A SYSTEMATIC APPROACH TO APPRAISAL/EVALUATION OF CIVIL ENGINEERING PROJECTS, WITH SPECIAL EMPHASIS ON TECHNOLOGY

BY

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(1989)

To my parents

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SYNOPSIS

This study sets out to develop an appraisal/evaluation methodology for Civil Engineering Projects, that incorporates technological considerations into this decision-making process. A secondary objective is the need to ensure that this methodology is flexible, comprehensive and integrated.

As a first step, a background is provided to the concept of technology. This reveals two diverging schools of thought namely, 'Appropriate technology' and the 'Technological fix' schools in relation to the future role of technology. This study shows clearly that both these schools of thought demand a clear understanding of the role of technology in human development. Accordingly, the next portion of the work concentrates on a study of the concepts of 'development' and 'technological development'. Detailed analysis of these two stages of the work, shows that the required appraisal/evaluation methodology, must include for a human and global context, be multi-disciplinary in approach, and consider the existing technological state and mode of transmission of new technology to the relevant community.

A study and analysis of existing methods shows that, in evolving from a conventional cost/benefit analysis (CBA) to 'impact' methodologies and currently, 'integrated' approaches, the process of appraisal/evaluation has become increasingly broader in context.

Drawing mainly on these earlier works, a methodology of appraisal/evaluation has been developed which attempts to meet the requirements described above, and which is a logical extension of the existing methods and trends. Adopting a systematic approach, involving the application of systems analysis and dynamic programming, and based on multi-level matrix methods, this methodology allows for the incorporation of any number of disciplines, interactions between different disciplines and varying levels of analytical detail into the appraisal/evaluation process.

The proposed appraisal/evaluation methodology is validated by applying it to a case study of a civil engineering project (a water supply scheme for a major city in a developing country). The practical viability of the proposed method is illustrated clearly by this case study application. It is concluded that the proposed methodology, though tediously long, provides greater insight to the costs and benefits involved, forces the appraiser to consider many of the aspects ignored in the actual appraisal of the project, highlights the limitations imposed by lacking or insufficient data and emphasises the fragmentary nature of the existing appraisal methods.

Finally recommendations are made which relate to the refinement of the proposed methodology, particularly in the data handling and output formatting areas. Some suggestions are also made in this final chapter, on possible future directions in this field of study.

DECLARATION

No portion of the research referred to in this thesis has been submitted in support of an application for another degree or qualification at this or any other university or other institution of learning.

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CHAPTER ONE

INTRODUCTION, PROBLEM DEFINITION, OBJECTIVES AND MAIN FINDINGS

CHAPTER 1

INTRODUCTION, PROBLEM DEFINITION, OBJECTIVES, AND MAIN FINDINGS

1.1 Introduction

The last hundred years following the industrial revolution have seen radical transformations take place in the human environment. In great measure these changes have resulted from effects of mathematical and physical sciences on the development of technology.

At the beginning of twentieth century, life in the western world was characterised by a transport scene dominated by the horse, the train and very few cars, darkness which could only be lightened by gas, paraffin and tallow as electricity was still in its infancy. Homes were warmed by coal and wood, telegram services were based on the Morse code and letter writing was the main mode of communication. Telephones were few and home and working conditions dreary. Tuberculosis, Cholera and Diphtheria were major killers (Caldecote , 1983).

Today, it is hard to imagine a home in the western world which does not have a whole range of domestic appliances including televisions, radio sets, refrigerators etc. that have replaced the drudgery of living conditions. Millions of dull repetitive jobs have been done away with as new methods of production have evolved. Machines now do much of the hard and dangerous work in industries such as coal mining. Child labour has been abolished. A relatively high standard of medical and health services is available to all who require them. Such has been the effect of advancing technology on the industrialised world (Caldecote, 1983).

In the less industrialised countries, however, even though a privileged few have tasted the fruits of these technological advances, a vast majority have remained largely unaffected and continue to live much as they have for hundreds of years before, in much poverty, disease and illiteracy. Nevertheless, the technological model set up as a result of the industrial revolution has become the one that is being eagerly copied by the

less industrialised nations in their pursuit for development (Ghabbour, 1977). The concept of development has thus come to pass as a technocratic process and our modern world is based on science and technology.

This transformation from a predominantly agricultural economy to an industrial one was characterised by the growth of productive forces, goods produced and needs and consumption in a number of forms (Birou et al, 1977). It has however, given rise to a number of serious side effects. Stated briefly, these include a dwindling of natural resources caused by a meteoric rise in the consumption of industrial products in the last three decades, severe food shortages in the less developed countries, high population increases due to reduction in infant mortality rates and disease, increased pollution levels and environmental degradation. There exists also an ever increasing gap between the 'developing' and the 'developed' countries of this world (Mamadou 1977, Grant 1977, Picht 1977). It is probably more sensible to substitute the terms 'non-industrialised' and 'industrialised' to categorise the world since it is industry which is the fundamental characteristic of the contemporary developed societies. (Mamadou, 1977).

It is also true, that expansion and application of science and technology has created interaction with social, cultural and institutional progress of mankind (Gumaz-Millas, 1977). Disruption of social patterns, the growth of power and domination amongst individuals and nations (Zea, 1977a), the vulnerability of producing very large systems for disruptive action by a few people, and increased unemployment have resulted from these interactions. In spite of the recent initiatives towards world peace, the system of nuclear deterence is being rendered more and more precarious through the emergence of new nuclear powers so that the world is threatened as it has never been before with the twin dangers of war and famine (Picht ,1977).

Development of the industrial civilisation has, it can be argued, created structural problems for mankind, for whose solution, institutions and instruments are lacking because organisation systems of the world are from the pre-industrialisation days. There are no authorities vested with the responsibility of solving these problems, which are mostly of a global nature, nor are there any authorities endowed with the power to institute and train people for emergency measures which cannot be postponed much longer in several instances.

In the face of these existing problems, for which solutions have yet to be found, the world faces prospects of fresh disruptions as emphasis in the development of science and technology shifts from production of empirical tradition bound technologies of the industrial revolution to the more experimental mode of the upcoming 'sun-rise' technologies (Picht, 1977). Today, it is possible to argue that optimism surrounding the idea of progress with advent of the industrial revolution in the eighteenth century, has not met its promise (Zea, 1977b).

Thus it is, as new realms open up daily, in the fields of nuclear power, biotechnology, laser technology, computers, robotics, cynerbetic intelligence, instantaneous distant communication and supersonic transportation, that it becomes increasingly important for mankind to ask itself to what these new developments tend. Equally important, is the need for man to ask himself to what extent he is able to control these new directions being taken in technological advancement and human progress (Collingridge, 1980). It is concern for these issues of the role and control of technological advance, that forms the basis for this work.

1.2 Problem Definition

Many fears have arisen about the benefits and disbenefits to society due to increased use and expansion of science and technology. Some of these are issues at the centre of current controversies but there are a number of issues of great importance to the future of mankind that are very poorly comprehended at present. A list of the issues involved is contained in table 1.1 .

Solutions have been proposed to overcome these problems and consist essentially of two schools of thought (Braun and Collingridge, 1977) namely:-

-An approach requiring a critical scrutiny of the criteria used in decisions on technology and calling for a radical re-thinking and re- organisation of all our social structure. The description of 'Appropriate technology' has been used for this approach.

- An approach advocating use of more of the kind of technology that already exists so that hope for the future lies in continuing improvements

made to society by the application of science and technology, while overcoming difficulties with new and improved technologies. Those who think that technology can solve its own problems are said to believe in a 'technological fix'.

But even while proponents of the 'technological fix' school of thought continue to argue that

".....pessimism characterising recent discussions on technological advancement and the accompanying context of human development is unwarranted so that humanity should go ahead and take its chance despite the possibility of bad luck or bad management, because the prospects are so exciting" (Kahn , 1979)

TABLE 1.1 TECHNOLOGICAL ISSUES FACING HUMAN DEVELOPMENT

CURRENT ISSUES	POORLY COMPREHENDED FUTURE ISSUES
1. Limits to growth	1. Role of technology
2. Poverty	2. Poor management
3. Food shortages	3. Social and cultural change
4. Dwindling resource base	4. Dynamics of technological change
5. Environmental degradation	5. Quality of life issues
6. Rapid technological advance	6. Control of arms and violence
7. Increasing North/South gap	7. Build-up of atmospheric carbondioxide
8. Debt crisis	
9. Population growth	
10. Energy crisis	

Source : Kahn(1979), P68-69, Table 2.4, Brandt(1980), Streeten(1982), Goldemberg(1988) and Kellogg and Schware(1981).

and the 'Anti fix' group continues to deny this, the ills and benefits to society through application and expansion of technology, continue to grow. Indeed it looks like this debate is going to continue for a long time but is unlikely to succeed in controlling the consequences of technology, if in fact this is even attempted.

The main issue then, is to develop the methodologies, institutions and mechanisms which will allow humanity to translate its commitment to technology (advanced or appropriate) for the betterment of mankind through the use of new and hopefully improved ways of making decisions regarding choice and effects of technology.

The problem is thus pin-pointed to the the decision-making process, and hence the appraisal of investments in technology. In traditional terms appraisal may be defined as:-

'.....an application of the theory of economic choice, in particular the choice of investments...'(Schneider , 1973).

Obviously, appraisal methodologies in their conventional form based on this idea, have been weak as instruments of control of technological change and it is this weakness which is the problem.

Implicit within the school of thought advocating the 'appropriate technology' approach, is the idea of radical rethinking of criteria used in choice of technology so that implications of introducing new technologies to any society are assessed before this change is implemented. Any attempt to do this has become known as 'technology assessment'. It is felt that, even though 'technology assessment' cannot replace the political processes of reaching decisions on social and economic problems, it can help the decision makers to make sensible choices in the future. This necessarily requires the pure methodology of investment appraisal to be linked to development objectives and hence to planning and implementation activities in the investment process.

Herman Kahn, 1979 who advocates that

".....humanity should go ahead and take its chances....."

states that, the requirement is the need for "planned muddling through" as on "planning". It is recommended, in fact, that development economists should begin to de-emphasise national planning so that while being important, it is not essential, as proved by the fact that none of the contemporary developed countries, inclusive of Russia utilised national planning during initial stages of their development (Bauer , 1972). The need then, is for flexible and comprehensive planning which, while it provides developmental directions, guide-lines and perspectives does not impose restrictions.

1.3 Objectives Of This Study

The primary objective of this study is to produce a methodology of investment appraisal, for civil engineering projects, which incorporates technological and related implications into the decision-making process.

Secondary objectives of this research, arising essentially from above recommendations and suggestions, is the requirement for the proposed investment appraisal methodology to be:-

-flexible
-comprehensive
-integrated

1.4 Work Done

1.4.1 Conceptual background

This stage consisted of a review of the concepts of technology, development and existing appraisal/evaluation methodologies. Detailed literature reviews of these concepts were carried out and are presented in parts of the first three chapters of the main part of this research.

1.4.2 Analysis of the concepts

The Data obtained from the review of the concepts of technology, development and appraisal/evaluation was then analysed to establish the present and future trends taking place in relation to them. A number of methods were used to carry out these analysis including:-

-sequential tabulation of trends
-interpretation of events using linked arrow networks
-chronological accounts (where relevant) of histories of these concepts
-application of case studies.

The approach adopted in presentation of the analysis in relation to the reviews required that, these be presented within the same chapter in sequential order, rather than as separate pieces of work.

1.4.3 The framework for new work

Results of the review and analysis of the concepts forming the first part of this research were then analysed, as a whole, in this stage of the research, to link the concepts studied. This led to formulation of a framework within which new or extensional works could be carried out in the field of appraisal and evaluation of projects. Accordingly the requirements, analytical tools and the related core concept of decision making were studied as the next step leading to the definition of a frame of reference for the proposed work in establishing an appropriate appraisal/evaluation methodology.

1.4.4 The suggested approach

Having defined the rationale forming the basis of the suggested approach to appraisal/evaluation of Civil Engineering projects, the extent and analytical method was established which consisted essentially of a systematic, multi-level matrix approach to the appraisal process. A suitable format was then established to ensure ease in application of the proposed methodology.

1.4.5 Validation

A case study approach was adopted for purposes of validating the proposed approach. The case study was based on factual information for a major water supply project in a developing country. The presentation included for a description of the actual appraisal done on this project and illustrated application of the proposed methodology to the same project.

1.4.6 Conclusions

The research was completed with a discussion of the work done, a list of conclusions that could be drawn from it and some recommendations for future work in this area.

1.5 Main Findings

The main finding of this work is the clear need to incorporate into the required appraisal process, the following considerations:-

i) Conceptual requirements including:-

- Introduction of a global context into the process
- The urgent need to place human development and condition at the centre of the process
- Recognition of the need to include a multi-disciplinary context into the process

ii) Technological requirements including:-

-consideration of the existing technological state of the relevant society
- inclusion of an analysis of the mode of transmission of new technologies to the relevant society

iii) Methodological considerations which are stated in the objectives and require that the method should be:-

-flexible
-integrated
-comprehensive

The proposed methodology is based on a multi-level matrix method using a systems analysis approach . This method is found to be practically viable and better able to provide an insight to

i)The actual costs and benefits
ii)The technological costs and benefits
iii) The costs and benefits left unaccounted
iv) Limitations of available data
v) Significance of the issues involved.

It is however a time consuming and tedious exercise to appraise a project using this approach. Also lack of sufficient data creates tremendous problems in practical application of the proposed approach. In spite of this, however, the methodology does have the advantage that it highlights this deficiency in the data available.

A number of preliminary findings were also reached and a schematic representation of all these in relation to the main findings are shown in figure 1.1.

1.6 A guide to the thesis

A schematic representation of the chapterisation of this report is given in figure 1.2.

Chapter 2 contains a review of the concept of technology as well as an analysis of the present issues in this area .

Chapter 3 concentrates on a study of development, current developmental issues, technological development and issues facing it at present. An analysis of past, present and likely future trends is also included in this section.

Chapter 4 includes a detailed study and analysis of existing appraisal and evaluation methodologies together with trends followed in the development of these methods.

Chapter 5 concerns itself with the definition of a framework within which an improved appraisal methodology can be evolved. It includes an analysis of the requirements, the available analytical tools and decision-making processes and techniques.

Chapter 6 describes the rationale behind the proposed methodology, the extent of detail likely to be involved and the actual analytical method recommended as well as the format for the presentation of results obtained from its application.

Chapter 7 includes a description of the format suggested for the methodology.

Chapter 8 illustrates practical application of the suggested approach using a major water supply project in a developing country as a case study.

Chapter 9 finishes off the research with a set of conclusions reached, discussion and recommendations for further work on the methodology proposed and finally recommendations for future work in this field.

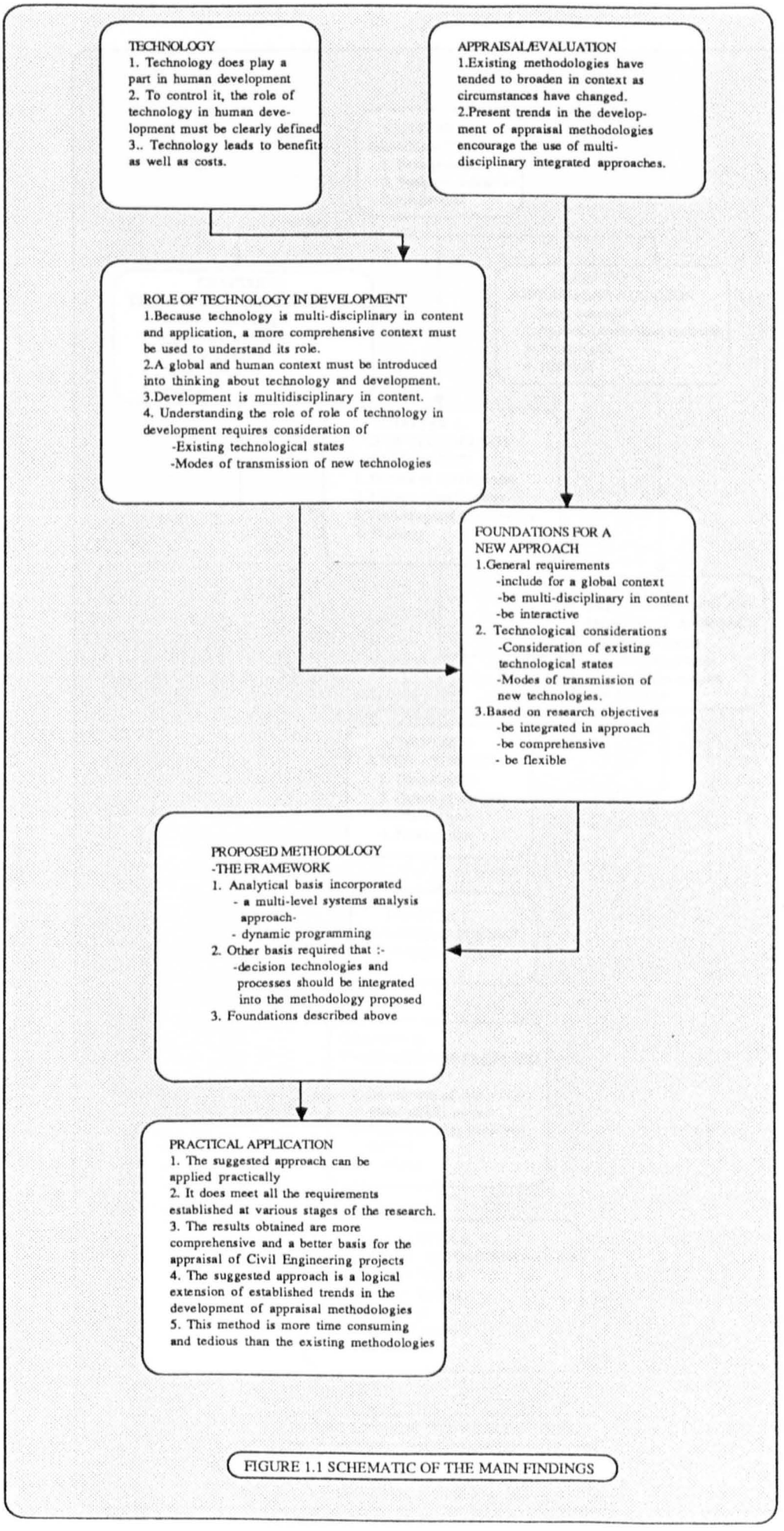

FIGURE 1.1 SCHEMATIC OF THE MAIN FINDINGS

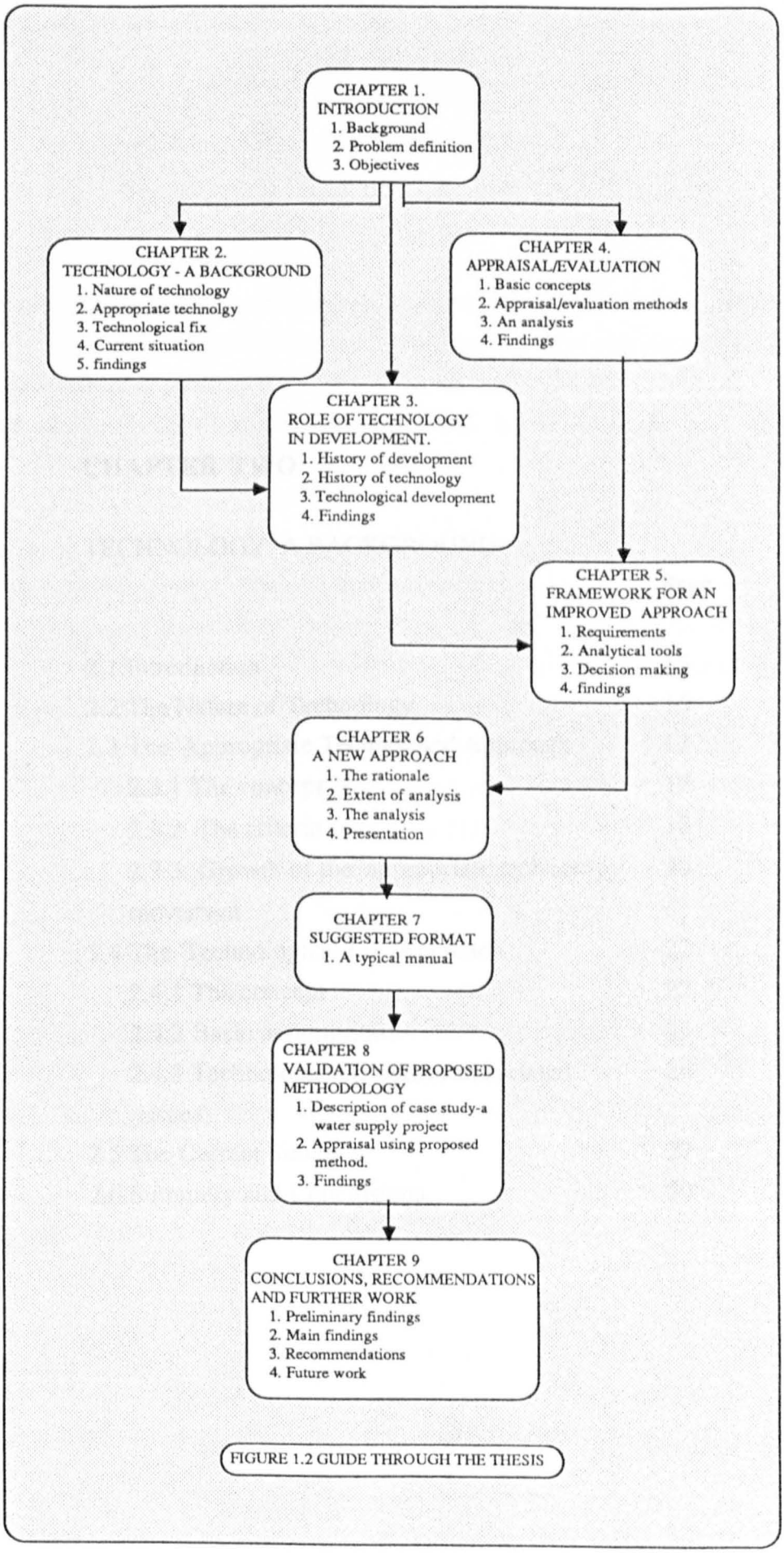

FIGURE 1.2 GUIDE THROUGH THE THESIS

CHAPTER TWO

TECHNOLOGY: A BACKGROUND

CHAPTER 2

TECHNOLOGY: A BACKGROUND

2.1 Introduction

Ours is an age of disorder, crisis and uncertainty about the future. It is also very exciting. In many ways, at the core of the present situation, has been the emergence of the technostructures of today, giving rise to civilizations referred to, variously, as the technocratic age, the space age, the computer age and the 'information' and 'bio' societies.

Imagination of the people who bother to think about the future is gripped by two very conflicting and contrasting pictures, although both acknowledge that changes are taking place all around them, on a scale unparalleled in history. The first of these groups, while accepting that things are changing, finds it difficult to accept that familiar social, economic or political structures around them will be shaken by these changes. They sit back confidently, expecting these changes to pass them by, and the future to continue as always or even to get better. The second type of thinker, becoming increasingly popular, is facing a bleak future brain-stormed by disaster media communications, steady diets of bad news, and nightmare scenarios created by major think-tanks. This group of thinkers conclude that the end of the world is near, if present trends continue (Toffler, 1980).

Based on this type of thinking, two schools of thought have emerged which offer possible ways to solve problems being caused by rapidly expanding applications and production of new technologies in the more advanced countries. These are referred to as:-

i) the 'Appropriate technology' movement
ii) the 'Technology fix' approach

This chapter contains a review of the principles behind these two schools of thought as well as a study of the challenges and issues facing mankind today. Conclusions derived from an analysis of the material reviewed are presented at the end of the chapter. In the main these highlight the importance of understanding the role of technology in human development.

2.2 The Nature of Technology

At present there are many differing and dissenting views being expressed in relation to the definition of the general role and nature of technology. The central point of divergence is concern over socio-economic and political background in formulation of technology and the deterministic nature of technology itself.

In its simplest version, technology can be viewed only as involving changes in artefacts (Murphy, 1967). Recent trends have been to redefine technology in terms of socio-technological phenomenon so that scientific, cultural, institutional and political concerns are taken into account in addition to the material and artefact improvement. Accordingly, a definition by the Organisation for Economic Co-operation and Development (OECD) (1981) which states that:-

"...technology is, in fact, the use of scientific knowledge by a given society, at a given moment to resolve concrete problems facing its development, drawing mainly on the means at its disposal, in accordance with its culture and scale of values." A similar definition, is presented by United Nations Industrial Development Organisation, UNIDO (1981) according to which, technology consists

"....of a system of knowledge, skills, experience and organisation that is required to produce, utilize and control goods and services. "

Today, as we face a quantum leap forward, the whole nature of technology is changing. Until recently technology was thought of as an instrument to change the world and for harnessing the forces of nature to work in the service of man but today they are tending to change man himself. For a long time, organisation was a human device for coordinating and harmonising collective action and technology was employed to achieve this end. With Cybernetics, it is this organising principle which becomes the object of the objective itself. The computer, though always an instrument of a given 'logic' of an organising power, enables the 'rationality' fueling it to extend its determining action under cover of effectiveness (OECD 1977). Recent technological developments can be described as the 3C's and I: communication, control, command and intelligence, and it is these features that are influenced by innovation of computer technology resulting in considerable impact on international technological and economic relationships (Aida, 1983). Arrival of the 'information society' places mankind on the threshold of a new kind of society (Lyon 1988). Even while some talk of the 'information society', others

are using the term 'biosociety' which according to His Royal Highness, Prince Claus of Netherlands (1988) is a society:-

".... in which much use is made of our knowledge of life processes to intervene in those processes to bring about changes in those living organisms..."

Looming ahead is the 'chemical society', already in motion in Japan, as compound plastics and ultimate materials of the future start taking shape in the form of ceramics.

2.3 The 'Appropriate Technology' Approach

2.3.1 The concept

The critical role of technology was first brought into perspective by Schumacher (1979) in 1962, and the term 'intermediate technology' expressed his views on how development could be achieved (Dunn, 1978). However, because this term conveyed this type of technology as necessarily being a backward one, it did not gain much favour, especially in the developing countries. Accordingly a new term was evolved to describe Schumacher's and other similar ideas. The term chosen was 'Appropriate Technology' or AT .

P. D Dunn (1978) who certainly appears to be in agreement with Schumacher describes an 'appropriate technology' as being:-

".....concerned with all aspects of community development leading to a total or integrated development and hence an improved quality of life for the individual members ....."

C. G. Baron (1978) believes that technology is:-

"....more appropriate for production of a given product which employs more labour, preferably at a lower capital investment per unit output, and is at least reasonably competitive with more capital intensive techniques in terms of unit costs of production in the country in which it is used."

R. S. Eckaus (1977) remarks that:-

".....the use of any particular technology is not an end in itself. The criterion for an appropriate technological choice must be found in the essential goals and processes of development."

Thinking along the same lines N. Jequier (1983), defines an 'Appropriate technology' as :-

"..... now being recognised as a generic term for a wide range of technologies characterised by any one of several of the following features; low investment cost per work place, low capital investment per unit of output, organisational simplicity, high adaptability to a particular social or cultural environment, sparing use of natural resources, low cost of final product or high potential for employment."

In a different vein, W. Reidjk (1982), defines 'appropriate technology' as being aimed at :-

".....the production and application of the tools, 'organisational arrangements', 'technical provisions' and 'emancipation' to obtain the means of self-management, self-sufficiency and self-development in order to satisfy and fulfil the fundamental needs of existence, relation and growth of base groups in their own cultural and natural environment."

It is not surprising therefore, that even after fifteen years of recognition, it is not clear what 'Appropriate technology' actually stands for (De Groote, 1988). Nevertheless, it has been shown in work carried out previously by the present author (Bambrah, 1985), that even though no universal accepted definition exists for this term, it is possible to isolate a set of sub-elements, one or more of which appear to form part of most definitions of 'Appropriate technology'.

2.3.2 The criteria

W. Reidjk (1882), reasons that appropriateness of technology is defined in two interrelated ways namely:-

- a direct relationship between fundamental need, the means to satisfy those needs and tools to produce the means
- by the assumption that people at the basis of society are capable of deciding about their own life and work. The ultimate goal is spiritual, economical and political autonomy. Hence self-development, self-

sufficiency and self-management are the three means which decide the appropriateness of a technology.

He defines the key concepts as being:-

i) Self-sufficiency which means that technical provisions are installed as closely as possible within a neighbourhood or region so that it implies a maximum use being made of locally or regionally available resources. The ultimate goal is economic autonomy.

ii) Self- management implies that people manage and possess their own organisations and means of production. Self management according to Walravens (1980) ultimately implies political autonomy.

iii) Self-development refers to emancipation so that individuals are aware of their own capabilities and needs. Self-development can be found in liberation movements all over the world (Rosvak, 1977). Self-development ultimately leads to spiritual autonomy.

Within Reidjk's (1982) framework of the 'appropriateness' criteria, relationships between the key concepts may be viewed as shown in table 2.1 below:-

TABLE 2.1 REIDJK'S AT FRAMEWORK

NEEDS	MEANS	TOOLS
Growth	Self-Development	Emancipation
Relations	Self-Management	Organisational Arrangements
Existence	Self-Sufficiency	Technical Provisions

The hypotheses behind Reidjk's (1982) definition of AT is :-

-fulfilment and satisfaction of fundamental needs of people by self-sufficiency, self-management and self-development in harmony with requirements of the human nature.

-self-sufficiency, self-management and self-development should be applied synchronously.

Within the framework of this criteria, AT is seen, as a development strategy. Hence Reidjk (30) argues that :-

"..... the concepts of appropriate technology may be used as a model of analysis"

so that relevance of a project can be evaluated with regard to its potential to satisfy and fulfil fundamental needs. In this theory then, the concepts of self-sufficiency, self-management and self-development play a central role as a means of fulfilling and satisfying the fundamental needs of growth, relation and existence.

In work carried out previously, by the present author (Bambrah, 1985), it was concluded that a fundamental weakness in the AT movement is caused by the lack of a recognised definition of AT. E. W. Hommes (1982), suggests that this difficulty could be overcome by linking the definition of AT to broader development strategies, a view supported by the present author (Bambrah 1985). From this point of view, the case presented by Reidjk (1982) is very attractive.

2.3.3 Growth of the 'Appropriate technology' movement

A quantitative analysis carried out by Jequier and Blanc (1983) led to the following conclusions:-

-The AT movement is primarily an urban movement based in very large cities, and the structure of the movement closely reflects existing political structures (highly centralised countries tend to have centralised AT movements while movements in countries organised on a federal basis are very decentralised).

-Data regarding fields of activities in this movement confirm the conventional wisdom of AT (e.g solar energy is a major attraction for this field) as well as suggesting that the degree of specialisation of AT

activities in each country closely reflects the technological traditions, social challenges and level of international competitiveness of its different industrial sectors.

- International organisations based in the industrialised world account for almost two thirds of the total world expenditure on AT.

-Developing countries spend almost as much on research and development in AT as the developed countries and in terms of manpower hours, developing countries effort measures more than twice as much as the developed countries.

- Governments are the main source of funds for AT activities throughout the world and have a particularly high input in developing countries. Only eight percent of the movements in developing countries are funded by foreign aid programmes.

-The cost of personnel is much higher in the industrialised countries than in the developing countries although both parts of the world employ almost exactly the same number of people in the AT institutions.

-The major obstacles to innovations in AT are the lack of finance and the presence of bureaucracy.

-An analysis of the communication networks in AT movements show for instance, that organisations in Latin America have as much contact (at least) with Western Europe as with North America, more South to South communication than has been assumed until now , that relatively large amounts of information and technology flow from the South to the North and a small communication between international organisations and specialised AT institutions.

- On the basis of age, budget, staff size and the number of fields of activity all AT institutions fall into one of seven operational types of organisations, so that the most promising paths (or evolutionary dead ends) can be suggested for development of institutions in this movement.

-The ideas of the AT movement have penetrated much deeper and higher than has been believed until now.

