ENVIRONMENTAL IMPACT ANALYSIS : APPLICATION OF ENVIRONMENTAL SYSTEMS MODELS IN THE GEORGETOWN-BUTTERWORTH CHANNEL ZONE

by

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ABSTRAK

Baru-baru ini suatu kesedaran terhadap pentingnya pengurusan alam sekitar telah menimbulkan suatu keperluan mengujudkan teknik-teknik sistematis dalam penganalisaan impek alam sekitar. Melalui penggunaan model-model, dua keupayaan penilaian impek alam sekitar dapat dikemukakan. Pertama, model-model membolehkan ramalan tentang besarnya impek masa depan dan simulasi bagi kualiti-kualiti alam sekitar akibat dari penyebaran bahan-bahan pencemar. Kedua, simulasi model membolehkan pengujian polisi-polisi yang meliputi kembangan perusahaan sewilayah dan lokasi kegiatan-kegiatan di dalam keadaan-keadaan alam sekitar yang berbeza.

Zon selat antara Georgetown-Butterworth telah mengalami perkembangan yang amat pesat akibat dari polisi-polisi rancangan-rancangan lima tahun Malaysia yang menggalakkan perusahaan yang rapi. Pengalaman ini yang meliputi pertubuhan beberapa kawasan perusahaan serta terdapatnya penghijrahan masuk yang besar bukan sahaja menyebabkan perkembangan keupayaan pengeluaran tetapi juga mendatangkan impek-impek alam sekitar. Model-model 'Ecologic-Economic' yang dibentuk daripada model 'Input-output' Professor Leontief amat menggalakkan apabila digunakan dalam meramalkan masalah impek alam sekitar.

Sebaliknya, model-model penyebaran pencemaran yang khusus kepada ekosistem-ekosistem tertentu dapat digunakan untuk ramalan-ramalan mengenai masalah-masalah pemilihan tapak atau penempatan.

Analisa impek alam sekitar telah dilakukan melalui Sistem Penilaian Impek Alam Sekitar atau 'Environmental Impact Assessment System (EIAS)' yang disyorkan. Sistem ini merupakan satu alat bagi pembuat keputusan polisi untuk menilaikan impek-impek alam sekitar untuk keputusan dasar. Dengan ini EIAS menjadi satu komponen dalam Sistem Maklumat dan Pengurusan Alam Sekitar atau 'Environmental Information dan Management System (EIMS)' yang lebih meluas yang merupakan suatu struktur pentadbiran kerajaan untuk memenuhi keperluan-keperluan pengurusan alam sekitar di peringkat nasional. Struktur EIMS juga dicadangkan di dalam tesis ini.

Analisa impek telah meramalkan kenaikan kadar penggunaan air berdasarkan kepada peringkat perkembangan ekonomi yang diramalkan. Implikasi - implikasi polisi akibat dari ini adalah i) suatu pengawasan ketat terhadap kumpulan - kumpulan industri yang diketahui sebagai pengguna air yang berlebihan ii) meninggikan pembekalan air dan iii) amalan penggunaan semula

oleh industri-industri. Suatu anggaran jumlah pembuangan air menunjukkan bahawa jika ada kenaikan keupayan penggunnan semula daripada 25% ke 75% buat tempoh 15 tahun, ini akan membolehkan pembekalan air yang mencukupi. Anggaran BOD (biological oxygen demand) dan bebar gantung (suspended solids) oleh kumpulan-kumpulan industri telah menentukan apakah jenis industri yang merupakan punca utama bagi bahan-bahan pencemar diatas.

Ramalan penyebaran pencemaran di dalam beberapa cabang Sungai Pinang di Pulau Pinang menunjukkan implikasi-implikasi kualiti di hilir sungai bagi kuantiti anggaran pengeluaran BCD yang berbeza. Anggaran-anggaran ini membayangkan perlunya menilai polisi-polisi terhadap penempatan kegiatan-kegiatan perusahaan di sepanjang beberapa cabang lembah Sungai Pinang. Sungguh pun kualiti air cabang Sungai Air Terjun boleh dapat dikawal, cabang-cabang sungai lain memerlukan pembersihan untuk memulihkan kualiti air di dalammya.

Model-model penyebaran di kuala dan di terusan menunjukkan bahawa paras pasang-surut memainkan peranan penting dalam memperkekalkan kualiti air. Dengan menyatukannya dengan butir-butir arus di dalam terusan, di dapati bahawa implikasi alam sekitar adalah lebih serius di bahagian utara terusan. Ini adalah disebabkan oleh aliran keutara semasa air surut di mana isipadu air adalah kecil

dan proses percampuran air pencemar adalah kurang dibandingkan dengan keadaan pada air pasang. Dengan ini, kegiatan-kegiatan perusahaan mestilah ditempatkan seberapa jauh keutara yang mungkin.

