses reflect evaluations of the same dimensions. When the dimensions to be examined are not well-defined, it may be necessary to allow the interviewer to vary the context sufficiently to probe for key dimensions using a less-structured format. Although structured formats are, of course, required in mail surveys, the choice of the survey form for other types of surveys must again be determined by the type of information required (Dillman, 1978).

Whatever type or form of survey is selected, it is essential that any survey process give special attention to the selection of the sample of respondents to be surveyed. Since the major rationale for the use of a survey versus other forms of primary data collection is usually based on the need for data from a representative sample, the careful completion of the sampling process is the key to the success of a survey (Babbie, 1973). The sampling process is, in turn, dependent for its adequacy on two factors: the acquisition of an adequate sampling frame and the use of a well-designed technique for selecting a sample from the sampling frame (Dillman, 1978).

The sampling frame is a list of the population of persons from which a sample is to be selected (i.e., all of the persons in a community). Its acquisition is often the most difficult part of the survey process. Commonly used sources for preparing sampling frames include telephone directories, utility lists, county agent or similar county officials' lists, lists of licensed drivers, commercial mailing lists, and similar sources. Any list chosen should be carefully examined for possible omissions and supplemented when necessary.

The technique for selecting a sample from a sampling frame may take several forms. A simple random sample selected by numbering items in the sampling frame and choosing a selected number at random may be used when specific characteristics of sample members (age, sex, education, etc.) are not expected to be of significance or data on such characteristics are not available. A stratified or cluster sample is more likely to be selected (Babbie, 1973). In a stratified sample, some characteristic such as the age, residence area, or similar characteristic of population members is chosen, and the sample is selected to be representative of different strata of the characteristic (i.e., rural and urban residence). In a cluster sample, respondents are selected with special attention to their area of residence. Techniques for drawing such samples are readily available in computerized form, and thus this part of the sampling process has become relatively straightforward and much simpler than the acquisition of a sampling frame (Groves and Kahn, 1979).

The step of survey design cannot be described in general form because it varies from one survey effort to another. In all efforts, however, the instrument must be carefully designed with questions that are unbiased, that allow for direct and unambiguous responses, and that elicit responses related to specific informational needs. The design of a questionnaire requires careful item delineation and analysis (Selltiz et al, 1959).

After the initial design of the survey, it is essential that it be carefully pretested. No matter how careful the construction of the initial survey, the instrument must be pretested to diagnose unanticipated problems in question interpretation and administration. Surveys that have not been pretested should seldom be used. Even a limited pretesting will alleviate many problems.

The administration of the questionnaire or survey form, though seeming to be a straightforward process, requires careful supervision. In mail surveys, this administration should include several waves of questionnaires and post card reminders (Dillman, 1978). In telephone and personal interview surveys, efforts must be made to assure that sample members are recontacted, if the initial contact is not made or the survey is incomplete, and careful supervision of interviewer performance is essential (Groves and Kahn, 1979).

Finally, prior to data analysis, surveys must be checked for completeness and the sample screened to check for obvious response biases or for refusal rates that are sufficiently high to threaten the sample's adequacy. Only if such items are checked prior to the initiation of the analysis and prior to the release of those personnel who were responsible for questionnaire administration and who can most readily assist in the interpretation and attention of such problems will it be possible to correct potential errors.

These steps, though only some of the key steps in the survey research process, clearly reveal the need for care in the survey process. Proposed survey procedures that do not adequately describe these steps should be viewed with skepticism. The survey process is thus one requiring the use of experienced and well-trained social science personnel.

Sample and Expert-Opinion Surveys

Impact-related surveys use two general forms: the standard sample survey and the expert-opinion survey. The first of these forms, which involves obtaining information from a representative sample of community residents, is the most common form of social survey and has received extensive use in impact research (Selbyg, 1978; Thompson et al, 1978; Little and Lovejoy, 1977; Lopreato and Blisset, 1978).

The second form has been used extensively in community leadership analysis (Hawley and Wirt, 1974), and has received renewed emphasis in the area of impact assessment. In expert-opinion surveys, the sample consists of community decision makers and opinion leaders who are assumed to provide views representative of various interest groups in the community. Such surveys have been popular in impact assessments because they can be done rapidly and may provide the type of information required if that information relates to the actions of various groups. Expert-opinion surveys often use a survey and resurvey format in which leaders' views are assessed and analyzed, responses are reported to them, and their views again surveyed. This technique is commonly referred to as the delphi-technique (Finsterbusch and Wolf, 1977). It is widely used in the evaluation as well as the assessment stage of impact efforts. The obvious advantage of expert-opinion surveys is their ease of application and their relevance for assessing group issues. The disadvantages stem from the frequent misuse of such surveys as substitutes in research efforts which, in fact, require random sample surveys.

The use of survey methodologies requires the completion of a comprehensive and relatively complex research process. The advantages of survey methodologies stem from their ability to obtain data on topics not covered in secondary sources and data from a selected group of respondents that are likely to be representative of the total range of views in a community. Their disadvantages stem from their complexity, their time and financial resource requirements, and their inability to obtain information that cannot be verbalized or that is not consciously recognized by respondents. The use of surveys in assessments is widespread, however, and as noted below, assessment efforts seem likely to make increasing use of this method in the future.

Participant Observation Methods

Participant observation methods have a long and distinguished record in social research (Goffman, 1961; Whyte, 1955; Glaser and Strauss, 1967; Vidich and Bensman, 1958). They consist of methods in which the researcher obtains information through direct observation and possible participation in a social setting (Gold, 1958). Whether or not researchers choose to participate in the social setting and to let their exact purposes be known to local residents will depend on the research questions being examined, but direct observation of the setting (site area) for which assessments will be made is essential. This is a particularly strong method for studying the ongoing nature of social acts and activities, for examining the roles individuals take in participating in activities, for discovering the relationships and alliances that exist in a local area, and for gaining a feeling for the overall context in which activities occur (Lofland, 1971).

In general, the participant observation method involves living in an area for an extended period, taking careful notes on social activities, persons, and their perspectives, formulating concepts and hypotheses, and testing these concepts over time. The time frame for completing such methods may involve several months or even years, and one or several observers may be involved. Whatever its exact form, however, participant observation analysis requires the same careful principles of observation, analysis, and reanalysis common to other research methodologies.

The advantages in the use of the participant observation method stem from its ability to more adequately capture the meaning behind and the nature of ongoing activities that may not be fully evident even to the residents of an area and thus not be recorded by them in surveys or other similar forms of data collection. In addition, it is often a cost-effective method requiring limited manpower. Its disadvantages stem from the difficulty involved in assessing the generalizability of the data obtained because of the tendency for observers to be contacted by persons with given, and biased, points of view. For impact assessments, the method possesses the additional disadvantage of requiring relatively extended periods for data collection. The use of the participant observation method is essential for discerning many of the most significant dimensions of change that occur during large-scale developments.

Unobtrusive Research Design

Unobtrusive research designs consist of methods that involve the collection of primary data but do not involve direct contact with area residents. They include such methods as videotaping and tape recording every-day activities (McCoy, 1975), and analysis of the content of newspapers and other written materials describing the activities of the population of an area (Ludtke, 1978). To the extent that these methods sometimes fail to provide the rigor evident in other techniques, they are less desirable than other research designs for impact analysis. Social analysis based on casual observations, unsystematic newspaper analysis, and similar procedures appear much too often in impact assessment research. If completed with systematic rigor, these techniques are, however, valuable research methods capable of being applied with considerable utility in impact assessments. Their careful use in impact analysis is thus clearly advantageous.

The advantages of these techniques lie in their ease of application and in their often low resource requirements. Their disadvantages are evident in the difficulty entailed in determining the representativeness of the information obtained from them and the direct relevance of such indirect information to specific impact issues. Given these latter uncertainties, it is likely that unobtrusive methods will be used largely to supplement more traditional research methods.

Conclusions Concerning Conceptual and Methodological Alternatives

The conceptual approaches underlying, and the methodological alternatives available for use in, social impact assessments show great diversity, ranging from those that place strong emphasis on individuals (symbolic interaction) to those that emphasize total population changes (human ecology), and from those that see conflict as the key social process (conflict theory) to those that emphasize consensus (functional theories). Methods ranging from those that use interpretations of printed documents as data sources (unobtrusive measures) or secondary data to those that utilize highly structured questionnaires for data collection (surveys) can be applied in the assessment process. Such diversity has both positive and negative implications for social assessment efforts. On the one hand, this diversity provides a flexible knowledge base that is applicable to a wide range of phenomena. On the other hand, this diversity allows for substantial differences in the interpretations given to the meaning of any single set of events. Given the diversity of phenomena to which social analysis must be applied, however, the use of a wide range of approaches and methods appears to be essential if complex social phenomena are to be adequately characterized and predicted.

FACTORS AFFECTING SOCIAL IMPACT ASSESSMENT

The process of social impact assessment and the social factors that it is intended to project are, as with demographic impacts, affected by project, area, and new resident characteristics as reflected in a large number of historical, cultural, economic-ecological, demographic, and social organizational variables. In addition, the nature of the social assessment process is, in large part, a product of the nature of the overall assessment effort and of the role of the social assessment process within the overall assessment effort. The effects of project, area, and new resident characteristics and of the overall environmental assessment process on the assessment of social impacts are thus the focus of this part of the chapter and are briefly discussed below.

Project Characteristics

The nature of the project clearly affects the nature of the social impacts experienced in an area. Developments with high levels of employment result in larger numbers of new persons and are more likely to induce significant social changes than those with smaller levels of employment. Likewise, projects with relatively expedited construction periods are more likely to have significant effects than those with extended construction periods. Finally, projects relatively close to large metropolitan areas are likely to have less significant social impacts than those in sparsely settled areas. Variations in project characteristics may thus markedly affect the magnitude of social impacts experienced in an area (Freudenburg, 1979).

Area Characteristics

The predevelopment characteristics of an area also affect the nature of the social impacts in the area. These characteristics involve a large number of factors, including historical, cultural, economic-ecological, demographic, and social variables.

Historical Factors

The history of a rural area may have a significant effect on the social environment of the area, particularly that history related to other large-scale resource developments. In many rural areas of the western and southern United States, for example, the area's historical experience with growth, with large-scale developments, and with various auspices for such developments may play a major role in determining the social nature of the area (Murdock and Leistritz, 1979).

For many rural areas, their recent history has been one of decline. Despite recent patterns of renewed growth in rural areas (Beale, 1976), many of the potential sites for projects, such as energy-related facilities (Federal Energy Administration, 1976) are in areas that have shown little renewed growth and, in fact, have experienced decades of population and economic decline. For such communities, large resource developments will have consequences that they are ill-prepared to manage. Service infrastructures are likely to be poorly developed and services insufficiently professionalized to meet new service demands.

For areas that have been experiencing slow or moderate growth, past expections may have provided local leaders and decision makers with a useful base of experience that will allow them to more effectively manage patterns of growth. Finally, for areas with histories of extremely rapid growth, a new development may simply compound existing problems and further overload existing facilities.

An area's experience with large-scale developments and developers may also affect the social nature of the area and its desire to support further developments. Thus, for many areas in the West, the boom and bust cycles of the past have made citizens cautious about growth and its expected benefits (McKee, 1974). In addition, since many rural areas have experienced large-scale developments that have significantly altered the level of local control and autonomy (Kraenzel, 1955), many areas may resist developments that are under the control of entities located outside the local area. The history of an area, in general, and in relation to developments in particular, is thus an important determinant of public acceptance and other types of social impacts.

Cultural Factors

The culture, the total way of life of a population in an area, may also alter the types of social impacts that are experienced. If the culture is significantly different from that of the mainstream society, the social impacts experienced may be particularly acute. The most evident of such cultural effects are those experienced by Native Americans and other minority groups. Many Native Americans value industrial development less than the maintenance of cultural cohesion, kinship ties, and tradition (Albrecht, 1980) and may be less able to take advantage of the new employment and other opportunities created by developments even when such developments are favored (Schwartz, 1977). Thus, subcultures that place strong emphases on group interaction and cohesion, whether involving minority or majority groups, may find developments less desirable and hence show greater resistance to them than groups in the mainstream of American culture. When subcultural groups are located within an impact area, special concern should be given to discerning the likely effects of such cultural practices on social impacts and the effects of social impacts on cultural traditions.

Economic-Ecological Factors

The economic and ecological context of an area also affects the social impacts experienced by the population in an area. Areas in which agriculture predominates have distinctively different ways of life than areas dominated by mining and manufacturing. Communities in which tourism and services dominate are distinctively different than those dominated by industries. In addition, areas dominated by forests may be distinctively different than areas in the arid Great Plains (Webb, 1931; Kraenzel, 1955; McKee, 1974; Odum, 1936). In fact, the distinctive effects of such ecological and economic context variables are some of the best documented in the social science literature (Duncan and Reiss, 1956; Hathaway et al, 1968; Duncan et al, 1960; Odum, 1936).

The influences of economic and ecological factors are effected through a number of social, structural, and procedural factors. An area's economic activity, for example, will affect the sequence of social activities and even institutional and social structures in the area. The economic activities associated with an agricultural area, for example, will affect the scheduling of social events (festivals, etc.), the nature of informal organizations (for example, Grange versus union halls) and the nature of other enterprises (retail trade and financial institutions). In addition, whereas agricultural and other extractive industries have historically been labor-intensive, making large families advantageous as sources of additional labor, industrial and occupational structures make large families a source of additional expenses. In like manner, the pronounced seasonal variations in northern climates lead to somewhat different social interaction patterns than are evident in more temperate climates. Although one must be careful not to adopt a simplistic form of ecological or economic determinism, ecological and economic differences between areas are clearly important sources of social variation that require careful analysis.

Demographic Factors

The size, distribution, and composition of the population of an area also clearly have implications for social effects. The size and distribution of a social group or population affects the frequency and forms of social interaction, the nature of social control, and other cultural factors in an area. In smaller areas, social controls over inappropriate behavior are more likely to be exercised by family or kinship groups and to be exerted by peer or group pressures than in larger areas where more formal controls may be necessary. Similarly, the characteristics, particularly the diversity of characteristics in a population, may affect the social context of an area. In areas with a uniformity of age, education, racial, and other characteristics, new persons with different characteristics are likely to be more difficult for local residents to accept than in an area where diversity is common, and persons with different characteristics may be perceived as less unique and hence more readily accepted. In sum, then, the size, distribution and composition of a population are likely to affect the types of social impacts experienced in an area. They are factors whose effects have long been the subject of sociological investigations (Durkheim, 1933; Wirth, 1938) and the assessment of such factors must be an important consideration in any social impact analysis.

Social Factors

Finally, it is evident that predevelopment social conditions will affect the nature of the social impacts experienced in an area. Although these predevelopment social conditions are, in turn, a reflection of many of the factors discussed above, it is evident that their state at the initiation of a project is an essential consideration. Thus, such factors as the forms of predevelopment social structures and social interaction patterns, and the prevalent perceptions of residents concerning the area may affect the social impacts experienced. An area with a highly formalized social class structure and highly formalized social interaction patterns may find the placement of new impact-related residents within the social class structure to be more difficult than in areas with less formalized structures. In addition, groups in leadership positions in such structures may become sources of opposition to developments because of the obvious shift in the class structure that may accompany a shift in major economic activities in the area (Murdock, 1979).

The social perceptions of the area's residents may also alter the nature of social impacts. Areas whose residents have high levels of satisfaction with existing community conditions may be less receptive to developments than those that perceive their communities as less desirable. Perceptions of the need for economic development may be critical in causing communities to search for economic development and growth (Lonsdale and Seyler, 1979). Strong attachments to given types of land use and environmental preservation may also alter a population's receptiveness to various types of resource developments (Lewis and Albrecht, 1977; Lovejoy, 1977). The social conditions of an area prior to development clearly affect the nature of the impacts likely to be experienced during development.

The historical, cultural, economic-ecological, demographic, and social characteristics of the site area are thus of key importance in determining the nature of the social impacts likely to be experienced in an area. Although only a limited number of the many factors included in these dimensions can be adequately assessed in any impact situation, a careful consideration of such dimensions is essential in the assessment process.

Characteristics of In-migrating Populations

A final set of factors likely to affect the substantive nature of social impacts experienced in an area are related to the characteristics of new persons coming to the site area as a result of the development. The historical, cultural, demographic, and social characteristics and experiences of these people will affect the way they react and adapt to the site area, the ease with which they are accepted by local persons, and their subsequent impacts on the site area. Although analyses seem to indicate that resource development-related migrants are similar to migrants in other areas (Murdock et al, 1980), the general effects of a substantial number of new migrants on an area and on the assimilation process of migrants and longtime residents are well-documented factors of significance to the social context of an area (Price and Sikes, 1975). The potential social effects of the characteristics of new residents on site areas' social patterns must be carefully examined.

If They can be

The project, area, and new resident social characteristics clearly exert a significant range of effects on the magnitude and the nature of the social impacts experienced in an impact area. As with demographic dimensions, however, it is often the interactive products of these three general sets of factors, rather than their separate effects, that are of greatest significance. The complexity as well as the importance of these dimensions is thus evident and requires concerted attention.

The Effect of the Assessment Context

The context in which the assessment of social factors is completed is not only affected by substantive factors, however, but also by the context in which the actual assessment process takes place. This context often includes extremely limited time frames and financial resources, a misunderstanding of the breadth of social phenomena, and a total environmental impact assessment mandate for the agency completing the analysis that may lead to the near exclusion of social dimensions.

The time frames for an assessment effort often are limited to only a few months of intensive effort, but many forms of social research, particularly extensive surveys and participant observation studies, may require much longer time frames if the results of the research effort are to be adequate and accurate. Expedited forms of such efforts may simply be impossible. Short time frames may thus eliminate such methods from consideration or lead to efforts that are less comprehensive and less methodologically sophisticated than desired (Freudenburg, 1981). Although different types of social questions require different social research approaches, the time constraints of assessments often limit analyses to secondary data and other similar research designs.

Financial resources may also place particularly severe constraints on social analysis. As noted above, surveys and similar types of social analysis can simply be too costly for use in such an analysis. Cost constraints are likely to limit any analyses that are dependent on primary rather than secondary data. Since social analyses tend to be more dependent on primary data than many other forms of analyses (such as the demographic), the effects of cost estimates on social analyses are likely to be particularly evident.

The social assessment is also often affected by a less than distinct definition of social impacts, as noted above, and by a resulting paradoxical handling of the social assessment process within the general assessment effort. That is, the social assessment process is deemed, on the one hand, to include all factors not included in the economic or demographic analysis. Thus, the social assessment process is often seen as the logical place for public service, minority group, cultural, psychological, as well as standard, social analysis. Its personnel and financial resource allocations, on the other hand, may simply be made as if it were a single uniform area of analysis. As a result, the social assessment analyst is often required to do an impossible breadth of assessments with a minimal level of resource commitments.

Finally, because the assessment process is itself often inclusive of social, physical and biological science, political, and other dimensions, and yet restricted in physical length, the discussion of social dimensions in assessment efforts is often reduced to such a minimal length that it is inadequate for the interpretive types of analyses often necessary in social analyses. In part, then, the format requirements of impact statements (see page limitations in Council of Environmental Quality, 1978) often are especially problematic for the social analyst.

The assessment process is, in sum, often ill-matched to the requirements of social research. This problem, though unlikely to be solved in the near future, must be recognized and addressed in assessment evaluations.

Both substantive (project, site, and new resident) characteristics and assessment process factors are likely to affect the social assessment process and its subsequent products. The methodological, analytical, and resource requirements necessary to fully address all of these factors are clearly not presently available. Those that can be addressed must be examined, however, and even those that are difficult to address must be recognized and their effects considered in the social assessment process.

SOCIAL IMPACT ASSESSMENT TECHNIQUES

The process of social impact assessment is a complex and diverse process and the social assessment techniques used in assessments have often reflected that diversity. The techniques employed in assessment efforts have included those using secondary and primary data and those using secondary, survey, participant observation, and unobtrusive methods. In nearly all cases, however, whatever the method used, the major conceptual and methodological choices surround the three major processes of:

1. Baseline profiling
2. Baseline projections
3. Impact projections.

In this section, the most prevalent techniques used in the completion of these three steps in actual impact assessments are discussed.

Baseline Profiling

As with many other types of impact assessment, one of the major steps in the assessment process is that of describing the area prior to development. In social assessments, this usually involves a description of a large number of variables derived from secondary data sources. One of the most comprehensive lists of the basic dimensions measured in social assessments and some of the common indicators of those dimensions is presented by Fitzsimmon et al (1975). The aspects listed in these authors' social well-being account are shown in Table 6.1. For each dimension, some of the components and a few of the many indicators of each component are shown.

An examination of this table reveals the breadth of indicators that may be included in a social assessment profile, as well as the tendency for social assessments to include a large public service component, to rely heavily on secondary data indicators (that is, public service agency and census data), and to incorporate standard sociological variables within a broad sociocultural perspective. Although the specific variables shown in Table 6.1 are influenced by the fact that the social well-being account is designed for specific types of developments, the range of expectations it reflects for the social assessment is not unusual.

Because of the wide range of dimensions usually assessed, the completion of the social baseline usually involves the use of secondary data, participant observation and expert survey methods. That is, secondary census and public agency data are used to describe many of the service and demographic and context variables. Participant observation analyses, usually severely limited in scope, are used to describe what Fitzsimmons et al (1975) refer to as aggregate social effects, and a limited number of structured or unstructured surveys are conducted with community leaders and other residents in the community to determine the nature of existing institutions and other community factors. Community-wide random sample surveys may occasionally be performed, but the

Table 6.1. Dimensions, Components and Selected Indicators of Social Well-Being

Dimensions: Individual, Personal Effects		Community, Institutional Effects		Area Socioeconomic Effects		National Emergency Preparedness Effects		Aggregate Social Effects	
Components	Selected Indicators	Components	Selected Indicators	Components	Selected Indicators	Components	Selected Indicators	Components	Selected Indicators
1. Life, Protection, Safety	a. persons served by agencies b. staff size and budget of agencies c. accessibility of agencies	1. Demographic	a. size b. density c. ethnicity	1. Employment and Income	a. workers by type b. occupation and industry of workers c. persons below poverty level d. satisfaction with employment	1. Water Supplies	amount and quality of water	1. Change in Quality of Life	a. self-development b. quality of inter-personal relationships c. standard of living d. satisfaction
2. Health	a. morbidity levels b. mortality levels c. number of out-patient health facilities d. number of health care personnel e. cost of health care f. satisfaction with health care	2. Education	a. school enrollment b. dropout rates c. number of personnel and facilities d. satisfaction	2. Welfare & Financial Compensation	a. number of people receiving assistance b. persons below poverty level c. satisfaction	2. Food	amount and type available	2. Changes in Relative Social Position	equity of distribution of benefits and costs
3. Family and Individual	a. number of families b. number of unemployed c. number of divorces d. family-related services	3. Government Services	a. number of governments b. government budgets c. satisfaction	3. Communication	a. households with radios and televisions b. newspaper circulation c. satisfaction	3. Power Supplies	effects on power availability	3. Changes in Social Well-Being	a. changes in the quantity and quality of services b. changes in income c. economic stability
4. Attitudes, Beliefs, & Values	Expectations of impacts on: – local environment – local economy – local community – population characteristics & composition – local participation in decision-making – local values and customs	4. Housing & Neighborhood	a. persons in substandard housing b. number of units c. costs of housing	4. Transportation	a. number of vehicles b. number and quality of highways c. satisfaction	4. Water Transportation	number of miles of waterway		
5. Environmental Conditions	a. visual quality b. pollution levels c. accessibility d. land use patterns e. conflict between those desiring alternative uses	5. Law & Justice	a. number of violations b. number of policemen c. budgets d. satisfaction	5. Economic Base	a. persons employed by industry b. number and type of establishments c. satisfaction	5. Fuels	change in different types of fuels		
		6. Social Services	a. number on welfare b. social service personnel and facilities c. satisfaction	6. Planning	level of local planning	6. Other Factors	INR		
		7. Religion	a. church membership by denomination b. number of clergymen c. church stance on community issues	7. Construction	effects of construction on population, housing, and other factors				
		8. Culture	a. ethnic composition b. language c. historical sites						
		9. Recreation	a. types of facilities b. costs c. satisfaction						
		10. Informal Organizations and Groups	a. number, size, and membership in groups b. coordination between groups						
		11. Community & Institutional Viability	a. change in size, type, location, etc., of services b. change in residents' image of community						

Source: Social Assessment Manual: A Guide to the Preparation of the Social Well-Being Account by Stephen Fitzsimmons, Lorrie Stuart, and Peter Wolf, Washington, D.C., Bureau of Reclamation, 1975.