-A number of fundamental problems exist in relation to the AT movement namely; lack of experience in starting and developing meaningful activities coupled with rapid growth , complexity of the research and development process and inability of specialised AT groups to master the problems facing technological innovation from conception to successful commercial application and finally the weakness of its links with the investment systems.

-There is a strong need to develop the methodologies, institutions and mechanisms which will allow the system to translate its commitment to AT into new technologies, new ways of doing things and new organisational structures.

- The ways in which interest and receptivity to AT can be expressed in the form of innovations is not clear, and serious work needs to be done on the process of technological decision-making to overcome this vital challenge to the movement.

2.4 The 'Technological Fix' Approach

2.4.1 The concept

A natural consequence of the dawning realisation that finite resources available in the world are insufficient to support indefinite expansion of gross world product and population is mounting opposition to continued economic growth. A further contention that even if resources were available, pollution and ecological imbalance or mismanagement problems would lead to disastrous consequences also supports the need to limit present growth rates of the industrialised nations.

Proponents of the 'Technological fix' school of thought, however, argue for rapid world-wide growth, for developing world industrialisation and for the continued use of more and more advanced technology. They argue that to stop the present rates of growth in the industrialised world is highly impractical, that while the propensity to change may not be inherent in human nature, it is firmly embedded in most cultures.

They argue that everywhere people have become curious, more future oriented and dissatisfied with their condition. According to this school of thought, people want more material goods, covet a higher status and greater control of nature (Kahn, 1979).

Members of this school of thought believe that the coming of a post industrial society need not result in the end of humanity's future economic and technological challenges. It is argued by this school of thought that even after the transition to a post industrial society :-

"……there may still be plenty of room for economic growth, technological dynamism, exploration and innovation - either as ends in themselves or, more likely, as means to a greater end." (Brown and Kahn, 1977).

The scenario for future prospects created by the 'Technological fix' school of thought is aptly described by Kahn (1976) in the following passage abstracted from his book entitled 'The next two hundred years':-

"Two hundred years ago almost everywhere, human beings were comparatively few, poor and at the mercy of the forces of nature and 200 years from now, we expect, almost everywhere they will be numerous, rich and in control of the forces of nature....."

2.4.2 Basic assumptions

As stated by Khan (1979) some sensible assumptions regarding growth and change, which are accepted widely are:-

i) Modernisation is both natural and inevitable.

ii) Change always involves risk, pain and dislocation as well as doubt. Alleviation of these symptoms should be the objective and not elimination.

iii) The manner in which change occurs is subject to a degree of intervention which may not always be knowledgeable and may not always achieve what it sets out to do.

iv) Nothing can prevent further change.

v) Modernisation no longer means "Americanisation" or even 'westernisation'. Each country will have to find its own way forward.

vi) If a relatively unified commitment to the way forward is chosen, it will be much easier and safer to develop.

vii)While not all the experience, methods and equipment of the more developed people are useful, many of these can and should be exploited.

viii)It is simply untrue that no possibility exists for an attractive, human, high quality and effluent technological society.

This school of thought does not accept the concept of "limits to growth" (Meadows, 1974). Modernisation through economic growth and technological advancement is the main theme of this school of thought.

2.4.3 Technological progress and related issues

Applied technology continues to advance at an incredibly rapid pace although, its funding is slowing down slightly, in the face of opposition from many people who are frightened, or annoyed by the emerging post industrial society as well as the many problems it brings about. Herman Kahn (1979) produced a list of a dozen technologies that were in his opinion likely to develop to an extraordinary degree in the next twenty to thirty years. Included in this list were the following:-

i) New and very abundant sources of gaseous and liquid fuels.

ii) Other inexhaustible and relatively inexpensive energy sources.

iii) 'Pollution free' industries and transportation systems

iv) Finding and extracting mineral resources.

v) Conventional and unconventional agricultural and artificial foods.

vi) Materials, progress in fibres, foams, composites, ceramics, crystals, polymers and adhesives.

vii) Human-machine communications and capabilities in:-

-hardware improvements to operating speed, storage capacity, reliability and information transfer rate.

-software improvements involving data compression, programmer productivity, voice communication and automation in programming.

viii) Automation through improved machines, tele-operators, robots and intelligent robots.

ix) Bio-engineering and genetic engineering in agriculture and animal husbandry.

x) Bio-physics and bio-chemistry.

xi) Ultrasensitive sensors for use in satellites and elsewhere.

xii) Other exponential growth in space based commercial ventures.

Herman Kahn (1979) further went on to state that these and other developments in space related technologies offered exciting benefits in the near future.

Today, ten years later, the marriage between computers and telecommunications has certainly started a new age of information. Different perspectives of this new revolution are offered. Some see this revolution as putting personal computers into the home, others see it in direct broadcasting by satellite, automated work or in the use of push-button democracy (Lyon, 1988).

Bio-technology, often described as the second of the late twentieth century scientific and technological revolutions, is also set to affect society, at least as profoundly as information technology. Supporters of bio-technology would argue that the revolutionary character of this technology lies in the range of its applications, which involves a wide number of areas of productive activity related to a broad spectrum of human needs.

On the space front, the United States is back in competition with other countries, in particular, the Soviet Union and Western Europe. To quote John Hiscock (1988) from the 'Daily Telegraph':-

"Now that they are flying again, an American Government might consider itself in a better position to respond to recent Soviet overtures for co-operative ventures such as an exploration of Mars."

Furthermore , as stated by John Petty (1988), the Russians aim to have a man on Mars by the year 2005.

There is however, another side to this story of continued unprecedented progress. The world continues to suffer famine after famine (Ethiopia, Bangladesh and at present Sudan) and floods (Bangladesh, India and recently even France). Erosion and forestation problems continue, as do problems of environmental pollution. Chemicals, fertilisers, sludge and sewage are all finding their way into the North sea. Environmentalists think that irreversible damage is being done. Yet the solution to these problems calls for the consideration of even bigger problems. Even if the North

sea could be cleansed, where would the toxic wastes currently being disposed off into the North sea end up? (1988).

Many attempts have been made over many years, by environmentalists, to alert the politicians to environmental crisis. Yet Mrs Thatcher, for instance, only became impressed enough to act on this matter, after looking at a detailed study of environmental issues contained in an important US congress report, particularly because it contained a warning that the 1988 drought in America was connected to changes in the climate. Issues closer to home, such as the death of thousands of grey and common seals around the British coasts (1988) and poisonous contamination of water treated at works operated by a local authority remained matters of controversy. (1988)

On issues of energy, while energy consumption continues to increase, no 'technological fix' has been found to provide the world with "unlimited and economical quantities of clean energy from renewable or inexhaustible sources" (Kahn, 1979). Instead, the magnitude of disasters that can be caused by what was once considered the most attractive option of nuclear energy is more apparent since the Chernobyl disaster over three years ago. Until, two and a half years after this disaster, dispute was still going on over whether this radioactively blighted town located eleven miles from the nuclear station should be destroyed (Smiley, 1988). In the United States also, safety fears, poor operating conditions and equipment failure have resulted in upto eleven shut-downs a year. This is threatening to compromise the Pentagon's ability to keep it's arsenal of nuclear missiles in operational readiness (Davies, 1988). In the United Kingdom, on the other hand, obsolete nuclear reactors may literally have to be towed away on the back of a lorry so that they can be buried without being opened thus avoiding the danger of radiation (Berry, 1988).

Neither have the technologies developed to drill North sea oil, shown a completely successful track record. Even while the inquiry set up to investigate the cause of the Alpha Piper disaster (in which 167 people died) was going on, an explosion had occurred on the Ocean Odyssey drilling rig leading to the death of a wireless operator (Gribben, 1988).

To sum up, a recent study (Belgrave, 1987) investigating energy security in the 1990's concludes that:-

"....the combined consequence of Chernobyl and of low prices will be to increase the share of oil in energy demand and to increase the share of Middle East oil in OECD imports.....The probability remains of periodic crisis in energy especially oil supplies....The world has to live with uncertainty in energy matters, but governments can act to reduce that uncertainty and consequent vulnerability."

And, of course, as stated by Belgrave (1987):-

"Governments will always be reluctant to take action to avert a future and uncertain risk, and the problems of international co-ordination which is necessary for success in energy policy is formidable."

2.5 The Current Situation

A review of the major challenges and issues facing human progress at present highlights the following as being the areas of concern:-

i) North/South disparities (Brandt, 1980; Streeten, 1982): The gap that exists in the social and economic conditions separating the 'rich' countries from the 'poor' countries (normally referred to as the North and the South) is the most serious problem facing mankind today. As stated in Goldemberg et al (1988) the most telling way to describe this gap is the population and income situation:-

"....with only a quarter of the world's population, the industrialized countries account for 80 percent of the global income."

A recent study of global trends stated that " The less developed countries continue to be the nations with least favourable development profiles. Indeed, the gap in social terms between richest and poorest nations was found to have widened over the fourteen year period of the study. " (Ester, 1988)

The fourteen year period talked of ran from 1970 to 1984.

ii) Global economic problems (Streeten, 1982; Goldemberg, 1988): A serious consequence of high interest rates (due mostly to the recession of 1980 - 83) has been a global debt crisis involving developing country

debtors and the international banking system. So that the " sad reality " according to Ester (1988) is that:-

" the LDC's now find themselves in the position of having to choose between paying interest on their long term debts or dealing with starvation. "

iii) Poverty (Goldemberg, 1988): A fundamental reality in developing countries is the poverty of majority of human beings who live in them, and is reflected in the extent to which elementary minimum needs are not satisfied. Whether it is food, shelter, health, education or employment, the living conditions of the majority of people in these countries are pathetically low. The most appalling aspect of poverty is hunger. Average daily consumption in developing countries is less than 2200 kcal per day (96% of the daily minimum requirement) compared to the average diet in the developed countries of 3350 kcal per day (129% of the daily requirements). In Africa, for instance, there are still countries where one child in four dies before its first birthday, and twenty to twenty five million children less than five years of age die each year in these countries due to diarrhoea caught from polluted water.

iv) Environmental degradation (Goldemberg, 1988): Since 1960's, environmental side effects of energy production and use have been attracting public attention especially acid pollution and disposal of radioactive wastes from nuclear stations in industrialized countries and deforestation, soil erosion and desertification in developing countries. These and other problems are now becoming critical with discovery of the depletion occurring in the ozone layer.

v) Atmospheric carbon dioxide (Goldemberg, 1988; Kellogg and Schware, 1981): The current rate of carbon dioxide accumulation is about 1.2 ppm per year. Man's activities are resulting in a build-up of carbon dioxide in the atmosphere. As the concentration of this gas increases in the atmosphere, more and more infra-red radiation is trapped in its lower layers, resulting in heating up of the earth's surface. This can lead to climatic changes. The precise effect on world agriculture of this effect and related shifts in precipitation patterns would vary from crop to crop and from region to region.

vi) Global insecurity and danger of nuclear war (Goldemberg, 1988): As nuclear weaponry of the United States and the Soviet Union grows, so does the danger of war. The direct and immediate causes of global insecurity are superpower interests beyond their own borders. The dependence of industrialized market economies on Persian Gulf oil is a major source of global insecurity and a potential trigger of nuclear war. As stated by Ester (1988):-

" All in all, the state of peace in the world of 1987 is much more precarious that it was in 1980. "

vii) Nuclear weapons proliferation (Goldemberg, 1988): Although at present, nuclear facilities and spent fuel repositories located in almost all non-nuclear weapon countries are under international safeguards, this provides only a partial and transitory barrier to proliferation. If nuclear power comes to produce a significant fraction of world energy, safeguarding of weapons usable materials will become even more precarious. If global energy strategy is to be compatible with the achievement of global security, it has to come to grips with the problem of nuclear weapons proliferation. This can be achieved either through global control of proliferation or a transition away from oil without overdependence on nuclear power technology.

viii) Under-nutrition and food supplies (Goldemberg, 1988): With at least 450 million people undernourished (about 10% of the total world population) and the possibility of having to feed as many as two billion additional people by the year 2000, the question of adequacy of food supplies becomes open to examination (Scrimshaw and Taylor, 1980). However it is noteworthy that only 25 million tonnes of cereals would suffice to meet requirements of the undernourished population today. This represents only 1.7% of current food production, 15% of world grain trade or 10% of the cereal currently fed to animals in developing countries. If the present global production of about 1500 million tonnes of grain were accessible uniformly to the world population of 4.5 billion people, every person in the world would have enough food -about 2750 kcal per day . Undernutrition today, is due to inequalities and inefficiencies in food distribution (Hall, 1985). Increasing food

production and availability in developing countries is doubly important because it is these countries that will have to absorb the bulk of the 2 billion additional people by the end of the century.

ix) Population growth (Goldemberg, 1988): Practically every problem discussed so far depends on the availability and use of natural resources, but population pressure has been escalating rapidly and it is now fairly clear that a demographic transition is taking place. At present it appears that there will be an enormous increase in world population before it stabilizes in the year 2100. Against this background of rapidly increasing populations in the developing countries, problems associated with poverty, resource limitations, under-nutrition and food production, the environment etc are going to be even more difficult to solve.

x) Energy resources (Streeten, 1982): The world is currently suffering from a crisis of oil, woodfuel and electricity. Most studies of global energy problems are so preoccupied with the supply of energy that they tend to overestimate the growth of energy demand while failing to deal adequately with the end uses of energy or with opportunities for improvements in end-use efficiency. A recent study (Goldemberg, 1988) has concluded that it is possible to formulate energy strategies which contribute to the solution of other major global problems. This study reveals that there is such a wide range of possible outcomes to global energy problems that the future is much more a matter of choice than prediction.

2.6 Summary and Conclusions

Figure 2.1 below shows a brief analysis of the material contained in this chapter.

It is clear from this analysis that the role of technology in human development needs to be clearly defined to ensure an improvement in the human condition as a result of using it. While technology has in many ways made life more comfortable, stimulating and free from drudgery, it is important to understand that:-

-there are many problems that technology cannot solve.
-unanticipated consequences can arise from the use of technology.

-it can be inappropriate to use certain technologies in certain circumstances.

In making decisions about technology three broad aspects need to be considered namely:-

- Maximization of the benefits of technology.
- Minimisation and elimination of the disadvantages of that technology.
- Fair and equal distribution of the benefits, the disbenefits, participation and control of that technology.

These perspectives highlight the need to focus on the question of how benefits and disbenefits of a technology are defined. The objective is to place human development at the centre of technological choices. Accordingly, the next chapter is devoted to a study of the role of technology in human development.

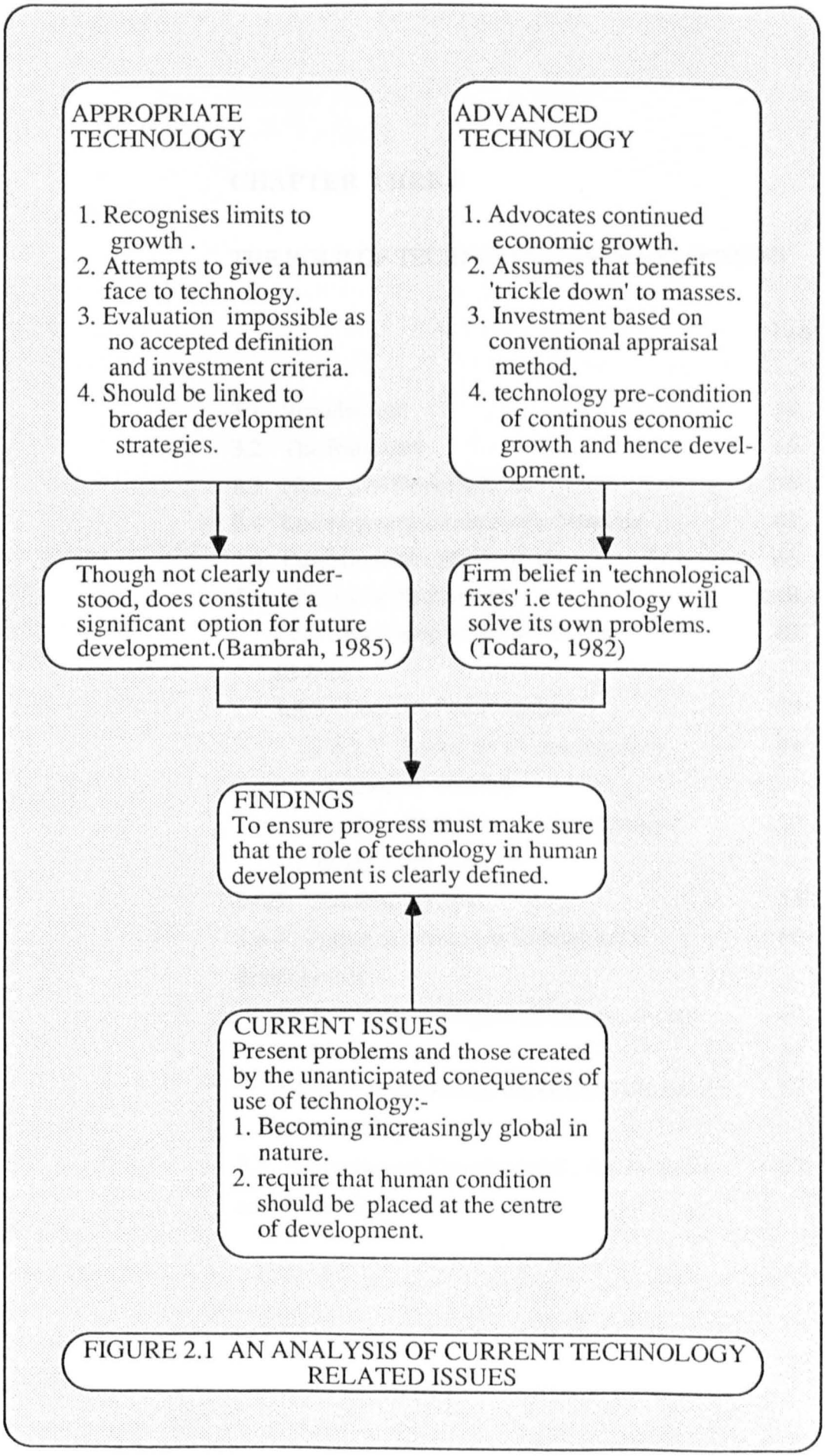

FIGURE 2.1 AN ANALYSIS OF CURRENT TECHNOLOGY RELATED ISSUES

CHAPTER THREE

THE ROLE OF TECHNOLOGY IN DEVELOPMENT

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3.1 Introduction

Following the conclusion reached in the review and analysis of the role and nature of technology, attention is directed in this section to a review of the concept of development. This study reveals a need to incorporate into the thinking on development, a global and human as well as a multi-disciplinary context. Subsequently, an attempt is made to define the role of technology in development. A case study approach has been adapted for this latter part and reveals that in making decisions about the role and control of technology in development, it is particularly important to understand the implications behind the existing technological status of a society, the mode of transmission of new technologies, and the multi-dimensional nature of technology.

3.2 The Rationale

The problem of survival is addressed by human beings in two basic ways (Porter, 1980):-

i) They modify the effects of a hostile environment by producing and using artefacts such as shelters, clothing dams etc. Ways are found at the same time to force the environment to yield the materials necessary for this type of survival.

ii) They employ considerable spiritual and psychological capacities (in the belief that the human mind is capable of re-defining within limits, human needs) to adapt to the environmental realities surrounding them.

Since the first approach requires the use of artefacts, tools and materials for the use of man, it is essentially technological. The second approach is, by contrast, a behavioural one. Although not to the exclusion of the behavioural approach, Western (industrial) nations have chosen a predominantly technological approach as the premier survival strategy. The results of this western brand of survival have been nothing short of spectacular, as described in the last chapter. So popular is this model of human

survival that it has been eagerly copied by other nations, first termed 'backward', and later 'underdeveloped' and even later called 'developing' countries. This model is spreading all over the world and may become the universal trait of all humanity (Ghabbour, 1977) based on the belief that use of advanced technology is what makes industrialized societies 'modern'.

At present, as stated by Juan Gomez -Millas (1977):-

"Western culture has two forms of politico-economic expression sprung from the same roots: the capitalist and the socialist form; both lead to an expansion of industrialism and develop 'modern' societies that are similar in various ways."

Economic growth (real increase in a country's GNP or GDP) is however a main tenant of either of these development models and industrialised societies are characterized by a higher rate of long term economic growth than pre-industrialized societies. The usual explanation for this characteristic has been to break-down growth rate to increase in input of productive factors, (labour and capital works etc) and technological progress as shown by the following equation (1988):-

$$V = Ak + Bl + r$$

where V = rate of economic growth
A and B = structural coefficients
k = increase in capital
l = increase in labour
r = technological progress

Although the central focus of economists and policy planners in articulating theories to explain economic growth has usually been on the accumulation of capital - the value of k, or net investment ratio, technological progress does seem to have been significant at least in the long run. An important fact about this model of development is the embarrassment caused to the empirical economists who have tried to explain the past economic growth of industrial countries in accordance with this model, in that the value of r invariably turns out to be too high: implying that economic growth is determined mainly by technological progress taking place outside the economic system in question.

As stated by Kogane (1988) :-

"If technological progress is indeed interrelated with the development of economic variables, then these in turn could be interrelated with changes in non-economic or social factors such as values and institutions. In order to discern how these interact, we need to observe developments in the long-term past, because the different realms of a society - technology, economy, culture and polity - each have their own distinct rhythms of change."

Ardnt (1987) states :-

"Modernization based on the absorption of western science and technology, attitudes and behaviour, is seen as a necessary condition of economic growth."

Since economic growth is a precondition of long-term development, if as argued by Seitz (1988) :-

".....technology is what makes economic growth.."

it becomes necessary to understand the relationship between technology and development, to justify the use of technology in society.

An attempt to understand the role of technology in development must, then, of necessity direct attention in the first instance to the long-term past. Accordingly, this chapter contains an analysis on the history of 'development' and 'technological development'.

3.3 History of Development

Development as a process has been going on in Europe and elsewhere for many centuries before anyone consciously put forward material progress as a state policy objective (Arndt, 1987). By the middle of the eighteenth century, in Britain at least, material progress had come to be regarded as desirable. From Britain, the policy of material progress or 'modernization' spread firstly to Europe, and then, through European expansion to the rest of the world (Arndt, 1987).

However, from 1850 onwards, western economists (following contributions from J. S. Mill) were taking growth for granted and concerning themselves more with other aspects of economic welfare; distribution, stability and allocative efficiency etc. (Arndt, 1987). Economic growth remained the main concern of 'backward countries' and it

was not until the second world war that a major interest of western governments in the 'Third World' was born, giving rise to modern 'development economics' (Economic Journal, 1943). This interest was born principally out of the fact that the war had changed balance of world power as the former colonial powers emerged greatly weakened and 'National' independence movements greatly strengthened (Seitz, 1988).

Thus, according to the United Nations (1948),the meaning and purpose of development, arising from:-

" ....the improvement of standards of living came to be regarded as the principle objective in the planning of economic development."

so that the central issue became one of 'raising standards of living'. It was this term, which, sharpened and narrowed by the economists to mean:-

"the process by which an economy is transformed from one whose rate of growth of per capita income is small or negative to one in which a significant self sustained increase of per capita income is a permanent long-term feature" (Adelman, 1961)

came to dominate the literature from 1950 and through most of the next two decades so that economic development came to be equated to economic growth.

Until around 1960 this view persisted and capital formation remained the cornerstone of modern development economics. Another feature of those early years was the tendency to think of economic development as 'industrialization' so that it was not until the second world war that the term 'economic development' replaced 'industrialization' (Arndt, 1987). Since economic development could not be left to the market forces, it became normal to plan it, giving rise to 'development' plans (usually five year plans). Thus it was, that, capital formation, industrialization, growth and planning dominated the development scene.

By the end of the fifties, a shift had already begun to occur in economic thinking, so that H. W. Singer (1964), could tell a conference in Ethiopia, in 1961, that there had been a shift in the whole of the thinking about the problem of growth and development so that:-

"The fundamental problem is no longer considered to be the creation of wealth but rather the capacity to create wealth..."

This led to the introduction into economic literature of investment in education , manpower planning and the brain drain, as well as a revival of technical assistance based on new ideas about human capital and education. However this shift in thought :-

"....did not in any direct way challenge the prevailing orthodoxy which virtually equated economic development with growth of per capita income." (Arndt, 1987)

What, it did concern itself with was:-

"The organisation of education and training of the whole people as primary factors in economic growth of the less developed countries." (United Nations, 1963)

One more strand firmly embedded in the economic growth school of thought was treatment of international trade as a primary instrument of economic development (Johnson, 1961). The notion, created in 1950's that international trade might play a more positive role in economic development derived from three concerns namely:-

- the foreign exchange gap of the developing countries
- disenchantment with the import substitution strategy (involving use of specific skills and aptitudes of labour to produce manufactured goods)
- Soviet offers to neutralize the role of the general agreement on tariffs and trade (GATT).

To the negative experience of import substitution policies pursued by some of the countries was added the more positive experience of a number of Asian countries pursuing an export orientated strategy based on export of labour intensive manufactures. This experience was further reinforced as empirical evidence for the 1970's became available which showed that annual rate of growth for manufactured exports was as high in 1970's as in the 1960's in spite of a fall in the real growth rates of developing countries (Riedel, 1984). Thus it was that export oriented industrial development became popular.

However a new wave of thought, with more far reaching change was started off towards the 1960's, which concerned itself more with the objectives of development than the means of development ,and resulted in concern with the concept of 'social development'. As far back as 1965, H. W. Singer (1965) pleaded that:-

"The problem of the under-developed countries is not just growth; but development; development is growth plus change; change, in turn is social and cultural as well as economic; qualitative as well as quantitative.....The key concept must be the improved quality of peoples lives"

In 1969, concern for social development gave way quite suddenly, to a denunciation of growth oriented development economics of the previous twenty five years (Arndt, 1985). The first of these dramatic statements was given by Dudley Seers (1969), who stated that it was:-

".....very slipshod of us to confuse development with economic development and economic development with economic growth."

He argued that the questions to be asked about a country's development should be re-addressed in terms of changes in unemployment, poverty and inequality. In early 1970's this became the dominant theme of development literature. At first the emphasis was on inequality and powerful support was given to it by Robert. S. McNamara (1972a) in 1971 when he declared need for action:-

" ....to reduce the crushing disparities of opportunity..." as illustrated by "...severe maldistribution of income and wealth which exists within the developing countries."

Over the next two years, this emphasis shifted from inequality to poverty so that in 1972, McNamara (1972b) suggested that :-

"....the first step should be to establish specific targets within the development plans of individual countries, for income growth among the poorest 40 percent of the population."

Thus the 'poverty oriented strategy ' ensuring that most of the growth, in GNP, would accrue to the bottom forty percent was adopted aiming at a guaranteed 'minimum income' at or above some established poverty line (Arndt, 1987). In 1975, when the international labour organisation (ILO) launched its 'basic needs' approach, the 'poverty oriented strategy' was given an even more specific formulation. However by this time, the world scene had changed greatly from the late 1960's when the social objectives had first become predominant over economic growth, and priority had to be redirected to 'problems of the poorest countries' and to 'recapture the momentum of economic growth' (1976). The 'basic needs' approach as well as the 'unified

approach' (one of designing of the development indicators better able to capture development as multi-dimensional by involving change in structure as well as output, than GNP per head (Baster 1972) fell victim to these new preoccupations.

Translated into a review of the literature on 'development economics', one can see that the earliest of the major contributions which can be regarded as distinctive of this school and which is still mentioned in textbooks dates around 1943. Most of this "grand' theory however, was produced in 1950's. Hence by the first years of 1960's, students had available to them, the Lewis model, some dual economy theory, the use in planning and the Harrod-Domar 'fundamental equation of economic growth', Rostow's stage theory, Leibensteins's 'critical minimum effort', Rodan's "big push', Scitovsky's externalities, Hirschman's linkages, Nurkse's 'hidden savings potential of disguised unemployment', Leibenstein's model of agricultural wages and productivity, Eckau's on factor proportions, The Mahalanobi's version of the Feldman model, Myrdal's regional polarization theory, the trade pessimism of Prebisch and Singer, the arguments by Rodan and others justifying development planning, the investment criteria debate, balanced and unbalanced growth, arguments for import substituting industrialization and more. (Leeson, 1988; Meier, 1984)

During 1960's, the progress in theory was more modest and problems of underestimation of population growth, food production and foreign exchange difficulties were reflected in the literature giving rise to 'two-gap' models embodying foreign exchange constraints. With the attack on Lewis type models over surplus labour in agriculture, most notably the work by Schults on farmer rationality, attention began to be directed to agricultural development and problems involved in extracting food surplus from agriculture. Planning practice and aid-giving developed alongside rapid growth of literature on planning techniques. Accumulation of data for cross-sectional analysis by Chenery Kuznets and others became possible because of the build-up of statistical resources of the United Nations and the dissemination of Latin American structuralist theories was probably a major element in the evolution of development theory (Leeson, 1988)

Two events marked change in economic ideas in 1970's. The third world countries, by then substantially decolonized shifted their interest from issues of independence to economics. Thus came about the demand for 'a new international economic order' which consisted essentially, of a programme of demands on the developed countries revolving around trade. At the centre of these demands was the recognition that the old system of free trade did not meet the needs of the developing countries. It was argued

that the old economic order blocked social justice by creating an unjust division of wealth, that it embodied dependence and domination as well as lack of reciprocity, and hence this system could not foster authentic development. It was thus concluded that all nations must have effective access to resources and a share in the decisions governing their use.(Goulet, 1980)

The second of these events was the coalition of Arab members of the organisation of petroleum exporting countries (OPEC) and their united action to raise the price of oil. The stage for this action, galvanized by the war between Egypt and Isreal in October 1973, was laid by the Club of Rome in the form of their book entitled, 'The limits to growth' which highlighted early exhaustion of oil and other non-renewable resources. The main conclusions drawn by the 'limits to growth' model were:-

> - if the growth trends in world population, industrialisation, pollution, food production and resource depletion continued unchanged, the limits to growth on this planet would be reached in the next hundred years.
>
> -It was possible to alter growth trends to establish sustainable ecological and economic stability. The sooner this was started, the better would be chances of success. According to this model, the state of global equilibrium could be designed so that the basic material needs of each person on this earth could be satisfied and each person would have an equal opportunity to realise his individual human potential (Meadows et al, 1972).

The 1970's thus began the period that demanded a radical rethinking about development so that, while some saw no point in stopping the growth process (Kahn, 1979), others argued strongly for the case against economic growth as a development strategy (Goldsmith et al, 1972). Concern and disillusionment with development led to the questioning of the whole concept of development. At the same time planning techniques began to become more sophisticated as economic analytical tools such as social cost/benefit analysis and the 'impact' approaches became more elaborate (Leeson, 1988).

By the first years of 1980's, perception had begun to creep in that macroeconomic decisions were being made by governments in a thoroughly myopic way. It was becoming clearer that the limited horizon (both spatially and temporally) which had once been legitimate was no longer so. The world had become a much more

interdependent place so that new approaches were being discussed which held the best hope of tackling spatial and temporal problems (Stewart, 1984). By 1986, the total value of world debt was in excess of three trillion dollars i.e some half of the total gross domestic product of the developing countries, and for more than a decade, the world economy had suffered from low real growth, a major contraction of trade, and record levels of unemployment (Holland, 1987). While part of 1970's and much of 1980's have been concerned with questions of North/South economic relations, the new international economic order, the common fund, special drawing rights, codes of conduct for the multinational co-operations, international monetary fund's (IMF) stabilization policies, the oil shock and latterly, responses to the African famine as well as the changing role of the world bank (Leeson, 1988), an over-riding trend this decade has been the East- West competition among the 'Northern Industrialized Nations'(Williams, 1988).

This decade then, has been a dangerous one, characterised by unparalleled arms expenditures as well as unprecedented imbalances between the rich and poor countries. The wealthiest country, the United States is the world's largest debtor and the capital surplus countries (Japan and Germany) finance the US trade deficit. The developing countries of the world are starved as the arms race, other conspicuous consumption and capital movement arrangements pre-empt a large part of the world's resources and capital away from development in the poorer regions. Using a different style of development (export oriented growth) some success stories have taken place in this period, namely in countries of South East Asia. Unfortunately, development assistance policies in the 1980's have not built on this Asian experience which has resulted from several decades of development effort and sensible management of debt (Williams, 1988).