Penggunaan model ini kurang mempunyai pengesahan empirikal oleh sebab kekurangan data alam sekitar. Penambahan data alam sekitar adalah dicadangkan. Ini adalah wajib bukan sahaja untuk membolehkan ujian statistikal terhadap kebetulan angka-angka yang dianggarkan tetapi juga untuk tujuan penganalisaan impek alam sekitar.

ABSTRACT

Recent awareness towards the importance of environmental management have brought about recognition of the need for systematic techniques in environmental impact analysis. Through the application of models, two important capabilities in the assessment of environmental impacts become possible. Firstly models enable the prediction of the magnitudes of future impacts and the simulation of environmental qualities resulting from the dispersion of pollutants. Secondly, model simulation would also enable the testing of policies involving regional industrial growth and the location of activities under different environmental conditions.

The Georgetown-Butterworth channel zone has experienced very rapid growth following policies of rapid industrialisation in the Malaysian five year plans. This experience which includes the establishment of a number of industrial estates, accompanied by significant expected inmigration would bring about not only expanding production capacity but also environmental impacts. Ecologic-Economic Models developed from Professor Leontief's Input-Output model showed promise when used for environmental impact

projection problems. In addition to this, other hand pollution dispersion models which are specific to particular ecosystems could be used for predictions involving site selection problems.

The environmental impact analysis was done using a proposed Environmental Impact Assessment System (EIAS). The EIAS is meant as a policy maker's tool for purposes of evaluating environmental impacts for policy decisions. The EIAS thus becomes a component within a wider Environmental Information and Management System (EIMS) which is an administrative structure within the government to meet the environmental management requirements at the national scale. The EIMS structure is also proposed in this thesis.

The impact projection analysis predicted an increasing rate of water consumption given the projected level of growth. The policy implications arising from this would be i) a tighter control over industry groups which have been identified to be large water consumers, ii) increasing the capacity of water supply and iii) the practice of water recycling by industries. A projection of water discharge figures indicated that a shifting from 25% to 75% recycling over a fifteen year period would allow the projected water demands to be met. Projections of BOD

(biochemical oxygen demand) & suspended solids by industry groups identified the industries which are the major pollutors in terms of both these ecological commodities.

Prediction of pollution dispersion in the various tributaries of the Sungai Pinang basin in Penang Island showed the water quality implications downstream for different simulated levels of BCD discharge. These predictions threw light on the need to evaluate policies on the siting of industrial activities along the various tributaries of the Sungai Pinang basin. Although the quality of the Sungai Ayer Terjun tributary could still be controlled, the other tributaries would require cleaning up activities to restore the water quality.

The estuarine and channel dispersion models indicated that tide levels play a significant role in maintaining water quality. Combining this with information on the direction of currents in the channel, it becomes apparent that environmental implications are more serious in the north channel. This is because of the northerly flow during low tide when the volume of water is less and there is less dilution of pollution, compared to the situation during high tide. As such, industrial activities should be sited as far to the north as possible.

The applications however lack empirical validation due to the lack of environmental data. The expansion of the

environmental data base is thus advocated. This is necessary in order not only to be able to statistically test the accuracy of the predicted figures but also to enable more robust models to be applied for the purpose of environmental impact analysis.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Environmental impact evaluation - its role in environmental management

There has been an increasing awareness towards environmental implications resulting from concentrated and rapid transition especially in urban areas, following the implementation of development plans. However, local authorities responsible for administering such development, armed with zoning ordinances, including building and housing codes, face a lack of a comprehensive and systematic estimate of the environmental impact, implied by various proposed plans(1). As it is, estimates of environmental outcomes are available only in very vague and general terms; thus preventing easy identification of possible strategies of environmental management.

Such increasing demands for effective evaluative tools to meet the needs of policy makers and planners have given rise to statutory requirements for the formulation and determination of a set of Environmental Impact Statements (EIS), for every proposed development project in order to put into perspective the potential environmental changes(2). The United States Congress, for instance, passed the National Environmental Policy Act, (NEPA) in 1969, which

requires any project proposal submitted which is likely to "significantly affect the quality of the human environment," to be accompanied by a formulated set of environmental impact statements(3).

This has become policy also in Malaysia. An Environmental Quality Act was passed by Parliament in 1974, and in the Third Malaysia plan it has become policy whereby both public and private agencies embarking on the implementation of projects would have to assess the likely environmental effects and accounting also the means of avoiding such effects(4). A series of workshops has also been organised by the Department of Environment, in the Ministry of Science, Technology and Environment, to introduce and implement environmental impact statements in local project planning, the most important one being the National Seminar on Environmental Management and Environmental Impact Assessment held on 16th. to 20th. October 1978. Local environmental standards, a necessary set of criteria to evaluate the impact statements, are in the process of being determined and gazetted(5).