INR: Indicators not relevant to present discussion.

norm is for some combination of these three methods to be used (Schriner et al, 1976; Love, 1978). Although some early assessments relied almost totally on secondary data, baseline descriptions are seldom now performed using only a single method. This marks a significant increase in the level of realization of the complexity of and resulting detail necessary for the adequate assessment of social impacts (Freudenburg, 1981).

The limitations of these practices are that the use of secondary, or quickly conducted participant observation and survey efforts, often lead to the assessment of those phenomena that can be most easily measured or to the use of those data that are most readily available rather than to the assessment of the most important social phenomena. As a result, the perceptions and perspectives of interest groups, both for and against development, are often included in baseline assessments, but the viewpoint of the general public or the community as a whole remains unreported. Given the time and resource realities of the assessment process, however, such limitations seem likely to remain evident in social impact analysis.

Baseline and Impact Projections

The discussion of baseline and impact projections is presented in one section because the range of methods used in baseline projections is limited and because both projection processes share similar strengths and weaknesses. In fact, of all the aspects of social assessment, it is clearly the projection process which is the least developed and open to widely justifiable criticism. In almost all cases, data obtained by one of the standard social research methods are further expanded by additional iterations of data collection or by the application of conceptual perspectives to existing data bases to project social impacts. Although an extremely large number of methods could potentially be used (Miller, 1977), the most frequently used techniques include the application of:

1. trend extrapolation techniques
2. expert-opinion or delphi surveys
3. value forecasting procedures
4. social change and development theories
5. scenario forecasting techniques.

Before each of these techniques is discussed, however, it is essential to point out the major inputs that enter into the social assessment process. The most important of these are:

1. baseline data on social, historical, and cultural trends
2. projections of project-related demographic change
3. projections of project-related economic change.

For the social analyst, social projections are and must be made with full recognition of existing social patterns and trends and of the likely magnitude of project-related demographic and economic changes. The size, distribution, and composition of the population accompanying a development and the extent to which the development will alter the basic economic base of the area provide essential inputs into the social analysis. As noted above, such factors are among the most important determinants of social impacts. It is essential, then, to again emphasize that attempts to incorporate measures of the interdependence of the various socioeconomic dimensions, though often not computationally formalized in relation to social factors, is as essential in social assessments as in other parts of the socioeconomic assessment process. This consideration is important in examining each of the techniques that are presented below.

Trend Extrapolation

Perhaps the most widely used technique, and in fact, nearly the only technique used in baseline projections, is that of extending or extrapolating past trends into the future. This method is particularly useful in baseline projections because past trends are nearly the only guide to what will happen in the area in the future without development. In using such techniques, researchers generally take baseline profiles and extend these into the future. Thus, if the area has been dominated by agriculture and shown consistent population decline, these patterns are assumed to continue or to change in some specific manner.

The advantages of this approach are that it is relatively easy to apply and provides projections that are clearly supported by existing data. The major problems with the application of this technique in social assessments have been twofold. Social analysts have tended to use a relatively simplistic model of baseline conditions in rural areas and have failed to recognize that all social patterns change over time. Thus, there has been a tendency to perceive rural areas as at the extreme rural end of the rural-urban continuum and to idealize their predevelopment states. In addition, there has been a tendency to see rural areas as unlikely to change for predevelopment states unless a particular development impacts the area. Although social scientists acknowledge that American society as a whole is changing and seldom fail to extrapolate changes as in baseline demographic patterns, the extrapolation of social patterns often consists of simply assuming that past configurations will continue unchanged. Clearly, extrapolations of even baseline social patterns must take into account the ongoing societal patterns of change (such as those related to mechanization, mass communication, etc.) that are affecting rural areas. Techniques failing to do so are unlikely to provide accurate projections.

Expert-Opinion or Delphi Surveys

Delphi techniques have had a long history of use in a variety of social science fields (Freeman et al, 1978; Pill, 1971; Ament, 1970; Bender, 1969; Hill and Fowles, 1975). These techniques consist of surveying a group of experts or knowledgeable community representatives and then iteratively returning to them with the results of the earlier surveys to focus reassessments. By repeating this process, one can obtain increasingly integrated projections of experts' views of the future with and without development.

The advantages of this approach are several. It provides projections by community residents that have intimate knowledge of their community and its residents and projections that have received concerted and repeated examinations by these leaders. Finally, it is clearly a method likely to receive widespread support among local residents, since it is their and their community leaders' projections that are used in the analysis. This technique, then, insulates social researchers from both the charge that they have failed to include local perspectives or that the researchers are the source of erroneous projections.

The disadvantages of such techniques include those common to any survey. In addition, questions about the ability of local residents to project levels of change and about the extent to which the experts' (usually community leaders) views represent those of the larger community are areas of concern.

Although these dimensions are receiving increasing analyses (Freeman et al, 1978; Hill and Fowles, 1975), they are clearly considerations that require careful attention prior to the use of delphi methods.

Value Forecasting

Value forecasting is a technique that uses assessments of baseline values and beliefs to project how future developments are likely to be evaluated and accepted by local residents (Miller, 1977). Thus, if the area is one with patterns of ethnic homogeneity, relatively fixed social statuses and social interaction patterns, and slow acceptance of change, these "core" values may be projected to lead local residents to resist the social changes brought about by a development. The utility and validity of this method depends on the researchers' levels of knowledge concerning baseline values and the general state of knowledge concerning the ability to predict behavior from values.

This method is often used when baseline analyses have been conducted using participant observation methods. When such methods have involved long-term observations by well-trained social scientists, the assessment of baseline values is often quite accurate (Lofland, 1971). However, if baseline analyses were completed with limited periods of observation, this method can lead to dramatic and often questionable predictions (Kohrs, 1974). The ability of even the best assessments to predict behavior, however, is one that remains a central focus and unresolved issue in the social sciences generally (Schumann and Johnson, 1976; Clayton, 1972; Blalock, 1979).

Application of Social Change and Development Theories

Another technique widely used in social assessment projections is that of assuming that the impact area will display patterns similar to developing areas in other settings (Carnes and Friesma, 1974). Thus, the theoretical premises underlying theories of social change, and such specialized theories of social change as those related to economic development, urbanization, and modernity (Applebaum, 1970) have formed a major basis for predicting future social patterns. That is, such concomitants of changes in economic bases as decreases in the prevalence of extended families, formalizations of social relationships, increased alienation, and greater openness to change are predicted to occur in impacted areas as they change from predevelopment economic bases to those represented by the development.

This technique has the advantage of relying on a wide body of literature and theory and is, in many cases, the only form of projection that can be made. The difficulties in the use of such procedures include those inherent in the theoretical perspectives themselves and those resulting from the difficulties that exist in attempting to place impact areas along the continua that form the bases for many of the assumptions underlying such theories. Consensus on the types of changes that occur for groups and individuals as a result of economic and social change does not exist, and the nature of such changes form the basis of an ongoing debate in the social change literature (Armer and Schnaiberg, 1972; Cohen and Till, 1977; Inkeles, 1975; Rau, 1980). In addition, it is unclear where most communities should be placed on the continua of patterns that underlie such concepts. Even when these general theoretic patterns may provide useful projections, where a given impact area should be placed on the underlying continua and the level of change necessary for social patterns in the impact area to become more developed, more modern, or more urban is unclear. The development of this technique is dependent upon the accumulation of knowledge from additional basic research on social change as well as development of the social impact assessment art.

Scenario Forecasting

This form of projection is a specialized form of the methods discussed above (Vlachos, 1977). It involves systematically formulating a set of logical assumptions about future patterns in various social dimensions together and then tracing their likely interactions and trends over time. The assumptions used can be derived by any of the methods noted above and from any data collection form. Its unique features are its clear recognition of the basic assumptions used in its projections, its recognition of restraints on and dynamic interactions between component factors, and its tendency to examine multiple possible futures. Its logic is similar to that underlying any basic formalized projection technique.

The use of this technique, except in the most general sense, has been limited in social impact assessments. Its attractiveness stems from the conscious attempt to recognize and include patterns of interaction and dynamic relationships within a total sociocultural context. Its disadvantages stem from the fact that its level of utility is dependent on the level of knowledge concerning the basic patterns of interactions between social phenomena during a resource development. This method is one, in fact, that may be more advanced than the data available for social analysis. Its utility is thus likely to increase as the knowledge base concerning social impacts increases.

Conclusions Concerning Alternative Assessment Techniques

The five methods noted above constitute some of the most frequently used methods in social projections. In all cases, these projection techniques are largely nonquantitative, difficult to independently validate, and subject to wide variations in interpretations. The projection of social impacts thus clearly requires extensive development if social impact assessments are to gain a more equitable status in the socioeconomic assessment process.

The techniques actually used in social impacts assessment, both for baseline descriptions and baseline and impact projections, reflect a diversity of conceptual and methodological approaches. They reveal yet again the breadth and complexity of the phenomena to be assessed and the undeveloped nature of the social assessment process.

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

Perhaps no other socioeconomic dimension is so closely tied to many of the most widely recognized effects likely to occur as a result of repository siting as those considered by the social assessment process. Both the special and standard effects commonly associated with repositories contain major social dimensions (Bremmer, 1979; Herbert et al, 1979). As in preceding chapters, these dimensions and the methodological considerations they entail are discussed below.

Special Effects

Many of the special or unique effects of nuclear repositories involve major social dimensions. Thus, some of the most often noted of these special effects include (Hebert et al, 1979).

1. Fear and anxiety related to:
   (a) present health and safety
   (b) health of future generations
2. Concern over equity dimension of the siting process
3. Institutional concerns related to:
   (a) security
   (b) short-term and long-term site control
   (c) transportation and handling of materials
4. Public participation and monitoring.

These effects clearly are, in large part, social issues. That is, much of the fear and anxiety related to such projects result from perceptions of radioactivity and governmental management of such products. Equity issues of concern with who benefits from and who must pay the costs for a development are central issues in any social impact analysis, as are analyses of institutional structures within the prevailing social structure. Finally, although not a direct research dimension in social impact analyses, it is evident that the equity issue and most analysis of social and other development programs (Christenson and Robinson, 1980) point to the social bases for continuous citizen involvement in program development. Clearly, then, the special effects of nuclear repositories and the social effects of large-scale projects generally are closely related dimensions.

Standard Effects

The standard social impacts resulting from any large-scale development seem likely also to occur at repository sites. That is, the effects on interaction patterns, on social relationships, on social structure, on formal and informal relationships, and on community satisfaction and community perceptions are likely to be similar to those at other projects. However, the special effects noted above may affect standard social impacts such that the interaction of special and standard impacts could lead to the accentuation of standard effects. Thus, perceptions that the siting process was not completed with adequate local involvement or that a site was being imposed on an area with little regard for local safety and health concerns would likely lead to higher levels of antipathy toward such projects and to greater levels of conflict between longtime residents and project-related in-migrants than would be true for other types of projects. In addition, the demands placed on local leadership and management structures to respond to the siting process may be significantly greater than for standard developments and may lead to more rapid changes in community leadership. These and similar potential changes again point to the close relationship between the special and social effects of repository siting.

Methodological Considerations

One must be careful not to equate special and social effects both because special effects include psychological, political, and other dimensions not adequately measured by social assessment techniques and because the definition of social impacts would thus be left less clear than is desirable (see the discussion in preceding sections of this chapter). However, one implication that emerges from any comparison of special and social effects is that these effects are often not easily differentiated from one another nor are they capable of being assessed separately from one another. It thus appears desirable to suggest that the social assessment process should be expanded in repository analyses to include those special dimensions that are social or social-psychological in nature. Many of the special effects of repositories, though clearly not all, should be seen and assessed within the context of other social impacts. Perhaps the major methodological recommendation related to special and social effects assessments is that their commonalities should be systematically integrated.

For other social dimensions it appears that standard social assessment techniques can and should be employed. Given the breadth of issues underlying the social dimensions of repository siting, however, it is evident that a multidimensional approach is essential. That is, a combination of secondary, participant observation, survey, and other forms of analysis should be employed simultaneously in order to provide a more comprehensive and adequate assessment of the critical social dimensions. Finally, because of the critical and potentially complex nature and implications of social impacts, it is absolutely essential that the social dimensions of repository siting be examined with an adequate commitment of time and resources. A failure to adequately assess social dimensions may prevent completion of the entire nuclear repository siting process.

SUMMARY AND CONCLUSIONS

In this chapter, we have delineated the conceptual, methodological, and assessment process dimensions in the assessment of social impacts. The conceptual bases as well as the methodological alternatives for such assessments are diverse and reflect a broad base of subject matter. On the other hand, the actual assessment technqiues in use tend to be relatively underdeveloped and require extensive expansion and basic conceptual and methodological development and analysis. The discussion suggests that the assessment of social impacts is perhaps the most complex of all the aspects of socioeconomic impact assessment, but at the same time, the least developed and the least used and appreciated. The further development and perhaps even the survival of social impact assessments will require extensive changes in the substance and context of social assessments.

One of the first requirements for more effective social assessments is a clearer delineation of the nature of the term social as used in assessments and a delimiting of the phenomena that must be included in a social assessment. This will require both ensuring the inclusion of certain key dimensions and, at the same time, the exclusion of some elements presently considered as parts of many social assessments. Thus, social assessments should include, at a minimum, an analysis of: (1) the community and social structure of the impact area, (2) the key social processes and major patterns of interaction in the impact area, (3) the social institutions in the impact area, and (4) the attitudes, values, and perceptions of the residents of the impact area. The assessment of these factors would require analysis of key formal and informal groups, leadership patterns, patterns of social differentiation, basic values and norms, basic cultural themes, patterns of influence and social networks, forms of social organization and disorganization, perceptions of community, satisfaction with community, and similar standard social dimensions. It would, however, eliminate several dimensions often included in social assessments, including the examination of psychological states and community service demands. At present, the demands placed upon the social assessment process are often unreasonably inclusive and involve attempts to assess factors that are neither conceptually or methodologically compatible with social bases of knowledge. A clearer definition of the domain as well as the limits of social assessments is essential.

Equally important is the need to more effectively integrate the social assessment process with other aspects of the socioeconomic assessment process. As noted above, the social assessment process, though utilizing the results of other socioeconomic dimensions, is seldom formally integrated with them. This integration will require both conceptual and methodological developments. That is, few social theories effectively integrate social dimensions with economic, demographic, public service, and fiscal dimensions, and even fewer attempt to integrate social dimensions with environmental or technological dimensions which form major areas of impact in resource developments. Although this need has been expressed and some initial suggestions made for effecting such integrations (Murdock, 1979), the conceptual basis for integrating social dimensions with other aspects of the socioeconomic assessment process clearly requires much more extensive attention. Methodologically, also, such forms of integration are not present. Thus, there is no social counterpart to the computational linkages that exist between economic investments and employment requirements or to that between employment change and population growth. Such linkages must be developed and implemented if the social assessment process is to become an integral part of the socioeconomic assessment process.

Perhaps no other single development is as essential, however, as the development of more effective means for projecting social phenomena. Although one can legitimately argue that many of the projection techniques in other social science dimensions are superior only in form, but not inaccuracy, to social projection techniques (Ascher, 1978), the fact that social projections remain descriptive and that they seldom provide assessments of the magnitude or the distribution of impacts often makes them of little utility to decision makers and others involved in local area planning. Although the increase in the level of understanding provided by such assessment should not be discounted, more definitive projections are essential if the social assessment process is to influence decision making or to gain a more substantial role in the overall assessment process.

The assessment of social impacts clearly shares the need, expressed in the discussion of other socioeconomic dimensions, for a much elaborated data base on the near and long-term impacts of resource developments on social phenomena. Analysis of the actual social impacts of various types of resource developments in different settings and the long-term monitoring of impacted areas and events remain a widely recognized research priority (Murdock and Leistritz, 1979; Freudenburg, 1981). As with other dimensions, then, the social impacts of resource developments require substantial additional analysis and substantiation.

Finally, it is evident that the social assessment process must be made a full-fledged part of the socioeconomic assessment process, not merely an addendum or appendix to the demographic or public service analyses. Until the time and resources necessary to complete successful social assessments are provided, the assessment of social impacts will simply not be adequately completed. Although the marginal status of social assessments results, in large part, from the limitations noted above, it should be clear that such limitations cannot possibly be overcome if the social assessment process remains peripheral to the overall socioeconomic assessment effort. Only the acceptance and expansion of the social assessment process can ensure its ultimate utility for determining the social impacts and social implications of resource developments.

The conceptual and methodological challenges in the social assessment process are particularly pronounced and require immediate and concerted attention. It is also an analytical area in which the need for accurate and comprehensive assessments is especially essential, both to ensure the successful siting of resource developments, and to ensure that the impacts of developments are fully and equitably assessed and subsequently mitigated.

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CHAPTER 7

INTERFACING SOCIOECONOMIC DIMENSIONS

The assessment of the socioeconomic impacts of natural resource developments entails the use of procedures and methodologies from diverse fields, including economics, demography, sociology, public service planning, fiscal analysis, and several others. However, unlike many other areas of analysis in which the integration of key dimensions of these fields is largely limited to verbal discussion, in impact assessment actual computational interfacing of the various elements is essential and mandated. Thus, as specified in the National Environmental Policy Act, such assessments must "utilize a systematic, interdisciplinary approach which will ensure the integrated use of the natural and social sciences and the environmental design arts . . ." (NEPA, PL-190, 1970:857). The conceptual and methodological bases of the various disciplines must be effectively interfaced in impact assessments.

Unfortunately, attempts to computationally link various socioeconomic components are relatively recent (see Chapter 8 for a history of such developments), and the conceptual and methodological basis of interface procedures are relatively undeveloped. The assessment process has, in fact, played a major role in progressing integration procedures from the conceptualization to the implementation stage. Such integration, however, requires substantial conceptual and methodological refinement.

Because the art of interfacing is poorly developed, before initiating our discussion of the conceptual bases underlying interfaces, it is essential to define what the interfacing or integrating of socioeconomic dimensions entails. Although few formal definitions have been developed, the interfacing of socioeconomic dimensions in an impact assessment may be defined as consisting of the use of the output from projections in one content area (i.e., economics) as input into another area of analysis (i.e., demography). This output-input procedure may be single- or multiple-based and involve two or several content areas simultaneously. It may involve a formal quantitative procedure or the descriptive use of the results from one area in the interpretation of the impacts in another. The delineating features of an interface, then, are its abilities to link two sets of quantitative or qualitative projection procedures either formally or descriptively so that the results of the projections in one of the two areas acts upon or interacts with the other to influence (or mutually influence) the results obtained in the other projection area. This definition, though admittedly simplistic, makes the interfacing involved in impact assessment an integral part of the system's framework widely used in formal modeling and a part of the broad conceptual process involved in the integration of social science disciplines. As such, the interfacing of socioeconomic dimensions is of central importance to impact analysts in particular, and as a form of tracing interactions between social science dimensions, to social science in general.

CONCEPTUAL BASES AND METHODOLOGICAL ALTERNATIVES IN INTERFACING SOCIOECONOMIC DIMENSIONS

Although most methodological discussions of impact methods (Chalmers and Anderson, 1977; Murphy/Williams, Consultants, 1978; Denver Research Institute, 1979) present procedures for linking components, few provide any discussion of the conceptual rationales underlying the procedures utilized. In fact, the number of conceptual discussions of interfaces are extremely limited (Murdock et al, 1979a) and most consist of little more than discussions of the computations involved in the techniques. In this brief section we attempt to provide initial steps toward the establishment of a more effective conceptual base for the integration of socioeconomic impact dimensions.

In interfacing components from two or more computational sets, principles that reflect impact projection processes, the characteristics of the components to be integrated, the units of the interface, and the interface process are required. Specifically, we suggest (Murdock et al, 1979) that interfaces should have the following characteristics:

1. The use of a common interface procedure for baseline and impact projections
2. The use of procedures and data that can be effected at the lowest appropriate geographical level
3. The retention of the maximum number of significant aspects of each of the components being interfaced
4. The use of multiple interface points
5. The use of mechanisms for ensuring the feedback of changes from one component to another.

A discussion of the general rationales underlying these characteristics as well as their implications for each of the major substantive areas involved in interfaces in impact assessments appears below.

Baseline and Impact Projections

One of the factors that has caused inconsistency in some impact analyses has been the failure to employ consistent interface methodologies in both baseline and impact projections. The failure to use a common methodology in both major phases of a projection means that differences in projection results that are due to project effects cannot be differentiated from those that are the result of differences in the interface methodology employed. In economic-demographic interfaces, for example, it has been quite common (Toman et al, 1976) to use simple population-to-employment ratios for baseline projections but to match detailed economically derived estimates of required labor with demographically determined estimates of available labor to complete impact projections. As a result, baseline and impact projections are not directly comparable, demonstrating that the use of a common methodology for both impact and baseline projections is essential.

Areal Specificity

Interfaces of key components can be completed at a variety of geographical levels. The second characteristic suggests that the areal focus for interfaces should be the lowest possible level of geographical detail. An important trade-off is often involved in the selection of the focal level for interfacing, however. That is, the difficulties of data acquisition increase with the level of geographic detail required. The use of national or regional data (Stenehjem, 1978) may thus be advantageous if time and other resources are limited or if local data are not available. On the other hand, the interfacing of components at lower levels of geographical detail is suggested by the need to adequately characterize the differences in characteristics between impact areas. If these differences are substantial, and likely to alter the nature of the interface dimensions, relatively small areas are the preferred level for interfacing.

In interfacing computations this premise points to the desirability of performing computations at the county level or below rather than at the regional or other higher levels of geographical aggregation. When regional interfaces are involved, allocation functions are generally required to obtain values for county or municipal areas. In many cases, these allocation procedures are simplistic and do not allow the characteristics of smaller areas to be taken into account. For example, if the interface of demographic and service dimensions occurs at the regional level, then the important differences between the service availability in the region and those in smaller areas (which may be substantial if the region is a functional economic area and the local area is a small rural community) may not be adequately measured. In general, to the extent that the characteristics of small areas accurately reflect those of the larger areal unit the accuracy of projections for small areas will not be affected by completing interfaces at the larger areal unit levels. In nearly all other cases some inaccuracies will be introduced. Even the use of characteristic-specific functions, showing the smaller area's proportion of a larger unit's dimensions (such as the percent of the region's population 15 to 19 years of age accounted for by a county's population of that age), may not allow cyclical flows in the patterns (such as age structure changes) for smaller areas to be accurately predicted.

Finally, the application of rates at the lowest possible level of geographical aggregation is suggested by the need to ensure the greatest possible accuracy at those levels for which the data are most likely to be used. Increasingly, impact assessments are being employed not for region-wide planning but for county, community, and school district analysis because these areas are those that are the most likely to experience negative socioeconomic impacts (Murdock and Leistritz, 1979). To the extent that the use of small area data improves the accuracy of projections of changes for small areas (a premise that admittedly requires additional verification), the use of small area data is desirable. These considerations together with the fact that the accuracy of projections varies directly with the size of the unit for which projections are made has led to a compromise which has made the county the standard unit of analysis. Although the utility of this level of focus has yet to be fully established, its use appears to be gaining acceptance in impact assessments (Chalmers and Anderson, 1977; Denver Research Institute, 1979).