Also problems arising from East-West tension and the nuclear arms race, growing economic instability in the world and severe economic and social dislocations in the developing regions has brought to the forefront, an almost unprecedented need to strengthen international organizations. This has further been reinforced by growing concern with interdependent global problems (see section 2.5) including acid rains, ozone layer depletion, pollution of air and seas, the need to control drugs trafficking and infectious diseases, world population expansion and mass poverty in developing regions, none of which can be completely solved by a single 'National' government. In short, the 1980's have, in terms of economic growth, been a lost decade and in human terms, a brutal and mindless one (Williams, 1988). At present as stated by Strumpel (1989), with onset of the economic problematique of the 1970's, crisis theories have

dominated public debate of recent historical changes so that there is word of a crisis of legitimacy, of environment and of " overloaded " government.

3.4 Development Issues In The Nineties

As stated by Williams (1988), among the more positive development trends as we approach 1990's consist of:-

- progressive blurring of economic ideology as the centrally planned economies turn more and more to the use of market mechanisms for production incentives and allocation of resources while the free market economies renew selective elements of planning.

- lessening of East-West confrontation with elimination of intermediate and shorter range missiles, the agreed withdrawal and destruction of advanced weapons, Soviet withdrawal from Afganistan and its willingness to discuss other regional conflicts as well as other peace initiatives by the Americans and Russians.

-greater popular participation in politics in developing countries with increasing movements by people of these countries built on greater self-reliance

-a heightened awareness of the fragility of our planet and the importance of environmentally sustainable development.

a new realism in international co-operation as world decision-making becomes more diffuse with wider sharing of the power and direction of world economy combined with the need for a new model of development finance, recognising the centrality of human aspirations and goals.

A number of problems, however will still have tobe faced in the coming years. Crucial among these are:-

i)A crisis of the 'Nation State' in development.

Bjorn Hettne (1988) argues plausibly, in his recent paper that:-

".....a common feature of the crisis in different 'worlds' with their different systematic features is the crisis of the nation- state as a 'normal' form of political organisation."

He further argues that the types of states existing today (socialist and welfare states in Europe, the "over-developed' state in Africa, 'the ethnic' states in Asia and 'bureaucratic authoritarian' states in Latin America) seem to be more or less doomed. New 'modes of regulation' must be found. He then goes on to conclude that alternatives to the 'nation state' have two points of reference: the local community and the earth, so that it is difficult to see how the 'state' can be the crucial actor, except perhaps by regulating more power to other levels of decision-making consisting of the global, regional and local levels.

Other researchers in this field, however take a more moderate view on the role of the 'nation state'. Inis L. Claude Jr (1988) for instance, outlines the crisis as a paradox in that, because of recognition of the pressing need, both to promote realization of the ideal of an orderly world (where one sees commitment as essential to the prevention of trouble in the world) and to cope with the reality of a disorderly one (where need for national security is paramount), states are engaged in continuous tortured efforts to meet both these needs simultaneously.They thus find themselves committed simultaneously to a world order and protecting national security.

Yet others as stated in Kindleberger (1988), Graham (1948) and Cooper (1974) conclude:-

" ....There may be too much government at the national level as Graham thought, but there may be too little government internationally. World government is not yet, and in any case would have to be limited to a few functions. But the need to build world federal functionalism, to use Coopers phrase has surely arrived."

Klein (1988) in discussing international economic trends in the 1990's predicts that:-

".....that the necessity to think in global terms, to find ways to rationalize the world economy.....will grow, as more and more of the world's people insist on sharing in the fruits of modern technology and resource availability."

Thus he argues that failure to establish a strong international system requiring the various nations to share in a free trade system inclusive of enforceable rules of the game, will lead to protectionism, retaliation and ultimately futile retreat into self-destructive isolationism. It can be concluded from these discussions that a global context will have to be incorporated into the concept of development in the coming decades.

ii)The centrality of human beings in development thinking.

To quote Williams (1988) :-

".....for the 1990's we can envision that the great neglect of human needs during the past decade in terms of nutrition, health and education will be replaced by development strategies which put people first."

This view is supported by Mahbub Ul Haq (1988) who argues that it should be an exciting challenge, after many decades of development experience to establish this final supremacy of people in economic development. To achieve this centrality of people however, requires a radical transformation in thinking about development and what is :-

" ....needed today is a continuous process, not a single event or a single set of definitive targets, to institutionalise the importance of human beings in economic development." (SID, North/South Round Table 1988)

Although some emphasis has been placed on the improvement of the human condition through development economics, on the whole little has been achieved, due mainly to the absence of a systematic and sustained approach, both at the conceptual and operational levels. The challenge then, is one of ensuring that a continuous process is generated to place human beings at the centre of future developmental effort.

iii) The need for an inter-disciplinary approach.

Klein (1988) and Spechler (1986), state that:-

"....for the social and human sciences, inter-disciplinary efforts will necessarily become recognized as the only feasible approach to grappling with multi-faceted social problems" and that ".....the importance of developing economic policy in a broader social context will become as obvious as is the current reliance of psychological, sociological or political theory on economic conclusions."

Bruyn (1987) in discussing the meaning of social investment agrees also that the problems are inter-disciplinary and need to be confronted by behavioural scientists, co-operate lawyers, social investors and business scholars. Moreover, Klein (1988) and Heilbroner (1980), forecast that:-

"The desire of the third world countries to foster autonomous and indigenous development will also intensify." He argues that "To the extent that first world values are deemed essential for development, they cannot be implanted by simply insisting dogmatically that the modalities of industrialized nations be grafted in total onto alien cultures and socio-political systems."

This necessarily calls for an understanding of the many different cultural and socio-political dimensions of development. In short :-

"The case for evolving interpenetrating and interdependent cultural and development policies .....is strong."

3.5 Development: An Analysis

An analysis of the developmental trends described above is contained in Table 3.1. Table 3.1 contains a summary of the analysis of developement trends outlined in Arndt(1987) as well as section 3.3 and 3.4 above and appendices A, B and C contained in this report.

TABLE 3.1 DEVELOPMENTAL TRENDS

SOURCE	DRIVING FORCE/NEED	NEW DEVELOPMENT	DEVELOPMENTAL ETHIC/TREND
Monastries	Discipline	Discovery of concepts of space and time	Religious and super-natural beliefs
Crusades and travels	Exploration	Discovery of nature	Natural world
Protestant reformation and rise of capitalism	Understanding	Worldly goods and accumulation	Protestant ethic
Copernicus and Galileo	Need to make sense of the universe	Mental advancement	Beginning of scientific discovery
Newton	Need to manipulate matter	Transformation of man's perception of matter	Scientific revolution
Francis Bacon	Human endowment	Scientific development to aim at material advancement	Material progress and growth
Industries	Capital formation	Rapid expansion of ability to produce goods	Industrial revolution
Empires	Capital accumula-tion and raising living standards	Industrial production and large scale resource exploitation	Colonisation
Independence movements and wars	Need for freedom	Formation of the 'Nation' state	Economic development
National development plans	Capital formation accumulation and raising standards of living	International trade, aid giving and import substitution	Planned development
Development economics	Poverty, inequality and unemployment	Redefinition of development in social terms	'Basic needs' approach to development
North/South dialogue needs. Limits to growth models	Need to re-assess exploitation of finite resources	Demand for new international economic order	Multi-disciplinary approach to dev-elopment to solve spatial and temperal problems
East/West competition	Need for consumer markets	Post-industrial developments in information and bio-technologies	Rapid technological expansion
Global crisis in population, food, energy, economics & environment	Sustainability	Recognition of global inter-dependence, neglect of human condition and multi-faceted nature of development	Inter-disciplinary approaches to dev-lopment including global and human dimensions

The shaded boxes in table 3.1 show likely future developmental trends which emerge from this analysis. This analysis leads to two conclusions namely:-

i)Future trends require inclusion of human and global considerations into the development process

ii)Recent developmental trends call for the consideration of all the dimensions of the present society that act in an interlocked and inter-related way.

3.6 History of Technology

3.6.1 Background to use of case studies

As observed by Brawn (1984), there is nothing new about fear of technology; Prometheus was punished for stealing fire belonging to the gods, the ancient's were punished for looking beyond their natural domain, the machine threatened jobs and took over human skills, the industrial man feared encroachment upon his job. During the 1930's fears about loss of personal freedom emanating from imaginative writers preoccupied with visions of people enslaved by technocratically efficient masters were highly plausible. Lately people have begun to fear the destruction of mankind itself in a nuclear war, through environmental breakdown and the related effects of population expansion, resource limitations and famines. Even more recently, engineering works, long regarded as a cause of pure pride have become objects of worry and protest. Power stations, bridges, dams and motorways once seen as monuments of human ingenuity, are beginning to be viewed as objects of man's folly and his despoiling and abuse of nature. Today these fears include the social impact of microelectronics and biotechnology, unemployment, and loss of skills as well as privacy and freedom. A most pervasive, yet hardest is the fear of isolation, as power of the machines turns much communal effort into isolated tasks.

Many people have tried to understand the changes caused by technology and to offer, analysis of their beneficial or detrimental effects. They have tried also to recommend ways, in which positive features of technological innovation can be stimulated correctly so that the disadvantages can be mitigated. As a result, what has emerged gradually over the last few years is an inter-disciplinary approach that tries to set technology in its right context. This approach views the development of new artefacts and systems as a consequence of historical processes and seeks to comprehend the whole complex of social, economic and political relationships out of which technology grows (Elliot,

1988). A similar contextual history approach has been adopted for the purposes of this research. Two case histories have been carried out and following suggestions by Hughes (1988), "traditional categories with their time-worn connotations" have been avoided. Accordingly, abstractions of interaction, have been defined by the precise language of the case history itself.

3.6.2. Choice of case studies

3.6.2.1 Based on a contemporary 'developed' country

If the distinction of the world since the industrial revolution from the world before it :-

"....is the systematic, regular and progressive application of science and technology to the production of goods and services...." (Rostow, 1971)

then, seventeenth century Britain, with Francis Bacon and Isaac Newton, clearly played a major role in this development (Arndt, 1987). Bacon first linked science with material progress in describing endowment of the human condition with new inventions and riches, as the real and legitimate goal of new science (Bury, 1924). Newton with his synthesis put man in a position to understand, to predict and to manipulate nature (Rostow, 1971).

Though industrialization become the cornerstone of modernity, it has been plausibly argued by Mumford (1934) that the machine had been developing in western Europe, for at least seven centuries before the dramatic changes that accompanied the industrial revolution occurred. It could even be argued, as done by Ardnt (1987) that the real origins of westernization go even further back in history as:-

"Before industrialization could take hold on a great scale, a reorientation of wishes, habits, ideas, goals was necessary."

However the origins of western civilization are dated, it is difficult to see how economic development - the most consequential facet of westernisation, came to represent a policy objective in the embryonic and infant stages of capitalism before 1500 A.D (Arndt, 1987). With the passage of time the idea was formulated and gradually spread into political life and policy that, the expanded wealth of a nation was not merely an objective to be pursued as a means to larger military end, but that

increased production and welfare were themselves legitimate objects of state policy (Rostow, 1975).

Material progress and hence economic growth and development then, had come to be regarded as both possible and desirable, in Britain at least, by the middle of the eighteenth century. From Britain modernization spread, first to Europe, and later through European expansion to overseas areas of European settlement and before the end of the nineteenth century to Russia and Japan (Arndt, 1987). Thus, it can be argued that, it was in Britain that "westernization' began, so that in each place after Britain it was initiated by an intrusion from abroad (Rostow, 1971). It is on the basis of this knowledge that , the first case history chosen for the present work is that of 'Great Britain'.

3.6.2.2 Based on a contemporary 'developing' country

Essentially the developing countries consist of Latin America, Tropical Africa, the Middle East, South and East Asian countries and a number of Island Micro-states.

Table 3.2 contains a list of the contemporary issues and future prospects of development in these countries. As can be seen from the contents of this table, Tropical Africa, from among these 'developing' regions of the world appears to have the bleakest future for the rest of this century. This region, at present, faces prospects of, at best, economic stagnation, and at worst, economic break-down. It is from this region that the second case study is chosen. In particular the concentration is on Kenya, which being among the 'developing' world's lowest income economies is characterised by (Ominde, 1981):-

-one of the highest population growth rates in the world
-faces in the future a crisis of inadequacy of resources including among others land, water and wood fuel
-continued acceleration in soil erosion and deforestation

Additionally, this case history is rendered even more suitable for the present purpose by the fact that this country offers a history of change, caused to a large extent by outside intrusion, into what was regarded as a particularly unattractive place to develop either agriculturally or technologically in the first instance.

TABLE 3.2 CONTEMPORARY AND FUTURE ISSUES FACING DEVELOPING COUNTRIES

REGION	CONTEMPORARY ISSUES FACING DEVELOPMENT	FUTURE PROSPECTS OF DEVELOPMENT
1. LATIN AMERICA (Gwynne, 1988)	The major constraints on Latin American growth are external being related to international trade and capital flows. The 1980's have witnessed economic stagnation and rapid population expansion leading to lower average income and increasing poverty. Massive debts, high interest rates and stagnant exports means that these countries cannot pay back even the interest on debts. Complex and far-reaching restructuring of these economies is required to overcome these problems.	Without a reduction in external constraints and restructuring of Latin American economies, the long term prospects of these countries look grim. Stagnant economies mean stagnant employment and furthur increases in unemployment and underemployment both in urban and rural areas with increased poverty.
2. TROPICAL AFRICA (O'Conner, 1988)	The contemperory issues in this region range from famine, political conflict even, civil war, widespread hunger and malnutrition, failure of efforts to increase food production, economic stagnation and the world's highest population growth rate. Absence of data on natural resources, environmental degradation (soil erosion, deforestation etc) demographic trends and so on.	Very little that has been happening in Tropical Africa in recent years can be regarded as progress and in many respects the prospect, at least for the rest of this century is very bleak. The concern is with the almost certain prospects of decline and breakdown or merely stagnation for the rest of this century as indicated for instance in the Global 2000 report (Barney, 1982)

TABLE 3.2 (CONT) CONTEMPORARY AND FUTURE ISSUES FACING DEVELOPING COUNTRIES

REGION	CONTEMPORARY ISSUES FACING DEVELOPMENT	FUTURE PROSPECTS OF DEVELOPMENT
3. MIDDLE EAST (Lawless, 1988)	The contemporary issues facing the Middle East consist of its vulnerability in world economic affairs, reliance (political and for food) and disunity as well as disarray.	Abed (1986) estimates that OPEC (Oil Producing and exporting countries) may begin to re-establish some of its former power in the oil market beyond 1990. The major future challenge for this region is seen as appropriate formulation and implèmentation of new economic strategies and political survival.
4. SOUTH ASIA (Soussan, 1988)	The main contemperory issues facing this region consist of inequality (spatial and social), environmental maintenance, soil erosion, deforestation, international trade issues and financial flows, population trends and health issues, social change, urbanisation, energy supplies and political stability.	Although there has been some progress in all areas of South Asia in agriculture, the signs are that the prospherous people and regions will develop further, while the poor continue to get poorer. industry also will tend to widen the gap between the rich and the poor. The future of South Asia is seen as one of progress and stagnation, increasing prosperity for some and deepening poverty for others.

TABLE 3.2 (CONT) CONTEMPORARY AND FUTURE ISSUES FACING DEVELOPING COUNTRIES

REGION	CONTEMPORARY ISSUES FACING DEVELOPMENT	FUTURE PROSPECTS OF DEVELOPMENT
5. EAST ASIA (Gray, 1988)	Economic growth in this region over the last two decades has been remarkable and has not been accompanied by a decrease in inequality of incomes. The success of the NIC's (newly industrialised countries) has left in disarray much of the conventional wisdom concerning economic development. This region has created a new centre of advanced technology able to put up an alarming challenge to the older centres of industrial innovation in the West.	East Asian area of dramatic economic success is definable according to Gray (1988) only in cultural terms and the only common factor in this success is culture. The key question regarding this region is one of whether the East Asian experience is transferable
6. ISLAND MICRO-STATES (Connell, 1988)	These are defined as those with less than a million population and relatively low per capita incomes. Constraints to economic development consist of reliance on few primary exports, small domestic markets, reliance on imports, maintenance of plant and machinary, limited industrialisation, dependence on foriegn capital and high expenditure on administration	There seems to be little alternative to a future of economic and cultural dependence that would result from flucuating strategies alternating between different ideologies and internal as well as external sources of support- which are a function of the democratic process.

3.6.3. The case studies

Recent trends in historical research tend to concentrate on the interpretation of past events rather than providing a clear-cut chronological order of these events (Hughes). The reason for this change in perspective is fairly obvious. Recent discoveries have made most people aware of the high risk, costly and uncertain nature of technology. It is thus necessary to interpret past technological advances in an effort to devise instruments of control of technology. In keeping with these trends the case histories presented here contain an attempt of such an interpretation of past trends.

In the first instance however, a chronology of the histories was necessary. Unfortunately these chronological accounts of the histories proved to be too voluminous to be included in the present report. A summarised version of these histories is however presented in appendices A, B and C of this report.

In directing attention to the analysis of the chronological accounts, in order to interpret the events, the material was more easily compressed. Accordingly, the complete interpretation of historial trends is presented in the main text. By adopting a sequential linked arrow network of events as well as a number of visual aids, a pattern of developments has been evolved and is contained in Figure 3.1. For ease of comparison, the charts for Kenya and Britain have been presented alongside each other. This also has the advantage of highlighting similarities in the trends in both places, as well as allowing for the linkage of events occurring in Kenya as a consequence of its colonization by Great Britain.

Emphasis has, of course been placed on the interpretation of technological changes and developmental trends. However to the extent, that other realms of human development (cultural, social, political etc.) interact and can obviously be interpreted as interactions within the main theme of technological development, these other events have also been included in the interpretation. The endeavour throughout, has been to try and understand what causes these changes. In short, a continuous effort has been made to establish the 'driving forces' as it were, behind technological change.

FIGURE 3.1 ANALYSIS OF TECHNOLOGICAL AND DEVELOPMENTAL TRENDS

TRANSMISSION MODE	KENYA: DEVELOPMENTAL TREND	KENYA: TECHNOLOGICAL TREND	DRIVING FORCE	BRITAIN: TECHNOLOGICAL TREND	BRITAIN: DEVELOPMENTAL TREND	TRANSMISSION MODE
INDIGENEOUS	Hunting and gathering skills	Pebble tools	survival	Unknown	Primitive man	DIFFUSION
	Increased mobilisation	Hand axes (stone)	Improved survival	Flint tools, bone harpoons and other mesolithic technology and use of fire	Migrants (from the continent) → Wanderers and gatherers having knowledge of fire and fishing. probably migrant settlers	
	Ability to explore a range of environments. group hunting skills. tree-felling and campsite protection using fire. (Fire-working)	Specialised stone tools (cleavers, stone balls, pointed instruments etc)	Environmental specialisation with exploration / Exploration leading to new settling ground			
	Continued development of skills in hunting. Pottery beginning. Fish an important source of food. Sedentary way of life began to take form as did settled communities based on staple food sources. Obisidian stone began to be mixed and traded over great distances	Wood, leather, bone and stone began to be used. Bows and arrows were produced and stone mined	Beginnings of social contact / Inroduction of agriculture by diffusion and invasion	Neolithic agricultural technology. Knowledge of management of cattle. Big stone culture.	Migrants (from the continent) → Existing migrants absorbed by new migrants from the continrnt	
			Diffusion of development into settled communities Food clothing and shelter needs	Bows and arrows tipped with flint and copper dagger, battle axes. stone blocks wheat and barley, digging stick protection of camps with trenches enclosing upto 14 acres. Introduction of	Migrants (from the continent) → 'Beaker folk' imposed themselves as overlords on existing people intermingling and absorbing them. Skillful handling of enormous blocks suggesting a knowledge of perspective and servile labour. highly skilled use of metal. Trade over	
	Settled communities living in villages	Double-edged stone blades, bone harpoons, potsheds followed by stone bowls.	Indigneous development of communities food and shelter needs identified	tools (hammers, chisels etc) spinning and weaving	ciation of crops and animals led to formation of communities with needs limited to food shelter and clothing	
	Possible Egyptian influence / Imported beads and traces of iron		Peasant farming economy. Diffusion of goods/services led to increased choice	Iron replaced flint and bronze. Wooden ard and coins introduced. Swords, shields daggers and spears used. Wheat and barley staple crops. Also grew beans and vegetables. Sheep important. Timber main building material.	Celts → Cohesion into clearly defined tribes Existence of warfare Peasant economy based on subsistence. Increased movement of goods. Greater development in building of forts and self defence	
	Tribes defined. Grain grounding abilities developed. Trade began with the coast	Saddle quems, pestles mortars, stone bowls	Agricultural development. Organised communal activity and acquisition of goods. Beginning of trade			
			Arrival of money, taxation and currency leading to ownership rights without social obligation. Exploitation of natural resources and trade on a large scale. Mostly a material culture.	Building stone replaced tiles. Lime kilns and interior decor introduced. Pottery widespread. Improved ploughs and stone built corn dryers. Improvement in knowledge of crop rotation and animal breeding. Water wheels used to locate and extract gold ores. Open cast mining of lead. Craftsmen marketing goods. New coins started to pay for troops and introduction of buying and selling as well as taxation. Concept of profit introduced. Transport by water cheaper than overland. Beginning of towns and roads.	Roman conquest → Larger agricultural units with stone domestic quarters, barns, out-buildings, paddocks and enclosures. Stock raising emphasised. Sheep had a special place. Fruits introduced. beginning of purchase and requisition and exploitation of precious meatals. Advance in metal working skills. woollen textiles and rugs renowned. Development of trade and ports, shops and market outlets as shippers began to handle large cargos. Coinage, currency and taxation became inter-related . Towns and stone roads fundamental to Roman civilisation.	
DIFFUSION	With the Bantu invasion development began of agriculture and cattle-keeping skills.	Iron tools and implements and agriculture know-how diffused into the interior (Bantu migrants)	Migration into interior led to greater goods/services availability			
	Expansion of trade in gold,slaves and ivory at the coast. Trade also expanded beyond India to China with the Arab invasion at the coast	Cloth, beads agriculture, poultry, sailing and building (stone) technology. paper introduced but not indigenous (Arab traders)	Invasion of the coast led to deprivation			
				Power sources; Windmills and charcoal	Control of coinage, trade regulation, rapid increase in number of towns. Introduction of strip fields and wheeled plough. Exportation of	
	Degeneration of stone dwellings and other coastal developments.	New crops, improvements in ng of vessels, new building technology (at the coast only) (Portuguese conquest)	Degeneration of existing skills / Mainly Agrarian culture. About10% of the population urban. Control of trade, land and money. Religion becoming important. Power concentrated in the hands of a few.	Coins stamped out of sheets. Roman planning obliterated. Complex land tenure and market system developed which encouraged urban economic growth. Royal and church dues introduced. Evolution of the parish and feudalism. All land held by the KIng. Overseas contact as far as China. Beef cattle and pigs for meat. Sheep for wool. Introduction of heavy wheeled plough.	Anglo Saxon / Danes Normans → textiles but trade in hands of the Frisian merchants. After Norman conquest, lands fell into hands of King. A military system evolved based on mutual dependences expressed through duties and obligations between King and Barons and Lords and freemen. Feudalism developed	
	Dwellings of mud and wattle with thatched, Mukuti roofs began to be made.					
	Expansion of slave trade,disruption of existing social and economic structures. Contact with Europe and USA for the first time . Direct agriculture supplemented by basket-making, pottery, skin-tanning and iron work	Caravan routes established into the interior. Continued depletion of manpower and natural resources (Omani Arabs)	Further social and economic disruption			
			Profit began to be emphasised	Skills in estate management and sophisticated written records. Increased number of urban centres. Development of farming fo the market. Increase in local, regional and international trade. Exportation of finished goods as opposed to raw materials discovered to be more profitable.	Power; waterwheels and wind mills → Land controlled by lords who let out a part to tenants in return for rent and services. The remainder was worked on by tenants and the produce marketed or leased for cash income. Expansion of cloth industry, export of broadcloths and manufactured goods emphasised.	
			Beginning of national trade and industry. Still a predominantly agricultual economy	Decreased dependency on imports as cloth export, leather,pottery, iron and glass working skills developed. Cannon, gunpowder, paper and sandcloth introduced by continental immigrants. Beginning of drainage systems, consolidated land holdings, and combined arable and pastrol farming	Power; coal → Expansion of trade especially exports, commercial and industrial growth. Development of cottage industries. Increased local trade. Villages revolved around churches and manor houses. Exploration of trade possibilities overseas	
			Industrial revolution. Commerce significant. International commercial network evolved	Desruction of 'open-field' system. Improvement in agriculture. development of coke smelting, Watt's steam engine, Spinning jenny, Arkwright's waterframe and Crompton's mule.	Power; steam coal and gas → World-wide network of commerce. increased agricultural output and industrial productivity Women and children replaced men in spinning using machines powered by steam and water	
				Development of canals, waterways, roads and highways led to improved communications and commercial infrastructure, a financial revolution as colonial trade became subordinate to English interests	New power source; petroleum → Expansion of trade. Need for unprecedented sums to finance war with France led to formation of bank of England. Colonies developed to provide raw materials as well as markets for finished goods. trade developed with India.	
IMPOSITION	Eradication of slave trade. Establishment of British protectorate. Kenya became a colony of the British empire.	Military organisation and weaponary (British Invaders)	Abolition of slave trade / Expansion of trade, industry, and colonisation			IMPOSITION
	250,000 Kenyans pressed into African carrier corps. Reduced agricultural output	attacks on railway lines (German attacks)	world war I			
	Reallocation of land. Land taken from the Nandi reserves. Increased African entrepreneurship as well as discord	Renewal of productiuon of food. Introduction of air flights (British soldier settlement)	Economic survival	Factory system expanded. Development of railways and iron smelting. Iron industry moved to coal sites as coke became cheaper than charcoal. Steam power for ships. Discovery of the electron and x-rays	Increased movement of manufactured goods especially iron goods. Continued expansion of cotton industry. Integration of markets, national and international . Increased competition for industrial dominance	
			Liberal trade policies and expanded international trade		Power; electricity →	
	Highly stratified population of European managers, Asian artisans/traders and African labourers	New entrepreneurial ideas and technology (British capitalists)	Capitalism	Subscribers telephone instrument, improved productivity and continued investment in technical innovation Elecrically driven household devices, reorganisation of labour, tractors and energy in nucleus of an atom.	Introduction of gold standard. First world war. Disruption of international economic order, rise in competition, erosion of overseas capital and increased food production	
			Weaker international position			
	Seeds of discontent. New views on the treatment of Africans, formation of Kenya African Union and the beginnings of hope of self determination	Return of African soldiers (Returning soldiers)	Enlightenment	Introduction of gramaphone, radio, television tunsten carbide tools and plastics in household goods. Development of glass fibre and rubber foams. Concept of flats for housing began	Mass unemployment, acute housing shortage, international stagnation of industry and formation of National governments	
			Poverty and depression or extreme wealth			
	Mau-Mau and Maji-Maji revolts. Widespread unemployment and landlessness among Kikuyu. Overabundance of high school educated Kenyans	Small-scale rural entrepreneurship and return to subsistance and barter. Production of low cost indigenous goods	Depressed local capitalism and struggle for independence	Programme of economic aid to Britain. Bretton woods conference. Creation of IMF and IBRD. Discovery of ethylene. Invention of valve amplifier	Structural change abandoning free market and introduction of tarriffs and protectionism. Second world war. Negligible export	
			New basis of international finance			
TRANSFER	Independence. Harambee (self-help) and aid efforts to development. Beginning of democracy	Some infrastructure and a National Government	Beginnings of self development	GATT treaty. Beginning of self-service stores. Widespread demand for processed foods. First digital computer invention. Invention of the transistor	Aim to end quantitative restrictions on trade. Extreme austerity, food and raw material cosumption controlled and rationed	INDIGENEOUS
			Emphasis on exports and capital investment			
	Continued development along guidelines provided by industrialised countries. Extensive investment in infrastructure	Large scale importation of technology	technological dependence	Introduction to tower block estates.Introduction of FM/VHF television transmission, synthetic rubbers, high density polyethylene and world's first nuclear station. Integrated circuit technology and revolution in printing methods.	Suburbanism of Britain. Increased number of cars and concentration on infrastructure. Reform in education system	
			Rapid technological advance			
LIMITED TRANSFER	Import sustitition and 'Basic needs' orientated policies	Production of manufactured goods and trade protectionism	Self-development and management with aid programmes			
	Rural focus and export orientated development	Increased agricultural output	Decreased dependency			
			Continued technological expansion	Continued nuclear power and oil rig, artificial earth satellites, video recorders, microprocessors,laser technology etc. Factory made housing units	Oil and energy crisis, unemployment, shortage of housing, environmental crisis and competition in industrial output	

3.6.4. Future directions in technological development

3.6.4.1 Some thoughts on nature, society and technology

According to Robert. W. Kates (1988) theories on the human environment (using nature, society and technology as the organising concepts and rejecting as a priori subsumption of technology under social direction) can be arrayed along a simple continuum of causality based on the major interactive factors of nature, society and technology. Presented briefly these theories include:-

a) One-dimensional causality including:-

- supernatural control enshrined in myths of creation, divided between earth, gods and sky gods and ordained as dominion, imperatives, abominations and even science.
-Biological determinism rooting explanation of the human environment in biological relationships. (human fate, 'chosen' people both ethnic and racial, Darwin's biological process, co-operation and socialbiology).
-environmental determinism holding that the natural environment, or some selected characteristic thereof determines human, social and physical, traits).
-ecological balance viewing the economy of nature as an interdependent and balanced economy.
-social dominance focusing on the human capacity to tame or even create nature using a subservient technology.
-autonomous technology in which technology creates its own autonomous imperative.

b) Partial theories including:-

-nature and society based within two main intellectual traditions namely nature and nurture, and Malthusian.
-society and technology based on technological deteminism; historically oriented economists and global recession theorists involved in multi-decadal fluctuations.
-technology and nature used to explain the oldest and the newest human environment describing human evolution, environmental

crisis, and prescriptive alternative theories of appropriate technologies.

-nature technology and society made partial not by their factorial emphasis but by their limited domain of application.

c) Interactive theories including:-

-conceptual triads and Quadrads using words to express concepts illustrated with case studies.

-accounting systems built primarily around exchange values of energy , materials or monetary information.

-systems models attempting to bridge the gap between triads and accounting systems e.g Millar's living systems, adaptive ecological models, and global and regional models of doom and hope.

Kates (1988), concludes that one-dimensional theories persist, partial theories evidence power, provide explanation and methodology, and systems models await elaboration, their promise seemingly, always unrealized while the search for distinctive theories of human environment continues. Accordingly in searching for such a distinctive theory he suggests five lines of inquiry:-

-Metatheory where potential lies in taxomising and thus dividing the theoretical estate of human environment and to match the one-dimensional and partial theories to their productive issues.

-Selected theory which argues against eclecticism (commitment to a definite research strategy)

-Extended theory which is extension of well examined middle-range theory e.g extension of natural and technological hazard theory to resources.

-Prescriptive theory where a theory is directed towards some desired ends e.g the use of a climacteric(a critical period in human life) to prescribe a cure (e.g global opportunity and risk in achieving a just and sustainable human environment)

-descriptive theory attempting to explain 'what is' as opposed to 'what ought to be'

3.6.4.2 Thoughts on the cultural dimension of technology

Thomson (1988) states:-

"Real policies, unlike the decisions analysed by decision theory, usually involve a variety of actors and interests, conflicting perceptions of look at our environment ....we see it as it is filtered through a cultural screen ...." He further argues that, "Socially viable ideas of nature correspond to what Mary Douglas has called cultural biases - those sets of shared beliefs and convictions about how the universe is that sustain and justify moral judgements ..." (Douglas, 1978) and finally having analysed the cultural theory "...In giving us certainties that are contradictory but not chaotic, it stops us demanding to know which one is right and directs our attention towards the more realistic task of finding out how best to live with them all."