The EIS, once formulated play several roles in environmental management. Firstly, the statements provide a form of evaluative system over each development plan which can be used as criteria for selecting the optimum strategy while simultaneously avoiding potential undesirable and

possible irreversible and embarrasing consequences. Secondly, with such an evaluative system, policy makers would have greater confidence in approving and making allocations for development projects. Finally, development, controlled in this fashion, could enhance the long term view of the project's implementation, thus providing possibilities for predicting and managing the direction of future growth.

The environment impact statements are supposed to be comprehensive and interdisciplinary, requiring a wide range of expertise. They are also to ensure that the impacts of alternative actions are evaluated and considered within the planning phase in an integrated fashion.

Various analytical tools are now being developed to handle the processing and evaluation of these statements. As an example the U.S. Geological Survey proposed a procedure for evaluating environmental impact with an environmental matrix which serves as a check list linking man's activities and the resultant effects on the environment. The matrix proposed accommodates 8800 possibilities from 88 ecological situations listed vertically, and 100 project types listed horizontally. In actual use however, the matrix can be telescoped to a smaller number of related items as indicated in the case of a phosphate mining lease (figure 1.1).

Figure 1.1 reduced matrix for a phosphate mining lease

	Industrial sities and buildings	Highways & Bridges	Transmission lines	Blasting & Drilling	Surface excavation	Mineral Processing	Trucking	Emplacement of tailings	Spills & leaks
Water quality					2/2	1/1		2/2	1/4
Atmospheric quality						2/3			
Erosion		2/2			1/1			2/2	
Deposition Sedimentation		2/2			2/2			2/2	
Shrubs					1/1				
Grasses					1/1				
Aquatic plants					2/2			2/3	1/4
Fish					2/2			2/2	1/4
Camping & Hiking					2/4				
Scenic views & vistas	2/3	2/1	2/3		2/3		2/1	3/3	
Wilderness qualities	4/4	4/4	2/2	1/1	3/3	2/5	3/5	3/5	
Rare & Unique Species		2/5		5/10	2/4	5/10	5/10		
Health & safety							3/3		

Source: Edmunds and Letey, Environmental Administration, McGraw Hill Book Co. N.Y., 1973 p. 326.

The matrix is used by checking each action that is likely to be involved significantly in a particular human activity by making a slash diagonally from the top right to the bottom left of the appropriate cells. The upper left hand corner is used to indicate the magnitude of impact by a value from 1-10. Similarly the lower right corner is used to indicate the importance of the impact also by a value from 1-10.

On making an assessment of environmental quality, the matrix serves as a useful abstract where the relationship between human activities and the type of environmental implications can be quickly seen. However the technique suffers from the subjectivity involved in assigning a value between 1 and 10 to signify degree of impact. As such the evaluative system itself becomes prone to individual bias. However, given the extent of coverage of the matrix method, little time is allowed for sophisticated methods to be applied before the scores are entered into each cell. Nevertheless more powerful techniques should be sought and utilised for some of the cells which could not be fairly evaluated by subjective means. It is here that further research must be attempted to explore and experiment with alternative ways of environmental impact analysis.

Several points should be considered when devicing a tool for making environmental assessment. The first point concerns assessing environmental implications of development in an aggregated fashion. Although it is the individual activity that pollutes the environment, the resulting environmental quality is actually the collective and cumulative effects of all activities in a given geographic area. As such not only must the individual activity be considered on its own, but also among other activities as well.

Secondly, it is also important to be able to evaluate the long term environmental effects of any development plan. Although some of the activities brought about by development, may have small and unnoticeable immediate impacts, they may be potentially hazardous in the long run. This is referred to as dosage versus concentration of toxicity (6). In some situations environmental indicators may show pollution concentrations beyond acceptable standards, and sufficient attention may be brought to the pollution levels. In other situations, pollutants in small dosage, well below acceptable levels may, in the long run cause serious health complications to people affected.

The third point is related to the spillover effects of a given region upon neighbouring regions. Although

administrative boundaries define the areas of control of the respective local authorities, the general ambient environment has no limits. Thus tabulated data and impact figures being assessed under one local authority for its area of jurisdiction, must be assumed to be for an enveloped environment that ignores external influences. Attempts have been made to extend the area by managing the environment at the regional level, such that a wider environment can be contained within such an envelope. But, classical problems of defining a region are apparent(7). Thus the feasibility and effectiveness of whatever tools created to aid the decision making process is subjected to these problems of regionalisation.

Fourthly, it is important that such impact studies be made for different development alternatives. Project development planning alternatives as pertaining to land development involves either the substitution of different activities in a given location, or that of substituting a different location for a given activity. Effective tools which can demonstrate the environmental implications of these different alternatives either for site or activity would therefore be very essential to environmental management.