Retention of Component Characteristics

The need to retain the essential aspects of each component is an evident, but often neglected, factor in interfacing projections from different substantive areas. In many impact interfaces, simplifications of each component often occur prior to the interfacing of the components. Thus, even though an economic model may be utilized which provides sector detail on gross outputs and employment for economic projections, many of the most commonly utilized interface techniques simplify such data prior to their use in the economic-demographic interface by summing across sector employment types by sectors to get one estimate of required labor. At the same time the demographic analyses may produce age and age-sex specific data, but these data are often simplified to a single estimate of available labor for interfacing with economic components or aggregated to produce a total population figure for interfacing with service or other components. When this is done, the advantages gained in the use of detailed data are lost. For each of the major components such simplifications can entail a significant loss of information that should enter the interface. It is essential, then, to delineate the general features that should be included in all interfaces and to specify the elements that must be included in each interface component.

Although many of the individual factors that should be retained are specific to a given component (economic, service, etc.), at least two features are sufficiently general to suggest the conceptual utility of including them in all interfaces. These are the need to ensure that interfaces include (1) measures of the magnitude of the impacts and (2) measures of the distribution of impacts across key dimensions. For example, total employment demands as well as employment demands by sector, total available labor as well as available labor by type, total revenues as well as revenues by type should be included if at all possible. The distributional component is the most often neglected of these two factors. For example, an economic and demographic interface function that matches required and available labor to determine migration may suggest a need for little or no in-migration because total available and required labor are nearly equivalent. However, because both labor availability and demand are in actuality differentiated, significant in-migration may be necessary to fill specialized labor demands. Some of the available labor will not be at the appropriate skill level to address the demand and will not be employed at the development site. Unless interfaces include such distributional dimensions, substantial projection errors may result.

In addition to these general considerations, it is essential to suggest at least some of the aspects that should enter the interfaces between each component and other components. In the economic component, for example, it is essential that each of the types of employment demands created by the project enter as separate components of the interface. At a minimum, it is essential that construction, operational, and indirect types of employment be included because these types of employment require different types of skills, involve different population subgroups, and have different public service, fiscal, and social impacts. Unless employment types are differentiated, subsequent projections will also not provide an adequate level of differentiation. In addition, economic interfaces should include data by at least broad industrial economic sectors. One of the major advantages of sector detail is that it provides a more flexible base for interfacing with other dimensions. Thus, because data on the demographic characteristics of persons by occupation are available, sector-specific detail allows for more detailed projections of the demographic implications of given levels of employment change. Employment and sector differentiation are essential.

In the demographic component the key factors appear to be the inclusion of total population and population by age and sex. Although other demographic indicators, such as those on household composition, may be desirable, the close association between age and sex characteristics and nearly all other socio-demographic variables, such as economic, public service, and fiscal variables, suggests that age and sex detail provide an adequate level of differentiation. The substantial differences between subgroups within populations are often masked in total population values (see Chapter 3) and clearly suggest the need for age and sex detail.

For service interfaces the essential features not only include indicators of the level and distribution of services, but also indicators of service quality and of existing service infrastructures in impact areas. As noted in Chapter 4, this latter dimension is particularly important because it is often neglected in actual assessments. Although few assessment techniques ignore the availability of workers from the baseline population in interfacing economic and demographic models to determine migration levels, it is not uncommon to assume "no excess capacity" or to project service demands on the basis of new impact population only. As a result, infrastructure surpluses or deficiencies are not taken into account. In projecting different types of services, then, it is essential to consider existing service bases. This is not computationally difficult, if necessary baseline service data are available.

Projections of the quality of services are also seldom included in impact projections (see Chapter 4) or in interface computations. If included at all, they are often only verbally described in discussions of the assumptions underlying a set of projections or noted as qualifiers of the validity of such projections. The operationalization of the concept of service quality, except as indicated by the magnitude of service personnel per unit of population, is extremely difficult, but this difficulty does not negate the necessity of using quality of service indicators in interface procedures. For example, unless such indicators are provided, one might erroneously assume that an area's present medical service needs fit within acceptable limits. However, if the medical personnel involved are serving on a part-time basis or their specialties do not reflect those required by the project-related population, the overall estimates may be misleading. When interfacing service demands with projected population and other factors, it is essential to adjust the interface results in terms of service quality factors.

In the assessment of fiscal impacts it is important to include several basic dimensions. Foremost among these is the need to include separate indicators of different types of revenues and expenditures (see Chapter 5). Because the characteristics of different types of new residents and different types of resource developments have quite different taxation implications, it is essential to differentiate between types of revenues and expenditures. The use of single per capita indicators of public revenues or expenditures fails to take into account that different types of residents will generate different levels of revenues and expenditures. Those living in mobile homes, for example, will generate significantly less revenue than those living in single family dwellings. If the populations coming to a development area are expected to have significant differences in their characteristics, then separate revenue and expenditure estimators should be developed to take such differences into account. Although the exact number of categories of revenues and expenditures that should be used in any given situation will vary with the tax structure of the area being considered, some differentiation is essential.

When social components are involved, the interfaces are seldom quantitative in nature. Whatever the manner in which social interfaces are effected, however, it is evident that, at a minimum, patterns of interacting institutional, structural, and perceptual phenomena should be interfaced to trace their effects on: the patterns of interaction between various types of residents; the major social institutions--the family, religion, education, the political, and the social aspects of economic structure; the social structure of the area (that is, the effects on such factors as roles, statuses, social class, and the social organization of the community); and on the values, attitudes, and perceptions of people in the area. Although quantitative interfaces between such factors and others have yet to develop, these four dimensions should form basic aspects of any such interface. It is essential in all interface components not only to develop a means of interfacing them but also a means of ensuring that the interfaces effectively merge the major components of each dimension. This assertion clearly remains an ideal that is far from realization.

Multiple Interface Points

A majority of the interfaces between socioeconomic components utilize a single factor interface. For example, public expenditures are often obtained by the application of a single per capita rate of expenditure to total population values, and the interface points for economic and demographic models and the interface point for demographic and service modules are often single-faceted. Few components are simultaneously interfaced either with more than one other component or with more than one variable within each component. Fiscal components tend to be the exception in that income (to determine income tax revenues), housing demands (to determine property tax revenues), and population (to determine per capita revenues or expenditures) are all interfaced with fiscal factors. In an ideal conceptual design all components would be interfaced with all others at multiple points to take the mutual interdependence of socioeconomic dimensions into account.

The importance of these multiple linkages is as apparent as the interdependences that are known to underlie such dimensions. The specific dimensions of each component interact in numerous and complex ways. Thus, both employment and industry characteristics affect population size, distribution, and composition; population size, distribution and composition affect the magnitude, nature, and quality of services; and service quality affects employment, population size, and numerous other factors. Few dimensions are interrelated through only a single factor. If actual conditions are to be accurately simulated, the full range of interdependence that exists between socioeconomic factors must be included in the interfaces. Although it is clearly impossible to fully simulate all of these interdependencies, existing interface techniques (as noted below) require extensive supplementation to include multiple interface points.

Feedback Mechanisms

The need to ensure that changes in the conditions of one factor for one time period are fed back into (used in) the calculation of related factors for subsequent time periods is closely related to the design of multiple interface points, for if the interrelationships between items have not been linked conceptually and computationally, it is impossible to trace feedback relationships between factors. The need to carefully determine those relationships that should be treated iteratively must be given special emphasis. The very nature of the interactive relationships that exist between socioeconomic components points to the need for such emphasis. Although the presence of such feedback mechanisms in actual impact events has been thoroughly discussed in the impact literature (Gilmore et al, 1976; Murdock and Leistritz, 1979; Albrecht, 1978; Cortese and Jones, 1977) and at least partially included in the structure of several computerized models (Ford, 1976; Cluett et at, 1977), insufficient attention has been given to tracing the most influential of such mechanisms and to including them in impact projection methodologies.

The need for feedback mechanisms, if long-term projections are to be made, cannot be overemphasized. It is essential to trace the effects of factors at one point in time on other factors at latter periods. Thus, it is essential to examine such relationships as the effects of employment opportunities on indigent residents' employment and migration patterns in subsequent periods. It is important to assess the effects of changes in area income levels on service demands and on perceptions of the local community and the quality of life in the community. It is essential to measure the effects of community perceptions on migration patterns and the effects of fiscal structures on the quality of services. It is important to measure the effects of employment growth on population growth, population and employment growth on service quality, and the interactive effects of service quality on employment, population growth, and retention (the problem triangle). Finally, it is important to assess the effects of changes in business volume on the subsequent retail service mix and of this mix back on business volume. These interactive effects must be established, quantified, and included in impact projections. Substantial additional research is essential because most of these relationships have yet to be fully identified and even fewer have been quantified. The need to establish and methodologically implement feedback mechanisms should receive priority in the development of impact methodologies.

Conclusions Regarding Conceptual Bases

The delineation of the five dimensions noted above provides only an initial step in the formation of a conceptual base for interfacing socioeconomic impact components. These dimensions are not inclusive of all those that might be delineated nor are they premises without exceptions. They require supplementation and further specification. It is essential that impact scientists more carefully consider the goals they wish to achieve in interfacing model components rather than allowing established methodological techniques to determine their conceptual goals. The development of sound conceptual bases for the interfacing of impact projection components must be initiated and pursued with resolve.

FACTORS AFFECTING THE INTEGRATION OF SOCIOECONOMIC DIMENSIONS

The integration of socioeconomic components is affected by two sets of often difficult to reconcile factors. Extensive integration is necessitated by the nature of socioeconomic phenomena, but the methodological implementation of such interfaces is often limited by the nature of the impact assessment process and by the limits of existing methodological techniques and data. The factors underlying these dimensions are discussed below.

The need to examine the interrelationships between economic, demographic, public service, fiscal, and social impact dimensions is evident to anyone familiar with social science literature or with the impacts of major resource developments. Because it is neither possible nor appropriate, given the focus of this report, to chronicle the many individual interactions that occur between social science dimensions in impact situations, and because elements of these interactions are described in several other chapters of this will not be employed at the development site. Unless interfaces include such distributional dimensions, substantial projection errors may result.

In addition to these general considerations, it is essential to suggest at least some of the aspects that should enter the interfaces between each component and other components. In the economic component, for example, it is essential that each of the types of employment demands created by the project enter as separate components of the interface. At a minimum, it is essential that construction, operational, and indirect types of employment be included because these types of employment require different types of skills, involve different population subgroups, and have different public service, fiscal, and social impacts. Unless employment types are differentiated, subsequent projections will also not provide an adequate level of differentiation. In addition, economic interfaces should include data by at least broad industrial economic sectors. One of the major advantages of sector detail is that it provides a more flexible base for interfacing with other dimensions. Thus, because data on the demographic characteristics of persons by occupation are available, sector-specific detail allows for more detailed projections of the demographic implications of given levels of employment change. Employment and sector differentiation are essential.

In the demographic component the key factors appear to be the inclusion of total population and population by age and sex. Although other demographic indicators, such as those on household composition, may be desirable, the close association between age and sex characteristics and nearly all other socio-demographic variables, such as economic, public service, and fiscal variables, suggests that age and sex detail provide an adequate level of differentiation. The substantial differences between subgroups within populations are often masked in total population values (see Chapter 3) and clearly suggest the need for age and sex detail.

For service interfaces the essential features not only include indicators of the level and distribution of services, but also indicators of service quality and of existing service infrastructures in impact areas. As noted in Chapter 4, this latter dimension is particularly important because it is often neglected in actual assessments. Although few assessment techniques ignore the availability of workers from the baseline population in interfacing economic and demographic models to determine migration levels, it is not uncommon to assume "no excess capacity" or to project service demands on the basis of new impact population only. As a result, infrastructure surpluses or work (for example, see Chapter 1) and in numerous places in the impact literature (Gilmore and Duff, 1974; Gilmore et al, 1976; Albrecht, 1978; Cortese and Jones, 1977; Murdock and Leistritz, 1979), it is not necessary to list all of the interactions in each individual area. It seems appropriate, however, to discuss some of the broad impact events that necessitate an integrated social science approach by examining key interactions between each dimension and all others. The intent is thus to exemplify rather than to comprehensively delineate the interactions that underlie the need for component integration.

Although impact events involve a large number of dimensions (Murdock and Leistritz, 1979), they are clearly, in large part, the result of an initial economic stimulus to the local economy. As such, economic dimensions require careful integration with all other social science dimensions. The effects of increased employment, income, and business activity, as well as a likely shift in the overall economic structure of an entire area as a development proceeds, will change other socioeconomic dimensions (see Chapter 2 and Leistritz et al, 1980). Thus, population growth not only increases as a result of economic activity, but the very nature of the local population changes as new employees with young families move into the area. Employment-related growth means that the total population of the area will become larger, that more children will enter the population, and that persons with more diverse needs and desires will enter the area. Increased business activity also leads to indirect population growth as new service industries arrive to provide additional services to project-related populations. In addition, a larger proportion of young adults who might otherwise have left the area may remain in the area and obtain project-related employment. Economic changes lead to significant demographic changes in population structure and composition and affect present and future population patterns.

Economic impacts also affect service functions directly, by increasing the public and private potential for purchasing services, and indirectly, through population and fiscal effects. Increases in purchasing power lead to increased demands for more and better quality public services. New persons brought in by the increased economic activity increase the numerical level of demands on public services, and may demand service levels comparable in quality to those in their former areas of residence. The income generated by new persons and the increased incomes of many longtime residents as a result of the project will, in turn, increase both public revenues and expenditures and the availability of funds to support public services.

Economic activity affects fiscal factors by producing local area personal income growth and growth in business volume. Increases in these factors will lead to increases in tax revenues (income, sales, and property taxes). Economic activities are also likely to lead to increased expenditures, particularly if a significant number of in-migrating employees are needed to meet the demands of an expanding labor market. Thus, both fiscal revenues and expenditures show numerous areas of interaction with economic activity.

Social dimensions are also closely related to and interrelated with economic dimensions. Increases in business activity often lead to increased demands on private and public leadership, to subsequent shifts in leadership patterns, and to the emergence of new, more growth- (or nongrowth-) oriented leaders. Increased costs for housing and other services often associated with increased economic demands may adversely affect those on fixed incomes and other disadvantaged groups. Changing income situations may alter the social class structure of the local area, causing increased social mobility for some residents and decreased mobility for others (Murdock and Schriner, 1978), and as new employment-related groups move into the area, interactive patterns in the area may be changed, friendship patterns may be altered, and perceptions of the community may change rapidly (Albrecht, 1978).

In sum, then, economic impacts have ramifications throughout all other socioeconomic dimensions. They provide a major impetus to impacts in other dimensions and must be systematically interrelated with each of the other dimensions.

Demographic impacts also have close interrelationships and require careful interfacing with each of the other dimensions. In addition to those relationships with economic dimensions already noted, the demographic structure of the area may be a major factor in determining even the feasibility of initiating a resource development. The existing demographic structure will, in large part, determine the size of the local labor force (Easterlin et al, 1978) and the characteristics of that population (that is, its levels of education, and so on) will determine the quality of that labor force. Both of these factors may affect the developer's decision to initiate a development. After a development is initiated, local demographic structures and economic conditions continue to have reciprocal effects. As young people reach employment age, economic opportunities will affect their decision whether to remain in the area or migrate from it, and these decisions, in turn, will affect the labor force available for the development.

The demographic growth resulting from a development interacts in numerous ways with service and fiscal factors. Its size affects the magnitude of new service demands, and the characteristics of those involved in that growth will affect the type of demands. The size of the new population will determine local revenues and expenditures, and its characteristics will determine the relative magnitude of each. If the project-related population growth involves the in-migration of very young adults, it will lead to greater demand for apartments and mobile homes but to less demand for single-family dwellings than if the in-migration involves older groups. Since the per capital revenues generated by apartments and particularly mobile homes are less than for single-family dwellings, the younger in-migrating population is likely to generate less new revenue than an older population of migrants. Fiscal patterns and the services dependent on them are thus closely related to demographic patterns.

The effects of demographic factors on social phenomena are especially significant. The size and distribution of the new project-related population will determine the extent to which a development will affect the local social structure and whether new persons will come to dominate or be dominated by the existing structure. In turn, the composition (age, ethnic, and regional background) of the new population will likely determine the acceptability of the new population to the indigenous population and the extent to which new residents seek and obtain leadership and other positions of dominance in the area.

Overall, then, demographic phenomena are interrelated with each of the other dimensions. As with economic dimensions, demographic factors require interfaces with all other components.

The interfaces of fiscal and service factors have already been extensively described, but it is essential to emphasize that they are not only affected by other components but, in turn, affect the nature of economic, demographic, and social factors. Continued economic growth in a region is closely related to its tax structure and the existence of local services (Lonsdale and Seyler, 1979). Overtaxed service bases and negative fiscal impacts may lead to shifts in labor force residence patterns and to mismatches between population service availability and tax revenues (Gilmore et al, 1976). Inadequate services or decreases in services due to insufficient public revenue growth are major determinants of community satisfaction (Christenson, 1976). Such social impacts, such as leadership changes and community conflict, often result from controversies over local revenues and expenditures and from inadequate service provision. Fiscal and service dimensions are interrelated with other factors as both causes and effects.

The social dimension is the most comprehensive and the most poorly understood of the socioeconomic impact dimensions (see Chapter 6). Despite extensive descriptive and empirical analyses (Gold, 1974; Freudenburg, 1978a, 1978b, 1980; Albrecht, 1978; Cortese and Jones, 1977; Murdock and Schriner, 1978) that establish the significance of such factors, few have been systematically linked with other social science dimensions in impact projections. Social factors, such as resistance to developments, however, often affect the very likelihood of a development being accepted in an area. They affect the local levels of employment availability through their effects on career preferences, and they affect local revenues and expenditures through their effects on public acceptance of tax increases and revenue distribution formulas. Social dimensions must be integrated with economic, demographic, public service, and fiscal dimensions if effective and comprehensive projections are to be made.

These are only some of the many interrelations between socioeconomic dimensions. It is clearly impossible to adequately simulate the impacts of resource developments without taking these interrelationships into account, and this simulation is impossible without the development of effective procedures for interfacing the socioeconomic dimensions in impact projections.

The realities of the impact assessment process as well as the stage of development of existing methodological techniques, however, have resulted in interfaces that seldom approach the levels of detail necessary to actually simulate the interactions noted above. Most impact assessments must be performed with severely limited time and financial resources. As a result, the nature of the impact assessment process often leaves little time and provides few resources for the conceptualization or implementation of interfaces. Such limitations have meant that many of the conceptual ideals noted in the last section, such as the use of local level interface procedures and multiple interface points, have required data and conceptual approaches that cannot be obtained given the resources limitations usually inherent in the assessment process.

Even more limiting, however, has been the lack of adequate baseline data and methodological procedures. Although these limitations will be discussed in greater detail below, it is essential to note that we simply do not have the necessary data or procedures for interfacing numerous dimensions that we know are interactively and iteratively related. Thus, the data procedures have not been developed for interfacing such factors as income change with out-migration rates, changes in age-sex composition with tax revenues, service quality with local employment retention, service provision with public revenues, changes in migration rates for indigenous young adults with increased service demands, and if quantitative procedures are desired, for social dimensions with virtually any of the other dimensions. The conceptual basis for implementing, the data necessary to implement, and the procedures for implementing socioeconomic interfaces have yet to be adequately developed.

In sum, then, there is little doubt that the realities of impact events require that interfaces between socioeconomic dimensions be established. Unfortunately, it is equally evident that among the most important factors affecting the use of interface procedures in impact assessments is the underdeveloped conceptual and empirical state of the art of impact assessment. Until these conceptual and empirical bases are adequately developed, severe limitations will continue to be evident in impact interfaces.

TECHNIQUES FOR INTERFACING SOCIOECONOMIC ASSESSMENTS

The interface techniques used in actual impact assessment procedures are presented in this section. Although some variations may appear in individual impact assessments, as a whole, there are relatively few deviations from the general procedures noted below. Additional discussion of these procedures can be obtained from several excellent reference sources (Chalmers and Anderson, 1977; Denver Research Institute, 1979; Murdock et al, 1979; Murphy/Williams, Consultants, 1978; Texas General Land Office, 1978; Burchell and Listokin, 1978).

The discussion emphasizes quantitative interfaces and the most established techniques in each interface area. The interfaces between economic, demographic, public service, fiscal, and social dimensions will be discussed in turn beginning with descriptions of economic and demographic interfaces with other dimensions. Because these interfaces involve a limited number of combinations, this approach decreases the discussion of interface procedures from the perspective of the fiscal, service, and social dimensions. It is essential to recognize, however, that this is only a product of the mode of discussion and does not reflect the relative importance of these dimensions. Effective interfaces must involve the merging of equal factors from multiple dimensions. Finally, it is important to note that because of the extensive description of some interfaces (such as the economic-demographic) in other chapters, the discussion of some interfaces is limited in this section.

The economic dimension is generally interfaced with the demographic and fiscal dimensions and seldom directly interfaced, at least quantitatively, with either the service or social dimensions. As a result, only its interfaces with the demographic and fiscal components are discussed here.

The economic-demographic interface is the most thoroughly developed of all interface procedures. It has received extensive attention (Denver Research Institute, 1979; Murdock et al, 1979; Cluett et al, 1977), and similar forms are becoming evident in most impact assessments. The two procedures most commonly used are population-employment ratios (either a total ratio or separate ratios for different types of employment) and techniques which match available and required employment. Since each of these are described in detail in Chapter 3 (on demographic impacts), we briefly note only the general form and characteristics of these procedures.

The use of single or employment-specific population-to-employment ratios was the first technique widely used to interface employment growth with population growth in impact analyses. It was nearly the only procedure used in early impact assessments (Dalstaed et al, 1974; Leistritz et al, 1976), and may still be the most widely used technique (Denver Research Institute, 1979; Murphy/Williams, Consultants, 1978). The technique involves a direct projection of population assuming that each employed person will have a given number (such as 1.9 or 2.5) of persons associated with them.

The disadvantages of this technique stem from its almost total dependence on the economic component. The demographic structure of and changes in the site area affect the result of the interface only as they affect the population-to-employment ratio. There are no mechanisms for taking other demographic factors into account and so a constant ratio or a ratio with a fixed pattern of change must be used. The technique is also usually single-faceted, noninteractive, and noniterative.

On the positive side, the technique possesses the clear advantages of ease of use, ready data availability, and clarity. Its strengths and weaknesses are evident, and its procedures are easily varied to examine alternative formulations. If used with ratios that are specific to the area of interest, it can, in addition, allow differences in local population structures to be partially accounted for and described.

The second form of economic-demographic interface involves a matching of employment demands from the economic model with estimates of employment availability from the demographic model (see Hertsgaard et al, 1978; Murdock et al, 1979b; Cluett et al, 1977; and Chapter 3). Generally, in this procedure estimates of required labor (labor demand) are derived from direct project employment estimates and from estimates of indirect employment determined through economic base or input/output procedures. These techniques project either total labor demand or demand by type, either by project phase (construction, operational, etc.) or by sector. Labor demand is projected using relatively comprehensive economic forecasting procedures.

The unique characteristic of this interface procedure, however, is in the projection of labor availability (labor supply). The supply factor is estimated by applying (a single or a set of) labor force participation rates to a projected base of population. If demographic detail is provided in the participation rate or rates used (such as age or age and sex detail), then the characteristics of the demographic structure of the area are taken into account. The result of the application of the labor force participation rates to the population base is a set of estimates of available labor based on the demographic structure of the area.