And in a recent paper Brian Wynne (1988) attempts to develop the argument that rigorous pursuit of the perception of risks leads towards a political and cultural view of technology as a social institution and process. Relating this to a sociological and psychoanalytic, interpretation of attitudes he suggests that technology is viewed as a cultural process. He then goes on to argue that only with this analytical approach to technology can the question of public perceptions of risks in technology dominated societies be taken seriously.

3.7. Technological development- an analysis and some conclusions

The story of man's technological development emerging from figure 3.1 is similar to the one described by Devore (1980) namely:-

".....the discovery of tools, the use of one tool to make another tool, the discovery and deliberate practice of agriculture, the industrialisation process and the melding of technological and scientific efforts in the creation of new potentials and the solving of problems associated with technological and social change."

To this extent, the case histories of Kenya and Great Britain as described above contribute nothing new to this story of man's development. This story has been narrated many times before. Neither is it new to discover that the history of human societies over the last ten thousand years can be explained in terms of successive technological and other revolutions, beginning with hunting and gathering, followed by

the discovery and use of irrigation, agrarian, agricultural, industrial and at present the post industrial revolutions (Devore, 1980; Darcy, 1968)

Nevertheless, some interesting interpretations can be made from these case studies namely:-

i) The effect of the 'mode of transmission' of new technology to a society

Table 3.3 contains an analysis of broad patterns emerging from a detailed consideration of the links between the existing state of development of a society, and the achievement of a new, possibly more advanced, technological state.

It can be seen from these trends that the mode of transmission of new technologies to these countries have had profound effects on developmental trends in the past. In effect, this factor is so powerful in its role of directing developments that it can lead to temporary stoppages in indigenous developments within the communities involved. Hence, as can be seen from figure 3.1, while no external interference occurred during the stone age in Kenya, technology was evolved independently and indigenously within the primitive communities. While in Great Britain, little or no indigenous technological development could occur because new technologies were being diffused and integrated into the existing communities. Later on in history these trends reversed as a result of Britain becoming free of external interference while Kenya coming under foreign domination.

The broad patterns established, hold true for Kenya and Britain, though at different points in time and different states of technological advancement. It can be concluded from this analysis that in developing from one to another state of technological development two characteristics affect the outcome namely:-

-the existing technological state and resource availability
-the mode of transmission of the new technology to the relevant society

In this respect, an attempt to forecast future modes of transmission and consequences of technology reveals the trends shown in the shaded portions of Table 3.3 below. These conclusions indicate a clear need for a global and human context within thinking about technological development in the world today.

ii) The multi-dimensional nature of technology.

Figure 3.1 clearly illustrates that from being a secondary activity necessary for the survival of the primitive man, technological advancement has reached a level where it has become so integrated into his life-style that all aspects of his life from food, clothing and shelter to basic activities such as transport, entertainment etc involve some application of technology. Clearly then, technology has changed man's ways of doing things and his behaviour. It can thus be concluded that technological development is an interdisciplinary activity.

It can be argued as done by Baark and Suedin (1988) that no longer is it enough to comprehend man's relationship to technology with biases such as environmental and engineering science. That, indeed, a more comprehensive perspective is definitely required to deal with the crisis of understanding and managing linkages between technology and other dimensions of human development. It is also necessary to accommodate in our present understanding, not only the growth and extent of technological and scientific knowledge over the last few decades but also the change in context (economic followed by social and now ideological) within which this change occurs (Boyle, 1984).

TABLE 3.3 TECHNOLOGY AND ITS TRANSMISSION

NATURE OF TRANSMITTING PEOPLES	TRANSMISSION MODE OF NEW TECHNOLOGICAL KNOWLEDGE	DRIVING FORCE BEHIND TRANSMISSION
Primitive man and civilisation	Indigneous evolution	Survival
Invasion and inter-mingling with existing peoples	Diffusion through integration	Increased mobilisat-ion and need for agricultural land
Conquest of people and imposition of overlords	Imposition by force	To spread religion and to empire form-ation for resource accumulation
Withdrawal of over-lords and replace-ment with Nations	Transfer through protectionist trade (acquisition by segregation)	Economic growth and increased consumerism
1) Globalised peoples for sustainability Or 2) Isolated super-powers and eradicated peoples	competitive marketing	Improvement in human condition
	Forced introduction	Super-indusrialism and economic breakdown

CHAPTER FOUR

REVIEW OF EXISTING APPRAISAL AND EVALUATION METHODOLOGIES

CHAPTER 4

REVIEW OF EXISTING APPRAISAL AND EVALUATION METHODOLOGIES

4.1 Introduction

A number of methodologies have evolved over the years which involve themselves wlth the appraisal/evaluation of investment proposals. This section is concerned with a detailed study and analysis of these methodologies. Consisting essentially of a review of the existing methodologies in a historical fashion, a number of conclusions have been reached which reveal that the content and context of considerations in these methodologies has tended to broaden out in recent years. Furthermore, it is clearly seen from this study that recent trends in appraisal/evaluation have tended to integrate the different facets of the decision-making process.

4.2 Technology, Appraisal and Evaluation

To the extent that technology existing at a given point in time, determines the quantity and types of good/services or production processes that can be produced/used from or with available resources, technology sets the limits to which human wants can be satisfied. Resource availability and use thus constitute a major concern of the application of technology.

As there are a variety of resources available and usually a number of ways of converting these resources into the required outputs, several options are usually open in terms of the ways in which the required transformation of resources to outputs can take place. It is necessary to justify the use of a particular option in practice. This requires a comparison of all these options as well as an assessment of each one in search of the 'best' alternative. It is the objective of an appraisal exercise to achieve this end.

Consisting essentially of an analysis of a proposal to invest resources, this process provides the basis for making a decision to accept one of a number of ways of investing the resources, or of rejecting the proposal altogether. A number of appraisal techniques have evolved over a period of time to fulfil this propose. Figure 4.8 shows a summary of the evolution of various project assessment techniques and the rest of this chapter contains a study and analysis of these methods.

4.3 Conventional Cost/Benefit Analysis

Cost/benefit analysis is not a recent development. It's origin can be traced back to welfare economics of the nineteenth century, in the works of Dupuit (1844). The first real attempt at formalisation of procedures for valuing costs and benefits was only made in 1950 with the publication of the 'green book' (U.S Government, 1950) in the United States. It was however, with the simultaneous publication of Eckstein (1958), McKean (1958) and Krutilla (1958), that the real turning point came. These publications contained, in essence, an attempt to formalise public investment basis in relation to established criteria of welfare economics. From the United States, it spread to the United Kingdom where it was first applied to the Road Research Laboratory study relating to the motorway M1, (Hender, 1971). Following publication of their works by I. M. D. Little and J. Mirrlees, (1974) CBA found wide application in the developing countries.

The basic principle of CBA is simple; it involves weighing up of the advantages (benefits) and disadvantages (costs) of a project involving public policy, in particular, public expenditure, in order to decide the worth of a project. This technique was initially designed by economists, for particular use in evaluating projects in order to decide which of a number of projects was likely to be the most profitable or in order to decide whether a project was economically feasible or not. Seeking to determine not only whether a satisfactory return to the economy will be provided by the objectives of the project, CBA is an application of the resource allocation theory, a subject at the heart of economics. Stated briefly, CBA involves the following steps:-

-Specification of the objectives of the project.
-Identification of alternative courses of action or projects that would satisfy the specified objectives.
-Identification of the following costs and benefits for each of the alternatives
    i) direct costs and benefits
    ii) indirect costs and benefits
    iii) intangibles
-Calculation of the value of the costs and benefits.
-Calculation of the cost of capital or resources
-Calculation of the net present value at the required discount rate or calculation of the internal rate of return.
-Evaluation of the significance of the intangibles.

-Ranking of the alternatives.

Conventional methods of CBA thus involve, assessment of the benefits and costs of alternative investment policies and, their reduction to a common denominator- a project is accepted if its net benefits exceed its costs and are greater than those of the next best course of action.

Although, the principles of CBA are extremely easy to understand, technical and practical difficulties encountered in its application tend to bring its usefulness into question. The main sources of dissension (Pearce, 1971) centre upon the following

i) the philosophical foundations of CBA
ii) its foundations in economic theory
iii) the serious problems encountered in its practical application

Figure 4.1 outlines the main points of dissension in the use of CBA.

As a result of the weaknesses observed in application of the conventional CBA methodology described above, a number of innovations were introduced into the existing framework. The next section describes these modifications in detail.

4.4 Innovative Cost/ Benefit Analysis

4.4.1 Imaginative Proxy Pricing Mechanisms

Having established the physical nature of a project and the amounts of inputs and outputs to it, the next stage of the cost/benefit method is to proceed with an economic appraisal of the project. It then becomes necessary to decide what rules are to be adopted and what prices are to be assigned to the various inputs and outputs involved. The problem arises from the fact that market prices followed by the private sector fail to reflect social priorities. In general, when planners consider the differences between prices viewed from a private or public point of view, they are concerned with the the following six cases (Faaland and Parkinson 1986) :-

i) money is worth more in public than private hands.
ii) the price of labour since use of labour involves a cost to society.
iii) the price of capital.
iv) the price of foreign capital.

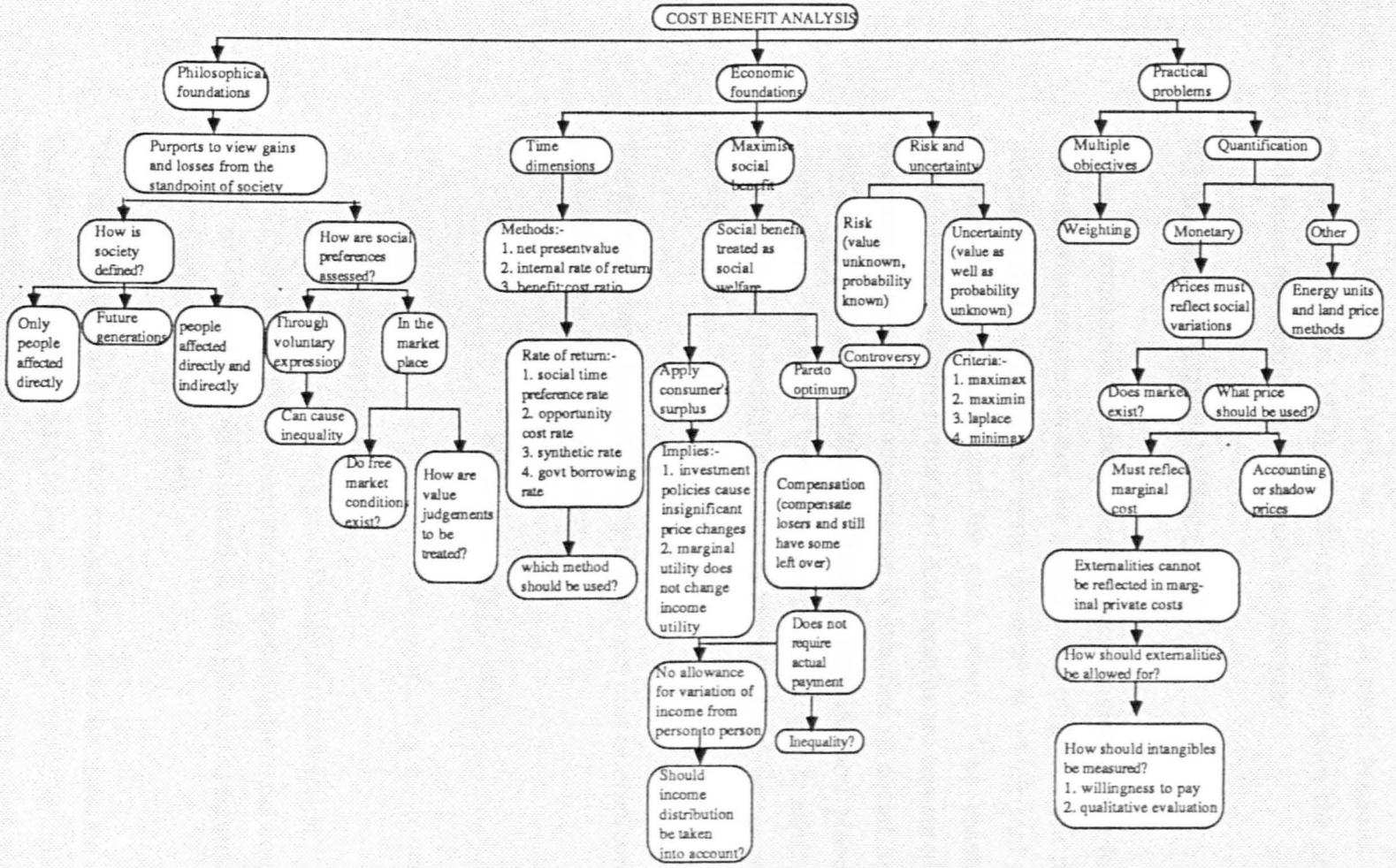

FIGURE 4.1 COST/BENEFIT -AN ASSESSMENT

v) Anomalies due to geographical differences
vi) artificial distortions caused by taxation etc.

A number of systems of project pricing have been devised, including among others that of Little and Mirrlees (1969) as well as UNIDO (United Nations Industrial Development Organisation) (Lal 1972). Dealing essentially with the problems of quantification, both these methodologies have much in common.

i) The Little and Mirrlees Method (1969)

A major contention of the Little/Mirrlees method is that in any price system, what matters is not the actual price of goods but the relative prices as these relatives measure the rates at which real goods and services can be exchanged for each other. The essence of the Little/Mirrlees system is that costs and benefits are measured in foreign currency and particular importance is attached to social income (Lal 1972, Faaland and Parkinson 1986). This method places a lot of emphasis on the use of border prices of traded goods arising from the belief that most developing countries are very far from optimising their foreign rate (Lal 1972).

The cost of labour is evaluated by using a net cost of employment called a shadow wage rate (SWR) where

$$SWR = C - 1/s\ (c - m)$$

where:-
C = payment to worker
1/s = coefficient giving social value of consumption
c = increase in consumption resulting from the employment
m = loss of output assumed to take place in agriculture because worker moves to town

The issues raised in figure 4.2 naturally lead to the question of whether the aims that will be achieved by this method cannot be established by other methods of a less complicated nature. The experience of those who have worked in less developed countries is that, with comparison

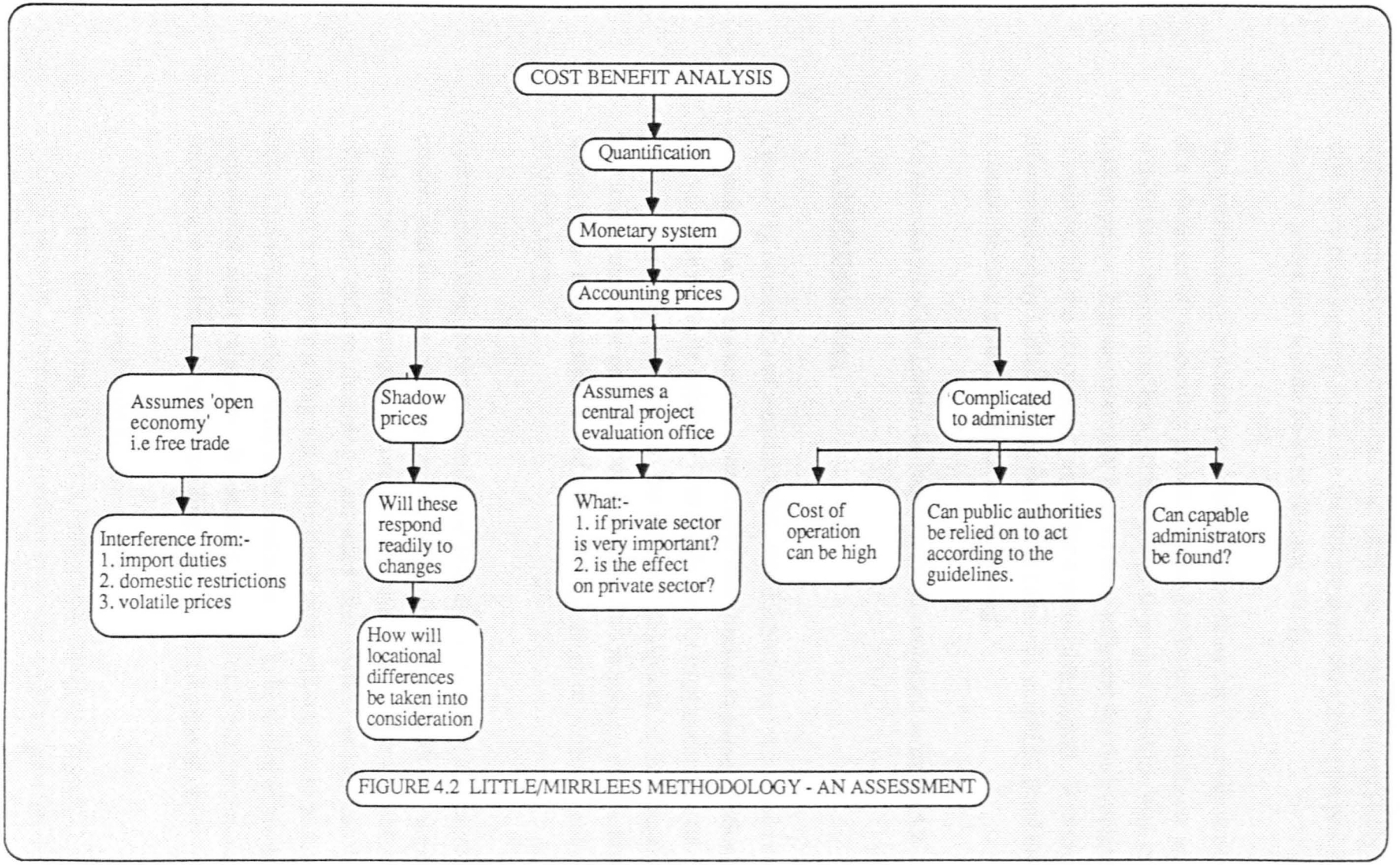

FIGURE 4.2 LITTLE/MIRRLEES METHODOLOGY - AN ASSESSMENT

to the real things that can go wrong in a project errors arising from inappropriate prices are minimal and when they occur are more likely to arise from misjudgment about the market situation than about the precise shadow prices that should be used (Pearce, 1971).

This methodology contains essentially, guide-lines for the construction of a whole set of accounting prices, designed to be self - consistent and to fulfil their function of being better guides to project selection than the market prices. It is not normally easy or even efficient for the evaluater to estimate all the accounting prices for a particular project. It is thus recommended by Little/Mirrlees that project analysis should be fitted into a comprehensive system of investment planning.

An assessment of the Little/Mirrlees method is contained in figure 4.2.

ii) UNIDO Guide-lines

Consisting essentially of a social CBA, this methodology recognises the authority of a government to control new investments to pursue National interest. The rationale behind it is to single out for implementation those projects that contribute most to the ultimate objectives of the country. The main reason for carrying out a social CBA in project choice is to subject it to a consistent set of general objectives of national policy (UNIDO 1972).

This methodology seeks to summarise interaction between a particular project and the rest of the economy. This it does through the use of market prices and national parameters. According to Deepak Lal, (1974) in the main, this methodology assumes that market prices can be corrected for the most flagrant deviations from willingness to pay, to reflect the relative values with sufficient accuracy to be useful in project formulation and evaluation. It assumes that national parameters can supplement market prices by providing the differential impacts of:-

- income saved from income consumed
- income accruing to the rich from that accruing to the poor
- income generated as foreign currency to that generated in domestic currency

- in taking the form of merit wants as opposed to income in general

In short, these national parameters reflect value judgements on the distribution of consumption over time, among classes and regions and the importance of paying for imports with exports rather than foreign debt, whether economic or political and the importance of specific merit wants that may be relevant. Thus, national parameters provide information about the rest of the economy, essential for formulation and evaluation of any particular project, and to which the project level planner has no access.

The central value that this methodology aims at establishing the shadow price of investment, formulated in accordance with the following equation (Lal 1974) in the case of a labour surplus (developing) economy.

$$Pinv = \frac{(1-s)(y-wj)+(w-z)j}{i-s(y-wj)}$$

where:-
s = common marginal propensity to save out of private profit or public sector income
y = common marginal output to capital ratio of the advanced sectors of the economy
w = the wage rate
z = the direct opportunity cost of labour reflecting loss in output of the traditional sectors
j = marginal output/ capital ratio of the advanced sectors
i = social rate of discount

Figure 4.3 brings out some of the issues likely to be raised in connection with this methodology. The main limitations are due to the following considerations:-

-the national plan data are useful only so far as they are reliable forecasts of the future

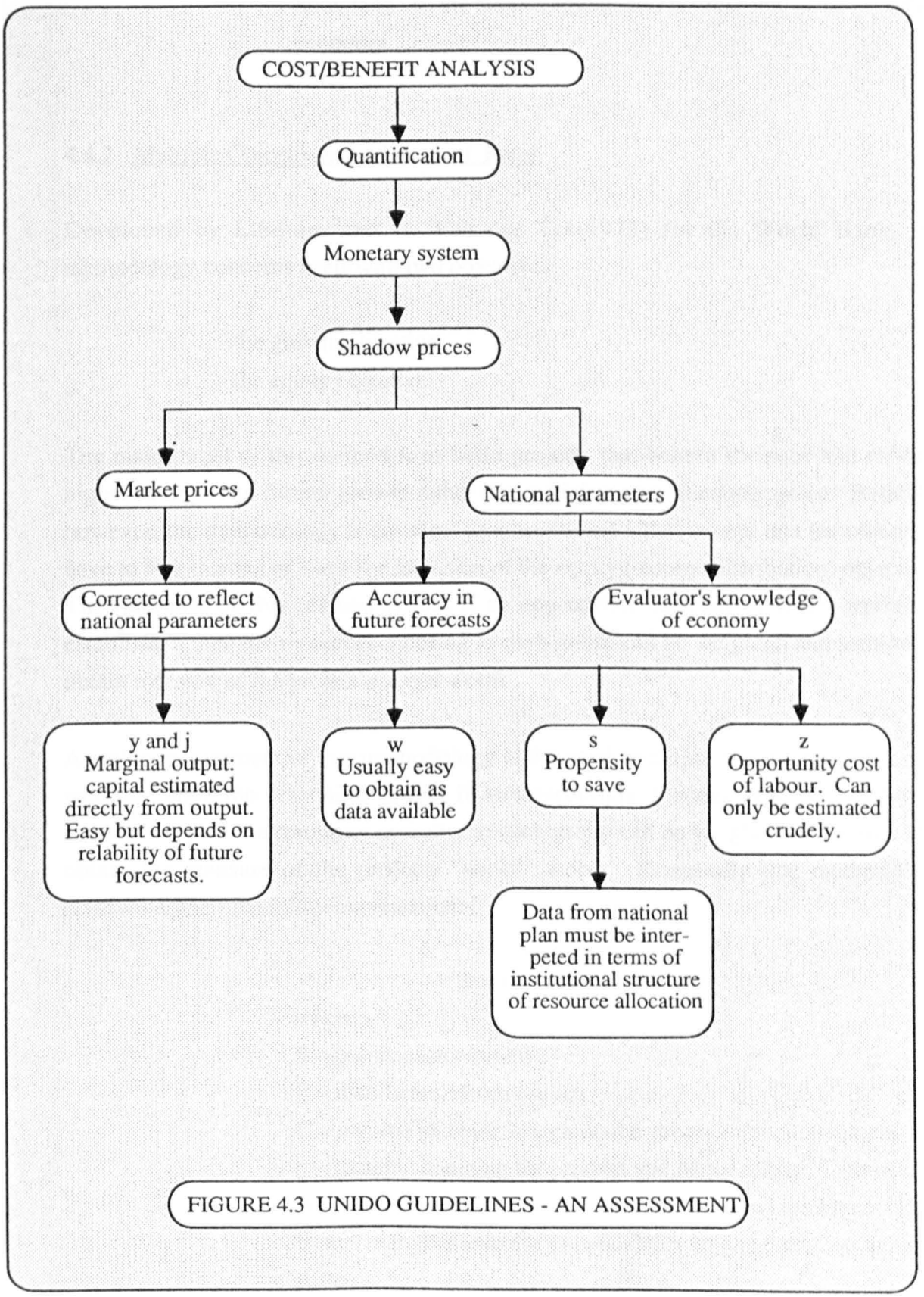

FIGURE 4.3 UNIDO GUIDELINES - AN ASSESSMENT

-the national plan data must be supplemented by a reasonable knowledge of the technological and institutional structure of the economy

4.4.2 Multiple Objectives and Discount Rates

Developed by L.Squire and H. Van der Tak(1975) for the World Bank, this methodology concerns itself with two objectives:-

- the growth objective
- the equity objective

The main thrust of this method is to build projects that benefit the poor and result in higher savings and further growth rather than a higher current consumption. Basically, however, the methodology is the same as a traditional CBA, except that the objectives have to be extended to allow for inclusion of the equity (income distribution) objectives. The rationale of this method is that if an appropriate concept of social welfare is established, then the resources accruing to each group can be weighted and summed to obtain measure of the project's social worth.

A major requirement of this methodology is the need to define clearly, the concept of welfare, since the reasoning is that if an appropriate concept of social welfare is established then the resources accruing to each group can be weighted and summed to obtain the measure of the projects "social" worth. Essentially this methodology revolves around the following equation:-

$$S = (E - Cb)Wf + CWc$$

where:-

S = public sector benefit

E = total benefit from project

C = income increase in a particular group in private sector

b = factor accounting for product and factor market distortions

Wf = social welfare function: increase in social welfare resulting from a marginal increase in availability of real resources to public sector

Wc = social welfare function: increase in social welfare from marginal increase in the availability of consumption to a particular income group

If W = Wc/Wf and a weight of 1 is attached to Wf then

$$S = E - C(b - w)$$

The evaluation W is recommended along the following lines by the originators of this methodology:-

$$W = d/v$$

where:-

v = value of a marginal increase in public income measure in free foreign exchange divided by the value of a marginal increase in consumption at domestic prices to someone at the average level of consumption (Wa) i.e. v = Wf/Wa

d = value of a marginal increase in consumption at domestic prices to someone at the level of consumption C divided by Wa i.e. d = Wc/Wa

and so

$$S = E - (b - d/v)$$

Where:-

d is then designed to allow for different values assigned to public income and private sector consumption. It can be set at unity if income distribution as a criteria of project selection is not desired.

v is designed to allow for different values assigned to public income and private sector consumption.

It is further suggested that the projects worth should be presented in the analysis based on market, efficiency and social prices where:-

- the market price analysis would constitute a financial appraisal

- the efficiency prices would correct distortions in factor and product markets assuming any constraints on the government`s ability to re-distribute income.
- the social price would take into account distributional impacts as it is very likely that the economy will suffer from some fiscal constraints.

Figure 4.4 provides an outline of the issues involved in using this methodology. Some of these are discussed in greater detail in the next section:-

1) The " shadow price" is defined as "the increase in welfare resulting from any marginal change in the availability of commodities or factors of production."

" Shadow " prices that ensure efficient allocation of resources despite distortions, have been recommended in this method. This is because constraints are a part and parcel of any society and can take a number of forms including economic, political and administrative etc. Some constraints by their very nature tend to divorce market prices from economic ones. e.g. trade taxes. Any changes,in these constraints will require a change in the shadow prices so that a clear understanding will be required of:-

i) the country`s objectives and then interrelations so that marginal changes can be evaluated.
ii) the constraints and policies that determine the country`s development at that time and in the future.

2) This knowledge is usually presupposed in this methodology and of course, this may not (probably will not) be the case in reality. Also the calculation of shadow prices implies existence of an intrinsic value of inputs and outputs for a given welfare function, an application that some authors (Prou 1973) would contest. Finally this methodology reduces government objectives to two goals and this may be difficult and "benefit-cost analysis may rest on conceptualisations and theories of unknown qualities."(Rossi and Wright 1976).

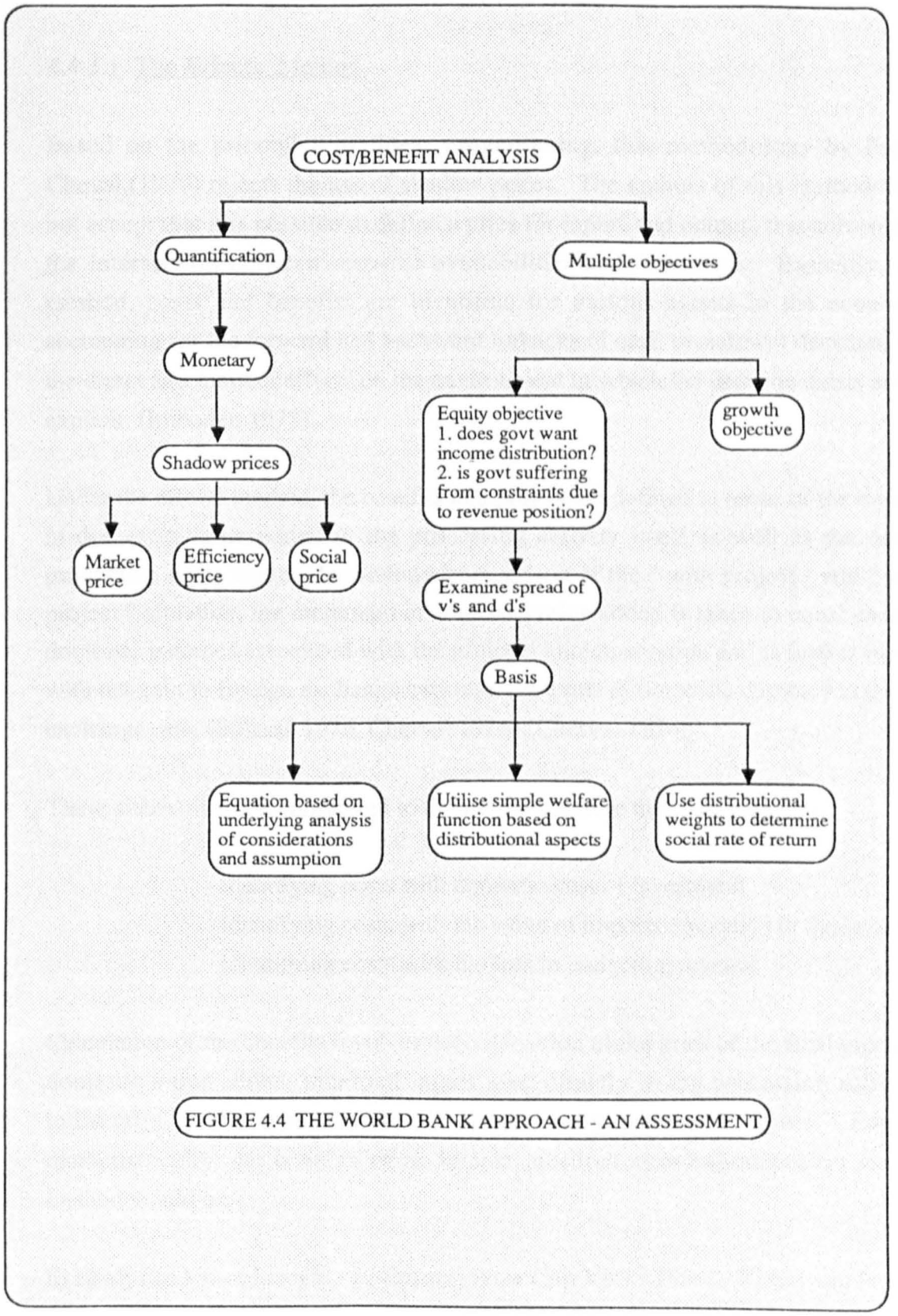

FIGURE 4.4 THE WORLD BANK APPROACH - AN ASSESSMENT

4.4.3 Further Developments (Programme Budgeting etc)

4.4.3.1. The Effects Method.

Based on the principles of linear programming, this methodology by Prou and Cheval,(1970) rejects the use of shadow prices. The authors of this methodology do not accept that it is possible to define a price for inputs and outputs that corresponds to the intersection between resource availabilities and objectives. Basically, in this method, costs and benefits are identified for various agents in the economy by accounting for the forward and backward linkages of each investment decision, so that the direct and indirect effects on the environment in which the decision exists are made explicit. (Imboden 1978).