Fifthly, environmental impact assessment should also be looked upon from a policy implementation point of

view. Environmental impact statements have not evolved to replace, as substitutes, the current administrative machinery dealing with planning and control. They have rather come about as new scientific and statistical tools to supplement the needs of policy makers and local officials involved in the decision making process. Environmental models and impact studies are thus mainly directed at policy implementation and perhaps guide in policy formulation as it throws light on the general issues requiring policy. It is however important to note that the actual policy identification and formulation is still to be undertaken by policy makers.

Finally, environmental management, like all other management systems, requires data that facilitate analysis for rational decision making. Whilst economic planning is dependent on available statistics generated on production, expenditure and trade, and socio-economic policies are evolved out of data collected through censuses and supplemented by individual researchers, there is however, a continuing lack of a satisfactory methodology that can provide the data input, analysis and statistical output of facts and figures pertaining to the environment. The environmental problems have very often been misidentified, and there have been difficulties also, of evaluating the effectiveness of a chosen strategy, to tackle them. In this

sense the expenditures incurred each year on environmental action would seem to have been wasted as a result of being unable to monitor the effectiveness of the implemented strategy.

There have been attempts made to obtain some degree of sensitivity to the prevailing environmental situations through the many researches and data collected. The research groups include students and very concerned organisations, like that of the Consumer's Association of Penang and the Young Scientists Group, as well as relevant agencies in government, particularly that of the Department of Environment(8). Many of these have been invaluable in meeting some planning needs; and many have identified the right problems which can contribute to some meaningful solutions. But, as yet, the available environmental data sources have only been modest. This situation has hindered progress in the development of the required environmental management system to control the implementation of economic development plans with sufficient regard for environmental implications.

The effectiveness of the environmental management process is dependent on the incorporation of these points. Taken together, they suggest an important role to designing and use of alternative evaluative models of environmental impact. These then may be used to simulate various possible

situations and thus allow for the formulation of appropriate preventive or control strategy in environmental management.

The development of such models involves several technical and conceptual problems yet unresolved. In essence much of the framework of environmental management has been drawn up. The task is then to adapt and experiment with different concrete situations to show the viability of such modelling and analysis.

1.2 The role of models in environmental studies

Environmental management decision making largely involves balancing the good of economic development with the price paid for the deterioration in environmental quality. However, too many factors are involved in the interactions of the many components within an ecosystem which curtail our ability to relate economic development against environmental deterioration. For this reason, several mathematical models have been developed and applied as tools to analyse a particular environmental situation.

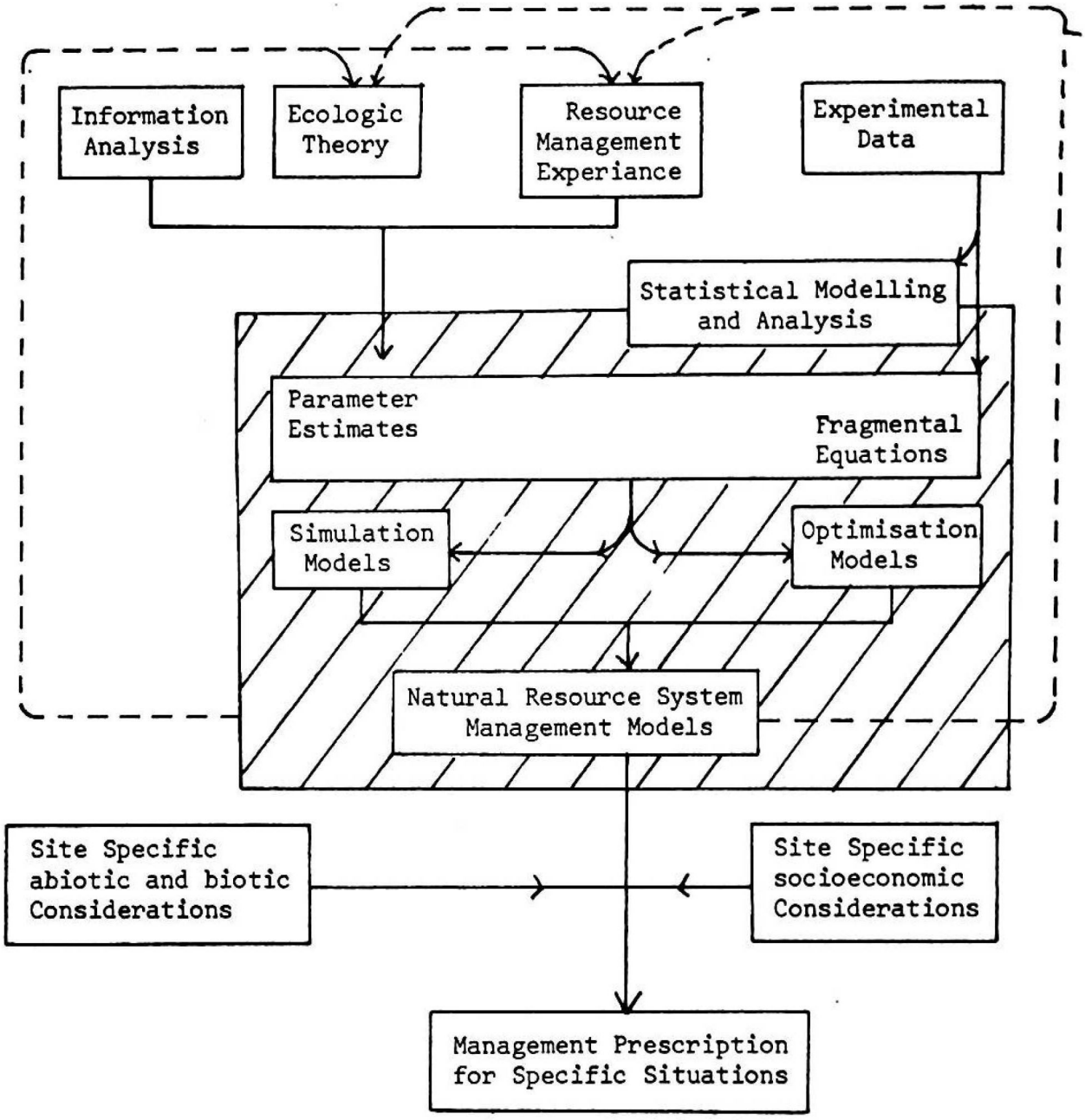
Two major roles of environmental modelling can be identified. Firstly the model presents itself within the framework of a particular management problem, whereby policy simulations can be conducted(9). Secondly the model itself becomes available for further theoretical analysis and development(10). This can then be applied under experimental