The key component of this interface is the matching procedure that integrates the projections of labor demand and supply. This matching may involve several levels of complexity. The sum of labor supplies (across various demographic characteristics) may simply be subtracted from the sum of demands (across various employment types) or, as in the most complex of existing procedures (Hertsgaard et al, 1978; Cluett et al, 1977), the matching may involve additional sets of rates and assumptions about the extent to which each type of employment demand can be filled by each type of available labor. Whatever the level of complexity, however, the matching procedure produces a projection of the extent to which labor demand either exceeds or is less than the labor supply.

The excess or deficit of labor demand in comparison to labor supply is, in turn, used to project migrating labor. If the supply exceeds the demand, then out-migration will occur, while a supply deficit will lead to in-migration. The demographic impacts of in- or out-migrating workers are subsequently determined by applying a set of employment-related demographic characteristics (that is, family size, age of dependents, and so on) to the projection of in-or outmigrating workers. The procedures may be applied at the regional (Monts and Bareiss, 1978) or county level (Hertsgaard et al, 1978) and use one or several employment and population types (Murdock et al, 1979b).

The advantages of the procedure are that it allows both economic and demographic characteristics to affect the results of the interface. Thus, through the inclusion of demographic as well as economic characteristics, both changes in population and employment structure affect the level of expected new employment and population. In addition, if the technique includes a procedure for differentially matching different types of employment demands to different types of available labor, the procedure may more effectively simulate the actual effects of increased employment opportunities on shifting employment patterns in developing areas.

The disadvantages of this technique lie in the relatively large data bases that are required for its use, and in the relatively large number of projections and explicit assumptions that underlie the matching procedure. Whereas the population-to-employment ratio technique requires data on employment demands and population-to-employment ratios and is dependent for its accuracy on the accuracy of the assumed population-to-employment ratio, the matching routines require more data and many more assumptions. Data must be obtained on labor force participation rates by detailed characteristics, the extent to which various types of available labor may be able and willing to fill different kinds of labor demands, on the demographic characteristics of various types of labor, and numerous other factors. These data items are often simply not available without extensive primary data collection. Assumptions must be made not only about employment demands, but about future labor force participation rates, about future labor supplies and their compatibility with various types of demands, about the characteristics of workers in the future, and about the demographic patterns that underlie the base to which the assumed labor force participation rates are applied. The detail used in this procedure thus requires extensive data bases.

Whatever procedure is used, the economic-demographic interface is often the first performed and thus in a sequential assessment procedure, its accuracy and its level of detail will affect the accuracy and level of detail of subsequent procedures. Its design requires careful elaboration and systematic analysis.

The economic-fiscal interface is a multifaceted interface in which revenues are either directly interfaced with economic factors or indirectly interfaced with economic factors through population, and expenditures are indirectly interfaced through the demographic component. Although some authors (Burchell and Listokin, 1978) delineate up to six major interface procedures, most existing techniques appear to be derived from two basic procedures.

The simplest of these involves the use of per capita rates and is an indirect procedure. Given that an economic-demographic interface has been completed, this procedure takes projection of new population and applies per capita revenue and expenditure values to them to project total public costs and revenues. Single per capita revenue and expenditures may be used but in each case population as determined by economic factors forms the basis of the interface.

The advantage of this technique lies in the simplicity of its data inputs and its ease of computation. Its disadvantages are similar to those for population-employment ratios in that differences in the nature of different types of fiscal events are not adequately simulated.

The second general procedure is a more direct procedure. It involves interfacing data on project-related personal income and gross business volume with appropriate data on tax rates and assessment ratios to determine tax revenues and the application of costs per capita or per unit of service to determine expenditures. In this procedure income, sales, and other corporate tax rates are applied directly to the estimated project-related increases in personal income and business activity. Other major tax revenues, such as property taxes, are usually obtained by the application of average tax levels per capita or per type of unit (apartment, single-family dwelling, and so on). Expenditures are derived from the application of either per capita costs per type of expenditure or by costs per unit of service. In the latter procedure, the units of service required are based on rates per unit of population. The application of these rates to projected population values determines total units required, and an average cost per unit is applied to the number of units to determine total expenditures for the service. For example, hospital costs per hospital bed might be used to determine total hospital costs. The ratio of hospital beds per unit of population can be applied to projections of new population to determine the total number of hospital beds required. Given the average cost for the construction and operation of a hospital facility per bed, the application of these average costs to the projected number of beds required will determine total hospital costs.

The second procedure inputs a wider range of economic impacts into the projection of public revenues. Its advantages lie in the greater level of differentiation it provides in the specification of the forms of inputs that enter into the economic part of the interface (i.e., income versus business activity). As such, it allows differences in these inputs by areas to be taken into account and avoids the assumption of an average mix of economic changes in impact areas. This can be particularly important because the patterns of distribution of employment-related impacts may be quite different than those for the business activity associated with a project. Its disadvantages stem from the greater complexity of procedures it demands in the economic forecasting procedures that produce basic inputs into the interface and in the greater detail it requires in the application of tax rates and cost schedules.

Overall, then, the economic-fiscal interface procedures demonstrate the complexity of interactions involved in socioeconomic impact events. Economic activity, demographic patterns, service demands as well as revenue and expenditure patterns operate interdependently, and their interfaces require multiple-level conceptualization and methodological development.

Although demographic interfaces with economic dimensions have been discussed, the interface between demographic and fiscal components requires further explication, and demographic and service interfaces must be described. Each of these interfaces is discussed below.

As noted in the discussion of the economic-fiscal interfaces, one of the most frequent means for projecting the fiscal impacts resulting from a resource development is to project fiscal impacts on the basis of per capita rates applied to new populations or on the basis of per unit revenues and costs, with the number of units having been determined on the basis of population projections. The procedures underlying these techniques have been described above and require little further explication, but both the advantages and disadvantages of these procedures should be specified.

The major elements of the procedure delineated above are a set of per capita revenue and cost rates, a set of rates of units required per unit of population, estimates of costs per unit of service, and a set of projections of future population levels. This latter element involves the limitations inherent in the demographic projection process and these limitations affect the accuracy of fiscal projections. The use of per capita rates rather than characteristic-specific rates involves an averaging over various population types that can mask significant differences in the revenue generating and expenditure patterns of different population groups. The use of costs per unit of service has the advantage of providing cost estimates on the basis of different types of services, but requires the use of difficult-to-confirm assumptions about service-to-population ratios. In addition, none of the interfaces provide effective feedback on the economies of scale or other effects that may arise from the larger service bases accompanying increased populations (Lansford, 1980). Finally, the assumed linearity of the relationship between expenditures and revenues and population has not been adequately evaluated.

The advantages of these techniques lie in their simplicity and data availability. Per capita costs can easily be discerned from censuses of governments and capital and operating costs from a variety of engineering and other widely available estimates (Intermountain Planners, 1975; Stenehjem and Metzger, 1976; Murphy/Williams, Consultants, 1978). These characteristics seem likely to ensure the continued use of these procedures.

Interfaces between demographic and public service functions show relatively little variation from one assessment to another, as noted in Chapter 4. Population, either total or characteristic specific (usually age or age-sex specific population values), is used as a base to which rates of services demands per unit of population, such as hospital beds per 1000 population or police officers per 1000 population, are applied. The major variation in the use of such procedures is in the extent to which the interfaces take existing service levels into account. Because some services in some areas, such as hospitals and educational facilities, may have significant excess capacity while others, such as water or sewer services, may require supplementation of existing bases to meet even minimum standards, the inclusion of a means of taking existing service bases into account is highly desirable in demographic-service interfaces. This is generally done by compiling an inventory of existing services. This inventory is then compared to established standards

(Intermountain Planners, 1975; Murphy/Williams, Consultants, 1978), and the net deficit or excess of baseline service by service type determined. The total service demand as determined by the application of per population unit rates to projected population are then adjusted in accordance with the excess or deficit in existing services.

The demographic-public service interfaces described above are easy to use and are based on relatively easy-to-obtain data. Few, however, take the quality or distributional characteristics of services into account. They provide quantitative indicators only and require considerable interpretation and description when employed.

The last of the major quantitative interfaces is that between the fiscal and the public service dimensions. This interface normally involves, as noted earlier, the merger of per unit costs with estimates of service demands. Given the extensive description of this interface earlier in the discussion of economic and fiscal interfaces, it is necessary here only to note the relative advantages and disadvantages of this interface procedure.

Foremost among the advantages of this interface procedure are the ready availability of the data required to effect it and the ease and wide range of circumstances under which it can be applied. Its disadvantages include its failure to adequately account for interactive relationships between factors, its dependence on the underlying assumptions of the techniques used to project service and fiscal inputs and the fact that the procedure provides a relatively simplistic perspective on the complex set of interactions that actually take place between fiscal and service factors.

The last set of interfaces to be discussed are those between social and other dimensions. Such interfaces have received little attention and those that have been used have been qualitative in nature. The majority of these interfaces have involved two approaches--qualitative evaluations by researchers of the social implications of a given impact in another dimension or solicitations of experts' (or random samples of residents') perceptions of the social meaning of a given type of impact. The latter techniques most closely approximate interfacing procedures while the former are forms of data interpretation.

Although discussions of the pros and cons of expert versus random sample surveys are discussed in Chapter 6, it is essential to point out that even these techniques tend to make the social dimension a product of, rather than an active aspect in, the interface procedure. For example, when respondents' evaluations of the implications of a given level of population growth on community leadership are analyzed, the interactive or iterative effect of community leadership on population growth is seldom taken into account. In the poorly developed interfaces that have been designed between social and other dimensions, the social factors tend to be treated as reactive rather than interactive.

The interfaces between social and other dimensions that have been developed are largely qualitative. Of these, the two most often discussed are the demographic-social and the economic-social interfaces. The relationship most often drawn upon in the discussion of social impacts is that between population growth and social change. Whether conceptually or heuristically, the effects of population growth are used to project social events during impact situations. Coupled with this technique has been the examination of the effects of economic growth on social factors. Together, then, the demographic and economic explanations of social change have become the mainstays for explaining social impacts. Thus, the social factors associated with population growth and economically induced processes--such as ecological expansion (Murdock, 1979), urbanization, modernization, and economic development (Carnes and Friesma, 1974)--form major theoretical bases for explaining social impacts. In fact, although social conditions are sometimes discussed in relation to service or fiscal factors (Gilmore and Duff, 1974; Gilmore et al, 1976), it is only the economic and demographic interfaces with social dimensions that have received sufficient attention to merit discussion as interfaces.

Because of the lack of development of social interfaces, none is sufficiently developed to merit a discussion of its strengths and weaknesses. It is, in fact, sufficient to simply point out that social interfaces must be developed. Until this is done, the role of social analysis within impact analyses will remain largely a peripheral and ineffectual one.

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

Clearly, the limitations in existing interface procedures and the need for additional expansion of the interfaces between socioeconomic dimensions noted above are equally applicable to the methodologies to be used in assessing the impacts of repository siting. Their limitations cannot be overcome easily, and clearly analysis performed for repositories will share many of these limitations. Several additional considerations must be discussed, however, related to interfacing procedures in repository assessments.

Special Effects

Clearly, many of the special effects of nuclear repositories including such factors as fear and anxiety, concerns over equity, institutional viability, and public participation will affect other socioeconomic dimensions. Such fears as noted in Chapter 2 may prevent investment in local businesses and in secondary service industries. The special characteristics of such repositories may (as indicated in Chapter 3) prevent population growth or even lead to population decline. Repository siting will also require assessments of additional public service dimensions and public service costs (see Chapters 4 and 5) and clearly affect levels of social acceptance and social perceptions in siting areas (Chapter 6). The interfacing of special effects with each of the other socioeconomic dimensions is thus an important consideration for assessment methodologies. Given the current state of the art, it must be acknowledged that most of these interfaces cannot be readily quantified and are likely to remain largely descriptive in the foreseeable future.

Standard Effects

For standard effects, the interface problems for repository analyses are substantially the same as for other types of developments but may involve additional elaborations. Several dimensions require emphasis in repository siting analyses. In particular, it should be emphasized that the use of interfaces at appropriate geographical levels and the use of mechanisms for ensuring the feedback of changes from one component to another are essential for assessing the impacts of repository sites. The use of all procedures at the regional, county, and community level is also essential, if the impacts of alternative repository sites are to be adequately assessed and the reactive nature of many of the effects of repository siting clearly require feedback mechanisms. In addition, however, for repository siting, effects may occur and be influenced by events at multiple geographical and methodological levels. For example, failure to address economic or public service concerns may affect social and political acceptance. The standard demands in interfacing socioeconomic dimensions may thus be significantly increased when such interfacing involves the siting of nuclear repositories.

Methodological Considerations

Methodologically, the development of interface procedures will involve additional considerations and complications when used in the nuclear repository siting process. The use of such procedures in the siting process entails the delineation of additional interfaces between special effects (fear, concerns over equity, and so on) and other standard socioeconomic impacts and between such factors at multiple geographical levels.

The limitations of present methodologies suggest that the development of such interfaces will require substantial additional conceptual as well as methodological development, which is likely to be only partially complete by the time initial assessments are required for many sites. A substantial effort in the social and special effects area is thus essential in the coming years, if the interfaces necessary for fully assessing the socioeconomic impacts of nuclear repositories are to be adequately developed.

SUMMARY AND CONCLUSIONS

The conceptual and methodological bases for interfacing socioeconomic dimensions have received insufficient development. No clear conceptual premises have been developed to form a basis for interface development and existing procedures have evolved from only a few basic techniques developed largely on the basis of convenience. Although the development of conceptual bases for interfaces requires concerted attention, an initial evaluation suggests that the use of common procedures for both baseline and impact interfaces, the employment of such interfaces at the lowest appropriate geographical level, the retention of the most significant aspects of each component in the interface procedure, the use of multiple interface points, and the use of interfaces with feedback or iterative mechanisms are desirable features in the design of interface procedures. At present, most interfaces are single-point, single-dimension, and noniterative and thus require extensive development.

Of the interface procedures most widely used, the economic-demographic interface is the most developed and complex and may be multifaceted, multidimensional, and iterative. Nearly all other interfaces involve the application of rates or ratios from one dimension to the outputs of another dimension. The interfaces so designed include the economic-fiscal, the demographic-fiscal, the demographic-service, and the service-fiscal interfaces. The interfaces of social and other dimensions are the least developed and are largely qualitative.

The status of socioeconomic interfaces reflects both problems and promises. The fact that relatively few of the necessary interfaces have been designed and that many of the existing ones lack the breadth and complexity necessary to adequately simulate the interactions that take place between social science dimensions in impact situations clearly points to the primitive stage of development of interfaces and indicates the need for concern about the extent to which socioeconomic assessments do, in fact, provide the integrated assessment mandated by NEPA and believed essential for interdisciplinary research. There is little to lessen this concern in the existing methodologies used or in the conceptual basis underlying impact interfaces.

On the other hand, there is also promise in the socioeconomic interfaces that have been used in impact assessments. These interfaces represent some of the first attempts to systematically and quantitatively integrate dimensions from several disciplines and to thus combine the methodological strengths of the various disciplines. They attempt to combine the economists' methods for characterizing and differentiating parts of an economy, the demographers' techniques for demographic projections, the public fiscal analysts' knowledge of tax structures, the public service analysts' methods for projecting service demands, and the sociologists' techniques of social assessment. Although substantial additional development of these techniques is essential, the progress to date represents a major first step in the formal integration of social science dimensions.

The future development of interface procedure is likely to be demanding and exciting. There is substantial work to be completed to bridge the conceptual gaps between--and to design the techniques necessary to combine--elements that span several disciplines. If impact researchers are careful to ensure that scientists from all the appropriate disciplines play an equitable role in the evolution of these interfaces, then the tasks to be done may also be among the most creative and successful of those undertaken by social scientists in the coming years. The interfacing of socioeconomic dimensions provides a challenge and an opportunity for social scientists to attain the often enunciated goal of producing a truly integrated approach to social science analyses.

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CHAPTER 8

COMPUTERIZED IMPACT PROJECTION MODELS

As indicated in the preceding chapters, each of the aspects of socioeconomic impact assessment may require a large number of very precise calculations. Because the sheer volume of these computations may become quite burdensome to the analyst, it has become increasingly attractive to systematize the computational procedures. In addition, the usefulness of techniques for economic, demographic, public service, and fiscal impact assessment may be quite limited unless important interactions among these impact categories can be taken into account (see Chapter 7). In response to the need to more systematically account for interrelationships among the various impact dimensions and to provide for integration of impact assessment techniques, many analysts have attempted to develop comprehensive models which incorporate a number of impact categories and provide for specific linkages among these impact dimensions.

Another important factor influencing the development of socioeconomic impact assessment techniques is the needs of decision makers. Local decision makers in particular not only want specific answers; they want timely ones. Despite the growing number of impact assessments, such analyses are often difficult to understand and too outdated to meet local needs. The frequency of changes in development dimensions, such as changes in facility size, location, and other factors, often negate the validity of the assumptions on which the formal impact assessment of a project may have been based. As a result, many impact statements tend to be outdated before they are published, and the differences between the effects they predict and those that may occur as a result of altered project structures may be impossible for local decision makers to discern. As a result of such problems, local decision makers and planners have increasingly demanded impact assessments and impact assessment methodologies that provide local area projections for a wide range of socioeconomic factors under a variety of possible sets of development scenarios, and that do so with only a limited time delay in the production of such projections.

In response to these demands, a substantial number of computerized socioeconomic impact assessment models have been developed. These models all provide a relatively wide range of outputs and do so in a timely and flexible manner. Further, they provide a valuable mechanism for systematically accounting for interactions among the various impact dimensions. These models, however, differ widely in input data requirements, computational procedures, outputs, and in many other respects. The criteria that should be used in choosing such a model and the relative advantages of the various models under different circumstances are often difficult to discern. As a result, decision makers may avoid using such models despite their obvious advantages because they have no means of evaluating the relative merits of different models.

The purpose of this chapter is fourfold. First, the history of the development of computerized socioeconomic impact assessment models is briefly reviewed. Second, a number of such models which have been employed extensively in impact assessment and policy analysis are briefly described. Third, criteria for the evaluation of impact assessment models are discussed, and selected models are evaluated in terms of these criteria. Finally, the application of such models to respository siting is discussed. The intent is to present information which will be useful to environmental decision makers in evaluating and selecting alternative modeling techniques. The intent is not to suggest which are the best models for, as will become apparent, the models have counterbalancing strengths and weaknesses, but rather to provide a basis for choosing models to meet specific needs.

HISTORICAL BACKGROUND OF COMPUTERIZED MODELS

The basic techniques for economic and demographic impact assessment have been developed and refined over a considerable period (see Chapters 2 and 3). Public service and fiscal impact analysis has a shorter but still substantial history (see Chapters 4 and 5). During the decade of the 1960's, however, there was growing recognition of the interdependence of various forces and hence an increasing interest in finding ways of taking such interdependencies into account. During the same period, the capability for developing more complex models which would integrate multiple dimensions was greatly enhanced by the increasing power and availability of electronic computers. Early work emphasized both developing more complete, detailed models for single dimensions (e.g., economic, demographic) and attempting to integrate various dimensions (e.g., economic activity and population, population and land use). Early activity in social science modeling was concentrated in the areas of national econometric models[1] and urban land use models.[2] By the end of the decade, however, some attention had been given to both (1) integration of the economic and demographic sectors and (2) application of integrated economic-demographic models in rural areas.

The development of integrated economic-demographic models also was stimulated by an increased interest in alternative economic development strategies for lesser developed countries. Because analysis of alternative development strategies in such settings appeared to require explicit consideration of interactions among diverse phenomena in the economic and demographic systems, substantial resources were devoted to the development of integrated economic-demographic models for a number of counties.[3]

One regional economic-demographic model which was developed during the late 1960's had a substantial influence on subsequent socioeconomic modeling efforts. The Susquehanna River Basin Model differed from most earlier models in that it provided for a specific linkage of the economic and demographic sectors and that it included nonmetropolitan areas whereas previous models had generally focussed only on a single large city (Hamilton et al, 1966; Hamilton et al, 1969). The model made extensive use of feedback loops to link its various components, a model structure which was inspired at least in part by the earlier work of Forrester (1961).

The basic concepts embodied in the Susquehanna Model had considerable influence on the subsequent development of regional economic-demographic projection models (see Figure 8.1). The research group at Battelle Laboratories which developed the Susquehanna Model subsequently constructed similar models for the City of San Diego (San Diego, Comprehensive Planning Organization, 1972) and for the State of Arizona (Battelle's Columbus Laboratories, 1973). The Susquehanna Model also influenced the structure of a regional forecasting model developed by the Tennessee Valley Authority (Bohm and Lord, 1972). These models in turn influenced subsequent model development efforts. Notable among these were the series of economic-demographic models developed by the States of Arizona and Utah (Bigler et al, 1972; Anderson et al, 1974; Reeve et al, 1976; Beckhelm et al, 1975; Anderson and Hannigan, 1977), the MULTIREGION Model developed at Oak Ridge National Laboratory (Olsen et al, 1975; Olsen et al, 1977), the North Platte River Basin Model (Matson and Studer, 1975; Carlson et al, 1976), and the CPE Model developed at the University of Colorado (Office of State Oil Shale Coordinator, 1974).

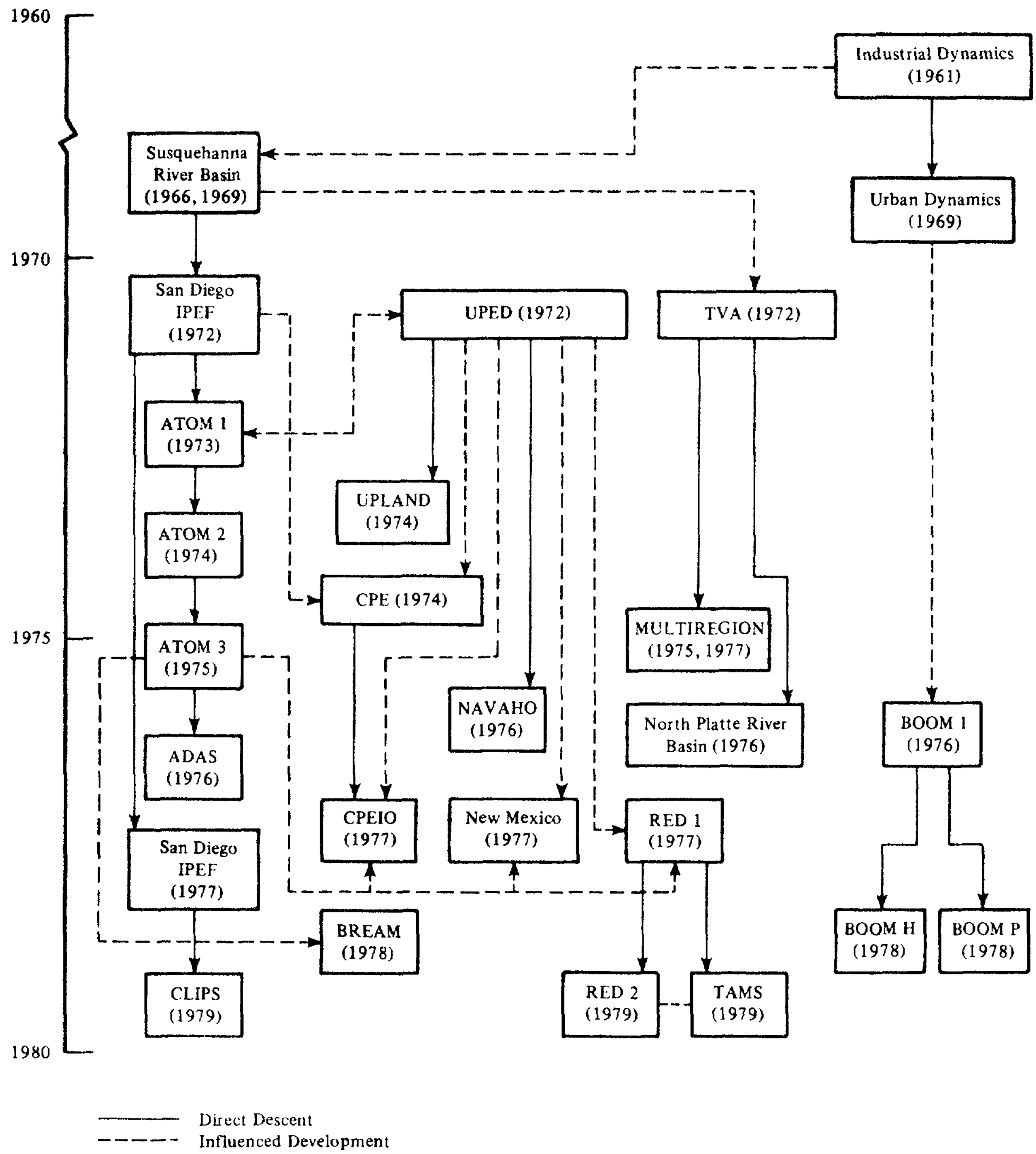

Figure 8-1. Partial Genealogy of Socioeconomic Impact Assessment Models, 1960-1979

These models all provided for linkages between the economic and demographic sectors through a submodel which simulated the operation of the labor market and provided for in- or out-migration from the study area in response to changes in labor market conditions (that is, if the demand for labor increased more rapidly than the "natural increase" in labor supply, in-migration would occur). The models differed somewhat in the degree of sectoral disaggregation within the economic module. For example, while the Susquehanna Model utilized only three employment categories, the ATOM 3 Model included eighty-eight employment sectors. The models also differed in the degree of spatial detail of their outputs with some providing employment and population projections at the county level (for example, ATOM, UPED, CPE), while others provided projections only at the multicounty regional level (for example, Susquehanna, MULTIREGION). A third characteristic in which these models differed significantly was in the time increments associated with their projections. While a few models provided projections annually (for example, ATOM 3), several produced estimates only at five-year intervals (for example, UPED, MULTIREGION).