Under the effects method, the benefits of a project are defined in terms of the movement in domestic value added in the processing activity itself as well as the domestic production of its inputs. Involving a comparison of the " with project " and " without project " situation, the increment in domestic value added is taken to equal changes in domestic incomes associated with the projects implementation and is further identified with net gain in foreign exchange expressed in terms of domestic currency at the actual exchange rate. (Balassa 1976, Cherval 1974a, Cherval 1974b).

These alternatives are considered to define and measure the costs namely:-

- identifying costs with domestic cost of investment
- identifying costs with the value of imports embodied in the investment
- identifying costs with the loss in budgeting revenue

Calculation of the benefits involves decomposition of the price of the final product into domestic value added, imported inputs used directly in the processing activity and indirectly in the manufacture of domestically produced inputs. Expressed mathematically, net benefits of an import substitution or export project under this method would be:-

$$Ej\ Ef\ afj\ Pfd\ Vji - (Piw\ Cti - Ej\ Em\ amj\ Pmw\ Ctm\ Vji) = PiwC - Ej\ Em\ amj\ Pmw\ CVji$$

where:-

Pid = domestic price of the product

Pjd, Pmd and Pfd = price of domestically produced inputs, imported inputs and primary factors respectively
aji, ami and afi = corresponding amounts of inputs per unit output
Vji = total requirements of project j per unit output of product i
Superscript w refers to world market prices in foreign currency
t = ad volorem tariff (subsidy)
C = actual exchange rate : domestic currency per foreign currency

If however imports are subject to quantitative restriction rather than tariffs before domestic production is undertaken, the above equation will not hold. The situation can however be re-established if the loss of quota profits following the replacement of imports by domestic production is treated in the same way as tariff revenue.(Balassa 1976, Cherval 1974a, Cherval 1974b)

It is, as stated by Imboden (1978), important to note that the authors of this methodology consider project analysis as part of the planning exercise. They see the role of the project appraiser as that of identifying the consequences of an investment decision and an analysis of the effect of alternative investments. It is then up to the decision-maker to adjust the benefits according to his objectives (income distribution, savings, foreign exchange etc) and to choose a package of investments that correspond to existing social, economic and political constraints.

In comparing the effects method and social cost/benefit analysis, it can be stated that while social CBA provides guide-lines on how to calculate the trade-offs between government objectives, the Prou and Cheval method leaves the integration of objectives to the subjective judgement of the decision-maker. The effects method then can be considered as a simplification of the social CBA. (Imboden 1978). By making no allowance for the opportunity cost to the national economy of productive factors other than labour and land the effects method has no suitable benchmark for making decisions on projects, nor will this method rank projects according to economic profitability. (Balassa 1976). In spite of this however, it may well be much closer to the way in which investment decisions are taken in reality.

4.4.3.2 The Impact Approach.

Used essentially by the US agency for International Development (USAID) and the Swedish International Development Authority (SIDA) this methodology deals with three basic issues:-

- the identification of more important goals
- design of activities most likely to bring about the desired changes
- efficient administration of the activities involved

The elements of project evaluation according to this methodology (USAID 1974, Zohar and Popandreou 1974) are:-

i) problem statement.
ii) judgement standards or criteria.
iii) identification of indicators permitting measurement of resulting changes.
iv) collection of data for -
    -rates of change
    -direction of change
    -nature of change
    -amount of change
v) interpretation of the data analysis.

Three concepts stand central to this methodology namely:-

- effectives with reference to targeted outputs and realisation of purposes
- significance with reference to achievement/contribution of/to economic development and to what extent
- efficiency with reference to costs justifying benefits and whether same targets can be achieved more efficiently

This methodology requires project officers to be involved in the formulation of plans to enable evaluation to be linked to basic developmental issues. This would require project officers to be involved with project proposals as well as implementation. This in turn would call for the evaluation process to include:-

-development of a logical framework setting the stage for evaluation.
-group reviews

The establishment of the logical framework (USAID 1973) is to set the stage for evaluation and it:-

i) Defines project inputs, outputs, purpose and higher goals in measurable or objectively verifiable terms.
ii) Hypotheses the causal (means-end) linkage between inputs, outputs, purpose and goal.
iii) Articulates the assumptions (external influences and factors) which will affect the causal linkages.
iv) establishes the indicators which will permit subsequent measurements or verification of achievement of the defined outputs, purpose and goal.

This methodology has a number of advantages, including the following:-

-explicit statement of the underlying assumptions
-ability to deal with a multiplicity of goals
-ease of understandability by non-scientists
-flexibility with regard to information and skills as well as analytical tools to be used.

However, it does not provide information on the relevance of the goals or efficiency of the purposed project unless it is specifically compared with alternative courses of action.

This approach, then emphasizes the results (consequences) of a project. In the long run, it establishes, the social, environmental, economical and political etc changes which can be attributed to a project so that it is possible to know whether these changes are :-

-desirable or not
-transient or permanent
-immediate or delayed
-planned or unplanned

4.5 Impact Analysis and Related Methodologies

4.5.1 Environmental Impact Analysis (EIA)

As stated by Porter and others (1980) concerns of the previous decades led to the institutionalisation of new methods, organisation and laws intended to extend the

horizon of environmental planning in 1970's, leading to the emergence of EIA. NEPA (National Environmental Policy Act of 1969, USA) has to be the starting point of any analysis of the EIA since it owes its emergence as major activity in the US to this act. In essence, it is a form of applied policy analysis (Andrews 1988).

EIA can, according to Wathern (Wathern 1988):-

"...be described as a process for identifying the likely consequences for the bio-geophysical environment and for man's health and welfare, of implementing particular activities and for conveying this information, at a stage when it can materially affect their decision, to those responsible for sanctioning the proposals."

EIA methods are used for various activities, impact identification, prediction, interpretation, communication and devising, monitoring schemes etc. So widely has EIA been adopted in project planning that there is a danger of its use being confined to the appraisal of projects. Primarily, the EIA process consists of the pattern shown in figure 4.5:-

According to Kennedy (Wathern 1988, Kennedy 1984) criticisms against EIA fall into five categories:-

- little effect on decision-making process
- few tangible environmental benefits
- inadequate opportunity for involvement in the decision-making process
- expense involved
- delay in action

Various approaches have been developed toward EIA during the last ten years and have been presented by Bisset (1988) in terms of common themes and trends characterising the methods developed since 1978. Included in his discussion are the following:-

- index approaches (check-lists and approaches based on multi-attribute utility theory)
- systems diagrams
- simulation modelling
- sound ecological principles

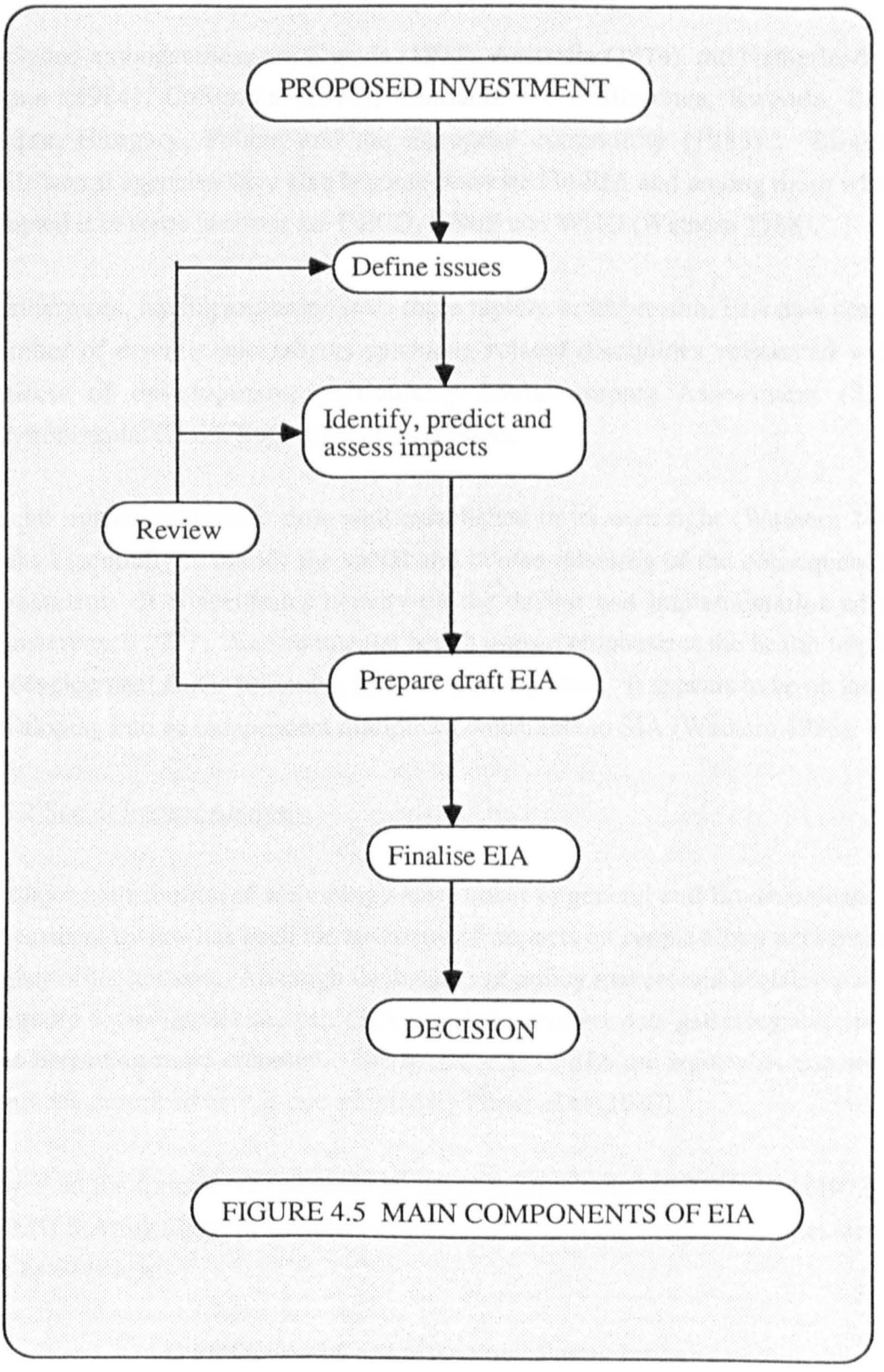

FIGURE 4.5 MAIN COMPONENTS OF EIA

Since a federal dimension to land-use planning was first given to EIA under NEPA in 1969, a host of other countries have implemented or realised the potential of EIA.

Included amongst these are Canada (1973), Australia (1974), the Netherlands (1981), Japan (1984), Colombia (1974), Thailand, the Philippines, Rwanda, Botswana, Sudan, Hungary, Poland and the European community (1985) . Bilateral and multilateral agencies have also become interested in EIA and among those which have adopted it in some measure are OECD, UNEP and WHO (Wathern 1988).

Furthermore, having expanded even more rapidly in its breadth, EIA now comprises a number of discrete specialisms spawning related disciplines concerned with other aspects of development, particularly Social Impact Assessment (SIA) and Environmental Health Impact Analysis (EHIA).

Social impact analysis is now well established in its own right (Wathern 1988) and seeks essentially to clarify the social and human meaning of the consequences of an investment. It concentrates heavily on the design and implementation of policies (Finsterbusch 1977). Environmental health impact emphasizes the health implications of development and is becoming increasingly important. It appears to be on the point of developing into an independent discipline comparable to SIA (Wathern 1988).

4.5.2 Social Impact Analysis

A major contribution of technology assessment in general and Environmental Impact assessment by law has been the treatment of impacts on people along with treatment of higher order impacts. Although the instinct of policy makers and decision-makers was to ignore social impact analysis (SIA), by 1977 primary data gathering and use for SIA was becoming more common. The boundaries of SIA are somewhat uncertain. The approach described here is one adopted by Porter et al (1980).

Based on the framework proposed by the U.S. army corps of Engineers (1973) section 122 (U.S Army Corps of Engineers 1972) guide-lines the first seven of the eleven steps are listed below:-

1) Profile (social and technological description).
2) Projection without project (forecasting).
3) Projection with project (forecasting).
4) Identification of significant impacts (impact identification)

5) Description and display of impacts (impact analysis)
6) Evaluation of effects with publics (impact evaluation)
7) Mitigation of adverse effects (policy analysis)

The other four steps refer to public hearing and official reporting sequences ending with the preparation of the impact statement. A number of other approaches have been developed notably general strategic approaches including:-

- Finsterbusch approach (1977) which de-emphasizes impact analysis to stress development of adjustments through policy adjustments.
- The second strategic approach emphasizes modelling. This approach makes three important points (Battelle-Seattle 1974) namely:-

i)it attempts to determine the objective content of the data in the presence of biases.
ii)it recognises the dynamic nature of social data.
iii)it seeks feasible and robust solutions rather than optimal ones.

4.5.3 Technology Assessment (TA)

Since early 1970`s, people, particularly decision and policy makers have become aware that many issues that were legitimatly solvable in terms of short term technological or economic considerations at the local level, are no longer so; that in fact the need is for a longer term social and environmental consequences at much broader levels. One response to these problems has been the Technology Assessment (TA) process which seeks to inquire into the short and long term effects arising from the interaction of technologies and social systems (Boroush, Kan Chen, Christakis 1980) Resulting essentially from structural reforms implemented, edged on by the belief in 1960`s that the Congress was losing its influence, the office of Technology Assessment was established in 1972.

Providing generally a systematic aid to better informed policy-making, (OECD 1983) TA generally consists of :-

i) Definition of task to be assessed (relevant issues and problems scope of inquiry and ground rules)
ii) Description of technologies (major and supporting technologies as well as those which can compete with them)

iii) State of society assumptions (identification of major non-technological factors influencing the application of the technologies under consideration)

iv) Identification of impact areas (social areas most likely to be affected by the technology under assessment)

v) Preliminary impact analysis (tracing and integration of process by which assessed technology makes its influence felt)

vi) Identification of action options (develop and analyse various programs to maximise public advantage from the assessed technologies)

vii) Complete impact analysis (analyse the extent to which each action option would alter the specific social impacts of the assessed technology) (Boroush , Kan Chen, Christakis 1980)

Implicit within the technology assessment approach is the re-appraisal of the role of technology in contemporary society. It implies a detailed understanding of the nature of technology and innovation , a careful consideration of all its consequences, a careful consideration of alternative technologies and decisions based on an open and broad decision-making approach.

There are however, a number of problems (OECD 1983) that can be associated with the use of this methodology namely:-

- the meaning of the term is still unclear and no workable definition exists for it.
- the criteria used in this type of assessment is largely subjective.
- qualitative as well as quantitative measures must be used creating complexities.
- majority of the studies only consider a limited number of impact categories.
- in most studies, only technical parameters aspects get considered when the main concern is development, feasibility, timing, areas of application etc of the technology itself.
- economic impacts are dealt with at sector and local levels only.
- too much emphasis is placed on environmental impacts.
- non technical and non economic impacts on society are treated as composite elements in a social scenario and rarely evaluated on their own.

TA methods are difficult to describe because the problems as well as data differs across the many problems studied. In his paper on social science research and its use by the policymakers, Saxe (1986), argues that examples analysed for OTA indicate that TA can influence how national policy is formulated without necessarily changing it.

4.5.4 Risk Assessment

Risk assessment has, as stated by Wynne,(1987)

> "....developed as a more sophisticated, probablistic scientific treatment of essentially the same regulatory problems as its predecessor, technology assessment but under explicit conditions of uncertainty."

Risk measures the probability and severity of loss or injury and uncertainty refers to a lack of definite knowledge, or a lack of sureness. Although formal risk analysis in the 1950`s and 1960`s was dominated by risk source, or "mechanical system" analysis, this period also saw the beginnings of more systematic environmental exposure and dose- effect analysis. (Wynne 1987). By 1981 the whole field was still (Griffiths 1981)

> "....very much in a state of flux"

but a pattern was beginning to emerge and three components seemed to exist (Griffiths 1981) namely:-

- The quantitative assessment of risk in terms of the likelihood of occurrence and the severity of the consequences.
- The decision on whether or not to proceed in the face of risks.
- The acceptability of risk to the public.

Lately it is being argued (Wynne 1980) that:-

> - risk management has to find a practical way of resolving a tension between system-wide risk management considerations such as public reassurance, a centralised role etc and situation specific risk definitions and controls.

Risk assessment like environmental impact assessment is a form of applied policy analysis, appearing to represent a number of discrete disciplinary subgroups rather than

a single interdisciplinary approach. Included among these are toxicologists, epidemiologists and biostatistians focusing on health risks, engineers and statistical decision analysts concerned with technological catastrophes and economists concerned with risk-benefit analysis as well as actuaries interested in probablistic studies and cognitive psychologists exploring human perception and behaviour towards risk. A comparative study of risk assessment and environmental impact assessment indicates clearly that while differing in practice, the two methods are intrinsically similar in concept and that prospects for integrating the two into a unified process are good. The idea is feasible (Andrews 1988).

4.6 Integrated Approaches

As the appraisal process has developed, it has moved through a sequence of changes so that new approaches have developed and while the main consideration in the past was economic in nature, present decision-makers are likely to have a number of assessment methods at hand including social, environmental , technological etc .A number of attempts have been made in recent years to integrate these closely interrelated approaches to appraisal (Wathern 1988).

Nijkamp (1980) proposed a framework for relating potential economic, social and environmental change shown in figure 4.6 produced in 1980. Recognising a similar complexity in developing countries, problems which overlap into social, economic, technological and political subject areas, Iverson (1985) suggested a general systems approach. This approach shown in figure 4.7 involves a series of steps which when properly interfaced, will isolate the key elements required to analyse the problem, its environment as well as potential solutions and their repercussions, creating a foundation for decision-making. Another approach designed along the same lines is based on acceptance of the fact that:-

> "...the project concepts must be subjected to a formal/strategic assessment using the following criteria:-
>
> - industry attractiveness
> - potential key advantages
> - inherent competitiveness (cost, quality and reliability)
> - technical and entrepreneurial risks
> - potential financial return in each option." (Jaafari 1988)

Other types of integrated approaches have also been developed. For instance many indirect effects can occur as a consequence of implementing a project. These externalities can take many forms and as stated by Bell, Hazell and Slade(1982).

"To have any hope of tracing all these repercussions, we need a framework within which all the transactions in the economy can be ordered and accounted for in a consistent way. Fortunately, just such a framework is ready to hand the so-called social Accounting Matrix or SAM."

Essentially an accounting system SAM represents the various incomings of of each and every account outgoings by a similarly ordered column. The array thus obtained, provide a picture of all the transactions in the economy at a moment in time, and in so doing it also reveals something of the structure of the economy in an integrated fashion.

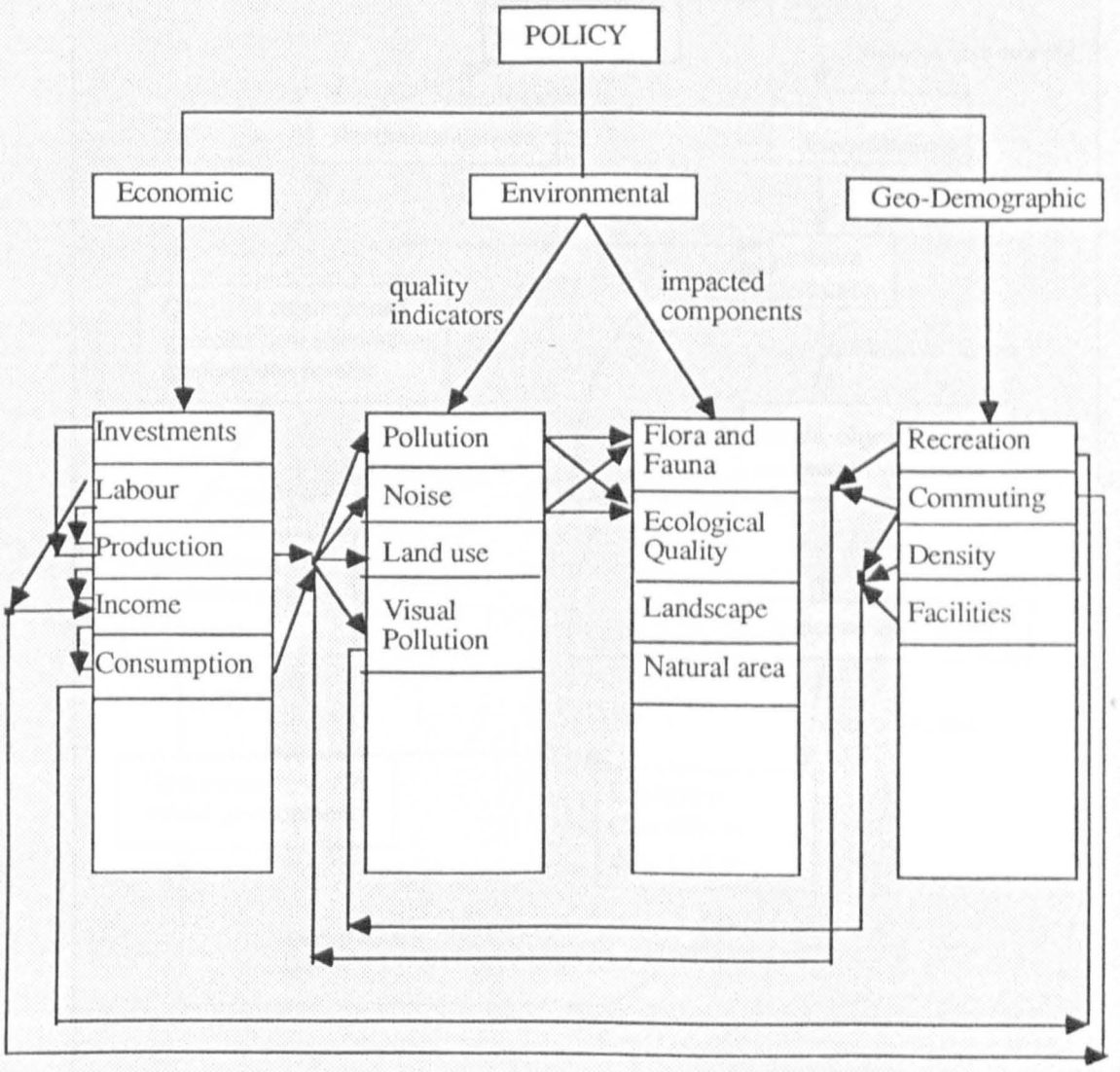

FIGURE 4.6 AN INTEGRATED APPROACH TO APPRAISAL
SOURCE: NIJKAMP (1980) AND WATHERN (1988)

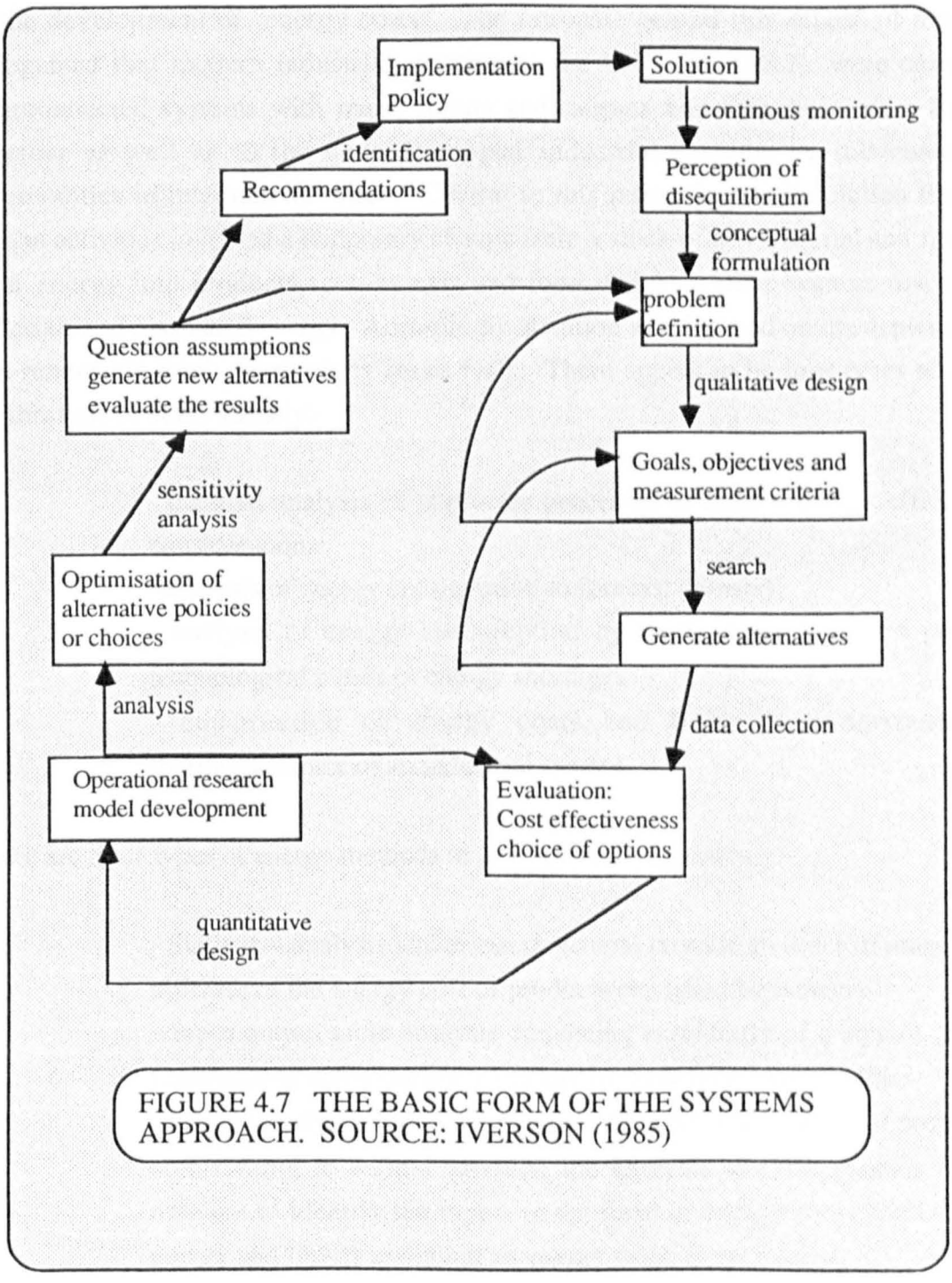

FIGURE 4.7 THE BASIC FORM OF THE SYSTEMS APPROACH. SOURCE: IVERSON (1985)

4.7 Energy Methods (Chapman 1977)

During the seventies, a growing realisation that financial costs of materials and products did not provide an adequate description of the resources needed for their production led to the development of "energy costs". The rationale behind this school of thought recognised that modern industrial systems as the U.K. and U.S.A. were complex interconnected systems with many inputs and outputs and that these were linked together as well as to the underdeveloped industrial systems by movement of commodities in international trade. Central to this rationale was the notion that all human activities involved a temporary change from a stock of raw material and flow of solar energy into products such as cars and food which in time became discarded materials and dissipated energy. Accordingly attention was focused on the depletion of non-renewable stock, particularly fossil fuels. There appear to be four types of aims for this type of study namely:-

- detailed analysis of particular processes to reduce energy efficiency considerations
- analysis of energy consumption to forecast demand
- analysis of energy consumption by basic technologies to predict technological trends or energy shortages
- construction of energy costs and flows to understand the thermodynamics of an industrial system.

There are three types of energy methods in practice currently namely:-

- Statistical analysis which can in general provide an order of magnitude estimate of the energy cost of products classified by industry.
- Input output table analysis consisting essentially of a square matrix summarising commodities necessary to make other commodities.
- Process analysis involving the identification of a network of processes contributing to a final product, the analysis of each process in the network to identify the inputs in the form of equipment, materials and energy and finally assigning an energy value to each input.

4.8 Conclusion and Discussion

Figure 4.8 shows a summary of the contents of this section. As can be seen from the evolution of appraisal methodologies, as the world situation has changed so also have

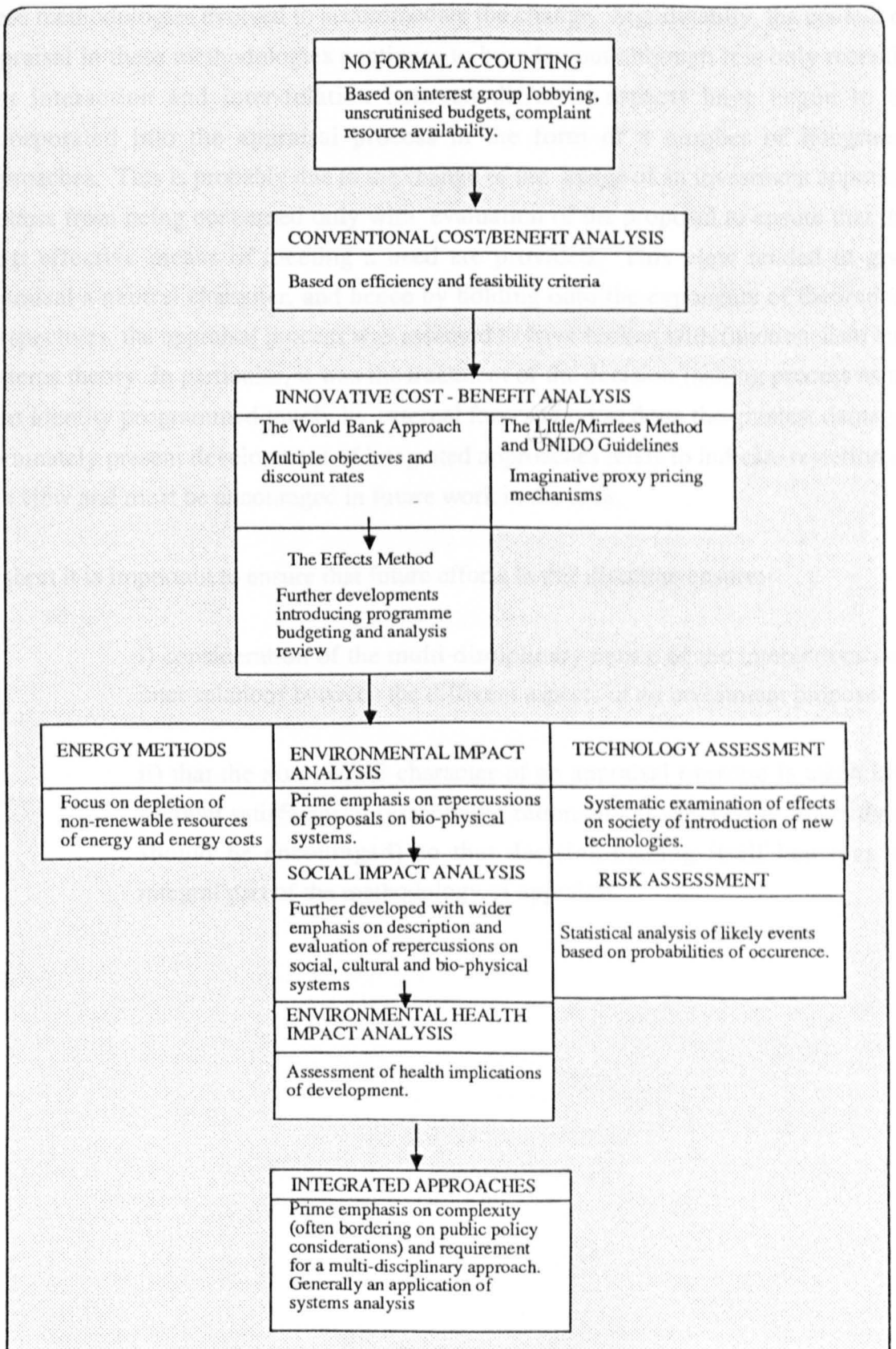

FIGURE 4.8 EVOLUTION OF PROJECT APPRAISAL (ASSESSMENT) METHODS

these methodologies evolved to accommodate the change. Significantly, the content of appraisal in these methodologies continues to broaden out although it is only recently that interaction and inter-relation between different aspects have begun to be incorporated into the appraisal process in the form of a number of integrated approaches. This is probably due to the change of the image of an investment appraisal process from being concerned only with evaluation of the proposal to ensure that the most effective means of meeting a need are provided. This view tended to give appraisal a neutral character, and hence by holding onto the exponents of theoretical perspectives, the appraisal process was assumed to have broken with functionalism and systems theory. In particular, it was the treatment of the decision making process as an inert identity programmed purely by external forces that has done the greatest damage. Fortunately present development of integrated approaches tends to indicate rejection of this view and must be encouraged in future work in the area.