situations again, within the framework of another policy problem. The two roles as such, run cyclically, one after another, involving continuous parameter estimation, balancing equations and calibration. These two roles can be explained further with reference to figure 1.2. The figure in schematic form demonstrates how mathematical models of different types can bridge the gap between ecologic theory, management experience, and experimental simulation and planning of environmental management strategy.

The shaded portion of figure 1.2 represents the locus within which models of various types derived from a wide variety of studies play a significant role. These models derive their parameters from data obtained outside this area which are obtained from ecological studies. They include experiences of resource management, information analysis, and data experimentation(11). The resulting models are of various levels and complexity.Some are drawn directly from basic data sources, while others are built upon basic models, and are more complex in nature. The latter are however more specialised and only serve specific purposes. These models feed back and therefore provide deeper insight into the issue of environmental resource management and analysis of experimental data.

Without the analytical power provided by model development, environmental management decisions must draw

Figure 1.2 The Role of Models in Environmental Studies



Source: Reproduced from UNESCO ,Man and Biosphere (MAB) final report No.2 1972, p.15

directly from resource management experiences. This can be perceived by looking at figure 1.2 ignoring the shaded portion and linking the management prescription process directly to the process of resource management experience. The result is subjective judgement of environmental situations on which the policy decisions are made.

However the entire ecological systems analysis does not empirically flow as smoothly as depicted in figure 1.2. For one thing, resource management experiences are not perfect, and experiences do not result in satisfactory information analysis mainly because much of the knowledge is not collected in the form of data. Much of the available information cannot be collected due to cost as well as technical drawbacks.

Modelling however should not be perceived as a substitute for empirical studies of the environment. Models do not cure poor data(12). But on the other hand it does not mean also that models cannot be meaningfully utilised if there is a lack of data base to derive variables for such models. Under those circumstances, however, there is admittedly a lack of predictive capability in such models.

In circumstances where data and information are not available or incomplete for specific ecosystems, models can however provide the ability to derive estimates from alternative sources where the data is available. These

models simulate the condition within the environment, but they must be calibrated by varying the values of the coefficients in the model until the conditions produced is sufficiently representative of the environment and its changes. Once this is done, the operation of the model can go on to experimentations in the form of feeding it with hypothetical inputs and noting the outputs. This represents a cheaper way of testing a great variety of alternative management approaches. Those alternatives that appear to be more promising can then be field validated in terms of actual pilot projects.

The environmental data base should therefore be expanded as much as possible. This is to ensure on the one hand, the ability to incorporate in the models enough of the crucial dimensions of the ecosystems and, on the other hand, once the models have been properly calibrated, the ability to analyse the impacts of development plans on the environment more realistically.