Socioeconomic projection models developed during the late 1960's and early 1970's were employed primarily as tools for state and regional economic planning. As interest in evaluating community-specific impacts of major projects grew, however, these models were found to have substantial limitations as impact assessment tools. The two principal limitations were failure to include a number of significant impact dimensions, particularly public service requirements and fiscal effects, and insufficient spatial and temporal disaggregation of outputs. Thus, in the mid-1970's attention turned to developing models which incorporated additional impact dimensions and provided outputs at county and subcounty levels. A number of models were developed to meet these needs, including the RED1 and RED2 Models (Hertsgaard et al, 1978; Leistritz et al, 1979); the BREAM Model (Mountain West Research Inc., 1978); the BOOM Models (Ford, 1976); the SEAM Model (Stenehjem, 1978); the WEST Model (Denver Research Institute, 1979); and the SIMPACT Model (Huston, 1979).

These "second-generation" models differ from the earlier economic-demographic projection models primarily in the number of impact categories included and in the degree of spatial and temporal disaggregation of their outputs. Thus, several of these models address public service requirements and public sector cost and revenue effects as well as economic and demographic impacts (for example, RED, WEST, SIMPACT); some provide projections for individual cities, school districts, or other subcounty areas as well as for counties and regions (for example, BREAM, RED, WEST); and most provide yearly projections of key impact indicators. The specific characteristics of a number of these models are described and compared in the sections which follow.

MAJOR COMPUTERIZED PROJECTION MODELS

Several factors were considered in selecting the specific models to be examined. First, attention was focused on models that address multiple dimensions of economic and social impacts and that provide projections at the county or subcounty levels. Second, those models which have been applied extensively in assessing impacts of resource development projects or which were designed for such applications have been given greatest attention. Relevant models were identified through review of numerous environmental impact statements, proceedings of conferences devoted to resource development issues, and professional journals.[4] After models had been identified, we attempted to obtain complete documentation materials for each. In some cases, lack of available documentation materials precluded detailed examination of a model.

The models which were selected for detailed examination include the following:

1. ATOM 3 (Beckhelm et al, 1975)
2. BOOM 1 (Ford, 1976)
3. BREAM (Mountain West Research, Inc., 1978)
4. CLIPS (Monts and Bareiss, 1979)
5. CPEIO (Monarchi and Taylor, 1977)
6. HARC (Cluett et al, 1977)
7. MULTIREGION (Olsen et al, 1977)
8. NAVAHO (Reeve et al, 1976)
9. NEW MEXICO (Brown and Zink, 1977)
10. RED 2 (Hertsgaard et al, 1978; Leistritz et al, 1979)
11. SEAM (Stenehjem, 1978)
12. SIMPACT (Huston, 1979)
13. WEST (Denver Research Institute, 1979).

Each of these models is briefly described in the following sections.

ATOM 3 Model

The ATOM (Arizona Trade-Off Model) 3 model was developed by researchers at Arizona State University with sponsorship from the Arizona Office of Economic Planning and Development and the Four Corners Regional Commission (Beckhelm et al, 1975). It represents a substantial refinement of the earlier ATOM 1 and ATOM 2 models. The model has been utilized extensively by the State of Arizona as a state and regional planning tool.[5]

ATOM 3 consists of three major submodels: demographic, employment, and labor market. The demographic submodel incorporates a cohort-survival routine utilizing 172 single-year age-sex cohorts. Two subgroups of the population are identified, the Indian community and the military population, and these subgroups are accorded special treatment in the demographic calculations. The employment submodel incorporates an 88-sector input-output model for the state. Employment for most sectors is projected at the state level and then allocated among the state's fourteen counties. The labor market submodel links the other two modules by evaluating the consistency of the output from the demographic submodel with that from the employment submodel. If there is an excess of jobs relative to the size of the labor force (that is, if the implied unemployment rate falls below some lower bound), it is assumed that in-migration will occur to reestablish the balance between the supply of and demand for labor. Conversely, if there is an excess supply of labor, it is assumed that out-migration will occur. Thus, the basic interrelationship between economic and demographic activity in ATOM 3 is the same as that found in a number of socioeconomic simulation models that have a common ancestry going back to the Susquehanna River Basin Model (Beckhelm et al, 1975).

BOOM 1 Model

The BOOM 1 model was developed by personnel at Los Alamos Scientific Laboratory. The model employs simulation techniques to estimate interaction between construction of a large-scale energy facility and secondary growth, migration, housing, and public service consequences (Ford, 1976). It emphasizes systems dynamics features which allow projection of important variables by simulating multiple interactions among sectors.[6] Some 48 variables are incorporated in model relationships with the values of most of the variables being drawn from other studies or based on "expert opinion and individual intuition" (Ford, 1976). Few site-specific data are employed in the model.

BOOM 1 contains five major subsectors: power plant, housing, retail and service, migration, and public. The model incorporates numerous interactions among these subsectors. For example, population may grow at levels higher than originally anticipated because adverse boomtown conditions induce high rates of construction worker turnover and reduce productivity, prompting expansion of the construction work force. The model provides projections for a single community only, and in the original version of the model the outputs were quite aggregated (e.g., total population, aggregate public sector revenues, and costs for all jurisdictions). The housing sector has subsequently been refined by Los Alamos personnel (Rink and Ford, 1978), and the public sector has been substantially disaggregated by researchers at the University of Texas (Monts, 1978).

BREAM Model

The Bureau of Reclamation Economic Assessment Model (BREAM) was developed for the U.S. Bureau of Reclamation by Mountain West Research, Inc. The model is employed by the Bureau in preparing impact assessments of water development and other resource development projects in the western states. The model's structure and data sources are described by Mountain West Research, Inc. (1978).

The model contains five major submodels. The model evaluates the consistency of the labor supply projections obtained from analysis of the area's population (demographic submodel) with labor demand implied by analysis of the area's economy (economic submodel). In the event that the supply and demand for labor are not in balance, adjustments are assumed to occur (labor market submodel). The principal adjustment mechanism is migration, although changes in the local unemployment rate also are assumed to occur. The construction worker submodel is used whenever a project is expected to require in-migration of construction workers. This submodel estimates the number of construction workers who will in-migrate, the demographic characteristics of these workers and their families, and their settlement patterns. Once employment and income are established for each county in the local impact area, the model disaggregates the county population projections and allocates them to the communities within the county (community allocation submodel).

CLIPS Model

The CLIPS (Community Level Impact Projection System) Model was developed by the Center for Energy Studies at the University of Texas at Austin under sponsorship of the Texas Energy Advisory Council (Monts and Bareiss, 1979). It was developed primarily to evaluate the local socioeconomic impacts of lignite coal development in Texas, but information regarding specific applications of the model was not available to the authors.

The CLIPS Model provides baseline and impact projections of employment, population, public service requirements, and associated costs for a designated impact region and for selected counties and cities within the region. Employment projection is accomplished using an export base technique whereby changes in export (basic) employment are determined by exogenously specified growth rates, changes in business-serving (indirect) employment are determined by changes in export employment and changes in household-serving (induced) employment are determined by changes in the region's population. The population submodel is based on a cohort-survival routine using five-year age-sex cohorts. Regional baseline population projections are used as control totals for the community population projections. A gravity model is used to allocate project-related workers and their families to communities of residence. The CLIPS Model relies heavily on the per capita cost approach in projecting public service costs, and the cost coefficients are drawn primarily from Murphy/Williams, Consultants (1978).

CPEIO Model

The Colorado Population and Employment (I-O) Model was developed by the Business Research Division of the University of Colorado with sponsorship from the Colorado Department of Local Affairs (Monarchi and Taylor, 1977). The model has been employed as a state and regional planning aid and also has been utilized in several energy development impact assessments.

The model consists of two linked submodels. The population submodel incorporates a cohort-survival routine using single-year cohorts. Four types of migration are considered in the population submodel: (1) retirement, (2) military, (3) college, and (4) employment-related. The population submodel is linked with the employment submodel through employment-related migration. The employment submodel utilizes an input-output framework in which employment rather than dollar value of output is the unit of measurement. The model can accommodate up to 25 employment sectors, and each sector can have basic, business-serving, and household-serving employment components. Assumed exogenous growth rates for basic employment in each relevant sector drive the economic submodel. The CPEIO Model provides annual projections of employment and population for a specified area of interest (i.e., region, county, or city), but it does not project the distribution of effects within the area (Monarchi and Taylor, 1977).

Battelle HARC Model

This model was developed by a team of researchers at the Battelle Human Affairs Research Centers. The model provides projections of demographic and public service indicators under both baseline and impact conditions for a selected site county. Projections are available at five-year intervals over a 35-year planning horizon (Cluett et al, 1977).

The model utilizes a cohort-survival routine to project baseline population in the affected area on the basis of the initial age-sex composition of the population and recent patterns of net migration. The population estimates are transformed into labor force estimates through the use of national labor force participation rates. The total employment requirements of a new development project are estimated by applying employment multipliers to the construction and permanent work force requirements of the facility (supplied exogenously). The proportion of the direct and indirect work force requirements which can be met by the indigenous population is then computed, and the remainder of the new jobs are assumed to be filled by in-migrants.

Migrating workers and their dependents are allocated to the site county and to adjacent counties with a gravity model which takes account of distance to alternative places of residence, housing availability at those locations, and the area's initial population distribution. Migrants who take up residence in the site county are then projected, separately from the baseline, throughout the projection period. Projections for this project-related population include consideration of employment turnover and replacement and relocation of workers formerly employed at the project (Cluett et al, 1977). Additional requirements for selected public and social services associated with the in-migrating workers and their dependents are estimated by applying state or national standards to the projections of project-related population. Services considered include health, education, sanitation, fire and police, recreation, social problems (i.e., crime), and government (administrative staff).

MULTIREGION Model

The MULTIREGION Model was developed by researchers at the Oak Ridge National Laboratory with sponsorship from the National Science Foundation and the U.S. Energy Research and Development Administration (now U.S. Department of Energy). The model provides projections of employment by 37 industry groups, population by 32 age and sex cohorts, and labor force by 16 age and sex cohorts for 173 BEA (Bureau of Economic Analysis) economic areas at five-year intervals. The model consists of employment and population subsectors linked through a module which simulates labor market conditions. Each of the BEA areas is treated as a labor market area. Labor demand in each area is affected by the area's attractiveness as a location for natural resource-based industries, manufacturing, and local service industries. Labor supply for a region is affected by its patterns of labor force participation, fertility, and mortality, and migration occurs to balance the supply of and demand for labor. Interregional interdependence is incorporated in the model through the inclusion of measures of access to markets via truck transportation. The model is intended for a variety of regional analysis applications (Olsen et al, 1975; Olsen et al, 1977).

Navaho Model

The Navaho Economic-Demographic Model was developed through a cooperative effort between the Navaho Nation and the State of Utah, Office of State Planning Coordinator. The model was designed for use as a tool for economic planning and policy making for the Navaho Nation (Reeve et al, 1976). Its basic structure is quite similar to that of the Utah Process Economic-Demographic Model (UPED) which had previously been developed by the State of Utah.

The Navaho Economic-Demographic Model has three major components: an economic module, a demographic module, and an economic-demographic interface module. The economic module uses the economic base employment multiplier technique to project future levels of secondary employment, given initial projections of basic employment. The demographic module utilizes the cohort-survival technique to develop estimates of future population and potential labor force. The interface module consists of a routine for matching jobs and workers by occupational group and equalizing the supply of and demand for labor through migration and commuting of Navaho workers and migration of non-Navaho workers. Model outputs are provided at five-year intervals and include Navaho and non-Navaho population by age and sex; population by broad occupational classes; number of households; school age population; Navaho labor force by age, sex, and broad occupational group; and basic and residentiary job opportunities by industry and occupation.

New Mexico Model

The New Mexico Economic and Demographic Model was developed by the Institute for Applied Research Services of the University of New Mexico with sponsorship from the Four Corners Regional Commission. The model provides projections for each of the state's seven planning districts at five-year intervals for the following variables: population by five-year age and sex cohorts, school age population by age and grade level, gross output for 40 industrial sectors, employment for each sector, labor force by five-year age-sex cohort, net migration by five-year age-sex cohort, average unemployment rate, and average per capita income (Brown and Zink, 1977). The model is reported to have been used by several federal agencies, but no specific information regarding the nature of this use was available to the authors.

The economic component of this model utilizes a multiregional input-output model with 40 sectors and 12 regions. The regions are the seven New Mexico planning districts, the neighboring states of Arizona, Colorado, Utah, and Texas, and the rest of the United States. The demographic component is a cohort-survival model using single-year cohorts. The economic and demographic components are linked through migration. In this model, economic migration is determined by changes in a region's employment rate (reflecting changes in the supply of and demand for labor), and the age-sex distribution of migrants is industry-specific. Other (i.e., noneconomic) migration may be specified by the user during scenario development.

RED Model

The REAP Economic-Demographic Model (RED) was developed by researchers from North Dakota State University, the University of North Dakota, and Arthur D. Little, Inc., under the auspices of the North Dakota Regional Environmental Assessment Program, a state-funded program created to aid planning efforts and to inform policy makers at the local and state levels (Toman et al, 1979; Hertsgaard et al, 1978). The model consists of six basic components or submodels: (1) economic input-output module, (2) cohort-survival demographic module, (3) economic-demographic interface module, (4) residential allocation module, (5) service requirements module, and (6) fiscal impact module.

The input-output module is used to estimate gross business volume by economic sector for a specified level of final demand. Employment requirements by sector and development phase are then derived from the estimates of gross business volume. The demographic module provides projections of population by age and sex and an estimate of the available labor force. The interface component links the projections of required employment from the input-output module with the projections of available labor force from the demographic module to determine the level of employment needs that can be met by the indigenous population and those that must be met by the in-migration of new workers. The residential allocation module estimates the settlement patterns of new workers and their families. The service requirements module develops projections of needs for selected public and quasi-public services based on changes in population and population composition. The fiscal impact module provides projections of the expected costs and revenues resulting from the associated economic and demographic changes. Outputs are available at the regional, county, and municipal levels and include such variables as employment by type, population by age and sex, school enrollment by age, housing requirements by type, public sector costs and revenues by type, and net fiscal balance.[7]

SEAM Model

Developed at the Argonne National Laboratory, the Social and Economic Assessment Model (SEAM) contains data on and has the capability of being used in any or all counties in the continental United States (Stenehjem, 1978). It has been used by the laboratory staff in conducting several regional assessments and national policy analyses.

The SEAM model consists of four major components. A demographic projection model provides county-level population projections by age, sex, and up to three population subgroups. An impact projection model forecasts annual changes in employment and population as a result of any given new energy or industrial project and superimposes these estimates on the population projections for the subject county. A spatial allocation model is used in specialized applications when detailed information on housing demands and settlement patterns of in-migrating workers are required at the community level. A public costs projection model utilizes population projections from the preceding models to estimate annual costs of constructing and operating public facilities and services necessary to accommodate the additional populations.

SIMPACT Model

The SIMPACT Model was developed by personnel of Arthur D. Little, Inc., in conjunction with an environmental impact assessment for a large steel manufacturing facility (Huston, 1979). The model has seven major components: (1) an economic-demographic block, (2) a private infrastructure block, (3) a social infrastructure block, (4) a utility infrastructure block, (5) a physical impact block, (6) a fiscal expenditures and finance block, and (7) a fiscal revenue block. The model provides annual projections over a 12-year planning horizon for a region and 11 subareas (e.g., cities or townships).

This model emphasizes detailed disaggregation of projected impacts. In the economic-demographic block, employment, payroll, gross business volume, investment, and land area requirements are projected for 18 sectors using multipliers from regional input-output tables. Population effects are computed from assumed demographic characteristics of in-migrating workers with demographic projections disaggregated by twenty occupation groups, seven income categories, six age groups, and six household size categories. Infrastructure requirements are projected in the areas of housing (10 categories), health facilities (3 categories), schools (4 categories), fire protection, law enforcement, streets, water, sewer, and solid waste facilities. The physical block includes projection of air pollutant emissions (5 categories), wastewater (by economic sector) and run-off water. Public service costs for each of the local jurisdictions are estimated in the fiscal expenditures and finance block while changes in the revenues of these governmental units as well as for state government are estimated in the fiscal revenue block.

WEST Model

The WEST Model was developed by researchers at the Denver Research Institute under contract with the Council on Environmental Quality (Denver Research Institute, 1979). The model is designed primarily for use by state and local officials and includes employment, population, income, public finance, and housing forecasting components. The employment component uses export base employment multipliers to estimate the levels of secondary (residentiary) employment likely to be associated with an initial increase in basic employment associated with a new development project. The population component estimates the magnitude of population growth associated with increased employment through a multistep process which involves first estimating the proportion of each type of workers who will be in-migrants to the area and then assigning household characteristics to each type of in-migrating worker (e.g., energy facility construction, other energy, secondary). The in-migrating workers and their families are allocated to places of residence using a judgmental approach which emphasizes interviews with community and company officials and local housing developers.

The public finance component includes routines for estimating both revenues and costs of local jurisdictions. The revenue and cost estimation procedures provide for the use of considerable local data regarding effective assessment ratios, tax rates, and per capita expenditure levels. The housing component provides a detailed analysis of the housing preferences of various types of workers, their ability to pay for housing, and the expected costs of various types of housing units. Model outputs are available annually and include employment by type at the county level, population at county and city levels, school enrollment by district, revenues, and expenditures (capital and operating) for counties, school districts and cities, housing by type, and income.

In summary, these brief descriptions of different computerized impact assessment models indicate both the similarity of their basic objectives and the substantial differences with respect to their input data requirements, computational procedures, and outputs. Without criteria for evaluating such models, the task of choosing an impact model may be quite difficult. In the next section, criteria that may be used to evaluate the relative strengths of such models are examined, and the models described above are evaluated in terms of these criteria.

COMPARISON OF FEATURES, STRENGTHS, AND WEAKNESSES OF COMPUTERIZED MODELS

Although the needs and thus the criteria for evaluating models are likely to vary for particular circumstances and decision makers, several general considerations must enter into the process of the model selection in virtually all circumstances. These criteria should include consideration of at least the following factors: (1) informational requirements, (2) methodological forms and validation, and (3) use characteristics. Each of these factors is discussed briefly in the following sections.

Informational Requirements

Clearly, the starting point in selecting a modeling system is the informational needs of the user--what information is needed, for where, and for what periods of time. Environmental impact assessments are requiring an increasingly large volume of socioeconomic data. These data usually include, at a minimum, information on the economic, demographic, public service, and social changes likely to occur under both baseline and impact conditions and for both construction and operational phases during impact periods (Council on Environmental Quality, 1978).

The economic data usually include data on changes in income, employment, business activity, and changes by type of industry. Information on demographic changes usually includes data on population increases and, increasingly, information for particular age, ethnic, and other groups and for small geographic units, such as municipalities, as well as for total impact areas. Public services data tend to concentrate on the number of new service facilities and personnel required to serve new in-migrating populations, on the costs of such increased services, and on the public revenues likely to be generated by new populations. Social changes are usually measured by data on the population's perceptions of developments, goals for their community,

community satisfaction, and likely changes in social structures. Because the costs of acquisition of single data sets (social, economic, etc.) are likely to require investments that may exceed those for an entire modeling effort, the inclusiveness of a model may be particularly significant. Those models that provide larger proportions of the necessary data items are thus clearly of greater utility.

Equally important is the need to ascertain the levels of geographic output provided by the model and its ability to provide outputs for alternative time periods. Many of the available models provide output only at the total impact area level or for counties, but not for individual cities or other government districts. As a result, such models, though useful for those involved in regional planning and decision making, are likely to be of little utility to the decision maker charged with allocating resources or assessing impacts for school districts or other local units of government.

At the same time, it is essential to ensure that models provide results for the necessary temporal periods. That is, impact periods, particularly construction periods, often show rapid changes from year to year and these changes often require careful planning and resource allocation. However, if such models provide results for only five-year periods rather than for yearly periods, year-to-year changes will not be detected.

Finally, it is essential that the model provide separate outputs for baseline and for construction impact and operational impact periods. Because impact assessment involves comparing impact-induced changes to a projection of baseline changes over time, data for both baseline and impact conditions are essential. Also, since construction and operational phases are separate in impact assessments and have distinct types of impacts, the production of separate results for each impact phase is essential. In sum, then, the temporal as well as geographical specificity of model outputs should be analyzed.

Methodological Considerations

Although the methodologies employed in various models involve numerous technical distinctions that are not appropriate to our discussion here, several aspects of model methodology should enter into evaluations of alternative models. First, some methodologies are generally more adequate than others. Although under any set of circumstances several alternative methodologies may be of equal utility, general assumptions can be made in regard to such methodologies. Thus, even a brief examination of information on demographic projection techniques will suggest that techniques using age cohorts are generally superior to those with less detail (Shryock and Siegel, 1973). A short consultation with experts in the appropriate fields will generally provide similar information in regard to other model dimensions. Second, it is essential to evaluate the extent of submodule integration in such models. Most such models involve a major premise that economic and demographic aspects of developments require careful integration. Many, however, make no attempt at effective integration of key components but rather simply apply separate methodologies to a common situation. Finally, the assumptions underlying the methodologies employed in such models must be carefully evaluated in terms of dynamic modeling capabilities, including such factors as the methodology's: (1) ability to project changes in the structure of model relationships over time, (2) incorporation of the key structural dimensions of the phenomena of interest, and (3) incorporation of feedback loops for updating baseline figures.

In general, models that allow the use of multiple rates for various factors during different phases of the projection period (such as changes in labor force participation rates or fertility rates), that utilize factors which most closely differentiate between key dimensions (such as industries or age cohorts), and that incorporate procedures that feedback changes, such as alterations of population age structures or changes in the economic structures, are superior to those lacking such features.