In short it is important to ensure that future efforts in this direction ensure:-

i) consideration of the multi-disciplinary nature of the interactions and inter-relations between the different aspects of an investment proposal.

ii) that the non-neutral character of an appraisal exercise is taken into account satisfactorily (essentially, rationality as opposed to subjectivity should be encouraged) so that decision-making itself becomes an integral part of the methodology of appraisal.

CHAPTER 5

THE FRAMEWORK FOR A NEW APPROACH TO APPRAISAL/EVALUATION

CHAPTER 5

THE FRAMEWORK FOR A NEW APPROACH TO APPRAISAL/EVALUATION

5.1 Introduction

This chapter draws together, the findings of chapters 2, 3 and 4. It thus identifies the requirements that need to be incorporated into the appraisal/evaluation process in linking it to the concept of technological and human development. A study is then made of each requirement in turn and a method of incorporating it into the appraisal/evaluation process suggested.

A review of the existing analytical methods establishes the fact that dynamic programming and systems analysis approaches lend themselves particularly to the type of problem under consideration.

Since the appraisal process has its roots in decision theory, a section is included in this chapter which reviews the state of art of decision-making. In conclusion a framework is established which outlines the total requirements for an appropriate and improved appraisal / evaluation procedure.

5.2 The Nature of the Problem

Figure 5.1 which is essentially a summary of the last three chapters creates a picture of the issues involved in devising an improved appraisal methodology for investment of resources with particular reference to the technological component.

Accordingly, it can be concluded that an improved appraisal methodology requires that:-

i) the process should be inter-disciplinary and interactive in approach.
ii) a global context must be introduced into the process.
iii) betterment of the human condition must be central to the whole process.

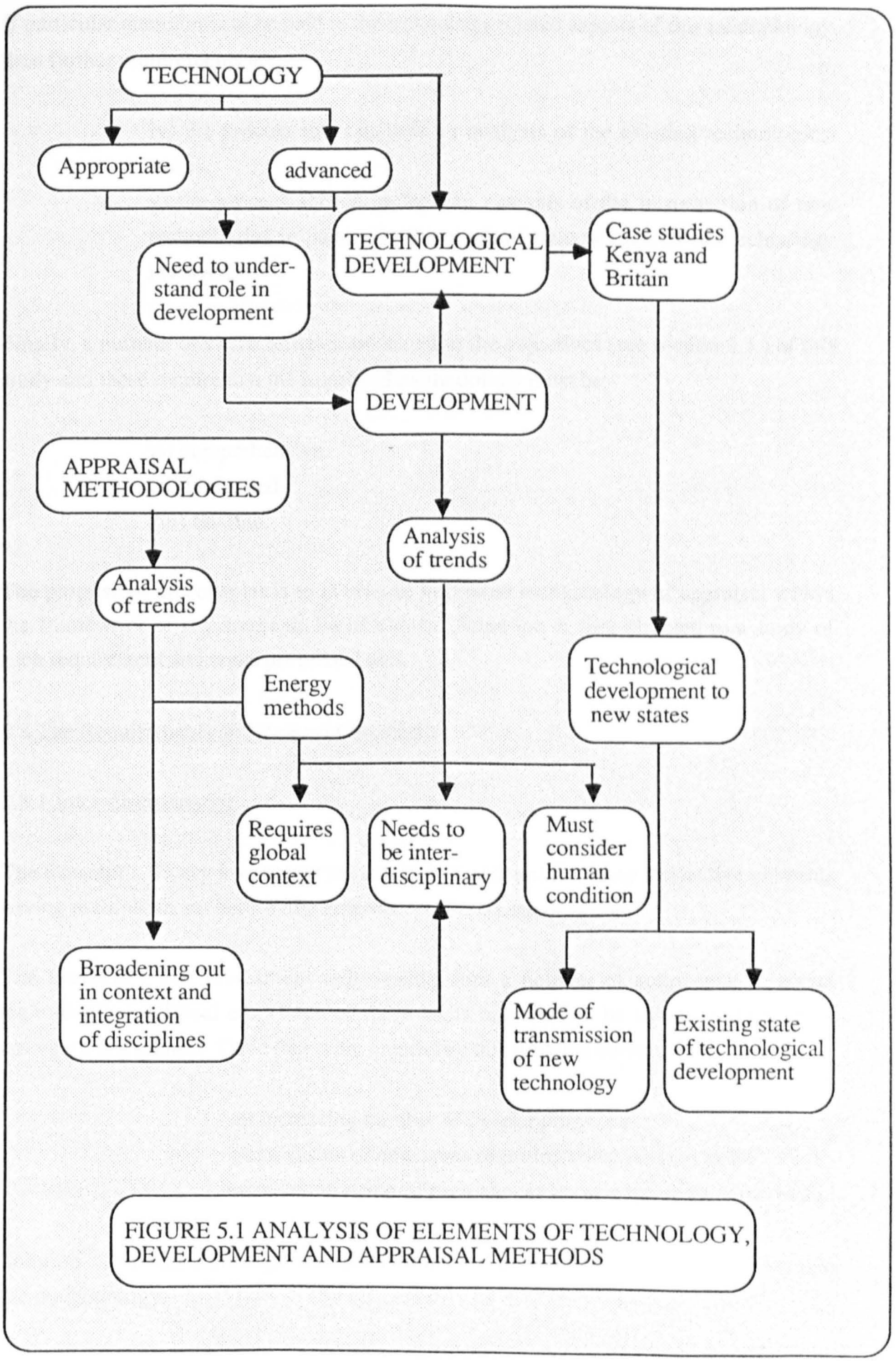

FIGURE 5.1 ANALYSIS OF ELEMENTS OF TECHNOLOGY, DEVELOPMENT AND APPRAISAL METHODS

If particular attention is to be paid to the technology related aspects of this methodology, then further requirements are:-

iv) the process must include an analysis of the existing technological status.

v) the process should include an analysis of the introduction of new technologies in particular the mode of transmission of the technology involved.

Finally, a number of characteristics are stated in the objectives (see section 1.3) of this study and these require that the improved methodology must be:-

vi) comprehensive.

vii) integrated.

viii) flexible.

The purpose of this chapter is to evolve an improved methodology of appraisal within the framework of requirements listed above. Attention is first directed to a study of each requirement and concepts related to it.

5.3 The Requirements and Related Concepts.

5.3.1 Inter-disciplinarity

The Concept : Every investment must take into account the many interactive elements having multiple facets before implementation of a course of action.

The Problem : The investment will overlap into a number of areas such as social technological,political etc. Each of these areas may further be subdivided into new emerging disciplines. Three facets are created by this problem namely:-

- an increasing number of overlapping areas.
- possibilities of new areas requiring consideration in the future.
-more sub-division of each area as knowledge about it increases.

Solution : Introduce concept of infinite number of disciplines and sub-disciplines into the methodology.

5.3.2 The Global Context

The Concept: Increasing interdependence and interconnectedness of the world gives rise to the need of recognising emerging global problems and population.

The Problem: There is at present a crisis of the "nation" state but as yet no plans for a global order. How are these "boundaries" in groupings to be crossed.

Solution: 1) Introduce global issues as part of the methodology

2) Introduce into the appraisal methodologies different levels of collective groupings and analyse impacts within each grouping successively until the whole range of population has been covered.

5.3.3 The Human Context

The Concept : Place betterment of human condition at the centre of the proposed methodology.

The Problem : The appraisal process must stress expansion of human capabilities in terms of social aspects, changes in value systems and psychological aspects. This requires a continuous process to institutionalise importance of the human being, both conceptually and operationally throughout the human population.

Solution : Devise the appraisal process by relating all other aspects of it to human development and the concept of continuity.

5.3.4 Existing technological status

The Concept : Identify and analyse those indicators which most accurately reflect the technological level of the environment in which investment is to be made.

The Problem : There is no definite list of such indicators that can be used, since the area is still new. Also the number of such indicators will change as more information becomes available so the problem is two-fold.

- what indicators should be used.
- how can these be updated as more information becomes available.

Solution : Prepare a preliminary list of the likely indicators and then allow for the possibility of an infinite number of indicators leaving room for new indicators to be incorporated as and when these are identified.

5.3.5 Mode of transmission of new technology

The Concept : Identify the modes of transmission (innovation, local and indigenous or importation) likely to be used in the use of technology implied by the investment.

The Problem : Need to devise a methodology for measuring performance of domestic and foreign markets in international trade.

Solution: Isolate and analyse the domestic and foreign components of every technology and process involved in the investment.

5.3.6 Comprehensibility

The Concept : Each facet and interaction of parameters involved in the analysis must be considered completely to ensure that a full and optimal solution is found.

The Problem : To be completely comprehensive a fundamental requirement is the availability of detailed information. This is rarely available in practice.

Solution: Ensure the best possible solution is found by incorporating every bit of information available and leave room for new information to be incorporated into the methodology as it becomes available.

5.3.7 Integration

The Concept: It has been shown in the previous requirements that an infinite number of aspects need to be integrated together in the appraisal process. Additionally in accordance with section 5.2.3 this process needs to be continuous.

The Problem : The problem involves recognition that:-

-a complete appraisal involves analysis of several disciplines each of which can be split into large numbers of sub-disciplines.

- each discipline has been considered in isolation in past methodologies, and only now is the need to consider these together recognised.

- a method is required that will:-

i) integrate all the elements together

ii) allow for new elements to be covered as these are discovered.

Solution : Expressed mathematically, (Wallis, 1984) integration can be defined as:- suppose f(x) is a function of x defined in the interval [a b] which can be sub-divided into N sections by points Pn (n = 0,1,2,3.....,N) with x = Tn at the point Pn such that:-

$$T_0 = a, \quad T_n < T_{n+1}, \quad T_n = b$$

Then letting the sum S be defined as:

$$S = \sum_{n=0}^{N-1} f(T_n)(T_{n+1} - T_n$$

$$= \sum_{n=0}^{N-1} f(T_n)\Delta T_n$$

Then as N tends to infinity

$$\underset{n \to \infty}{\text{LIM}}\, S = \int_a^b f(x)dx = \underset{\Delta T_n \to 0}{\text{LIM}} \sum_{n=0}^{N-1} f(T_n)\Delta T$$

Naturally as N tends to infinity, the function also becomes continuous.

This concept applied to the appraisal process offers a solution to the integration requirements of the proposed approach if it is interpreted as follows:-

-N is the number of disciplines

- as more and more disciplines are introduced into the process, N tends to infinity and hence becomes continuous.

- if the interval [a b] is defined as being no appraisal to complete appraisal (i.e point a represents no appraisal and point b complete appraisal) then the whole interval is covered.
- x is the discipline. since more than a single variable x will be involved, the integration may have to carried out over a number of dimensions which could be anywhere between 1 and infinity.

5.3.8 Interaction

The Concept : Obviously, if several disciplines overlap to make up the appraisal process, then interaction may occur between disciplines. Accordingly, consideration of the disciplines in isolation will result in a partial and perhaps wrong decision.

The Problem : The method of appraisal must ensure that all interaction between various elements of the appraisal process are covered by it.

The Solution: In mathematical terms (Wallis 1984)

If f`(x) is a function of x that takes the value f`(a) at each point f`(x), then f'(x) is called the derivative of f(x) with respect to x and the process of going from f(x) to f`(x) is called differentiation.

Suppose P is a point (x,y) on a function f(x) = y and Q is a point (x+Δx, y+Δy) then

$$f'(x) = \underset{\Delta x \to 0}{LIM} \frac{f(x+\Delta x) - f(x)}{\Delta x} = \underset{x \to 0}{LIM} \frac{\Delta y}{\Delta x} = \frac{dy}{dx}$$

and $\frac{dy}{dx}$ then becomes the rate of change of y with respect to x.

Interpreted to apply to the appraisal methodology, if interactions were to be taken into account using the concept of differentiation then:-

- Δx is change in one disciplinary element due to another.
- x tends to 0 would be interpreted to mean that the overlaps between disciplines must be as small as possible and hence the disciplines themselves should tend to become infinitesimal.
-This would be achieved by ensuring sub-division of the disciplines into an infinite number of elements so that each

interaction would form only a minute part of the overall process of appraisal.

-If more than two variables define a function, differentiation would have to be done over the range of dimensions.

5.3.9 Flexibility

The Concept: Since constraints on each appraisal are set by the system in which it is being carried out the methodology would need to suit a number of systems.

The Problem: The boundary condition would have to be adjusted to suit a particular system.

Solution: By introducing the concepts of continuity (sub-division into many parts), infinity (implying completeness and everything i.e. comprehensibility), flexibility is attained by working over any range within these limits.

5.4 Analytical Methods

5.4.1 General

A number of general analytical methods and procedures are available which can be used to analyse various components of decision making. A brief introduction to the concepts involved in each of these methods is given in this section.

5.4.2 Qualitative Methods (Burgess, 1988)

These consist of:-

i)Case study methodologies including the following types:-
- clinical
- literary
- philosophical
- biographical
- historical
- ethnographic

ii)Interviewing and related activities of:-

- data collection
- data analysis
- reporting of data

iii)Functional analysis (Burgess, 1988)

A number of techniques have been designed over the years to help organise an analysis into a systematic and local treatment of a problem and its many facets. Included among these are:-

- supra and subfunctional branched analysis useful initially in generation and evaluation of alternatives that are to be assessed and later in identifying the interactions of the subsystems.
- functional flow charting used to describe the order of decisions and processing of data required to solve the problem.
- arrow diagramming whose purpose is to approximately define a system through the inter-relationships of its major components.

5.4.3 Quantitative Methods (Iverson, 1985)

a) Linear Programming

i) This method encompasses a group of mathematical techniques to assist decision makers in allocating scarce resources to competing needs. However, the underlying mathematical model must be linear, hence the method is restricted in use to the problems that can be formulated according to constant returns to scale for both the objective function and constraints.

ii) A number of formulations can be used with this method including, mathematical formulation and graphical solutions, the Simplex alogarithm and the transportation models.

iii) The method is used frequently in situations requiring best mixes and optimal solutions.

b) Integer programming(Iverson, 1985)

i) This is essentially a special case of linear programming where solution variables are not permitted to take on fractional values

ii) It is frequently used in transportation studies and urbanisation projects.

iii) Usually this method is formulated along branch and bound alogarithms (total solution set divided into subsets and examined in sequence of steps), the cutting plane approach (obtaining optimum solution by use of the Simplex alogarithm without regard for the requirement of integer values) or the zero-one programming models (special case of integer programming in which all of the variables are restricted to the values of either zero or one).

c) Dynamic Programming(Iverson,1985)

i)This is a computational method designed to guide analysis through a division of the total problem into a series of sub-problems by means of a recursive relation.

ii) The application associated with this method involves complex systems containing variables interacting dynamically with each other. The problem is broken into subproblems, and the solution of the particular subproblem is based on solution of previous stages.

iii) There is no standard form or mathematical technique tailored for each decision problem in this method. Its use is particularly well suited for multistage or sequential decision problems and to situations requiring the allocation of scarce resources to a series of competing needs.

d) Decision Theory(Iverson, 1985)

i) This is concerned essentially with decision making in an environment of uncertainty.

ii) The main elements of a decision making model are represented as decision points and chance events. These nodes create a decision tree that graphically summarises the situation embodied in a decision problem.

iii) The main method used in formulation of the problem in this method is the decision tree.

e) Simulation Models (Iverson, 1985)

i) Simulation models are used to imitate the real world scenario. Computers are often used but are not necessary and manually computed simulation is often valuable in providing insight into a system.

ii) The most important advantage in the use of simulation is the ability to model dynamic and analytically complex behaviour of systems which could otherwise not be analysed.

iii) The major disadvantage of this method is the lack of a precise structure since the independent construction of each model does not allow for an overall approach to sensitivity analysis.

f) Systems Analysis(Iverson, 1985)

i) The systems analysis approach involves a series of steps which when properly interfaced will isolate the key elements required to analyse the problem and its environment as well as potential solutions and repercussions. By its nature, it lends itself to a sensitivity analysis and it creates a foundation for the decision making which is required. The systems approach provides a mechanism to illuminate the trade-offs involved and a means to formulate choices in such a way as to compel decision-makers to identify and articulate their values and is thus a powerful tool.

g) Expert Systems

i) These are essentially computer programs capable of being used as a decision making tool in a specialist field.

ii) A class of computer programmes that can advise, explore, analyse, catagorise, communicate, consult, design, diagnose, explore, forecast, form concepts etc. Such tasks constitute complex real world problems normally requiring significant human expertise for their solution.

h) Additional Techniques and Computing Methods (Iverson, 1985)

i) Game theory:-

- when it is possible to foretell probability of possible outcomes and when choices are being made in a hostile environment, the theory of games is employed and is essentially the modelling of conflict confrontation in a effort to identify optimal strategies.
-essentially creates a framework for quantitative analysis through which improved decisions occur.

ii) Inventory models:-

- The purpose is to balance the economic trade-offs between having too much and too little inventory (all items held for a period of time in order to use them more efficiently) available.

iii) Queuing models:-

-queuing theory like simulation, does not perform in optimisation but generates the statistics through which alternative system designs can be compared.

iv) Computing methods:-

- mathematical programming alogarithms are by definition systematic procedures to determine an optimal answer to the interactive process and can readily be programmed on a computer. Because of widespread applications of optimisation techniques, many compiling services are available including packaged programmes.

5.4.4 Implications for present work

The requirements outlined in section 5.2 above imply the use of an infinite number of disciplines interacting in a complicated and dynamic fashion. It is however, a fundamental assumption of the reasoning used to interpret these requirements that the disciplines and sub-disciplines involved can be identified as elements within the complete system. While not to the exclusion of all the other methods described above, by its very nature the proposed methodology is suited particularly to the application of the following analytical mehtods :-

-dynamic programming
- systems analysis
- decision theory.

5.5 Appraisal and Decision-making

Since the whole concept of appraisal has its roots in the process of making decisions, this section is devoted to a study of the state of art of this area. The ultimate goal of decision theory is to provide the analyst with a means to determine rational weightings between the many attributes or outcomes of an alternative so that an objective choice can

be made. As this pre-supposes a commitment to a complete rationality on the part of the individuals, agencies or institutions that will be making decisions, it is appropriate to ask to what degree such rationality can ever be or could ever be assumed (Nuefulle and Stafford, 1971).

Most writers on decision-making would agree that a practical planner cannot hope to be absolutely comprehensive. The best he can do is to arrive at the best possible and rational decision given the practical limitations of his working environment and experience. Any decisions made using these methods will rely to a considerable extent on subjective judgements and hence predictions using these methods cannot be treated as being highly reliable.

Many planning techniques are now designed to help the planner to make better and in particular more rational decisions. Rationality may be regarded as the making of decisions by exercising one's reason rather than merely guessing or reacting to emotional impulses. Carley (1980) has described rational decision-making in terms of five sequential activities namely:-

i) identification of the problem and goals, values and objectives related to it.
ii) listing of all possible alternative ways of solving the problem i.e listing of all alternative strategies.
iii) prediction of all consequences resulting from each alternative strategy
iv) comparison of the consequences with the goals and objectives of the problem for each alternative strategy.
v)selection of the strategy for which the consequences most closely match the goals and objectives or the strategy offering the most complete solution to the problem.

Although, it is only in recent years that the need for management to improve its decision making processes has been acknowledged, it is encouraging to note that there has been a remarkable shift in the approaches to assessment of resource development proposals in North America, Europe and elsewhere over the past two decades. Fifteen years ago the focus was on specific projects over a fairly narrow range of considerations, notably technical and economic aspects. Today they have a much wider perspective having broadened from projects to programmes and including the appraisal of policies. These changes have been made possible by some important modifications to existing decision making procedures, and the development of more sophisticated tools of analysis

(O'Riordon and Sewell, 1981). Included amongst these tools (concentrating particularly on public and non - profit organisations) are:-

i) Strategic planning

Recent trends in human development have as we have seen resulted in turbulence and upheaval aggravated by the increased inter-connectedness of the world, and changes in one place now typically result in changes elsewhere (Luke, 1988). As stated by Bryson (1988) the increased inter-connectedness is perhaps most apparent in the blurring of three different types of distinctions namely:-

- domestic and international
- among policy areas
- between public, private and non profit organisations

so that a world of interconnections and interdependencies exists in which no-one organisation or institution is fully in charge, while many are involved (Luke 1988, Bryson and Einsweiler 1988). This increased environmental uncertainty and ambiguity requires public and non profit organisations (and communities) to think and act strategically as never before. Strategic planning is designed to help them to do so (Bryson, 1988) and can be defined as

"...a disciplined effort to produce fundamental decisions and actions that shape and guide what an organisation (or other entity) is,what it does and why it does it." (Bryson 1988,Olsen and Eadie 1982).

As stated by Luke (1988)

"At its best, it requires broad scale information gathering, an exploration of alternatives and an emphasis on future implications of present decisions. It can facilitate communication and participation, accommodate divergent interests and values and faster orderly decision - making and successful implementation." (Luke,1988)

ii)Long-range planning

As stated by Bryson (1988), strategic planning and long range planning for organisations are used interchangeably and will result in similar outcomes. However in practice they differ in four fundamental ways namely:-

-long range planning emphasises specification of goals and objectives and their translation into current budgets and work programmes whilst strategic planning relies more on identifying and resolving issues.
- strategic planning focuses on the assessment of the external and internal environment of the organisation for more than long range planning.
-strategic planners are more likely than long range planners to summon forth an idealized version of the organisation and ask how it might be achieved.
-strategic planning is more action orientated than long range planning.

iii)Decision support systems (DSS)
The following definition by Sprague and Eric (1982), captures the key aspects of decision support systems (Sprague and Watson, 1986). They define DSS as:-

-computer based systems
-that help decision makers
-confront ill structured problems
-through direct interaction
-with data and analysis models.

5.6 Conclusion

The essence of appraisal, then is decision making and this requires availability as well as proper use and analysis of data followed by a rational assessment of the results of the analysis. Essentially there are two systems consisting of the activities involved in decision making, and the techniques and processes of making decisions. The need is to link these two systems within the framework of the requirements listed in section 5.2.

Based essentially on the requirements listed in chapter 5 using a range of the methods discussed in section 5.3 and integration of the appraisal process with decision technologies and processes as suggested in section 5.4, an appropriate approach to appraisal is evolved in the next chapter.

CHAPTER SIX

A NEW APPROACH

CHAPTER 6

A NEW APPROACH

6.1 Introduction

Figure 6.1 shows schematically the, elements that need to be considered in evolving an improved approach to appraisal and evaluation of projects. This chapter concerns itself with the description of an approach which incorporates the elements shown in figure 6.1 and which has been shown (in chapter 8 of this report) to be applicable to Civil Engineering projects.

Although the principles involved in this approach are fairly easy to understand, the explanation and description of the rationale and procedures that form the basis of application of this methodology can appear to be complicated. To avoid this danger, it is recommended that chapters 6,7 and 8 of this report should be read synchronously. Cross references between these three chapters are provided at relevant points in the text for purposes of clarity. Accordingly, a smooth transition is provided as the rationale described in this section, is translated into practically applicable procedures outlined in chapter 7 which is followed by an illustration of an application (contained in chapter 8) of the proposed methodology to a Civil Engineering project.

6.2 The rationale

Based essentially on the requirements listed in section 5.2, using a range of the methods discussed in section 5.3, and integration of the appraisal process with decision technologies and processes as suggested in section 5.4 and visualised in figure 6.1, an improved approach to appraisal is evolved in this section.

As established earlier, an approach that particularly lends itself to the analysis of complex and large problems is that of systems analysis. This is particularly true of areas in which the problem can be easily be split into sub-components which can be then analysed easily on their own and in relation to each other. It is not surprising therefore that new appraisal approaches tend to use this method of analysis.

The systems - analysis approach (Sprague and Eric, 1982) consists of the following steps:-

i)State a goal, establish an appropriate measure of effectiveness and develop an objective function.

ii)Determine the limitations and establish a set of constraint conditions.

iii)Determine a solution that achieves the stated goal and satisfies all the relevant constraint conditions.

In keeping with these recent trends, a systems analysis approach is adopted in evolving the proposed methodology. Following the stepwise approach described above, a systems framework is evolved as shown below.

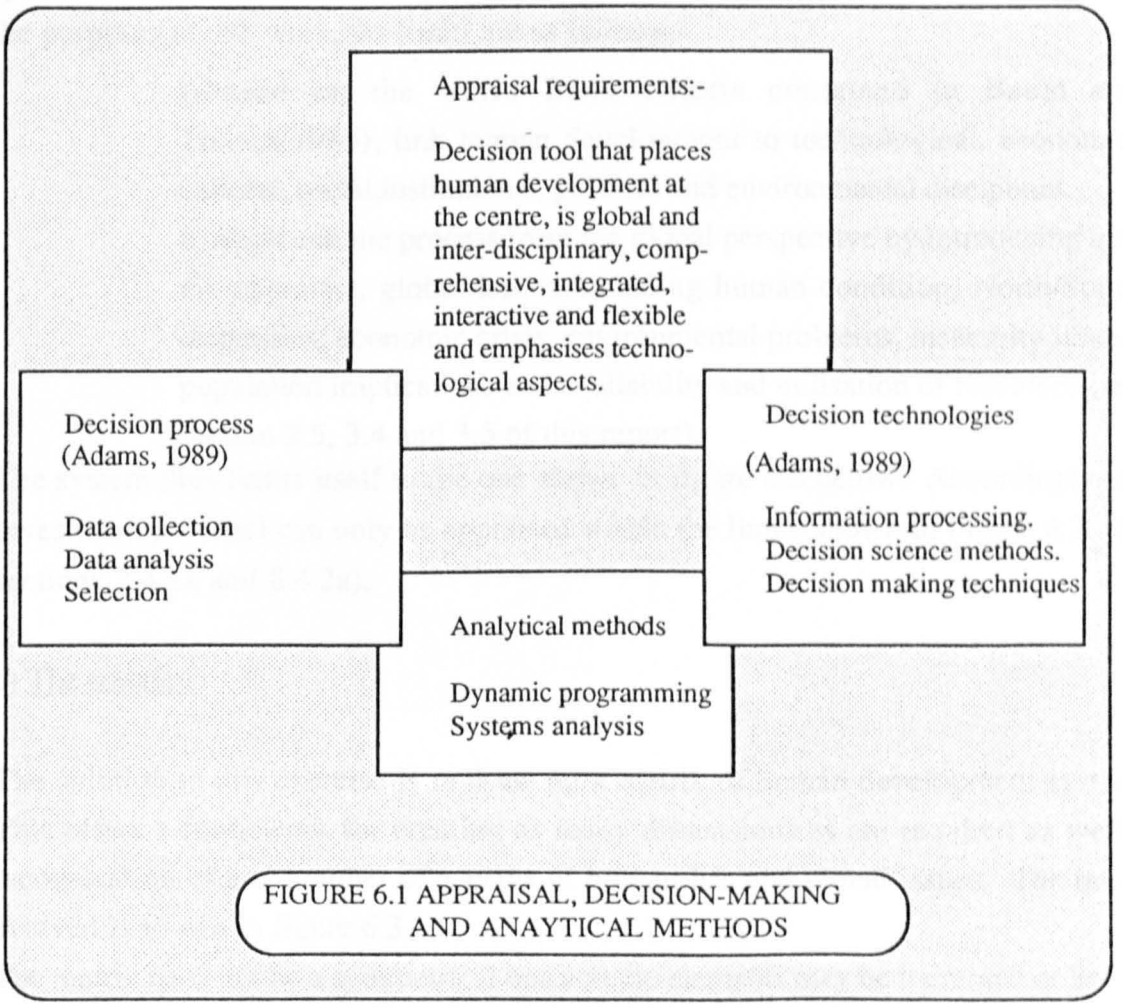

FIGURE 6.1 APPRAISAL, DECISION-MAKING AND ANAYTICAL METHODS

a) Goal, effectiveness and objective function.

The objective of this exercise is to establish a systems solution that will:-

1)Place human development at the centre of the appraisal process.

2)Incorporate a global context in this process.

3)Allow the process to be inter-disciplinary, comprehensive and flexible.

4)Integrate various aspects into a single framework while allowing for consideration of interactions between components.

5)Allows for technological considerations to be incorporated into it.

b) Limitations

It is possible to prepare an infinite list of disciplines that can be incorporated into the system. The user must decide exactly how many elements are to be considered. For the purposes of this work, the limits are as follows:-

i)Based on the world Bank criteria contained in Baum and Tolbert(1985), link human development to technological, economic, cultural, social,institutional, political and environmental disciplines.

ii)Approach the process from the global perspective by introducing into the appraisal, global issues including human condition, North/South disparities; economic crisis, environmental problems, insecurity issues, population implications and availability and utilisation of resources (see section 2.5, 3.4 and 3.5 of this report).

The system thus limits itself to the one shown in figure 6.2 below. Accordingly, any investment proposal can only be appraised within the limits shown in Figure 6.2. (See sections 7.4.1a and 8.4.2a).

c) The solution

The solution to this exercise is to draw up a matrix of human development systems. This offers a framework for creating as many dimensions as are required as well as incorporation of any number of aspects of human life and global issues. The matrix evolved is shown in figure 6.3.

The matrix need not be a symmetrical one and the elements may be increased or limited in either direction. The matrix may also consist of more than two dimensions depending on the problem. For example a third dimension could be added to the matrix shown in figure 6.3 as shown in figure 6.4.

For the purpose of this research the two dimensional system shown in figure 6.3 is used.