To this end, therefore, the basic requirement of environmental management is some ability to predict environmental consequences. This predictive capability is vitally needed in order to generate information as a guide to making decisions relating to exploitation, production and utilisation of natural resources, and the ability to analyse and plan economic growth more rationally in terms of its

environmental costs. In other words, the end product of such a management system serves two basic purposes. Firstly, it serves as a guide to evaluation of site-specific planning considerations. But more important, secondly, it provides the basic prescriptions to rationalize management with sufficient predictive capabilities over the environmental system. The reason why modelling is an effective method for meeting such objectives is its unique potential for handling simultaneously the highly interdependent and complex problems of the environment(13). In specific terms this covers i) the general ambient environment, ii) the geographic structural units to which these conditions relate and iii) human activities that change these conditions and subsequently the geographic structure. The environmental conditions, geographic structure and the human activities, and their interrelationships together have been identified as the three basic elements of an environmental planning system model(14).

A mathematical model is however merely a description of various relationships and as such is imperfect and incomplete(15). Their formulation and applications are possible only by way of making several simplifying assumptions(16). These are usually related to a static economy, a steady state situation and linear

relationships. Recognizing these limitations, models must be tested and retested in order to suit particular situations before actual policy simulations and policy decisions can be drawn.

1.3 Study focus: objectives and scope

The focus of this study is on formulating and demonstrating the application of environmental impact models using available empirical data in the Georgetown-Butterworth Channel Zone. Its objective is to simulate the use of these models within the framework of the larger environmental management process. To this end, the models used are operated at two different levels. Firstly, a macro ecologic-economic model would be used for projecting future environmental implications given the anticipated level of growth as projected within other planning policies. Secondly several dispersion models would be attempted for simulation impacts on a micro scale, for specific environmental systems.

Projected growth levels are derived from empirical observations of present industrial activities and development trends in the study region. Market demands exerted by consumers of the various industrial outputs, generally termed as final demands, for each projected level bring about certain impact implications. The demands imply

that production levels would have to be geared to supply sufficient quantities. This would involve the consumption of environmental resources and the release of industrial waste which form our interest in environmental impact assessment.

The predicted environmental implications for the different economic situations are projected from a set of interindustry technical coefficients and environmental coefficients. The former is derived for the region from the national interindustry coefficient computed from the national input-output table for 1970. The latter is estimated from empirically collected environmental data for a sample of different industries in the study area.

The Georgetown-Butterworth channel which is chosen for study is described in Chapter II. The area has been the focus of a lot of attention in recent years in studies relating to industrialisation and development. A great deal of interest has been generated in the area in the light of the decentralisation policy which is part of the regional develoment strategy outlined in the Third Malaysia Plan (1976-80). In this regard the Georgetown-Butterworth zone is recognized as an important regional counterpole that has the potential to draw industrialisation away from the main industrial centre viz. the Kuala Lumpur-Kelang Valley and to become the principal growth centre in the northern

Peninsular Malaysia (NPM) region(17). The economic implications of this is more extensive industrialisation necessary to provide employment not only to cope with population growth in the local economy but also to cater for an expected influx of migrants from the rest of the NPM region.

Chapter III and IV are devoted to describing the ecologic-economic model. In Chapter III, the modelling of the regional economy is discussed. This consists of the description of how the regional interindustrial technical coefficients, and how the regional final demand estimates are derived. The model proper is discussed in Chapter IV. Among the many variations of how the Leontief model has been adopted to suit environmental impact applications, three have been compared here and one chosen for use under this thesis. In this chapter also, the estimation of the required environmental coefficients is also described.

In Chapter V, a review is made of some environmental dispersion models to be used for analysing the spatial patterns of pollution. Many of these are very crude models. Nevertheless they are still an improvement beyond pure subjective judgement when used in combination with the macro-impact model above. The application of dispersion models in essense introduce a spatial dimension to the environmental impact analysis being attempted. The

ecologic-econometric approach presents a time dimension but ignore the dispersion patterns of pollution over geographic space. This dispersion is very important since the implementation of development plans generally involve considerations which are site or location specific.

The actual simulation exercise would be reported in ChapterVI. Here several alternative policies will be tested and the different environmental outcomes will be evaluated, through the use of a proposed Environmental Impact Assessment System (EIAS). The purpose here is to demonstrate an operational methodology which could be adopted for purposes of formulating rational policies of national economic interests as well as environmental management objectives.

Finally, to put into perspective the work under this thesis, Chapter VII has been included to discuss the potential development and operation of an Environmental Information and Management System (EIMS) in this country. The analysis of environmental impacts can be effectively carried out with such a system which incorporates the monitoring of the environment, the processing of data and application of analytical tools, and the generation of environmental impact statements to serve the needs of policy makers in the formulation of environmental management strategies.