Finally, it is, of course, evident that an overriding factor in model selection must be an evaluation of a model's accuracy in predicting impact and baseline conditions. Although most of the models have been developed recently, and relatively little evidence has accumulated for evaluating their validity, evidence concerning the validity of some models has been accumulated or can be derived by using available data sources. In addition, given samples of the outputs of model projections for various areas, several types of evaluations can be made quite easily. For example, estimates of economic factors, such as income at the county level and population levels for counties and incorporated areas are published periodically by the Bureau of Economic Analysis and the Bureau of the Census in the Department of Commerce. These estimates can be compared to those from the various models and some idea of their accuracy can thus be gained.[8] Such analyses provide a valuable and clearly essential step in model analysis and model selection.

Use Characteristics

Additional dimensions that must be considered relate to the use characteristics of such models. One of these dimensions is the availability and costs of obtaining the input data required for a model's implementation. Many models use input-output economic models that require the use of state or regional input-output interdependence coefficients. These are available in most areas, but if an appropriate set of coefficients does not exist, then the implementation of such models is likely to be quite expensive, requiring extensive data collection. Similar consideration must be given to other data dimensions.

It is essential to note that models that reduce data collection costs by utilizing national databases may accentuate problems in projecting local level conditions that depart markedly from national patterns. The trade-off between the need for locally oriented data inputs and the costs of collecting local data must be carefully evaluated.

The flexibility of use of the model should also be considered. Impact assessments and impact events involve numerous factors that are difficult to evaluate and predict. Thus, it becomes essential to examine the range of potential impacts under widely varying assumptions for such factors. Models that provide easy alterations of these factors and rapid outputs for alternative development scenarios are desirable. In evaluating models, the options provided for altering key assumptions, such as the number of projects, the size of the project, the location of the project, inflation rates, birth rates, per capita service usage rates, and other factors should be closely examined.

Yet an additional criterion to be considered is the availability and adaptability of the computerized form of such models. Some models can be accessed only through the agency that implemented the model while in other cases cooperative agreements can be established which provide the model code to a user agency. In general, efficient use of the model is facilitated by the ability to acquire the model code. In addition, however, it is essential to ensure that appropriate computer facilities and computer compilers are available if the computer code is to be obtained. The incompatability of different types of hardware and the lack of appropriate language compilers can make model adaptation very costly.

Model Comparison

In this section we attempt to compare the models, which were described earlier, in terms of the criteria noted above. Although numerous other models are available, these include a majority of those which attempt to project the impacts of large-scale resource developments, have published descriptions and have been widely used by national, regional, and local decision makers (Denver Research Institute, 1979; Markusen, 1978).

The comparison of these models is presented in three tables: Table 8.1 addresses Criterion 1 and describes the informational characteristics of the models. In this table, the dimensions examined by the model, the project phases, the geographical units, and the time periods for which projections are made are discussed. Dimensions considered as possible components of such models are the economic, demographic, interface, distributional, public service, fiscal, and social components.

Table 8.2 compares the methodological characteristics of the models. This includes the form of methodology used in each of several possible major components of such models, the form of model integration, the dynamic capabilities of each model component, and the extent of validation of each model. In this table, characteristics for the economic, demographic, interface, distributional, service, and fiscal components of each model are described.

Table 8.3 addresses Criterion 3 and provides information on the use characteristics of such models. In particular, it compares the data inputs and the computerization requirements of such models and the extent to which such models allow user input through parameter alteration and the use of interactive programming.

In comparing the models, we have been limited to the information provided in available reports for each model. In cases where such reports do not discuss a particular item, the designation INP, information not provided, is used. Given these limitations, it is essential to stress the need for users to conduct careful analyses of models that appear appropriate for their particular informational needs. Although it is impossible to discuss the data in Tables 8.1 to 8.3 in detail, even a brief description of the items in these tables indicates how diverse the models are in overall capabilities and characteristics.

Table 8.1. Informational Characteristics of Selected Socioeconomic Impact Assessment Models

Model	Dimensions Included	Project Phases Analyzed	Geographic Areas Included	Time Increments and Total Projection Periods	Total Number of Areal Units
ATOM 3	E,De[1],I	B,C,O	State and County	Yearly; NLS	14 counties in Arizona
BOOM 1	E,De,I,S,F[2]	B,C,O	City only	Yearly; NLS	Any given city
BREAM	E,De,I,Di	B,C,O	Region, County, Cities	Yearly; NLS	2 counties maximum
CLIPS	E,De,I,Di,F[3]	B,C,O	Region, County, Cities	Yearly; 20 years	INP
CPEIO	E,De,I,S[4]	B,C,O	Restricted to one area, any level	Yearly OAD; NLS	One areal unit
HARC	E,De[1],I,Di,S	B,C,O	Project and County	Five Year; 30 years	INP
MULTIREGION	E,De,I,D	B,C,O	BEA Regional	Five Year; NLS	All BEA Regions
NAVAHO	E,De,I,Di	B,C,O	Reservation Districts	Five Year; NLS	9 Reservation Districts
NEW MEXICO	E,De,I	B,C,O	State Planning Regions	Five Year; 20 years	7 State Planning Regions
RED 2	E,De,I,Di,S,F	B,C,O	State, Region, County, Cities	Yearly-OAD; 25 years	8 Regions, 53 cos., 350 cities
SEAM	E,De,I,Di,S,F[3]	B,C,O	County Cities	Yearly; 30 years	INP
SIMPACT	E,De,I,Di,S,F	B,C,O	Region, County, Cities	Yearly; construction 10 years operation	Region and 11 subareas
WEST	E,De,Di,S[4],F	B,C,O	Region, County, Cities	Yearly; NLS	INP

Dimensions
E = Economic
De = Demographic
I = Interface
Di = Distribution
S = Public Services
F = Fiscal
So = Social

Project Phase
B = Baseline
C = Construction
O = Operational

Time Increments and Total Projection Period
NLS = No Limit Specified
OAD = Or As Desired

Total Number of Areal Units
INP = Information Not Provided

[1]Demographic Model includes special population submodules.
[2]Costs are aggregated.
[3]Revenues are not calculated.
[4]Only two services projected.

Table 8.2. Methodological Characteristics of Selected Socioeconomic Impact Assessment Models

	Methodological and Integrative Forms by Component						Dynamic Capabilities by Component						
	Econ	Dem	Interface	Subarea Distribution	Service	Fiscal	Econ	Dem	Interface	Subarea Dist.	Ser	Fis	Validation
ATOM 3	I-O	CC-S	E-M-1	% Share	NA	NA	Yes	Yes	Yes	Yes	NA	NA	Historical
BOOM 1	E-B	E-P	E-P-1	NA	P-B	Per Capita	Yes	Yes	Yes	NA	NA	NA	Sensitivity
BREAM	E-B	CC-S	E-M-1	% Share and Gravity	P-B	NA	Yes	Yes	Yes	Yes	No	NA	INP
CLIPS	E-B	CC-S[1]	E-M-1	% Share and Gravity	NA	Per Capita	Yes	Yes	Yes	Yes	NA	Yes	INP
CPEIO	I-O	CC-S	E-M-1	NA	NA	NA	Yes	Yes	Yes	NA	NA	NA	Some Forms Unspecified
HARC	E-B	CC-S	E-M-1	Gravity	P-B	NA	Yes	Yes	Yes	Yes	Yes	NA	Sensitivity
MULTIREGION	E-B	CC-S	E-M-1	NA	NA	NA	Yes	Yes	Yes	NA	NA	NA	Historical
NAVAHO	E-B	CC-S	E-M-M	Gravity	NA	NA	Yes	Yes	Yes	Yes	NA	NA	INP
NEW MEXICO	I-O	CC-S	E-M-M	NA	NA	NA	Yes	Yes	Yes	NA	NA	NA	INP
RED 2	I-O	CC-S	E-M-M	% Share and Gravity	P-B	Per Capita	Yes	Yes	Yes	Yes	Yes	Yes	Sensitivity, Historical
SEAM	E-B	CC-S	E-M-M	LP	P-B	Per Capita Facility	Yes	Yes	Yes	Yes	Yes	Yes	Sensitivity, Historical
SIMPACT	I-O	E-P	E-P-1	% Share	P-B	Per Capita Faciltiy	Yes	Yes	Yes	Yes	Yes	Yes	INP
WEST	E-B	E-P	E-P-1	% Share	P-B	Per Capita	Yes	Yes	No	Yes	Yes	Yes	Sensitivity

Econ
I-O = Input-Output
E-B = Export Base

Dem
CC-S = Cohort Component Survival
E-P = Employment-Population Ratio

Interface
E-M-1 = Employment-Migrations-One Phase
E-P-1 = Employment-Population-One Phase
E-M-M = Employment-Migration-Multiphase Procedure

INP = Information Not Provided
NA = Not Applicable

[1]Cohort Component Survival Method used at Regional level only.

Subarea Distribution
% Share = Distribution to subareas on bases of Employment or Population ratio
Gravity = Gravity Allocation Model
LP = Linear Programming Model

Service
P-B = Population Based Projections

Fiscal
Per Capita = Per Capita Costs and Revenues
Facility = Projections of facility requirements also completed

Table 8.3. Use Characteristics of Selected Socioeconomic Impact Assessment Models

Model	Source	Input Data Requirements: Geographical Level	Input Data Requirements: Form	Flexibility: User-Alterable Parameters	Flexibility: Degree of User Interactivity	Computerization: Model Language	Computerization: Transferability
ATOM 3	State and Local	State and County	Primary I-O Other Secondary	None	None	FORTRAN	Other Models closely related (BREAM)
BOOM 1	State and Local	County and City	Secondary, Judgmental	None	None	GASP IV	Yes-Texas
BREAM	State and Local	Region and County	All Secondary	None	None	FORTRAN	Untested
CLIPS	State, Local Western U.S.	Region, County, City	All Secondary	SD, PC INP	Interactive	FORTRAN	Untested
CPEIO	State and Local	The given level of analysis	Primary I-O Other Secondary	SD, PC AE, UNEMP Output	Interactive (Knowledgable User)	SIMSCRIPT	Untested
HARC	National, State and Western U.S. Judgmental	County	All Secondary	None	None	INP	Untested
MULTIREGION	National and Regional	National and Regional	All Secondary	None	None	FORTRAN	Untested
NAVAHO	National and Reservation	Reservation and District	All Secondary	None	None	FORTRAN	Untested
NEW MEXICO	State and Regional	State, Region, County	Primary I-O Other Secondary	None	None	INP	Untested
RED 2	State, Region, Local	State, Region, Local	Primary I-O Primary Labor Force Other Secondary	SD, PC, BR, IR, TR, GM Output	Interactive	APL	Yes-Texas
SEAM	National and Regional	National and Regional	All Secondary	SD, PC Impact Area	Interactive	INP	Untested
SIMPACT	Region, State, and Local	Region, County, and Local	INP	INP	Interatctive	FORTRAN	Untested
WEST	State and Local	State and Local	All Secondary	None	None	FORTRAN	Untested

SD = Starting Date
PC = Project Characteristics
AE = Available Employment
UNEMP = Unemployment Rate
OUTPUT = Type or form of Output
BR = Birth Rate
IR = Inflation Rate
TR = Tax Rate
GM = Gravity Model Coefficients
IMPACT AREA = Selection of Impact Area
INP = Information Not Provided

As is evident from Table 8.1, only four models (BOOM 1, RED2, SIMPACT, and SEAM) contain as many as five dimensions. None addresses social factors and few contain the potential for such an expansion. All cover all three vital project phases, but areal coverage varies widely. Only six models analyze both county and city impacts. Most do provide yearly outputs but many are limited in the total number of units that can be included in the model.

In terms of methodological characteristics, Table 8.2, the differences are less pronounced. Only five systems utilize an input-output model, and only three do not use a cohort-component demographic projection technique. Almost all use an interface procedure that involves the matching of available and required employment to determine migration levels. Nearly all are dynamically programmed. None has received adequate validation, but some have been subjected to sensitivity and historical simulation analyses.

The use characteristics (Table 8.3) again show great diversity from one model to another. The RED 2 model requires the greatest amount of primary data while the SEAM model requires virtually no local data (except for the interface procedure where local data are necessary for nonwestern areas). All other models tend to be intermediate between these two in data requirements. Only five of the models are interactive (allowing users to alter various parameters) and, of these, the RED 2 model appears to allow the alteration of more parameters than other models. Nearly all of the models are programmed in languages likely to be available at major computer installations. The user of interactive languages (GASP IV, SIMCRIPT, and APL) is likely to decrease the core storage necessary for the use of such models and thus models using these languages are likely to be more adaptable to smaller computer systems. On the other hand, at small and medium size installations, compilers for such languages may not be readily available. Finally, in almost all cases, the adaptability of such models is untested. Although several models (including BREAM) incorporate aspects of the ATOM 3 model, and the BOOM 1 and RED 2 models have been adapted by various groups in Texas, the adaptability and transferability of such models remain largely untested.

Overall, then, the comparisons in Tables 8.1 to 8.3 suggest that available socioeconomic assessment models are least different in the methodologies employed and most different in the extent of information provided and in use characteristics. Since these latter two factors are ones central to decision makers' concerns, it is clear that careful evaluations of individual models are an essential first step in model selection.

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

The process for siting nuclear repositories will involve the assessment of sites representing multiple repository media in diverse areas of the nation (U.S. Department of Energy, 1980). This process will require the nearly simultaneous assessment of multiple sites with methodologies that are comparable from one site to another, that provide timely results, and that allow user's concerns about key dimensions to be fully considered in the analysis of alternative scenarios. Given such considerations, and the discussion in the preceding part of this chapter, it is evident that computerized models might be applied with considerable utility in the siting process. Some of the advantages, limitations, and model characteristics necessary for the use of such models in the repository siting process are described below.

Advantages and Limitations

The positive attributes of computerized models clearly suggest their utility for the siting process. The commonality of methodologies imposed by their structures would ensure directly comparable assessments from one prototype site to another. The rapidity of their computations would allow the implications of alternative assumptions to be examined expeditiously and completely. Their direct user-accessibility would allow site-area decision makers to rapidly examine the implications of alternative fiscal or other policy choices. In sum, the use of computerized models in the siting process would ensure siting officials of comparable and quickly accessible information on multiple sites, and also allow siting and level area officials to examine the implications of alternative policy and mitigation strategies in different siting areas. The use of computerized models in the siting process is thus clearly merited.

At the same time, however, it is essential to recognize that many of the limitations of such models cited in this chapter will likely exist in models developed for the siting process. That is, it is unlikely that any computerized model will be developed that comprehensively integrates social and special effects impact assessments with economic, demographic, public service, and fiscal dimensions. Such models are thus presently limited to the assessment of economic, demographic, public service, fiscal, and environmental impacts. Although model structures can be expanded it is essential to recognize that such a model cannot address all of the important socioeconomic issues related to the siting process. The use of such models must be undertaken with full recognition of their limitations as well as their strengths.

It is also essential to caution that such a model, like any other instrument for scientific assessment, must receive careful calibration and validation. The development of such a model is thus only the first step in the completion of a useful computerized assessment methodology. With the increased availability of 1980 Census data, however, the present period appears to be an ideal one for initiating the necessary validation of any such model.

Methodological Considerations

Overall, it appears appropriate to recommend that the development of a computerized system for projecting many of the socioeconomic impacts of repository siting should be carefully pursued with full recognition of the potential advantages and limitation of such efforts. It is essential to also recommend, however, that such a model possess certain characteristics. If such characteristics are not present the maximum utility of such a model for the siting process cannot be assured. Specifically, a computerized model for use in repository siting should:

(1) contain integrated economic, demographic, public service, and fiscal components, with additional components desirable

(2) provide simultaneous projections at multiple geographical levels including state, region, county, municipal, and school district levels

(3) provide year-to-year projections of construction and operational impacts for such factors as:

- (a) business volume
- (b) employment
- (c) income
- (d) population (total and by age and sex)
- (e) public service demands by type of service
- (f) revenues by source

(g) expenditures by type

(h) net fiscal balances

(4) be user-accessible and fully interactive, allowing for easy alteration of a relatively large number of key parameters

(5) be easily transferable from one site to another.

Finally, given the number of models previously developed it should be:

(6) developed or adopted from the structures of existing models.

These characteristics are directly derived from comparisons of model's characteristics and applications as described in this chapter and reflect clear priorities in the siting process (Department of Energy, 1981). Thus, the dimensions noted in the first recommendation are clearly essential to the siting process and the most adequately developed of those in the modeling field. Although additional dimensions might be desirable, those specified should provide a useful and well-developed base for further development. The second set of characteristics are also essential given the wide public base of concern and interest in the siting process. The third set of characteristics are those standard to any socioeconomic impact assessment and thus must be included in any such effort. The fourth set of characteristics are essential if the likely concerns of local residents and the rapidly changing issues likely to surround the siting process are to be addressed. The fifth set of characteristics are necessary to ensure that the product is applicable to a variety of siting areas and the sixth recommendation is suggested by cost and efficiency considerations. Given the extensive resources already expended on model development in various settings, the range of available methodologies and the time dimensions normally associated with an original model development, an extensive adaptation effort seems preferable.

Given the above considerations, then, a model structure that combines attributes of the RED 2, SEAM, BREAM, and similar systems should be adapted. Such an adaptation effort should be initiated as soon as possible by personnel with extensive experience in model development and adaptation.

Overall, then, the repository siting assessment process should be able to make extensive use of the computerized forms of assessment models provided that such use is made with full recognition of the limitations as well as the strengths of such systems. A computerized model with characteristics that ensure ease of use, ready accessibility, and rapid projection capabilities could play a critical role in the nuclear repository siting program.

SUMMARY AND CONCLUSIONS

Given the increasing demand for environmental impact assessments, the development and use of computerized socioeconomic assessment models appear likely to increase. The results of the discussion here suggest several considerations related to that use.

First, it is clear that such models cannot address many issues relevant in environmental decision making. Questions related to social and environmental quality questions are not presently included in such models. These models provide most of the data requirements necessary for a complete socioeconomic impact assessment.

Second, the methodology employed in such models requires extensive and continued development. The unknown validity of most models requires careful attention. In large part, given the similarities in the modeling methodologies employed, it appears that the enthusiasm and the need for such models has led to the development of similarly configured models before the validity and utility of such configurations have been adequately assessed. One of the major tasks of model developers in the early 1980's should be the assessment of the validity of their models in comparison to the data provided by the Census of 1980. Until such assessments are made, the unanimity of methodologies may simply indicate how little is known about socioeconomic impacts. In addition, more attempts to adapt such models to other settings are essential.

Finally, however, the results suggest that, if properly selected, such models can meet a wide range of possible decision makers' data needs and that such selection can, in large part, be done with only limited technical expertise. For example, using data such as those in Tables 8.1 through 8.3, it is possible to select models that assess a wide number of dimensions or those that provide only basic economic and demographic outputs. Given that choice, the user can eliminate those models that do not cover the level of geographical units or time periods they desire or that do not have the capacity (total areal unit coverage) they desire. Except for selected models, methodological consideration can largely be left to a second and more intensive level of selection. The user can then additionally select models on the basis of: their ease of use, eliminating those with costly primary data collection (if desired) or using such models to provide greater sensitivity to local conditions; their degree of user interactivity; and their likely adaptability to available computer systems. In sum, the results suggest that a decision maker can select an appropriate socioeconomic assessment model with only limited technical assistance and that many of the dimensions of such selection are clearly ones whose significance may be greater for decision makers than for the technical modeler. If the selection of such models can be done with care, then the analysis here suggests that computerized socioeconomic assessment models may provide a valuable tool for use in the decision-making process.

NOTES

1. It should be noted that econometric modeling has a long history, with the first development of national models occurring in the 1930's. These activities were greatly accelerated, however, when computer systems became readily accessible. For a succinct review of national econometric modeling, see Greenberger et al (1976, Ch. 6).

2. For a review of these models, see Goldstein and Moses (1973). For a critique of urban land-use modeling efforts, see Lee (1973).

3. For example, see Obermiller et al (1975), Rodgers et al (1976) and Kelley et al (1972). A review of such modeling efforts is provided by Sanderson (1978).

4. A number of bibliographies also were consulted (Chaing and Snead, 1976; Nakamura, 1978).

5. The state has subsequently developed another model incorporating many of the features of ATOM 3 but utilizing an export base model in the economic sector. For a complete description of this model, see Anderson and Hannigan (1977).

6. The BOOM 1 model thus has its conceptual roots in the earlier work by Forrester in the areas of industrial dynamics (Forrester, 1961) and urban dynamics (Forrester, 1969). The formulations of key interactions in this model were based in large part on a case study by Gilmore and Duff (1975).

7. The basic model structure incorporated in the RED1 and RED2 models was also used as the basis for the Texas Assessment Modeling System (TAMS). For a complete description of the TAMS Model, see Murdock et al (1979).

8. This approach, which involves a comparison of data from past periods to those projected for such periods by a model, is often termed historical simulation (Pindyck and Rubinfeld, 1976). In addition, it is possible to use dynamic simulation techniques and sensitivity analysis (Pindyck and Rubinfeld, 1976) to analyze such models. This involves a comparison of the trends shown in the model output for the projected future periods to those noted in impacted areas in the past.

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CHAPTER 9

USE OF IMPACT ASSESSMENTS IN THE POLICY PROCESS

As indicated in the preceding chapters, growing awareness of the need for thorough analysis and comprehensive growth management planning in rural areas affected by major development projects, coupled with increased legal requirements for impact assessment and mitigation, has led to an increased demand for procedures which provide timely and accurate impact information. As a result, socioeconomic impact assessment techniques have received increasing attention. Computerized socioeconomic impact models have become particularly popular, as noted in Chapter 8, because of their wide range of outputs, flexibility and quick response times.

At the same time, as the number of examinations of the forms and use of such modeling and assessment systems increases (Murdock and Leistritz, 1980; Leistritz et al, 1980), it becomes increasingly evident that development of such systems can be quite expensive and that in most cases these systems have received insufficient validation. It is also apparent that the adaptability of such models and other assessment techniques to settings other than the areas for which they were originally designed has received relatively little attention.[1] Furthermore, other, more general, examinations of the use of assessment methodologies and related forecasting techniques in the policy process suggest that they often have failed to achieve their intended purposes and that their utilization by policy makers has been less frequent than anticipated (Hoos, 1972; Fromm et al, 1975; Greenberger et al, 1976; Anscher, 1978).

Given the apparent need for mechanisms which can provide timely and accurate impact information and the necessity of effectively incorporating such information into the process of planning and policy development for growth management and impact mitigation (Low, 1980), an examination of the factors affecting the credibility and usefulness of assessments appears desirable. The purpose of this chapter is to examine factors influencing the usefulness of socioeconomic impact assessments in policy development and planning for areas affected by resource development projects. The examination is from two vantage points: that of the social science analyst who wishes to make an effective contribution to the policy process and that of the decision maker who has questions concerning the usefulness of assessments and the ways in which they can be utilized effectively in policy making. Specifically, our purposes are:

1. To describe the philosophy and the major uses of socioeconomic assessments, planning, and policy development;
2. To evaluate the factors affecting the usefulness of such assessments; and
3. To delineate those conditions critical to the development, adaptation, and utilization of such assessments.

The first section of the chapter thus reviews the general uses and capabilities of socioeconomic impact assessments. The second section is devoted to an evaluation of those factors which are critical in determining the usefulness and acceptability of such models to decision makers. The final section contains our conclusions regarding the usefulness and limitations of socioeconomic assessments and the necessary conditions for a successful assessment effort.