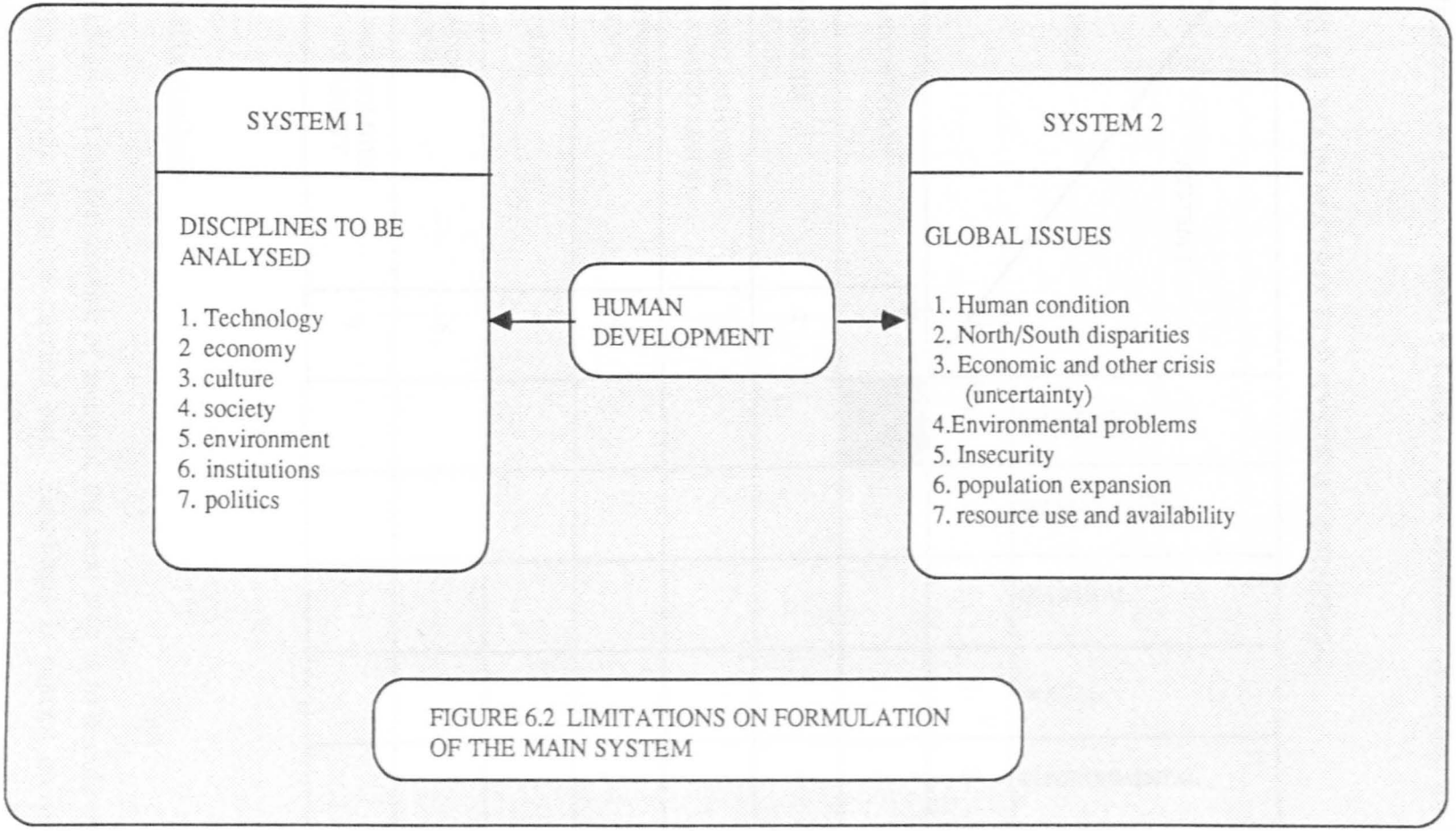

FIGURE 6.2 LIMITATIONS ON FORMULATION OF THE MAIN SYSTEM

Each cell is identified by the suffices i and j where suffix i represents one dimension and j the other dimension. Each dimension may be split into an infinite number of elements hence i = 1,2..... and j = 1,2,3,.... (see sections 7.4.1b and 8.4.2b).

FIGURE 6.3 MAIN MATRIX FOR SYSTEM DEFINITION

SYSTEM 1 / SYSTEM 2 (i → / j ↓)		ECONOMICAL	TECHNOLOGICAL	CULTURAL	SOCIAL	ENVIRONMENTAL	INSTITUTIONAL	POLITICAL
		1	2	3	4	5	6	7
HUMAN CONDITION	1							
NORTH/SOUTH DISPARITIES	2							
ECONOMIC AND OTHER CRISIS (UNCERTAINTY)	3							
ENVIRONMENTAL PROBLEMS	4							
INSECURITY	5							
POPULATION EXPLOSION	6							
RESOURCE UTILITIES AND AVAILABILITY	7							

6.3 Extent of Analysis

Having identified the framework of analysis, the next step is to decide the extent to which the analysis is to be carried out. Emphasis is placed on the level of comprehensibility and flexibility required. The system proposed lends itself also, to maintaining continuity at the operational level (see section 5.2.6 and 5.2.3 of the requirements).

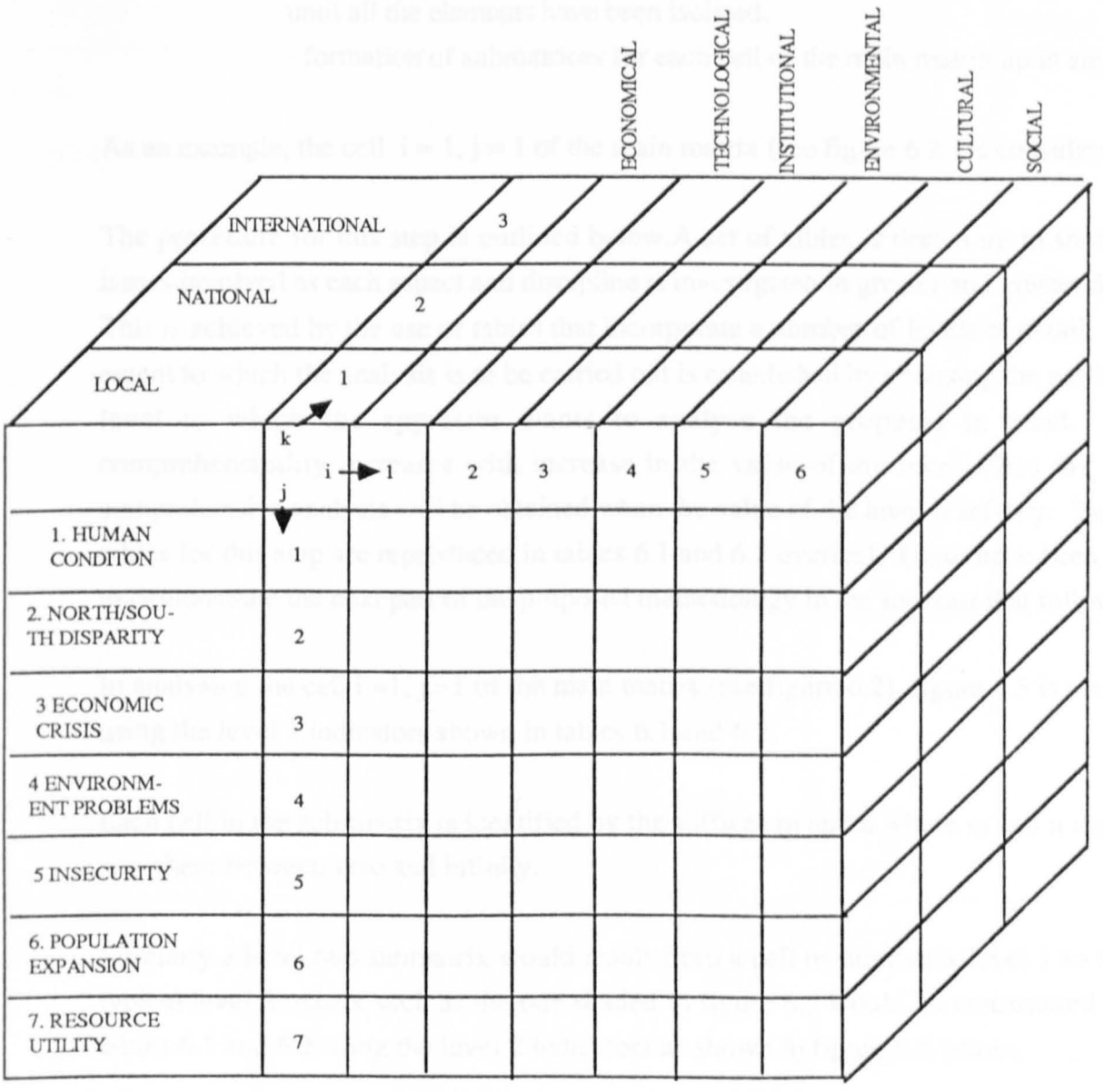

FIGURE 6.4 AN EXAMPLE OF THREE DIMENSIONAL MAIN MATRIX IDENTIFYING THE FUNDAMENTAL SYSTEM TO BE ANALYSED

A twofold approach is adopted in this step namely:-

- breakdown of each discipline and issue in the cell in successive steps until all the elements have been isolated.
- formation of submatrices for each cell of the main matrix up in step 1.

As an example, the cell i = 1, j = 1 of the main matrix (see figure 6.2) is considered.

The procedure for this step is outlined below.A set of tables is drawn up to show the issues involved as each aspect and discipline is investigated in greater and greater detail. This is achieved by the use of tables that incorporate a number of levels of detail. The extent to which the analysis is to be carried out is established by choosing the particular level to which the appraiser wants to analyse the proposal in hand. The comprehensibility increases with increase in the value of the level. Thus the most comprehensive analysis will be obtained when the value of the level is infinity. Typical tables for this step are reproduced in tables 6.1 and 6.2 overleaf. These have been used to demonstrate the next part of the proposed methodology in the sections that follow.

In analysing the cell i =1, j =1 of the main matrix (see figure 6.2), figure 6.5 is evolved using the level 1 indicators shown in tables 6.1 and 6.2.

Each cell in the sub-matrix is identified by the suffices m and n where m and n may lie anywhere between zero and infinity.

Similarly a level two submatrix would result from a cell in submatrix level 1 so that a typical level 2 matrix such as the one shaded in figure 6.5 would be constructed from tables 6.1 and 6.2 using the level 2 indicators as shown in figure 6.6 below.

Obviously level 3,4,5.....N (where N may lie anywhere between 1 and infinity) matrices may be constructed in successive steps until the required extent of analysis has been achieved.

Once the level of detail has been identified, it is easy to draw up a set of matrices that will describe the relevant sub systems. These are prepared on the basis of tables 1 to 14 contained in appendix 2A. The variables to be measured are then identified. Essentially these form the basis of the sub-matrices.

TABLE 6. 1: ISSUES INVOLVED IN TECHNOLOGICAL CONSIDERATIONS

SYSTEM (i = 1)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
1. TECHNOLOGICAL	1. PLANT	1. Existing Types	1. Locally made	1. Operation 2. Efficiency 3. Cost	
			2. Imported	1. Operation 2. Efficiency 3. Cost	
			3. Spare parts	1. Availability	
		2. New or advanced types	1. Locally made	1. Operation 2. Efficiency 3. Cost	
			2. Imported	1. Operation 2. Efficiency 3. Cost	
			3. Spare parts		
	2. MATERIALS	1. Locally manufactured	1. Quality 2. Availability 3. Distribution 4. Cost		
		2. Imported	1. Quality 2. Availability 3. Distribution 4. Cost	1. Goods 2. Freight 3. Insurance	
	3. SERVICES	1. Existing	1. Infrastructure	1. Transport & Communication	1. Cost 2. Sufficiency
				2. Water	1. Cost 2. Sufficiency
				3. Sanitation	1. Cost 2. Sufficiency
				4. Energy Supply	1. Cost 2. Sufficiency
		2. New	1. Infrastructure	1. Transport & Communication	1. Cost
				2. Water	1. Cost
				3. Sanitation	1. Cost
				4. Energy Supply	1. Cost

TABLE 6.2 HUMAN CONDITION CONSIDERATIONS

SYSTEM (j = 1)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
1. HUMAN CONDITION	1. POVERTY	1. Shelter	1. Availability 2. Qality 3. Cost		
		2. Infrastructure	1. Water supply	1. Quality 2. Cost	
			2. Sanitation & Waste disposal	1. Quality 2. Cost	
			3. Health	1. Life expectancy 2. Infant mortality 3. Population growth rate 4. Cost of services	
			4. Education	1. Literacy level 2. Availability 3. Cost	
	2. NUTRITION	1. Food	1. Consumption 2. Productivity	1. Cost	
			3. Distribution	1. Transportation	1. Cost
			4. Storage	1. Availability	1. Cost
		2. Quality	1. Deficiency	1. Calorie count	
	3. EMPLOY-MENT	1. Labour	1. Skilled	1. Education 2. Training 3. Wages	
			2. Unskilled	1. Wages	
			3. Unemploy-ment levels	1. Benefits	
		2. Other	4. Recreational facilities		
	4. INCOME DISTRIBUTION	1. Minimum wage	1. Suffuciency 2. Percentage in this bracket		
		2. Average wage	1. Percentage in this bracket		
		3. Maximum wage	1. Percentage in this bracket		

Section 7.4.2 outlines the practical procedure for this step while section 8.4.3 illustrates the practical application of the suggested approach in this step.

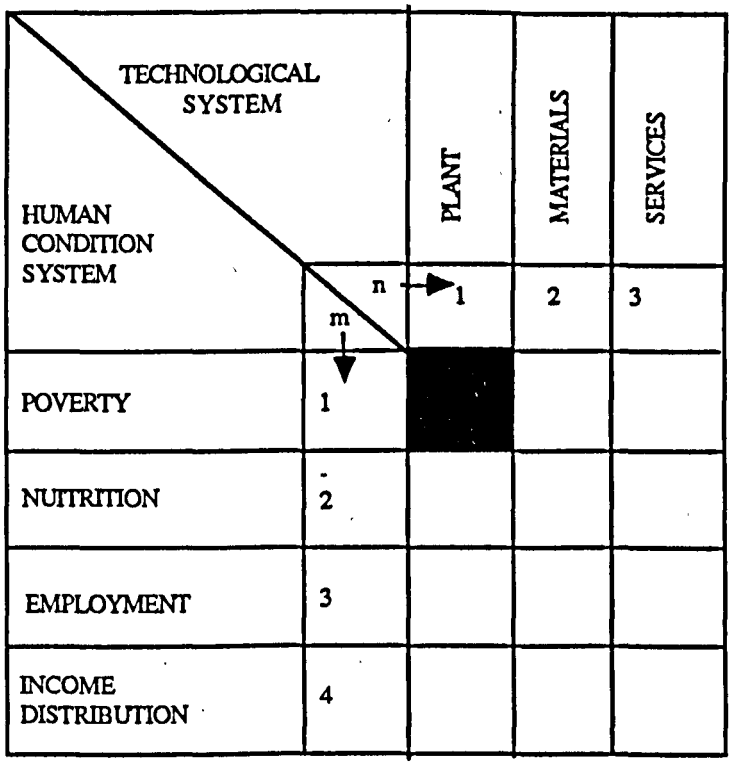

FIGURE 6.5 CELL i = 1, j = 1: MAIN MATRIX (SUB-MATRIX LEVEL 1)

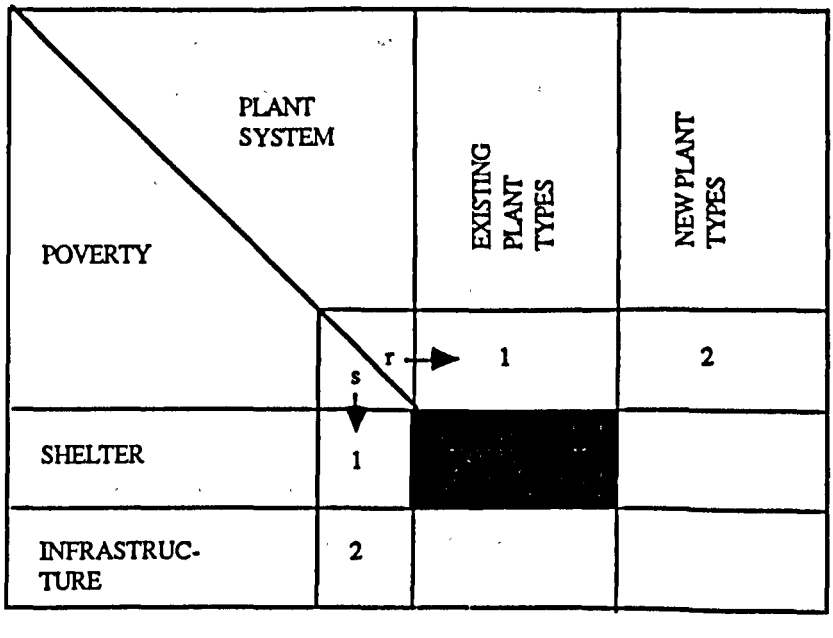

FIGURE 6.6 CELL m =1, n = 1:SUB-MATRIX LEVEL 2

6.4 The Analysis

Once the extent of the analysis has been established so also have all the indicators to be measured as these are defined by the level of detail to be analysed for the discipline under consideration. Accordingly provided data has been collected and is available in all the relevant areas, an analysis is carried out in two steps, the first of which deals with a systematic analysis of each cell in the main matrix and the second (which uses a dynamic programming approach within the main systems analysis framework) to analyse interaction between cells. The approach to the analysis is described below.

a) Analysis of each cell

Each cell of the main matrix is considered in isolation in this part of the analysis. Before embarking on the actual analysis, it is necessary to decide:-

-What form the output is required to take
- How the output is to be presented

It may be decided for instance that the following will apply:-

- analysis to be performed to level 1 only.
- the final output is to be produced using the cost/benefit methodology.
- where it is not possible to measure an aspect in monetary units a qualitative method may be used.
- the output must therefore, consist of:-

1)the costs
2)the benefits
3)the qualitative statements where quantitative output is not possible

Accordingly the analysis would produce the matrix shown in figure 6.6. The values obtained for total costs and benefits (by adding up the 'total' column) are then transferred to the main matrix for consideration in the final analysis.

The qualifications in each cell of the submatrix i = 1, j = 1 are then considered and a conclusive set of the qualifications transferred to the main matrix for analysis in the final stages.

A detailed analysis, such as the one described above is carried out for each cell of the main matrix. The results from each such analysis is then transferred to the main matrix for final consideration of the whole system. (See sections 7.4.3, 7.4.4a and 8.4.4).

b) Analysis of interactions.

In order to ensure that all the interactions between the systems have been considered, it is necessary to create a systematic framework of linkages between the systems. The matrix method suggested lends itself well to this requirement if used in conjunction with a dynamic programming approach.

For example, in analysing the cell i =1, j =1 of the main matrix, the process of analysing the interactions is defined as follows:-

-the technological aspect forms the major system (with which all others will interact). Having established this a standard 1xM matrix is created where M is the dimension containing all the systems involved in the analysis. Then the major element is analysed in conjunction with each minor system (all elements except the major one under consideration listed in dimensions i and j of the main matrix) in the standard matrix to produce a net value of the required outputs. For instance in the example under consideration, the standard interaction matrix would consist of a 1 x M matrix where m = (i + j - 1) i.e. a 1 x 13 matrix shown in figure 6.7. (See section 7.4.4b and an illustration of practical application provided in section 8.4.5)

-In order to analyse the interactions completely, each element of the main matrix is treated as the major system in turn. A matrix results from this analysis that is symmetrical about the diagonal and in which all the diagonal elements are non-interactive (see figure 6.7). This matrix is referred to as the output matrix 2

FIGURE 6.7 A SAMPLE INTEGRATED OUTPUT MATRIX

Major System \ Minor System	Techno-logical	Economic	Human condition	N/S disparity	Environ-mental	Economic crisis	Global insec.	popul-ation	Resource
Techno-logical									
Economic									
Human condition									
N/S disparity									
Environ-mental									
Economic crisis									
Global insec.									
popul-ation									
Resource									

NOTE:The diagonal elements are non interactive.

For ease of application the output from the interaction analysis is presented in the same form as the analysis performed in step 3.1 i.e. as costs, benefits and qualifications.

6.5 Presentation of results

After each cell has been analysed completely, firstly in isolation and secondly for the interactions, output in the chosen form is transferred to the main matrix. For instance in the example above, the chosen output format is costs, benefits and qualifications. (resulting from a qualitative analysis).

This output is presented in the form of two main matrices, the first containing the individual cell output and the second containing output from the interaction analysis.

Section 7.4.5 describes the procedures to be followed in producing the output matrices, while section 8.4.6 illustrates how these principles and procedures are applied practically to a water supply project.

6.6 Making a Decision.

It is essential when making a decision based on the output produced by this methodology to ensure that:

i) The problem was initially defined completely.

ii)The information gathered and analysed was handled as comprehensively as possible.

iii)The analysis ensured equivalence in the measurement of all the variables involved.

iv)The likely consequences of the proposal were considered as completely as possible.

v)If one of a number of options was to be chosen, it was ensured that the optimal solution (Not necessarily the least cost option) was chosen

The procedure for making a decision is outlined in section 7.4.6 and an illustration of application of the procedure is given in section 8.5.

CHAPTER SEVEN

SUGGESTED FORMAT - A TYPICAL MANUAL

CHAPTER 7

SUGGESTED FORMAT - A TYPICAL MANUAL

7.1 Introduction

The rationale and principles along which the proposed approach is to be evolved have been described in detail in the last section of this work. However, in order that these principles can be translated into a practically applicable form, it is necessary to present these in a suitable form. It is proposed that a manual should be produced which describes in a sensible manner the procedures to be followed in this methodology. Accordingly a typical manual is included in this chapter of the report.

7.2 Contents of the Manual

The manual contains a brief introduction outlining the objectives followed by an explanation of the analytical tools and the system of analysis which forms the basis of this methodology.

Next, a step by step approach is used to describe the procedure to be adopted. This basically consists of five steps involving the following:-

-Definition of the system
-Development of the evaluation criteria
-Data collection and analysis
-Presentation of results
-Making the decision.

7.3 A Typical Manual

This consists essentially of procedures to be followed in the application of the proposed methodology, and is described overleaf.

A TYPICAL MANUAL FOR A SYSTEMATIC APPROACH TO INVESTMENT APPRAISAL

CONTENTS:

7.3.1 General

Consisting essentially of an analysis of a proposal to invest resources, an appraisal provides the basis of making a decision to accept the proposal (or one of a number of alternatives contained in the proposal) or to reject the proposal. Although a number of methodologies of appraisal have evolved over the years, recent trends require a methodology that :-

i) places human development at the centre of any investment of resources.
ii) gives the appraisal process a global context
iii) is inter-disciplinary, comprehensive and flexible
iv) integrates all the components of the process as well as examines the interactions between the components.

If special emphasis is to be placed on a particular area then other considerations have to be outlined. For instance, if special emphasis is placed on the technological appraisal of the proposal under consideration then additional requirements would include:-

v) examination of the existing technological status
vi) the mode of transmission of new technologies.

7.3.2 Analytical tools

Based on a detailed examination of the terms of reference above, it is apparent that the appraisal process will involve use of many variables interacting in a complicated fashion. A framework of analysis and decision-making that particularly lends itself to the analysis of large and complex problems is a systems approach. Indeed it was because of the increasing complexity and magnitude of contemporary problems that this approach has become increasingly important since mid 1940's (Jewell, 1986). In this approach, problems are typified by a large number of interactive variables many of which defy quantification.

The suggested approach to appraisal is based on a systems approach. Typically, the proposed approach involves the following steps:-

i) Definition of the problem (frame of reference)

ii) Development of criteria for evaluation
iii) Data collection
iv) Evaluation (analysis)
v) Choice of optimal investment (decision)

Figure 7.1 shows how these steps are linked to the analysis of systems.

The systems approach has several defining characteristics (Jewell, 1986). It is repetitive and feedback is allowed from any step to any previous step. If applied with ingenuity and flexibility, it can provide a common basis of understanding among specialists from different fields and disciplines. The systems approach is most beneficial when goals and objectives of the systems involved can be reasonably well defined. It also aims for optimisation of the overall system rather than piecemeal sub-optimisation of its components or sub-systems. A principle useful in application of the systems approach is the fact that as progress is made through the system, no irreversible decision should be made until it must be made, hence maintaining maximum flexibility.

A number of obstacles, do however present themselves in the application of this approach and should be guarded against. These consist of:-

-perceptual obstacles caused by inability of the appraiser to visualise remote relationships
-cultural hurdles where development of the process is lacking in local customs and procedures
-habitual obstacles caused by ease in use of existing as opposed to innovative procedures

The proposed appraisal method consists of a number of steps. The next section contains an outline of the procedure involved in each of these steps.
The proposed approach method consists of a number of steps. An attempt has been made to produce an outline of the procedures involved in these steps, in the next section. It must be emphasised that these procedures attempt to provide guidelines only and should not be regarded as a detailed manual. The reason for lack of detail consist of the need to limit present work to outline conceptualisation of the proposed methodology.

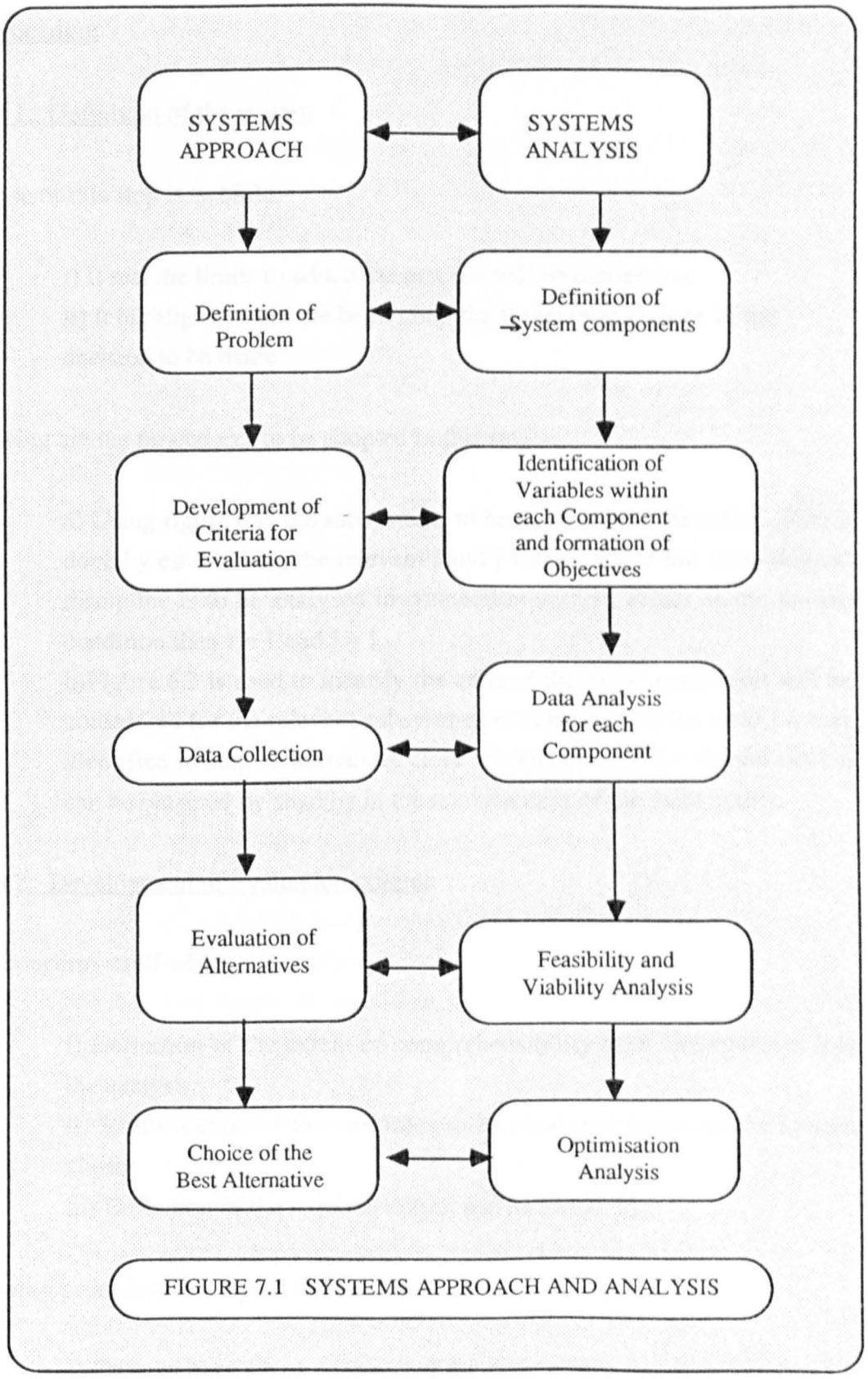

FIGURE 7.1 SYSTEMS APPROACH AND ANALYSIS

7.4 The Procedure

7.4.1 Step 1: Definition of the system

The purpose of this step is twofold:-

i) It sets the limits to which the process will be carried out
ii) It highlights, from the beginning, the fragmentary nature of the decision to be made

The following are the procedures to be adopted in this step:-

a) Using figure 6.2, the subsystems to be analysed are identified. This is done by establishing the relevant i and j values. e.g. if the technological discipline is to be analysed in connection with its effect on the human condition then i = 1 and j = 1.
b)Figure 6.3 is used to identify the cells of the main matrix that will be considered for the relevant subsystems (established by the i and j values identified in step 1a above). A clear visualisation of the chosen system can be obtained by shading in the relevant cells of the main matrix.

7.4.2 Step 2: Development of Evaluation criteria

This step concerns itself with:-

i) Definition of the extent of comprehensibility to be incorporated into the analysis
ii) Identification of the variables to be measured based on the system chosen
iii) Definition of the required output and its formatting

The following procedure is adopted in this step:-

a) The extent to which each cell of the main matrix (identified in step 1b) is to be analysed is determined by using tables 1 to 14 contained in appendix 2a. Essentially the level (indicated on these tables) to which the analysis will be carried out is identified in this step.

b) The variables which will be used or measured to analyse each component of the relevant level (chosen from table 1 to 14, appendix 2a) are then identified.

c) The format of the output is defined, for instance if a cost/benefit analysis output is the one chosen, it may be decided that the following should be the various elements of the output:-

-cost
-benefits
-qualitative elements

7.4.3 Step 3. Data Handling

Consisting essentially of the 'decision process' as defined in figure 5.2 this step involves:-

i) Data collection
ii) Data analysis
iii) Selection

The procedure for this step is outlined below.

a) As a first step a sub-matrix is created for each cell of the main matrix based on the selected level of analysis.

b) Each sub-matrix is identified and a detailed study carried out to identify the information available. This step indicates the availability of information or otherwise for each element of the sub-matrix.

c) Attention is next directed to those parts of the system for which no information is available or for which the data available is incomplete or insufficient. An attempt is made to analyse the effect on the final outcome of the proposed investment of ignoring these portions of the chosen system.

d) A decision is made on how to deal with the data deficient parts of the system.

e) Attention is directed to those portions of the system for which information is available. This data is sorted and arranged into an acceptable form.

7.4.4 Step 4: The analysis

This step involves itself with:-

i) Detailed analysis for each cell identified in steps 1a, 2a, 2b and 2c.
ii) The interactions between these cells.

The procedure for this step consists of the following steps:-

a) Each cell is analysed in as much detail as allowed by the availability of data. The output from each analysis is presented in the output format described in step 2c.
b) The interaction matrix is defined for each system (identified in step 1) as the major system in turn. The results of each interaction analysis are then translated into the required output format.

7.4.5 Step 5: Presentation of output

The purpose of this step is to produce an output in a form that will assist the decision-makers to accept or reject a particular proposal or alternatively to invest resources. This step constitutes the following:-

a) Results of the analysis carried out in step 4a are transferred to an integrated output matrix 1, having the format shown in figure 6.2
b) Results of each interaction analysis are similarly transferred to an integrated output matrix 2
c) A total output matrix is then produced by adding the output matrices 1 and 2 generated by steps 5a and 5b above.
d) Before passing the results onto the decision-makers, it is recommended that the following points should be used as a check list of what should have been accomplished by the process :-

- Has the problem requiring solution been defined completely?
-Have all the issues been addressed as widely as possible?
-Have all the consequences and implications of each aspect or element been thought through, debated and considered as comprehensively as possible.

-Has every attempt been made to bring all the foreseeable contingencies together in the analysis.

7.4.6 Step 6: Making the decision

Involving, essentially, the decision technologies as listed in figure 5.2, this process involves:-

i)Systematic consideration of the results presented.
ii) Decision science methods
iii) Decision making techniques

The recommended procedure for this step consists of :-

a) Assembling together of the integrated and total decision matrices for each of the options to be considered.
b) Ensuring that equivalence exists in the measurement of all the variables in each of these decision matrices.
c) Choice of the option providing the most acceptable change in human development based on optimisation theory used in decision-making

CHAPTER EIGHT

VALIDATION OF THE PROPOSED METHODOLOGY USING A CASE STUDY APPROACH

CHAPTER 8

VALIDATION OF PROPOSED METHODOLOGY USING A CASE STUDY

8.1 Introduction

This chapter illustrates practical application of the proposed methodology using a case study as the basis of validation. The case study chosen to validate the proposed methodology, is based on a water supply scheme of a major city in a developing country.

Although actual data for this scheme has been used throughout, the identity of the scheme is not revealed in accordance with requirements imposed by the consultants who provided the material for this case study.

A number of other reasons made this a particularly suitable case study for the present purpose, as described below:-

i) The city under consideration was the result of its being a watering place for railway workers in the first instance, so that data is available for the scheme from its very beginning.

ii) The data is available in accessible format for the present analysis so that very few assumptions are involved.