Notes

(1) Shaenman, P.S., and Muller,T., Measuring Impacts of Land Development: An Initial Approach, The Urban Institute, Washington, 1974, p.5

(2) Rich,L.G., Environmental Systems Engineering, McGraw Hill Book Co., 1973, p.186

(3) Kaiman Lee, and Noberg,J., Environmental Design Evaluation: A Matrix Method, Environmental Design and Research Centre, Massachusetts 1970, p.3

(4) Third Malaysia Plan, Government Press, Kuala Lumpur, 1976, pp. 225 and 226

(5) The first Malaysian standards are for quality of effluents from crude palm oil mills which were gazetted on 3rd November 1977

(6) Hayes,W.J.,Jr., "Test for Detecting and Measuring Long Term Toxicity" in Hayes,W.J.,Jr., Essays in Toxicology Vol.3, Academic Press, N.Y 1972 ,pp.65-77

(7) Isard,W., and Roger Van Zele, "Practical Regional Science Analysis for Environmental Management," in International Regional Science Review, Vol.1, No.1, 1975, p.2

(8) The Consumers Associations of Penang, or CAP has organised several environmental seminars and has put out some publications in the field. The Young Scientists group are composed of students from several schools and has undertaken some studies relating to the environment. At present the Department of Environment within the Ministry of Science Technology and Environment is undertaking an Interdepartment Participatory Programme(IPP) to define and organise efforts towards environmental management in Malaysia, as will be discussed in Chapter VII.

(9) Russel,C.S. and Spofford Jr.,W.O. "A Qualitative Framework for Residual Management Decisions." in Kneese,A.V., and Bower,B.T., Environmental Quality Analysis: Theory and Method in the Social Science, Resource of the Future Inc., John Hopkins Press, Baltimore, 1972, p.120

(10) Isermann,R. "Modelling and Identification of Dynamic Processes; An Extraction," in Vansteenkiste, Computer Simulation of Water Resource Systems, North Holland Publishing Co., Amsterdam, 1975, p.7

(11) This point emphasises the importance of an environmental information referral system, such as the one developed under the International Referal system (now renamed INFOTERRA) sponsored by UNEP (United Nations Environmental Programme). In a more comprehensive way, this should be embedded in an Environmental Information System as will be discussed in Chapter VII.

(12) Edmunds,S. and Letey J., Environmental Administration, McGraw Hill Book Co.(1973) p.99

(13) Nihoul, J.C. , "Modelling of Environmental Systems" in Vansteenkiste, (1975), op.cit.,research conducted by the Belgium National Programme on the Environment. p.133

(14) Ecological effects of energy utilisation in urban industrial system, programme on Man and the Biosphere (MAB) final report UNESCO MAP report series, No.13, October 1973, p.37

(15) A.R.LeFeuvre, "Use of Computer Technology to Develop Mathematical Models for National Water Systems" in Ciaccio,L.L.(Ed.), Water and Water Pollution Handbook, Vol.1, Marcel Dekker Inc., N.Y., (1971) p.264

(16) D'Arge,R.C., "Economic Growth and the National Environment" in Kneese,A.V., and Bower,B.T., (1972), op.cit., p.13

(17) Kamal Salih and Fu-Chen Lo, Industrialisation Strategy, Regional Development and the GrowthCentre Approach, A Case Study of West Malaysia, United Nations Center for Regional Development, Nagoya, 1975, p.117