PHILOSOPHY OF SOCIOECONOMIC IMPACT ASSESSMENT

The overall process of impact assessment and growth management includes far more than the identification of possible impacts and the dogmatic forecasting of the extent of economic and social changes. Rather, it includes the forecasting and monitoring of baseline socioeconomic trends, performing impact projections (often with consideration of alternative future levels and patterns of development), impact evaluations, and long-term planning and policy formulation with the objectives of minimizing those changes which are viewed as undesirable and of enhancing those changes which are considered beneficial. The process of projecting the impacts of a new development, then, should not be viewed as an end in itself, but rather as a means of providing essential information to those individuals and groups who are in a planning and decision-making capacity.

With the development of numerous socioeconomic assessment systems and models and the increased use of these techniques in impact assessment, analysts tend to become engrossed in the technical task of developing even more sophisticated systems and thus to lose sight of the pragmatic considerations related to their use. Although technical efforts are desirable because most of the techniques currently being used in impact assessments could benefit substantially from expansion and refinement, impact analysts must bear in mind that while conceptual and analytical sophistication may be necessary conditions for a useful impact assessment system, they are not sufficient conditions. Rather, if an impact assessment methodology is to serve a useful role in the impact assessment, mitigation, and management process, it must be designed with considerable attention to the form of information needed for this process. Thus, the needs of persons who will use the information must be given substantial weight in establishing methodology and evaluation criteria.[2]

Uses of Socioeconomic Impact Assessments

Impact assessments fulfill three important functions in the overall impact policy formulation and development process: (1) to project the social and economic profile of the study area under "baseline" and "impact" conditions, (2) to sensitize decision makers to critical problem areas and key relationships, and (3) to provide directions for future research.

The first function, projections of socioeconomic profiles, produces conditional forecasts of the levels of various economic, demographic, public service, fiscal, and social variables. These projections are critical to decision makers as a basis for evaluating potential problems which may emerge and for evaluating the efficacy of alternative policy options. Specifically, decision makers frequently utilize impact projections in three distinct types of applications: (1) facility and program planning, (2) project evaluation, and (3) policy analysis. In the first application, impact projections are often used as the "best available forecast" of future conditions, and the projected levels of critical variables are used as target values for facility and program planning. In project evaluation, interested parties frequently utilize impact projections--particularly the comparison of baseline (that is, without the project) and impact projections--in determining whether the proposed project is acceptable and what types of impact mitigation measures will be required. Finally, impact projections may be used to evaluate the likely effects of various growth management policies. As a projection tool, computerized assessment models are often particularly valued because of their capacity to deal with complex analytic situations and large data sets (that is, involving large numbers of variables and interrelationships), their ability to provide quantitative answers (even though these may be approximations), the replicability of the results, and the rapidity with which the implications of alternative policies or assumptions can be assessed (Fromm et al, 1975). It must be emphasized, however, that impact projections are conditional forecasts--they are contingent on the actions which policy makers will take and also on the validity of the basic assumptions concerning factors such as the level of development which will occur. While the use of models to produce impact projections which will be utilized directly in impact evaluation and planning is the predominant reason why public and private sector entities support the development of these models, the other two roles are also significant for models and other forms of assessment methodologies.

The role of assessments in altering the perceptions of policy makers is less apparent than their role in impact projections. Because they provide a simplified and explicit representation of the real world phenomenon being studied (often termed the methodology's "reference system"), they offer a means of portraying essential relationships and isolating critical problems. Thus, although an assessment is not used directly in the decision-making process by the policy maker, it may provide a frame of reference for evaluating the effects of alternative decisions. Because they provide an explicit representation of a real world system, formalized assessment procedures are controversial.[3] Nevertheless, assessments can provide a framework for discussion, and such discussion may improve the probability that key decisions will receive concerted attention (Greenberger et al, 1976). While assessments may serve to increase decision makers' awareness of key relationships and critical issues, they cannot be expected to resolve policy differences which are basically philosophical in nature.[4] Likewise, assessments cannot and should not be expected to replace the decision maker in his role of considering and weighing all available information and applying judgment in arriving at a final decision (Low, 1980). Neither should the existence of assessment projections remove the decision maker's responsibility for those decisions. This situation arises in part from the nature of assessment methodologies which, as simplifications of their reference system, cannot include all relevant variables and also in part from the nature of policy makers who are understandably loath to jeopardize their power by relying exclusively on mathematical algorithms as the basis for major decisions.

The third factor, the role of assessments in stimulating and guiding future research, is widely recognized.[5] The process of developing assessment methods consists essentially of conceptualizing relationships among variables, seeking empirical evidence to quantify and/or refine these relationships, and providing a computational structure which portrays the system under investigation. The absence of data to quantify certain relationships which are believed to be important suggests that these relationships constitute a priority area for further analysis.

A guide for such research design is provided if the methodology is subjected to sensitivity testing. In this process, the methodology is tested with the key coefficients for each of the relationships under investigation being specified at alternative values within a subjectively determined "reasonable range". The results of these simulations will reveal those relationships whose precise specification is most important in influencing the values of the output variables.

Finally, the process of methodology development and utilization may serve to promote communication between decision makers and technical specialists (Fromm et al, 1975).

Public and private sector officials who sponsor the development of impact assessment methodologies may recognize the benefits which arise from the role of such methods as educational tools for decision makers and researchers. Their decision to support the development of a methodology, however, typically hinges on whether they believe it will provide information useful in specific planning and policy contexts. Thus, we turn to a consideration of major factors which influence the usefulness of assessments to policy makers.

FACTORS AFFECTING THE UTILITY OF ASSESSMENTS

Numerous factors influence the extent to which the assessment methodology can be or will be utilized by decision makers.[6] It appears, however, that two considerations are of overriding importance in this regard: (1) the degree of congruence between the model's capabilities and the needs of decision makers, and (2) the decision makers' confidence in the methodology. In this section, the key dimensions of these two major considerations are explored.

Compatibility With Needs of Decision Makers

It has become axiomatic in treatises on policy-oriented modeling and methodology development to stress the importance of interaction between the analysts and the policy makers who are expected to use them (House and McLeod, 1977; Greenberger et al, 1976). In the case of socioeconomic impact methods, however, it appears particularly important to carefully define the types of decisions which are to be made and the types of information which are needed. Such methods may be used for several types of decisions and possibly by several distinct groups of decision makers, each having different information needs and levels of resources.[7] While different needs do exist, however, it will not likely be possible, given time or resource constraints, to implement a methodology that is all things to all people. Frustration and superficiality are likely to result from an overly comprehensive approach to methodology development. Priority uses and users for the method will exist, and these priorities must be identified and addressed.

Four groups which may be expected to be frequent users of socioeconomic impact assessments are local governments, state and federal policy makers, state and federal action agencies, and private sector managers. Local officials will naturally be most interested in the implications of development for their specific jurisdictions. They will likely be concerned with the implications under alternative conditions, as they will need this information in their facility planning and capital budgeting decisions and possibly as a basis for negotiation with the developer. They also are likely to be interested in the prospective effects of alternative local growth management strategies (i.e., different rates for utility user fees and hookup charges, infrastructure investment options, and local zoning alternatives) on the various impact categories.

State and federal policy makers should be very interested in the socioeconomic implications of alternative resource development patterns. They also may be confronted with decisions concerning financial assistance to impacted areas, including justification for such assistance, the level of assistance required, and the most appropriate form of such assistance (e.g., grants versus loans).

State and federal action agencies are most interested in the implications of development with respect to their specific programs. These entities frequently have information needs which closely parallel those of local officials, but on a regionwide basis, and they may utilize impact projections as target values in their program planning.[8]

Managers of development firms also have questions regarding socioeconomic impacts. From their perspective, however, the key questions may relate to the relative severity of impacts that may be anticipated at alternative project sites and the effects of various construction management strategies (e.g., extent of local hiring, use of bachelor quarters or company-subsidized transportation, and staging of construction activities) on the magnitude and distribution of impacts.

Because the various potential users of the method may differ in the types of information they desire and in the exogenous variables they consider important, as well as in the level of resources at their command, it thus appears vital that decision makers be involved early in the development process.

Input from decision makers is needed with regard to a number of major output features, including the impact categories (e.g., economic, demographic, public service, fiscal, social) to be addressed, the specific socioeconomic profile characteristics to be projected, the level of aggregation of outputs (e.g., total population or population by age category), the geographic units for which outputs are to be projected, and the temporal periods for which results are reported. The intended mode of use (for computerized models, for example, direct access by users versus human interface) may influence the format in which outputs are reported. Likewise, the users' definition of an acceptable period of time for completion of the assessment may influence the choice of methodology.

The specific uses which are contemplated also may influence the analytical methods to be employed, the data requirements, and the procedures for interaction between the methodology and its users. If, for example, some intended uses of the methodology will require projected population to be disaggregated by age and/or sex, then the method's designers likely will employ the cohort-survival technique in the demographic part of the assessment. This decision will in turn determine the types of data which will need to be assembled as input. Similarly, if the procedure is to be utilized to assess the implications of alternative taxation and impact assistance policies, provision may be made for convenient user alteration of selected tax rates and other fiscal variables.

At the stage in methodology development when user needs are specified and the overall design is established, a number of trade-offs must be carefully considered. Decisions regarding the scope of impact categories to be addressed, level of detail of projections, and other related factors may often have a substantial impact on the resources required to develop and maintain the methodology, as well as on the time period required for its development. More detailed projection techniques may impose greater costs for development and also may lead to greater requirements for computerization and to higher costs for each use of the method. Similarly, techniques which utilize substantial amounts of local data may be more reliable in projecting local level conditions that depart markedly from state or national patterns but may also imply substantial costs and extensive time periods for data collection. The design phase, then, requires active participation from both decision makers and methodologists in assessing the benefits and costs of various design alternatives.

Interpretation and Use of Results

If models are to play a major role in shaping important decisions, users must understand their capabilities and inherent limitations and must have confidence in their reliability in simulating the behavior of the reference system. In this section we will examine the factors which are important in determining whether decision makers will develop confidence in an assessment methodology.

Description and Explanation of the Assessment Methodology

The quality of a method's description is likely to be critical in determining the degree of confidence with which decision makers will view its results. Without an explanation of the premises and assumptions of the method, one cannot adequately interpret or act upon the results. Without knowing something of the purpose, logic, and capabilities of the method, one cannot decide whether it applies to a particular problem.[9] Reviews of socioeconomic impact assessment methods and models (Murdock and Leistritz, 1980) and of policy analyses in general (Fromm et al, 1975) suggest that the quality and completeness of assessment methodology descriptions and model documentation vary considerably. Further, representatives of sponsoring agencies tend to be less satisfied with the adequacy of method descriptions than are the directors of methodology or model development efforts (Fromm et al, 1975). This divergence in views suggests a substantial gap between assessment analysts and users, a gap which may seriously limit the usefulness of the assessments.

While written methods descriptions are necessary to the understanding and use of an assessment, it may not be a sufficient means of communicating the purpose, logic, capabilities, and limitations to decision makers. Rather, it will probably be essential to at least conduct a series of briefings for policy makers, and, ideally, decision makers and their aides should be involved throughout the assessment process. Communication between analysts and decision makers is likely to be more effective if the analysts are recognized by the decision makers as having both expertise in relevant subject areas and knowledge of local conditions. If some members of the analytical team have previous experience in interacting with the relevant decision-making entities, communication may be established more readily (Murdock and Leistritz, 1979b). It also is very useful for the sponsoring agency to have staff or trusted associates who are capable of assessing the validity of the method used. Finally, decision makers may be more receptive to efforts which are perceived as timely (i.e., the need for the information is recognized and the assessment effort has the potential to provide needed information within a time frame consistent with pending decisions).[10]

Methodology Validation

Validation is a test of whether a methodology provides an adequate representation of the elements and relationships of the reference system that are important to the uses which are planned for the method. Validation is not a general seal of approval; rather, it is an indication of the level of confidence in the methodology's accuracy under limited conditions and for specified purposes (Shapiro, 1973). Because all methods are designed to be simplifications of their respective reference systems, they can never be entirely valid in terms of being fully supported by objective truth. The various techniques of validation are aimed more at invalidating rather than validating a method, and they can reveal only the presence (not the total absence) of problems.[11]

Thus, it is suggested that "useful" or "convincing" are more appropriate descriptive terms to apply to methods or models than "valid" (Greenberger, et al, 1976).

Confidence in a given method can be enhanced by (1) critically examining its theoretical bases, assumptions, data sources, and computational procedures, (2) investigating its response to perturbations, and (3) testing its ability to reproduce historical data.[12] Most impact methods or models have undergone at least one of these forms of validation, but no computerized socioeconomic impact assessment model of which we are aware has been subjected to extensive validation in all three forms.

The first form of validation (review of theoretical bases and analytical procedures) consists of a review of the technical description/documentation materials by persons with expertise in impact assessment. Most methods have received such reviews, and the presence of descriptions of some of these in refereed publications suggests that their reviews were favorable. It should also be noted in this regard that one way for decision makers to complete such reviews is to utilize recognized socioeconomic impact researchers in the review effort.

The second form of validation (analysis of response to perturbations) involves altering selected input variables or parameters in a manner consistent with intended uses and evaluating the resulting outputs in terms of their consistency with expert understanding of key relationships and with evidence regarding the actual behavior of the same variables under similar circumstances. Most impact methods likely have been subjected to this type of validation by their developers. The strength of this form of validation is that the method's behavior is being examined under circumstances similar to those that may be encountered in actual use. Its limitation is that the evaluation is necessarily subjective.

The third form of validation (testing the ability to reproduce historical data) is frequently termed "historical simulation".[13] This form of validation involves choosing a past period for which the values of the output (endogenous) variables are known. The method is then supplied with the known starting values of the input (exogenous) variables and simulated over the period.[14] The values of the output variables estimated by the model are then compared with the actual values; a variety of statistical tests can be applied to evaluate the "goodness of fit" between the two series (estimated and actual) for each variable of interest.[15] In addition to evaluating the degree of correspondence between estimated and actual values, another important criterion is how well the method predicts turning points in the historical data.

Of the three general forms of validation, the comparison to historical data appears to be particularly appealing because it provides objective measures of performance. Further, such measures are easily understood by decision makers and their constituents. A method which closely reproduces historical data on the variables of interest gains credibility and wins the acceptance and trust of potential users (Greenberger et al, 1976). This approach to validation may require substantial effort in assembling historical data series for the key input and output variables, however, particularly for intercensal years and in rural areas. Because such efforts are time-consuming and expensive, historical simulation has been used less frequently than the other approaches. The historical simulation technique also has limitations because, although it offers a test of the ability to reproduce past changes, shifts in the structure of the reference system or major changes in values of key system variables could adversely affect the method's future performance. Ideally, all three forms of validation should be employed. It is unfortunate, therefore, that most existing methodological descriptions contain little or no information on the results of attempts to test their validity. Historical simulation evaluations have been particularly absent in computerized model descriptions (Chapter 8). In defense of the research groups that have developed computerized impact models, however, it should be noted that most of these models have been developed quite recently so that the time available for extensive validation has been limited. Further, because many areas where these models have been applied have relatively recent histories of rapid growth (Murdock and Leistritz, 1979a), the data available for testing the validity of these models under impact conditions have been sparse. Rigorous empirical evaluations of the validity of assessment methods should be given high priority over the next few years. Although some efforts have been made to assess the accuracy of projections, particularly in the areas of economic and demographic projections (Klindt et al, 1972; MacMillan and Lu, 1972; Hertsgaard et al, 1977; Glickman, 1977; Ascher, 1978), such assessments have been infrequent and additional analyses are clearly essential.

IMPLICATIONS FOR NUCLEAR REPOSITORY SITING

The discussion in this chapter points to several dimensions that have implications for the nuclear repository siting process. Thus, it is evident that the impact assessment process must occur in close association with other aspects of the siting process. Assessment information can play a key role in the design and implementation of the mitigation and community development aspects of siting and must entail, as noted above, direct participation from both those who shall interpret such information for policy makers and for policy makers themselves. It is evident, then, that in the siting of nuclear repositories, as in other large-scale developments, assessment, mitigation and community development and public participation research programs must be carefully integrated. If assessment information is to be of maximum utility, the development of impact assessment methodologies, mitigation strategies and community development a public participation strategies must be closely coordinated and occur nearly simultaneously. Methodologists and strategists must work interactively to ensure that the assessment information produced is, in fact, that of maximum utility to federal, state, and local decision makers.

The discussion in this chapter also again points to the need for the field testing and the validation of assessment methodologies and mitigation, community development, and public participation strategies. As noted in this chapter, methodologies are seldom validated after they are developed. As a result, the accuracy, reliability, and general utility of such methods and strategies often remain unknown. Given the range and extent of review and potential controversy likely to be associated with assessments for repository sites, it is absolutely essential that such validation be completed for methodologies and strategies to be used in repository siting analyses.

A final implication of the discussion presented above is that whatever form of assessment method or modeling system is employed in an assessment it is essential to recognize its limitations as well as its strengths. Any assessment can address only certain types of empirical, addressable questions. Thus, no assessment or other presently available socioeconomic research technique can predict such societal issues as the levels of societal acceptance of and preferences for disposing of nuclear waste. A socioeconomic assessment and related mitigation, development, and public participation analyses can provide information to assist federal, state, and local decision makers in policy formulation and to increase the knowledge base for addressing local concerns, but such analyses cannot be expected to predict national trends in perceptions nor to predict social reactions to as-of-yet unpredicted siting events. Consequently, as with other types of analyses described in this chapter, it must be recognized that socioeconomic assessments and assessment methodologies for repository siting can address some but not all of the issues surrounding the siting process.

For repository siting analyses the need for close interactions between researchers and policy analysts and decision makers, the need to field test and validate methodological approaches and instruments and the need to recognize the limitations as well as the potential advantages of research techniques are clearly as important as for other large-scale developments. Efforts to ensure that such factors are evident in the socioeconomic analyses of repository siting are thus essential and critical for the success of the siting process.

CRITICAL FACTORS IN METHODOLOGY DEVELOPMENT AND UTILIZATION

Rapid growth resulting from large-scale development projects has created a growing interest in impact assessment. A number of assessment methods have been developed, and we believe that they have considerable potential for providing information useful to decision makers. These methods will be most useful, however, if their inherent capabilities and limitations are thoroughly understood. They are most appropriately regarded as sophisticated mechanisms that allow us to see the future implications of alternative courses of action. When properly designed, impact assessment methods provide an efficient mechanism for organizing our assumptions and for projecting the implications of these assumptions into the future.

There are some things, however, which they cannot be expected to do. No matter how sophisticated their design, they cannot provide certainty in an uncertain decision environment (Kornbluh and Little, 1976). Neither can they be expected to resolve policy differences which are basically philosophical in nature. Finally, they cannot and should not be expected to replace the decision maker in his role of considering and weighing all available information and applying judgment in arriving at a final decision. Neither should the existence of a projection remove the decision maker's responsibility for those decisions.

Those who may use these assessments will find it necessary to develop criteria of method acceptability, whether as a basis for choosing among alternative methods or as a guide in deciding whether a given method can be used with confidence. While many factors may enter into such decisions, we suggest that three considerations should predominate:

1. The method must provide the types of information needed by the user. Increased communication between analysts and decision makers will be required to achieve better congruence between assessment capabilities and user needs. It must be recognized, however, that determination of information needs is not a trivial task. Decision makers frequently experience difficulty in articulating their needs in terms that are meaningful to impact analysts. Similarly, analysts often appear to be insensitive to the imperatives confronting decision makers. It may be necessary for the decision makers and impact analysts to jointly simulate a typical decision process before a final prioritization of needs can be developed.
2. The assessment should use tested, state-of-the-art techniques to provide the most realistic possible representation of the real world system being analyzed. To date, lack of empirical validation has been one of the major shortcomings of socioeconomic impact assessments. Impact analysts should give more attention to empirical validation of their products with emphasis on the ability to replicate actual outcomes in rapid growth areas, and potential users should demand objective measures of validity.
3. Because impact assessment methodologies provide at best a simplification of the system being studied, decision makers must evaluate them not in terms of an ideal but unobtainable "perfect method", but rather in terms of available alternatives (Forrester, 1968). While the present computerized models are by no means approaching perfection, they may well be superior to the manual or mental models which are the alternatives to their use. Further, there appears to be reason for optimism that they can be further refined and their performance improved.

For those entities that contemplate sponsoring assessment efforts, a number of questions frequently arise. While these questions may take different forms in different settings (for example, use of in-house staff versus outside consultants, development of a new method or model versus transfer of an existing one), their focus is on defining the conditions necessary for a successful impact assessment effort. While there is certainly room for differences of opinion in this area, we would suggest the following as important conditions:

1. Early involvement of potential users--Participation of potential users in the methodology design effort not only improves the chances that the resulting methodology will be compatible with their needs but also can provide the developers with easier access to local data bases. User involvement throughout the development period allows for correction of initial inaccuracies based on information about local conditions. Further, the meaningful involvement of users in the development process increases the likelihood that they will use the assessment.

2. Appropriate timing with respect to information needs--Awareness of the need for the information the assessment can provide and timely provision of information to meet those needs is also essential. If assessment efforts are pursued before decision makers feel the need for the information they can provide or if the development process is so extended that the important issues have been addressed prior to the assessment's completion, the effort is unlikely to be highly utilized or well received.

3. Knowledge of study area conditions--Socioeconomic impact analysis by its very nature requires a detailed understanding of the economic, demographic, public service, fiscal, and social conditions of the study area. If the researchers do not possess such knowledge, they must be willing to commit a significant effort to thoroughly understanding local conditions and relationships.

4. Knowledge of impact assessment techniques--Socioeconomic impact analysis generally and impact modeling in particular require a variety of skills, including thorough knowledge of economic, demographic, public service, fiscal, and social impact assessment methods and expertise in computer systems/programming. Because it would be

highly unlikely to find this combination of skills in one individual, a multidisciplinary team must usually be assembled.

5. Continuity of professional and technical support--Once the assessment methodology has been developed there is a continuing need for competent analysts both to assist users in various applications of the methodology and to update various data bases and coefficients. There is also a continuing need for advice from persons with expertise in the use and interpretation of impact assessment to determine when use of the results is appropriate and for interpreting those results. In addition, as the model is applied to a variety of problems, needs for refinement are often identified. Determination of the institutional setting (for example, mission agency, research institute, etc.) which can best provide a continuity of support will be important to the long-term usefulness of any methodology.

6. Resources commensurate to the task--Impact methodology development, like other research and development endeavors, is not inexpensive. For example, it is estimated that more than $2 million has been spent in development of the SIMPACT computerized assessment system (Huston, 1979). Development of some other regional impact modeling systems has involved costs of several hundred thousand dollars, not including background data collection and analysis. Transfer of an existing system may be possible at a cost substantially lower than that required to develop a new system (Murdock et al, 1980). This option is attractive, however, only if an existing model appears to meet information needs and if questions relating to documentation and computer system compatibility can be satisfactorily resolved. (The active involvement of the developer may be the best way to assure the success of a transfer effort.) In any event, the costs of the effort must be realistically assessed and adequate resources allocated.

In closing, impact assessments appear to have considerable potential for providing needed information in rapid growth situations. Recent general studies of the application of assessment methods and models in policy evaluation, however, reveal disappointment with respect to the frequency and extent of actual use (Fromm et al, 1975; Greenberger et al, 1976; House and

9. "Documentation" of a model can refer either to the specification of its conceptual design (including premises, assumptions, data sources, etc.) or to a detailed description of its software (computer program) and the computational procedures embodied therein. Although the second form of documentation may be vital to the technical personnel charged with the model's maintenance and modification, it is the first form which is critical to decision makers.

10. For a more detailed discussion of these factors in the context of a specific model development effort, see Murdock and Leistritz (1979b).

11. It is important to distinguish between validation and verification. Verification of a model is basically ensuring that the model "runs as intended"--that is, it executes the computations that its designers specified. Validation, on the other hand, tests the appropriateness of the design.

12. For more detailed discussion of these validation techniques, see Ascher (1978), Pindyck and Rubinfeld (1976), and House and McLeod (1977).