CHAPTER II

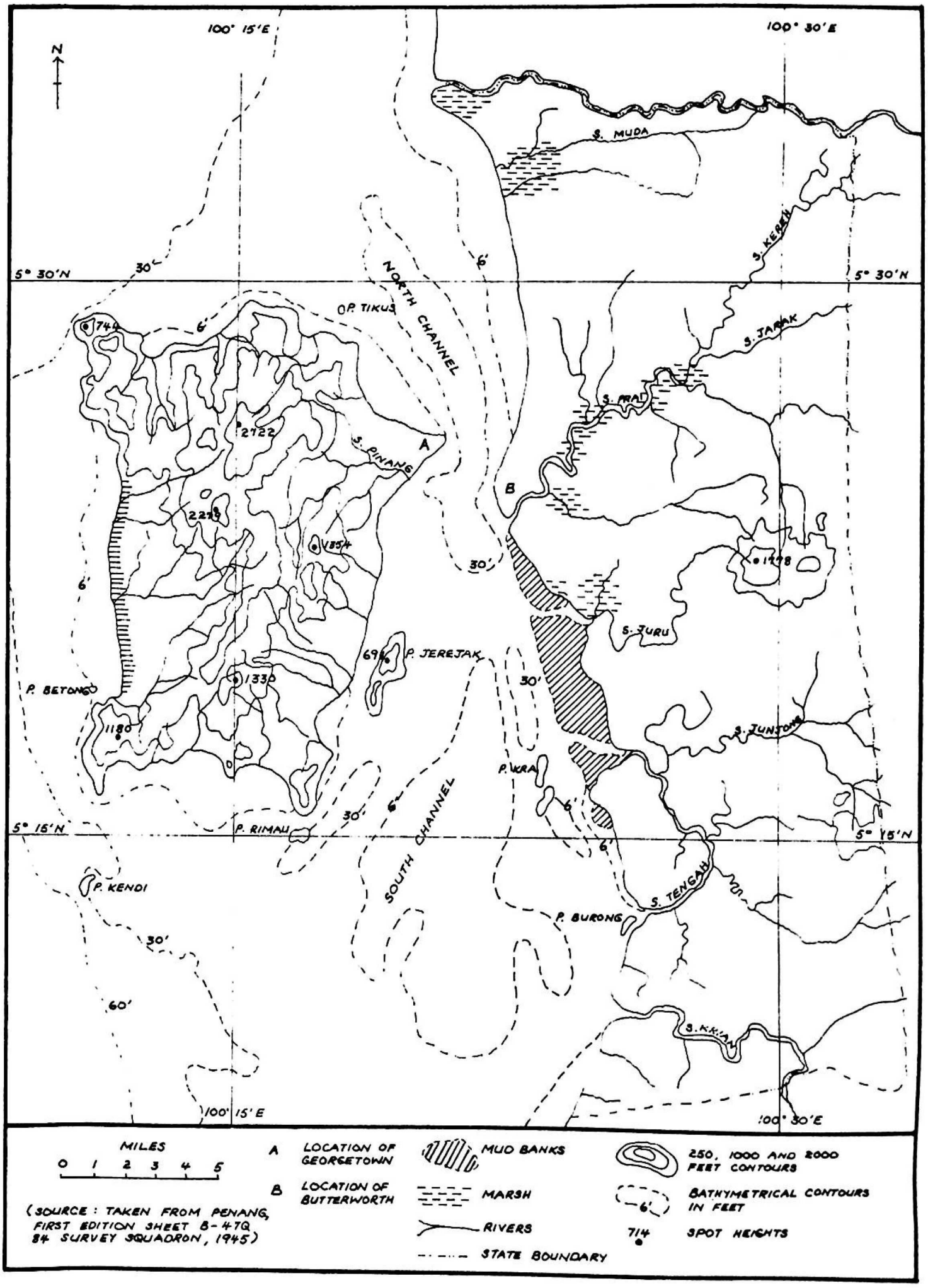
THE ECONOMY AND ENVIRONMENT OF THE GEORGETOWN-BUTTERWORTH CHANNEL ZONE

2.1 Description of Study Area

This chapter provides a description of the characteristics of the study area relevant to this thesis. The observations made here on the prevailing empirical situation will then allow the environmental models applied in the following chapters to draw upon them as elements in the models.

The Georgetown-Butterworth Channel Zone comprises the region around the two-to-eight mile wide stretch of water separating the Island of Penang (Pulau Pinang) from its mainland known as Province Wellesley (Seberang Perai). Penang island and Province Wellesley together, constitute the State of Penang. The Penang Channel consists of a North Channel, which is situated north of the Island's promontary where the City of Georgetown is located, and where the channel is narrowest, and a South Channel to the south of it (figure 2.1). The State of Penang is 397.75 sq. miles(1030.2 sq.km.) in area of which the island mass is 112.77 sq. miles(292.1 sq.km.) and the hinterland, 284.98sq. miles(738.1 sq.km.) making it the second smallest among the 13 Malaysian states.

Figure 2.1: Location and Physiography of Penang



The economic trends in the State of Penang observed by the production figures are used as evidence of the effects resulting from the implementation of development policies. These effects are then translated into environmental impacts, by incorporating environmental factors with the production figures, in the models.

The physiographic observations of the Penang Channel and the Sungai Pinang basin in Georgetown provide the structural framework required for the application of environmental dispersion models.

2.2 Physiography of the Penang Channel

A physiographic observation of the channel reveals a narrow lane of deep water midway between the two land masses, with shallow mud banks on both sides of it (figure 2.2). On the average, tidal streams during highwater at 5 degrees 25 minutes 5 seconds North, 100 degrees 21 minutes 1 second East (somewhere in the middle of the channel east of the Georgetown promontary), is 172 degrees, at the rate of 2.1 knots during spring tides, and 0.6 knots during neap tides. At 5 degrees 20 minutes 0 second North, 100 degrees 20 minutes 0 second East, (off the northern tip of Pulau Jerajak) the tidal stream is 194 degrees, at 1.4 knots during springtides and 0.4 knots during neap tides. The reverse flow towards low water periods for the first location is about 355 degrees at 2.1 knots during spring