13. Some authors refer to this approach as "backcasting" while others define backcasting as the situation in which the model is run backward in time. We follow the terminology of Pindyck and Rubinfeld (1976, p. 314) who distinguish historical simulation (where the model runs forward in time over a historical period) from backcasting.

14. Two basic variations of the historical simulation approach are possible. One alternative is to supply the (known) values of the exogenous variables to the model throughout the period. The other is to supply the model with exogenous variable values which were "estimated" using the same techniques employed to estimate these variables in forecasting applications.

15. Statistical measures which are frequently applied include the Thiel U^2 Coefficient, Mean Absolute Error, Mean Error, and R^2 coefficients. For further discussion, see Leuthold (1975), Pindyck and Rubinfeld (1976), and Senechal (1971).

McLeod, 1977). Overselling by assessment analysts and modelers and unrealistic expectations on the part of users are both cited as reasons for low levels of actual utilization of assessments in the policy process. While we are not aware of any study which has examined the use of socioeconomic impact assessment methods and models specifically, we suspect that these problems exist for this class of methods also. Greater commitments from both impact analysts and policy makers will be required if assessments are to achieve their full potential.

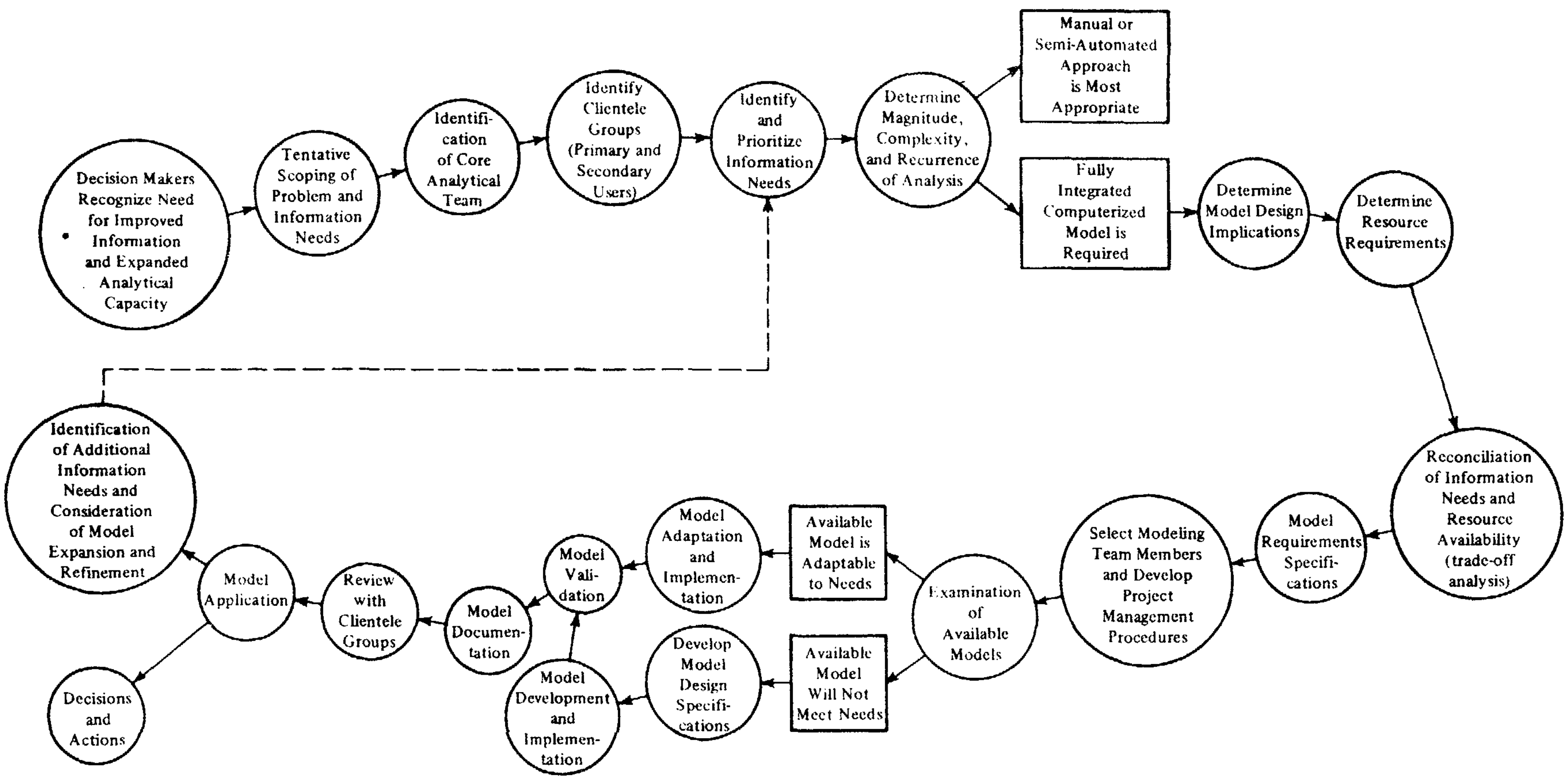

Figure 9.1. Key Considerations in Model Design and Implementation

NOTES

1. An exception is the discussion by Murdock et al (1980) of the adaptation of the Texas Assessment Modeling System (TAMS) from the RED 1 and RED 2 Models.

2. In a broader evaluation of the uses of federally supported models, Fromm et al (1975) found that very few of the model limitations cited by agency project monitors were related to modeling techniques or methodology. Rather, the major emphasis was on problems in applying models to decision making with the greatest number of comments relating to factors necessary in the decision process but left out of the model.

3. Several examples of such controversy are discussed in Greenberger et al (1976).

4. In general, models are most readily employed in situations where there is general agreement regarding the ends to be achieved, and a lack of goal consensus makes the modeler's task more difficult. For further discussion of this point with respect to forecasting in general, see Ascher (1978, Chapter 2).

5. For example, Fromm et al (1975) report that, when directors of modeling projects were queried concerning benefits of their model, the most frequent response was "educated the model builders".

6. For extensive discussions of these factors, see House and McLeod (1977) and Greenberger et al (1976). A more general discussion of the influence of forecasts is provided by Ascher (1978, Chapter 2).

7. For a detailed discussion of the use of a socioeconomic impact assessment model in a variety of policy contexts, see Leistritz et al (1980).

8. Specific examples include the use of impact projections as an aid in allocating impact assistance grants and as a basis for long-range highway planning in energy development areas of North Dakota (Murdock and Leistritz, 1976b).

9. "Documentation" of a model can refer either to the specification of its conceptual design (including premises, assumptions, data sources, etc.) or to a detailed description of its software (computer program) and the computational procedures embodied therein. Although the second form of documentation may be vital to the technical personnel charged with the model's maintenance and modification, it is the first form which is critical to decision makers.

10. For a more detailed discussion of these factors in the context of a specific model development effort, see Murdock and Leistritz (1979b).

11. It is important to distinguish between validation and verification. Verification of a model is basically ensuring that the model "runs as intended"--that is, it executes the computations that its designers specified. Validation, on the other hand, tests the appropriateness of the design.

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CHAPTER 10

CONCLUSIONS AND IMPLICATIONS

Our intent in this effort has been to provide an overview of the conceptual bases for and alternative techniques available for use in assessing the economic, demographic, public service, fiscal, and social impacts of resource development projects. In this chapter, we wish first to briefly summarize our conclusions with respect to needs for additional development and refinement of impact assessment methods and supporting data bases.

CONCLUSIONS: STATE OF THE ART IN SOCIOECONOMIC IMPACT ASSESSMENT

Our intent in this section is to summarize our impressions of the current state of the art in socioeconomic impact assessments for large-scale projects and to point out those areas where additional conceptual and/or empirical effort is needed to allow for more adequate assessments. In so doing, we are admittedly being evaluative and expressing views whose empirical validity has yet to be clearly established.

When the techniques which are most commonly employed in socioeconomic impact assessment are evaluated, one immediate conclusion is that current methods and approaches leave much to be desired. Many assessments appear to be based on inadequate methods, utilize inappropriate data bases, and frequently achieve, at best, a partial analysis of the relevant impact dimensions.

Examples of such shortcomings are abundant in recent assessments. In the area of economic impacts, they include the use of techniques which provide only very aggregate measures of economic effects and which are insensitive to key differences in project characteristics. Even more serious, secondary economic effects have been ignored altogether in many assessments (Berkey et al, 1977). Demographic impact assessment provides similar examples, including the use of simple population-to-employment ratios which ignore the structure of the population and the dynamics of population growth and decline. Demographic analyses also provide numerous examples of the use of inappropriate data bases. For example, many analysts have used an area's average family size derived from census data as an estimate of the demographic characteristics of in-migrating construction-related populations, even though extensive data bases concerning these characteristics are available from recent surveys.

The integration of the various impact dimensions, as noted in Chapter 7, is an assessment area where conceptual development has been especially deficient. It appears that adequate integration requires use of common procedures for both baseline and impact interfaces, employment of interface procedures at the lowest possible geographic level, retention of the most significant aspects of each impact dimension in the interface procedure, and use of feedback or iterative mechanisms. Most integration procedures in current use, however, are single-point, single-dimension, and noniterative. Further, in many cases analysts fail to consistently apply common interface procedures in both baseline and impact assessments.

Evaluation of changes in public service requirements has been similarly limited. Such assessments often have been based on the application of national service standards to total population changes. Such approaches not only ignore unique local conditions, such as service expectations of local residents and capacities of present facilities, but also ignore the effects on service requirements that may result from differences in key socioeconomic characteristics (for example, income and age structure) between in-migrants and the resident population. Further, many assessments have been very limited in the types of services examined, with some including only a small subset of the services provided by local governments and others making no explicit attempt to examine service requirements (Berkey et al, 1977).

Fiscal impacts of major projects are one of the major concerns of local decision makers. Fiscal assessments, however, have frequently been subject to limitations similar to those noted previously with respect to public service evaluations. In many cases, only a few of the cost and revenue components have been examined. In others, only public sector costs and revenues associated directly with the proposed project have been evaluated, the indirect and induced fiscal effects thus being ignored. Finally, few fiscal analyses have adequately addressed the temporal and jurisdictional distribution of costs and revenues, although it has become increasingly apparent that these distributional aspects are frequently a source of problems for local jurisdictions (Murdock and Leistritz, 1979; Gilmore et al, 1976).

In the area of social impact analyses the limitations are equally evident. A failure to properly define the content of social impact analysis and subsequent unrealistic expectations for them, the use of impressionistic data based on short-term observations, and the analysis of only public services or only those dimensions that can be derived from secondary data are some of the most common limitations. It is essential for social impact analysts to develop, and be provided with, an adequate set of resources to develop more comprehensive but definitive assessment techniques.

Overall, it is apparent that past impact assessments have frequently suffered from inadequate conceptualization and from a failure to utilize the most appropriate techniques and the most adequate data sets that were available. It must be recognized, however, that socioeconomic impact assessment is a relatively new and rapidly developing research area. While regional economists and demographers have long been interested in developing a better understanding of the forces affecting rural economic and population changes, it is only within the last decade that NEPA requirements have stimulated concerted efforts to provide integrated assessments of a broad range of economic, demographic, and social impacts. Further, as has been indicated in previous chapters, significant advances in the sophistication and, hopefully, the realism of these assessments have occurred in recent years. Thus, we turn our attention to evaluating the most advanced methods which are being employed in this area.

The state of the art in impact assessment (that is, the most advanced models that have been developed and employed) clearly represents a substantial advance over the techniques typically employed. These models and methods, however, still appear to have substantial limitations. The more salient deficiencies of impact assessment techniques appear to be in the following areas: (1) insufficient conceptualization of key dimensions and interactions, (2) inadequate data bases, (3) inappropriate levels of analysis, (4) insufficient orientation to the needs and concerns of decision makers, and (5) inadequate validation. The nature and significance of each of these shortcomings will not be examined.

Inadequate conceptualization of key relationships, while apparent to some degree with respect to all major impact assessment dimensions, is most evident in the integration of major components. As noted in Chapter 7, no clear conceptual premises have been established to provide a basis for interfacing socioeconomic dimensions. The lack of attention to this issue may arise at least in part from the traditional isolation of disciplinary specialties. Thus, the development of economic impact concepts and techniques has been the realm of the regional scientist, population analysis has been the concern of the demographer, and fiscal impact evaluations have been the concern of an equally specialized group of public finance analysts and planners. Only recently has the need for integration of concepts from these and other diverse disciplines become clearly apparent.

The traditional organization and reward systems of some major research institutions (for example, universities) may act to discourage the intense and sustained levels of interdisciplinary interaction required to achieve substantial advances. Segregation of the relevant disciplines into several different departments, often in different colleges, tends to limit interactions, except during those periods when the researchers are drawn together to conduct an "interdisciplinary" project. Because such projects often are of relatively short duration, truly effective interdisciplinary interaction may be difficult to establish, as differences in conceptual bases and specialized disciplinary phraseology often impair communication (Swanson, 1979). Existing reward systems, which often place heavy emphasis on publication in the leading professional journals of the researcher's discipline, also may discourage substantial commitments to integrative efforts. If interdisciplinary analyses are less acceptable to major journals than more discipline-specific efforts, researchers may be understandably reluctant to commit substantial resources to these activities, especially during their formative years (Swanson, 1979).

Whatever the underlying causes, conceptual bases and specific techniques for interfacing socioeconomic dimensions have not received sufficient attention. The economic-demographic interface appears to be the most highly developed, but even here the specific procedures employed are often ad hoc in nature, and their reliability under a variety of contextual conditions has not been adequately assessed. Methods for integrating other impact dimensions have received substantially less attention, and attempts at quantitative interfacing of social and environmental (physical) dimensions with other socioeconomic categories appear almost nonexistent (Murdock, 1969).

Insufficient databases pose limitations to socioeconomic impact analysis which are at least as severe as those resulting from inadequate conceptualization. Whatever the limitations in model conceptualization, it still appears to be true that our capacity to develop highly sophisticated regional models exceeds our ability to implement them, given the primitive nature of available data and data-gathering techniques (Miernyk, 1976). These limitations are applicable to nearly all aspects of socioeconomic impact assessment. Thus, in each of the socioeconomic areas discussed in the preceding chapters, limitations in databases are perceived as a major barrier to the development of more comprehensive and reliable assessment models.

The paucity of data available for estimating many of the relationships which are central to impact assessments has had several effects. One is the tendency of impact analysts to rely heavily on intuition and expert judgment (Ford, 1976) in quantifying many key relationships. Review of numerous impact statements and model descriptions leads us to conclude that virtually all analysts have relied heavily on this approach; levels of candor on the subject vary greatly, however. A second result of data limitations has been a tendency to utilize certain data sets in settings where their applicability appears questionable. The widespread use of data on worker characteristics and settlement facility sites in the Great Plains and Rocky Mountain states (Mountain West Research, Inc., 1975; Wieland et al, 1977) in projecting such patterns for a wide variety of facilities in diverse environmental settings is a case in point.

Many impact assessment efforts appear to involve levels of analysis which do not allow critical questions to be adequately addressed. Some of the most important questions to be addressed in impact assessment relate not just to the aggregate changes in various socioeconomic variables but also to the distribution of those effects--among groups in the affected population, among jurisdictions, and over time. For example, assessment approaches which treat fiscal effects only in terms of the expected changes in total revenues and total costs of typical local jurisdiction for a typical year after the facility is in operation simply fail to address some of the most important issues related to fiscal impacts. Similarly, demographic analyses which fail to give considerable attention to the likely settlement-commuting patterns of project workers will be of limited utility to local planners and decision makers. Overall, it appears that the level of analysis frequently has been based more on convenience for the analysts than on the needs of those who will utilize the information as a basis for decisions.

Another limitation which appears to be pervasive among the impact assessments we have examined is an insufficient orientation toward and sensitivity to the needs of decision makers. In general, impact analysts must give greater attention to the production of results that have meaning to policy makers and which can be acted upon by them. This requires not only the development of more adequate research techniques and conceptual specification but also a clear identification of key policy issues and a specification of critical questions at the beginning of an assessment effort (Murdock and Leistritz, 1979). More specifically, if impact assessments and particularly computerized assessment models are to achieve their full potential in guiding impact management and mitigation efforts, they must become increasingly oriented to the evaluation of the effects of specific impact management strategies. Thus, impact assessment models should be capable of addressing the likely implications of alternative approaches by the developer (such as alternative project construction schedules, expanded local recruitment, and provision of bachelor quarters or subsidized transportation for workers) and by public officials (such as alternative approaches to service provision and financing). Finally, such evaluations must be provided in a timely fashion, with many potential users requiring preliminary results within a three to six-month time period and subsequent updates and analyses of alternative strategies in even shorter time frames (Coddington and Gilmore, 1980).

A final consideration which has been noted with respect to every major impact dimension is the requirement for much more extensive validation of impact assessment models. As noted previously, published descriptions of the most widely used models give little indication of the extent to which their accuracy or reliability has been evaluated or of the results of those evaluations. Even when such evaluations have been reported (Thompson et al, 1978; Leistritz et al, 1979), they typically have been based on a very small number of observations, and hence the conclusions which can be drawn are similarly limited. In general, there is a clear need for the evaluation of the accuracy of impact assessments to become a systematic area of research (Murdock and Leistritz, 1979).

IMPLICATIONS: NEEDS FOR FURTHER REFINEMENT AND DEVELOPMENT

Our purpose in this section is to point out implications of our findings in terms of future needs in impact assessment and to discuss those research and analysis emphases which must be altered in order to improve the quality of impact assessments. Our remarks are directed specifically to three groups with vital interests in the impact assessment process: (1) impact researchers, (2) sponsors of impact studies, and (3) policy makers who attempt to utilize the results of these efforts. Overall, we hope to delineate aspects of impact assessment which require additional emphasis and to suggest possible mechanisms to facilitate the strengthening of impact assessments.

Review of current impact assessment practices reveals a need for additional conceptual and analytical refinement within each major impact assessment category. The need for improved conceptualization and refined analytical approaches is even more apparent when the integration of various impact dimensions is considered. If such conceptual and analytical refinements are to be achieved, it is essential to increase the levels of interest among social scientists in pursuing impact research as a legitimate research area with scientific merit. If impact research is viewed as pursuing questions tangential to the major interests of the various disciplines, social scientists will be reluctant to make substantial and continuing commitments to this area of research.

It is our opinion that impact-related studies allow researchers to address a broad range of questions which are basic to economics, demography, sociology, and several related disciplines (Murdock and Leistritz, 1979). The manner in which much impact research has been supported, however, has tended to deter pursuit of these more basic questions. Support for impact-related research has come primarily from agencies charged with preparing the impact statements. Short time periods and, to a lesser extent, limited funding for these efforts frequently have left analysts with no choice but to rely on established techniques and existing databases. To encourage significant advances in the quality of impact assessments, sponsors must give greater attention to initiating studies which will lead to the refinement of analytical techniques and development of expanded databases. At the same time, researchers will be required to be innovative in devising approaches by which contributions to analytical refinement and database expansion can be achieved within the time and budget constraints commonly associated with impact assessment projects. Provisions for ensuring the continuity of research efforts beyond the assessment process, such that techniques and databases can be developed in incremental fashion over the span of several sponsored projects, is a particularly crucial consideration (Murdock et al, 1976).

Further development of impact assessment techniques also will require researchers and research administrators to address a number of questions concerning the organization and management of such research efforts. While a number of researchers and administrators have discussed various possible mechanisms for organizing interdisciplinary research projects (Ellis, 1974; Rossini et al, 1978; Swanson, 1979), it still appears that most projects involving several disciplines have failed to achieve the level of systematic integration which is desirable in such efforts (Swanson, 1979). Certainly, most impact assessment efforts to date appear to suffer from a lack of adequate interdisciplinary integration.

It is imperative, then, that greater emphasis be placed on developing more effective approaches to the organization and management of interdisciplinary efforts and on establishing institutional mechanisms that encourage continuity in such efforts beyond the time span of any single sponsored project. For example, research administrators need to examine whether creation of special institutes or centers with personnel from a variety of disciplinary backgrounds will be a more effective means of encouraging productive interdisciplinary efforts than other, less formal structures involving committees or interest groups focusing on specific topics of multidisciplinary interest. Similarly, the effect of present reward structures in encouraging or deterring long-term commitments to interdisciplinary efforts must be carefully examined.

Finally, there may be a need to provide new avenues of communication for researchers and practitioners involved in impact assessment. Impact-related research, and particularly its interdisciplinary aspects, are often regarded as being outside the mainstream of the major contributing disciplines (for example, economics and sociology). Provision of alternative mechanisms for the communication of new techniques and findings could enhance the development of this field.

In terms of providing more adequate databases, it is readily apparent that more longitudinal and comparative analyses of the impacts of resource developments are essential. Longitudinal analysis is clearly necessary in order to address many of the specific impact-related issues identified in previous chapters. For example, determining how local economic interdependencies or social structures change over time as a result of development requires longitudinal data from developing areas (Murdock and Leistritz, 1979). The need for comparative analyses is equally clear. These studies are particularly important in discussing the effects of various contextual factors. Although most impact analysts assume that contextual conditions influence the various socioeconomic consequences of development, there is presently little evidence as to which of these conditions has the greatest influence or how important their influence may be (Murdock and Leistritz, 1979).

The importance of longitudinal and comparative analyses for impact assessment lies not only in their scientific value but also in their clear pragmatic significance. If such studies reveal contexts in which impacts are particularly severe and others where they are less problematic, this information could be very important in future decisions concerning project siting or impact assistance. These studies thus offer important pragmatic, as well as methodological, advantages.

Future impact assessment efforts must give greater attention to the information requirements of decision makers. Impact analysts need to give higher priority to identifying those entities which will be the principal users of the assessment and discerning the information requirements of these groups, including impact categories to be addressed, specific variables of interest and the most useful levels of analysis. While it must be recognized that determining information needs is not a trivial task and that the expressed needs of decision makers may require substantial interpretation by analysts, a greater commitment to tailoring impact assessments and assessment models to the needs of user groups is essential (Edwards, 1980). Further, there is a need to view impact assessments less as a mechanism for developing a one-time projection and more as an impact management tool to be utilized throughout the project planning and development process. Use of assessments in this mode will require greater commitments by both analysts and decision makers but should result in the development of methods which are increasingly relevant to the needs of their users.

It is an often-noted, yet still highly applicable conclusion that greater attention to the validation of impact assessment models and techniques is essential. Despite the extensive resources devoted to impact assessments and the development of increasingly sophisticated assessment techniques, the validity and reliability of different assessment methods has not been adequately evaluated. A major task for analysts in the early 1980's should be the evaluation of the performance of their methods in comparison to data provided by the Census of 1980, as well as data from other reliable sources. Until such assessments are completed, impact analysts will have little guidance concerning the relative reliability of alternative methods or the effect of various contextual factors on their performance, and decision makers will have little basis for evaluating the reliability of the information provided through the impact assessment process.

Finally, it is clear that the assessment of the socioeconomic impacts of nuclear repositories will require an especially careful and concerted use of existing methodologies and the expansion of methodological techniques in several substantive areas, particularly in relation to social assessment techniques. Although the special effects of repository siting cannot be fully addressed by standard socioeconomic assessment methodologies (and were, thus, not the major focus of this effort), it appears that many of these concerns, as they relate to the siting area, can be partially addressed by more adequate standard socioeconomic impact assessments and subsequent mitigation and community development efforts. If expanded assessments are comprehensively coordinated with the best of existing methodologies, many of the concerns related to nuclear repositories may be diffused. The future challenge for those involved in development of socioeconomic impact assessment methodologies is thus a vital one, that of ensuring that the assessments done for repository sites are accurate, comprehensive, and sensitive to the needs of the residents of potential siting areas.

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