8.2 The Case Study - A Historical Background

In 1897, construction was commenced of a railway line to link the coast to a cotton growing area. Preceding this, in 1896, a transport depot was established at a small watering place. At this watering place the construction of the railway line was later halted for a while to gather resources for the more difficult sections that lay ahead. Marshaling yards were laid out, workshops and go-downs built and an administrative headquarters established. Around this nucleus a small town of traders developed followed shortly afterwards, by establishment of the Provincial headquarters and later the Government itself.

During the early days, a supply of water was provided for the growing town, by means of an intake on a small river (called River A for the purpose of this study). However, the supply from River A proved to be of poor quality and in any case soon became

insufficient for the growing population. In 1907, a new supply was developed, this time at springs some distance from the town, from which a combined flow of 4546 Cubic metres a day could be abstracted. Thus began the planning of water supplies for this town referred to as town C for the purpose of this study.

By 1917, Town C had become a commercial centre with a hint of industry so that during late 1920's and early 1930's it became necessary to plan for further water supplies. The source chosen was another river (called River R) on which an intake was constructed at the site of a future dam, followed by a nine inch pipeline constructed in 1938, and later a treatment works and a storage reservoir on site B. This increased the supply to 7956 cubic metres per day.

Unfortunately, this total supply was only just sufficient to meet the immediate needs of the town which had grown considerably. Nor did the population stop increasing rapidly during the second world war years, so that in spite of the installation of booster pumps at the intake on River R, and the sinking of boreholes at a number of places, there was a shortage of water resulting in its being rationed. Immediately after the war, work commenced on the construction of a dam on River R. By 1950, this dam had been constructed, as had two raw water mains (12 and 16 inch diameters) and an extension to the water treatment works. The supply had at this stage, increased to 20,547 cubic metres per day. The demand at this point was in the region of 18,184 cubic metres a day. Accordingly, it became necessary once again to develop further water services for Town C.

This time a scheme involving construction of a dam on River S, a diversion weir on River C , a new treatment works and extensions to the pipe network was identified. By 1956, these works inclusive of a storage reservoir having a capacity of 27,276 cubic metres had been constructed although the new treatment works and pipelines had a carrying capacity of 18,184 cubic metres a day only. The total supply at this stage thus amounted to 46,597 cubic metres a day. In 1964, the maintainable yield was further increased to 53,416 cubic metres a day, by the addition of two diversion dams on Rivers M and N, an aqueduct to River S and extensions to the treatment works at site B. By 1969, The height of the dam on River S was raised resulting in a source capacity of 63,644 cubic metres per day. The treatment works were extended to yield 59,533 cubic metres a day and another reservoir having a capacity of 27,276 cubic metres was constructed at site B. Thus the total supply in 1969 was about 80,000 cubic metres while the consumption was in the region of 72,300 cubic metres a day.

Once again, it became apparent that increment would be required in the water supply to what had become a major city. Accordingly, a source on River C was identified. Raw water mains, pumping equipment, new treatment works and treated water pipelines were constructed. The work on this part of the water supply, which increased the water supply to the city by 127,000 cubic metres a day was completed in 1984. By June, 1986 the total supply to the city was in the region of 203,000 cubic metres a day but was fully committed, so that once again extensions to the water supply had to be planned. Accordingly, a study was carried out in 1986 which set out proposals to meet the projected demand of the city upto the first decade of the twenty first century. The case study used in the present work is based on the works completed in 1984.

Table 8.1 contains a summary of the history detailed above and highlights the phase of the works included in the present case study.

8.3 The Actual Appraisal

8.3.1 Terms of reference

The objectives of the project were stated as follows:-

i) an investigation of the existing position
ii) prediction of future water supply requirements
iii) identification of alternative ways of meeting the predicted future requirements
iv) recommendation of a scheme having capability of economic development to provide supplies for the next thirty years i. e. from 1970 to 2000

8.3.2 The analysis

8.3.2.1 Existing position

Four aspects of the existing position were considered namely:-

i) The total existing capacity of the water supply shown in table 8.1. The available water supply was approximately 80,000 cubic metres a day

TABLE 8.1 SUMMARISED HISTORY OF DEVELOPMENT OF WATER SUPPLY TO TOWN A

DESCRIPTION OF DEVELOPMENT AND COMMENT	YEAR FROM WHICH OPERATION BEGAN	SOURCE	AMOUNT CUMECS PER DAY
Watering Place. Water source very small, insufficient and bad quality. Was abandoned soon after operation began	1896	River A	Unknown
Administration centre, followed by Provincial Headquarters and finally the government offices. Source still used. Water quality good	1907	Springs K	4546
Commercial centre with a hint of industry. Water being rationed.	1917	-	4546
Expansion of commercial and industrial activity. Good quality water.	1938	River R, Boreholes, Storage reservoir, Treatment works and Booster pumps	7960
Increasing population and industry. Good quality water.	1950	Dam on River R, New treatment works.	20,460
Increasing industry and population. Good quality water.	1956	Dam on River S, Diversion of River C	46,597
Developed town becoming a city. Increasing population as well as migration. Good quality water.	1964	2 NO.diversions and Damming of Rivers M and N, Aquaduct to reservoir on River S supply	53,416
Continued growth (industrial and commercial) and population growth and migration. Good quality water.	1969	Extensions to treatment works and Storage, Increased height on River S	79,827
Continued expansion, population growth and migration.	1984	New source on River C, New treatment works and pipelines	203,000
Slowing down of population growth, industrial expansion and migration	1995	Dam on River T, Extensions to treatment works	324,247

ii)Administration which was carried out by the city council having 43 members through the city Engineer aided by a whole range of deputies and others, see figure 8.1.

iii) Capital expenditure trends which showed it to have doubled from 241,391 money units in 1963 to 473,764 money units in 1967. Estimated capital expenditure was shown to be 575,850 money units in 1968 and 1,678,700 money units in 1973. The total between 1968 and 1973 equaled 7,978,150 money units according to these estimates

iv) A study of the existing commercial and industrial trends showed that industries in the city included processing, manufacturing and general engineering concerns as well as a flourishing tourist industry .

8.3.2.2 Future position

Two aspects were considered namely:-

i) The spatial element; the area of supply was expected to increase by six times as much over the next thirty years.

ii) Population and water consumption; These were projected as shown in table 8.2 which also shows the growth rates per annum.

TABLE 8.2 PROJECTED POPULATIONS AND WATER CONSUMPTIONS

YEAR	POPULATION	POPULATION GROWTH RATE (%)	WATER CONSUMPTION CUMECS/DAY	WATER CONSUMPTION GROWTH RATES (%)
1970	507, 573		77,782	
		5.6		5.4
1980	875, 100		131,607	
		5.9		5.7
1990	1, 543 ,000		229,073	
		5.1		4.9
2000	2,574,000		369,590	

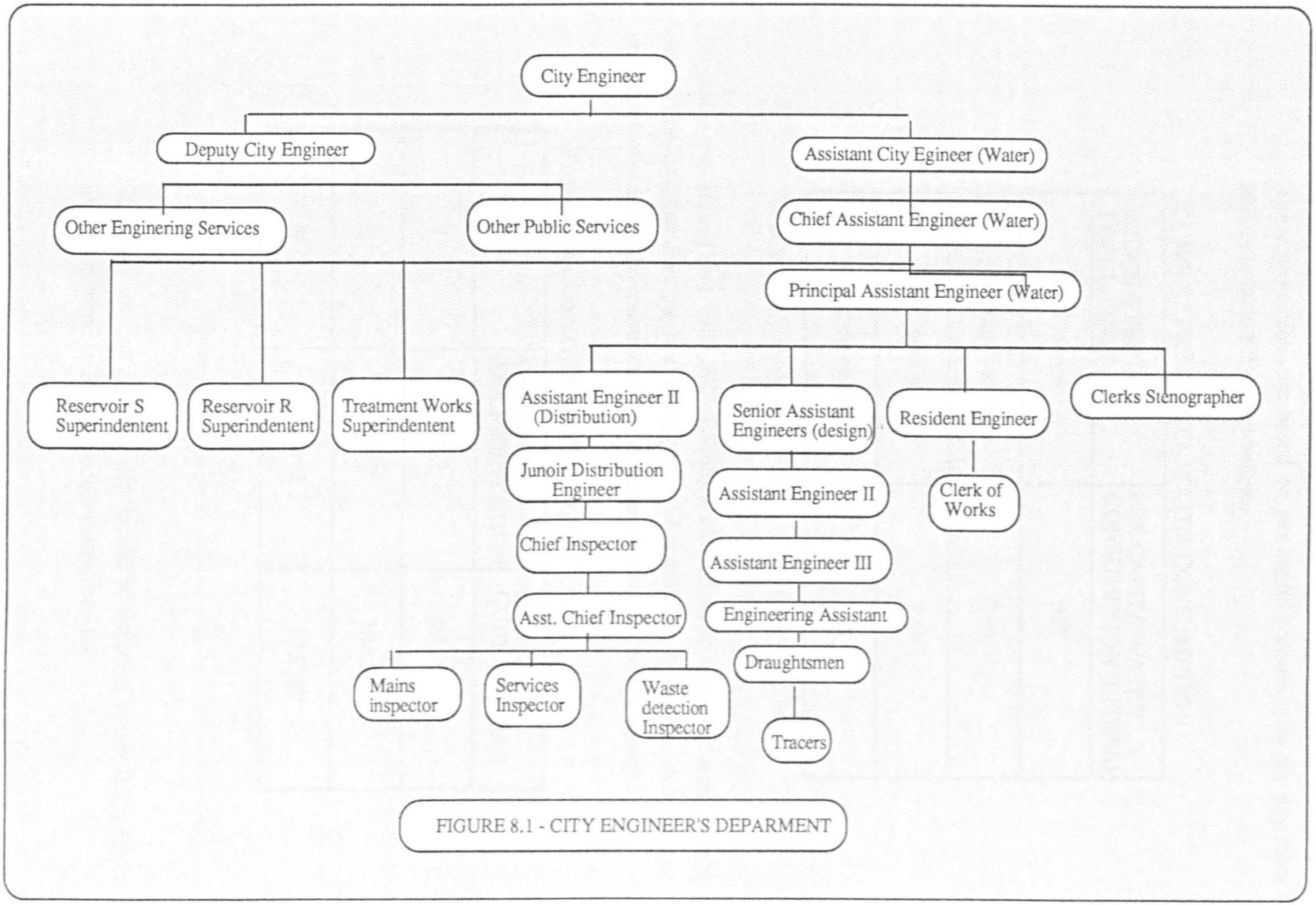

FIGURE 8.1 - CITY ENGINEER'S DEPARMENT

These projections are based on per capita consumption per day rates shown in table 8.3 shown below:-

TABLE 8.3 PER CAPITA WATER CONSUMPTION

DESCRIPTION OF POPULATION	PER CAPITA WATER CONSUMPTION (LITRES)
High income	455
Average income	264
Low income	114
Temperory settler	32

So that it was argued that (369,590 - 85465) = 284125 cubic metres of water would need to be supplied over the next thirty years. Accordingly, it was decided that the relevant works should be constructed in the stages shown in table 8.4 below:-

TABLE 8.4 CONSTRUCTION STAGES

STAGE	YEAR OF IMPLEMENTATION	CAPACITY CUBIC METRES
1	1972	59,098
2	1982	104.558
3	1992	136,380

The total amount of water that would be supplied under this project would therefore be 300,036 cubic metres per day.

This decision was based on the fact that

" experience suggests that economic considerations will limit the additional capacity provided by each stage to the water that will be needed during the ensuing ten years or thereabouts."

8.3.3 The alternatives - financial considerations

A number of aspects were considered at this stage, namely:-

i) costing considerations which involved:-

- comparison of alternative schemes, general estimates based on rating of the various component sections or capacity were used.
- For the adopted scheme detailed economic analysis was required based on a bill of quantities.
- Onshore and off-shore costs were determined; 10% of the off-shore costs and 20% of the onshore costs were allowed for further increases and contingencies.
- In assessing the overall figures, use was made of American literature. Costs were based on schemes carried out in the same region and elsewhere by the consultants.
-estimates of rate of increase of construction costs were taken at 6.7 % p. a based on works carried out in the same continent some years earlier. Actual rates at the time were:-

a) off-shore region 1 3% p.a
b) off-shore region 2 1.6 - 4.7% p.a
c) country 1 in same region 0% p. a
d) same country as project 0 -15% p.a

- In the case of machinery rate of price increase was 3% p. a based on the information available for England.
- Cost of pipeline materials were based on quotations of the manufacturers.

ii) Economic evaluation methods involving:-

- Opportunity cost of capital invested used as a basis of comparison and feasibility. A rate of 9% p.a was adopted based on the Ministry of Economic Planning and Development in the country.
- The internal rate of return " was used as a primary means of both ranking and evaluating the economic soundness of the schemes.
-The procedure adopted calculated the NPV of the gross costs and benefits for discount rates varying at 3%, 4%, 5%, 6%, 9% and 12% and then plotting them on a graph. Benefit : cost ratio for particular discount rates were also determined.
- Since neither the internal rate of return nor the benefit : cost ratio reflected the capital intensity of the scheme, the investment needed per unit output was also calculated.
- A discounting period of forty years was adopted.

iii) Benefits

- only direct benefits accruing from sale of water was considered based on the cost per unit of water sold.
- No attempt was made to quantify or allow for secondary benefits or intangibles (e.g effects on health service costs or fire protection).

iv) Typical analysis

- a typical analysis is reproduced in table 8.5

8.3.4 Selection of the recommended scheme

8.3.4.1 Sources of water

There were sixteen possible sources. Following the economic analysis shown in table 8.6 based on inflation, capital, operating and maintenance costs to arrive at the internal

TABLE 8.5 TYPICAL ECONOMIC ANALYSIS USED IN ACTUAL APPRAISAL

WATER SUPPLY STUDY	Data sheet for Program D.C.F II
SCHEME A	Nominal Rating of Scheme 45460 cubic metres per day
	Scheme Reference No. CHL - XP8JP

GENERAL DESCRIPTION

INTAKE ON RIVER C , NEAR T AT MAP REF. 842851
RAW WATER PUMPING STATION NEAR INTAKE
PIPELINE TO T.W'S.
T.W's 3c PUMPING STATION AT MAP REF.840840
PIPELINE TO TERMINAL RESERVOIR 'A' AT MAP REF.557638

NOTES

CALCULATION REFERENCE: Book No.....Page No...

INITIAL CAPITAL COSTS	K£
Dam/ Intake	50,000
Treatment Works : Excavation and Acess	-
Buildings and Plant	740,000
Pumping Stations	441,159
Pipelines : Dam/Intake to T.W. : Materials	56,000
Construction	18,900
T.W. to Service Res. Materials	964,560
Construction	382,600
Power Transmission \ Generation	8,200
Engineering...12% of K £3,020,727	362,487
Contingencies Offshore 10% of K£3020727	172,975
Offshore 20% of K£931,629	186,333
TOTAL	3,383,214

OTHER COSTS
Annual Costs 68000 m.u (year 1) to 254000 m.u (year 9)

Regenerative Costs at years 15 and 30:-
Treatment plant - 65,000 m.u

distribution and service reservoirs construction costs - 262,000 m.u/year

PRESENT VALUES IN M.U

Discount rate	6%	9%	12%
Capital and other costs *1000	6733	5750	5217
Service Reservoir and distribution * 1000	1753	1533	1353
Total Costs	8486	7283	6570
Total benefits	12264	8012	5609
Benefit/cost Ratio	1.45	1.10	0.85

Yr	Cost	Benefit
-5		
-4		
-3		
-2		
-1	1,873,160	
0	1,510,054	
1	92,977	86,000
2	126,053	183,000
3	160,966	255,000
4	198,021	351,000
5	236,609	448,000
6	277,646	543,000
7	317,765	638,000
8		
9		
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39		
40	317,765	638,000

Mean Annual output	53,550 m3/d
Capital Cost per unit	5.53 M. U
Internal Rate of return	10.1%

TABLE 8.6 ECONOMIC ANALYSIS FOR SOURCES OF WATER

SCHEME NUMBER	SOURCE	MEAN ANNUAL OUTPUT M3/D	BENEFIT/ COST RATIO	INTERNAL RATE OF RETURN	MEAN COST PER CUMEC (M.U)
1	1	38 188	0.85	7.4	84
2	1	38 188	0.81	6.5	91
3	2	28 652	0.80	6.5	97
4	2	28 652	O.79	6.4	100
5	2	28 652	0.79	6.2	94
6	2	28 652	0.78	6.0	91
7	2	28 652	0.77	5.8	93
8	3	38 188	0.69	-	-
9	4	38 188	0.55	-	-
10	5	29 098	0.48	-	-
11	6	42 020	0.47	-	-
12	7	38 188	0.46	-	-
13	2	52 447	0.44	-	-
14	8	43 669	0.42	-	-
15	8	43 669	0.41	-	-
16	2	52 447	0.37	-	-

NOTE: INTERNAL RATES OF RETURN LESS THAN 6% WERE NOT COMPUTED.

rate of return figures, it was decided that schemes number 1,2 and 3 were the soundest. It was argued that in all other cases the internal rates of return were so low that they could only be considered in 'exceptional' cases which did not arise in the case under consideration.

Of the three cases considered in greater detail, construction of a dam to provide storage within the relevant catchment and the sequence of development stages were used as a basis of selection. Table 8.7 below shows the economic analysis of these options.

TABLE 8.7 ECONOMIC ANALYSIS OF OPTIONS

DEVELOPMENT STAGE	OPTION 1		OPTION 2		OPTION 3	
	I.R.R	BENEFIT /COST	I.R.R	BENEFIT /COST	I.R.R	BENEFIT /COST
1	7.4	1.12	-	1.07	6.5	1.05
2	5.75	0.97	-	0.90	3.0	0.74
3.	4.5	0.85	-	0.85	2.8	0.77

It was recommended on the basis of this analysis that option 1 should be adopted.

8.3.4.2 The total scheme

As shown in the schematic in figure 8.2 below, the scheme analysed consisted of the following two stages of construction. Stage 1 works were composed of :-

-Intake 1 on River C
-Raw water pumping main
- Pumping equipment
- Raw water pumping station
- Treatment works
- Treated water pipeline

and future works consisted of:-

- Intake 2 at point P on River C

-Raw water gravity main

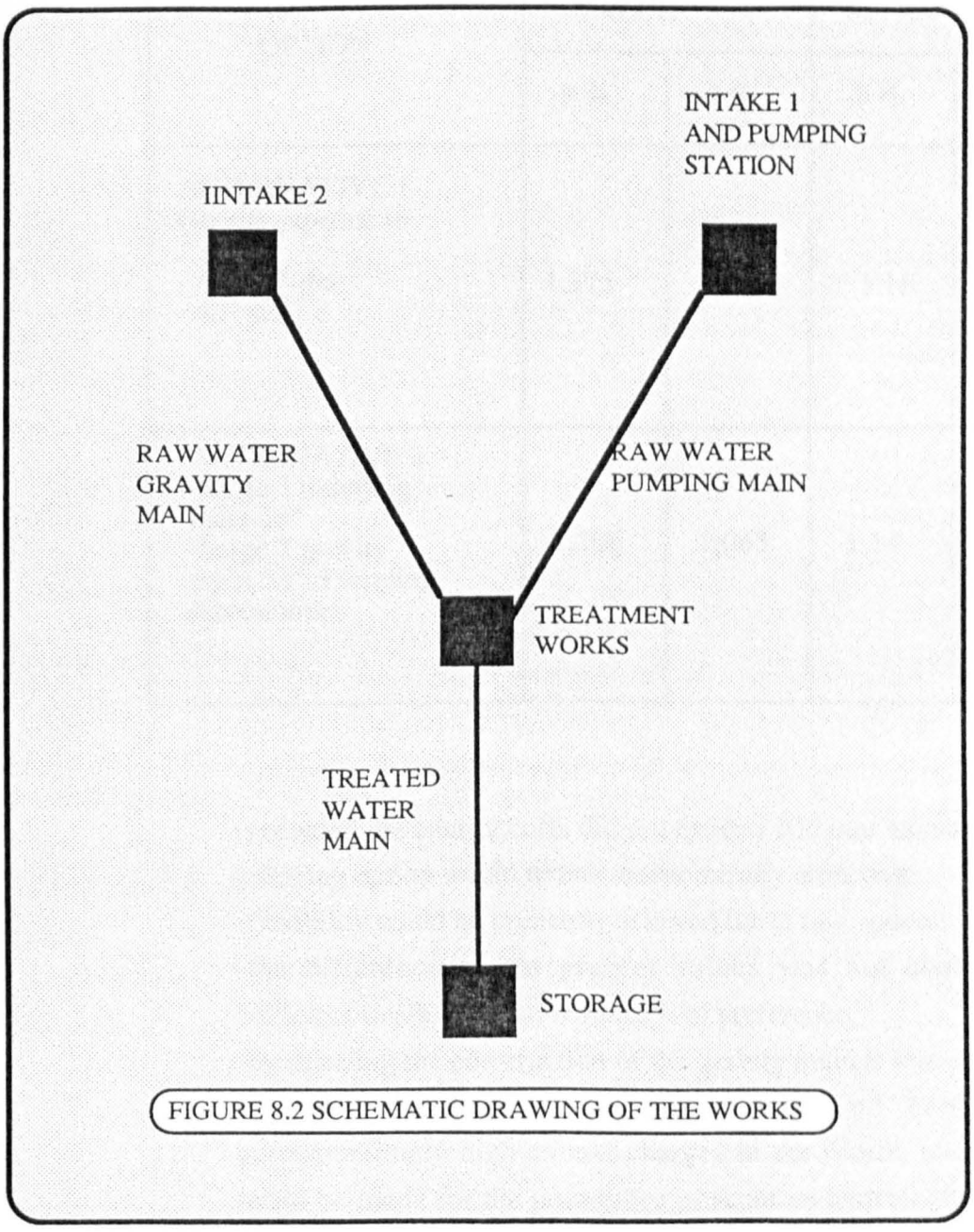


FIGURE 8.2 SCHEMATIC DRAWING OF THE WORKS

i) Intake considerations

The intake works were composed of a concrete weir, gabion bank protection, a penstock as well as fine and coarse screens. Two alternatives were considered and table 8.8 below shows the details of the economic analysis carried out to select the optimal option. Based on this analysis alternative two was selected. This choice was justified on the following grounds:-

TABLE 8.8 ECONOMIC ANALYSIS FOR INTAKE WORKS

OPTION	NET PRESENT VALUE		BENEFIT/COST RATIO	
	9 %	12 %	9 %	12 %
ALTERNATIVE 1 Gravity pipeline in 2 stages - 48"/38" dia - 40" dia	1,375	1280	1.16	-
ALTERNATIVE 2 -Stage 1 pumping main 28" -Stage 2 gravity main 50". Pumping discontinues	1,208	1,063	1.14	1.20

-provided the energy costs did not exceed 100 m.u annually, the pumping option would remain economically attractive.

-flexibility could be prudently allowed for in this option.

-the difference in net present values was not considered sufficient to allow for an indication of preference.

-by delaying the construction of the gravity main it was possible to avoid the high initial capital cost and hence the correspondingly high annual charges in the future, allowance could be made for the possibility of accurate hydrological data becoming available since no records existed of flow rates at the abstraction point, considerable flexibility could be created in the proposals made to revert to gravity pipeline option and finally the use of electricity would benefit the country's economy

The concrete weir itself had a simple section, 10ft high and of a concrete concrete construction. Use of a rock-fill weir was considered but rejected on technical grounds.

ii) Pumping equipment

Vertical shaft pumps (of the borehole type) having lubricated bearings were adopted. Economic comparisons were made between a number of fixed speed units but were not presented in the report. Likewise for the pumping station, although economic comparisons were carried out, they were not submitted. An 'in line' form having two reinforced concrete wells and a superstructure made of a reinforced concrete frame having blockwork infilling was adopted. Cost estimates were carried out for a number of options were not presented.

iii) Treatment works

Technical considerations based on the required quality of drinking water required the use of:-

-Coagulation and sedimentation

Coagulation required use of alum, gypsum and soda ash. Alum was to be imported while the other two chemicals were locally available. Bagged supplies were recommended in spite of cost saving offered by bulk buying of gypsum and soda ash. Of the three types of sedimentation tanks considered i.e horizontal flow rectangular type, circular clarifiers and vertical upward flow hopper type, the last option was adopted for a number of reasons. These included reduced risk of mechanical failure as no moving parts were required in hopper bottomed tanks, a small unit capacity allowed for the servicing of the units without significant reduction output, similar tanks had been installed in other earlier works and so experience in operating these tanks ensured fewer operational difficulties and finally the proven suitability in practice of these type of tanks for the required type of treatment. Rapid sand filters were used, slow sand filtration being rejected on technical grounds. Manual cleaning and simple controls were incorporated. Gas chlorination using simple manual controls was recommended as the cheapest option.

iv) Treated water pipeline

Three alternatives were investigated and analysed as shown in table 8.9 below. Alternative 2 was recommended based on this analysis :-

TABLE 8.9 ECONOMIC ANALYSIS FOR TREATED WATER PIPELINE

OPTION	CAPACITY		NET PRESENT VALUE (M.U)		
	PEAK GRAVITY M3/D	GRAVITY + BOOSTING M3/D	6%	9%	12%
1. GRAVITY	60,000	-	2184	2159	2158
2 GRAVITY AND BOOSTING	43642	60,000	2303	21	2063
3. GRAVITY AND BOOSTING	36823	60,000	2433	2178	2044

Table 8.10 provides a summary of the estimated costs of the project.

8.4 Analysis based on the proposed methodology

8.4.1 Procedure guide-lines

Use is made of the typical manual contained in chapter 7 to illustrate application of the proposed methodology. It is recommended that this chapter should be read with due reference to the manual contained in chapter 7 as a step by step analysis is performed in this section.

Attention is drawn to the fact that in concerning itself fundamentally with the illustration of how the proposed methodology can be applied particularly, this illustration limits itself to the social cost benefit analysis carried out initially with extension to illustrate how technolgical considerations may be appraised.

TABLE 8.10 COST ESTIMATES FOR THE WORKS

ITEM	TOTAL (M.U)	CAPITAL COSTS (M.U)		CUSTOMS DUTY (M.U)
		ONSHORE	OFFSHORE	
1. RAW WATER INTAKE AND PUMPING MAIN	156.5	58.8	97.7	
2. RAW WATER PUMPING MAIN	56.5	13.5	38.7	4.3
3. TREATMENT WORKS	365.5	200.2	164.6	0.7
4. TREATED WATER PIPELINE	1097.2	233.7	766.6	96.9
5. HOUSING	68	59.5	8.5	
6 TRANSMISSION LINE	24.6	24.6		
7 TELECOMMUNICATIONS	15	9	6	
8 ALLOWANCES	238.3	119.9	108.2	10.2
9 ENGINEERING	239.9	93.2	146.7	
10 MISCELLANEOUS	8.4	8.4		
TOTAL	2269.9	820.8	1337	112.1

8.4.2 Step 1: Definition of the system

a) the limits (see reference manual section 7.4.1)

Using figure 6.2 the system to be used as a frame of reference for the proposal under consideration is defined by identifying the relevant i and j values. The system which will be used in the present instance consists of the following:-

i) J = 1,2,3,4,5,6,7 for i = 1

ii) J = 1,2,3,4,5,6,7 for i = 2

This system thus limits itself to technological and economical aspects of the appraisal process.

b) Visualisation (see reference manual section 7.4.1)

The fragment of the main matrix shown in figure 6.3 that will be analysed in this example is shown in figure 8.3 below. This figure also shows in a very clear way the cells of the main matrix that will be analysed in the case under consideration.

8.4.3 Step 2: Development of the evaluation criteria

a) The extent (see section 7.4.2 of the reference manual)
Bearing in mind , the need to keep the present illustration as simple and fundamental as possible, the extent to which the system will be analysed is that outlined in level 1 of tables 1,2,8,9,10,11,12,13 and 14 contained in appendix D of this report.

b) The variables (see section 7.4.2 of the reference manual)

The variables that will need to be considered in analysing the system described in the above steps are described below:-

i) Technological indicators (i = 1, level 1 ,table 1; appendix D)
- -plant
- -materials
- -services

ii) Economic indicators (i =2, level 1 table 2; appendix D)
- -targets
- -identification
- -measurement
- -evaluation
- -choice

iii) Human condition indicators (j = 1, level 1 table 8; appendix D)
- -poverty
- -nutrition
- -employment
- -income distribution

FIGURE 8.3 MAIN MATRIX - SYSTEM DEFINITION

i / j		TECHNOLOGICAL	ECONOMICAL	CULTURAL	SOCIAL	ENVIRONMENTAL	INSTITUTIONAL	POLITICAL
		1	2	3	4	5	6	7
HUMAN CONDITION	1	■	■					
NORTH/SOUTH DISPARITIES	2	■	■					
ECONOMIC AND OTHER CRISIS (UNCERTAINTY)	3	■	■					
ENVIRONMENTAL PROBLEMS	4	■	■					
INSECURITY	5	■	■					
POPULATION EXPLOSION	6	■	■					
RESOURCE UTILITIES AND AVAILABILITY	7	■	■					

■ CELLS TO BE ANALYSED

iv) North/South disparity indicators (j = 2, level 1 table 9;appendix D)

-investment magnitude

-trade implications

-transfers

-welfare considerations

v) Economic problems and uncertainty indicators (j = 3, level 1 table 10;appendix D)

-debt crisis implications

-risk and uncertainty

resource exploitation implications

v1) Environmental considerations (j = 4, level 1 table 11;appendix D)

-disruptions and degradations

-depletions

-acid pollution

-carbon dioxide release

vii) Global insecurity considerations (j =5, level 1 table 12; appendix D)

-inter state considerations

-sovereign issues

-hazards

-dependence

viii) Population considerations (j = 6, level 1 table 13;appendix D)

-static position

-dynamic trends

-labour and manpower considerations

ix) Resource utilisation indicators (j = 7, level 1 table 14; appendix D)

-food resources

-energy resources

-mineral resources

8.4.4 Step 3: Data handling

a) Creation of sub-matrices (see section 7.4.3 of the reference manual)

As can be seen from figure 8.4 the system consists of 14 cells. A submatrix is created for each of these cells. The cells are identified by their i and j values and are contained in figure 8.5 to 8.18 overleaf. As indicated in step 2 a), the extent to which the analysis is to be performed is level 1. Accordingly the submatrices are produced to level 1 details.

b) Data review

The data available in the case study material studied in detail following which each element of every submatrix is marked (by colour coding) to indicate availability of data (see figure 8.5-8.18).

c) Assessment of data available

As can be seen from figures 8.5 to 8.18, a large number of elements in the sub-matrices had not been considered (due to the limitation of data within the case study material itself). This meant that a large number of considerations had been ignored or at any rate been considered insignificant to the final outcome when the project was first appraised.

d)Data Deficient Elements

Since the present illustration is limited to the most basic extent (i.e. level 1) it does not illustrate completely the flexibility and detail which the proposed methodology is capable of accommodating. To a large extent, information available does not, in any case permit a more detailed analysis. In spite of this limitation a level 2 analysis has been attempted for the cell detailed in Fig.8.5 based on assumptions (not necessarily incorporating actual facts) and is constained in Appendix E for purely illustrative reasons.

FIGURE 8.4 SYSTEM DEFINITION - MAIN ELEMENTS

i / j		TECHNOLOGICAL	ECONOMICAL
		1	2
HUMAN CONDITION	1		
NORTH/SOUTH DISPARITIES	2		
ECONOMIC AND OTHER CRISIS (UNCERTAINTY)	3		
ENVIRONMENTAL PROBLEMS	4		
INSECURITY	5		
POPULATION EXPLOSION	6		
RESOURCE UTILITIES AND AVAILABILITY	7		

FIGURE 8.5 SUB-MATRIX 1.1

HUMAN CONDITION / TECHNOLOGY (I = 1, J = 1)	PLANT	MATERIALS	SERVICES
POVERTY	REPLACEMENT OF SOME MANPOWER AS PLANT INCREASED HENCE COST	COST OF CHEMICAL STORAGE	RISE IN STD OF LIVING AS CLEAN WATER SUPPLIED TO LARGER POPULATION
NUITRITION	DECREASED EMPLOYMENT LEADS TO POVERTY HENCE-MALNUITRITION HENCE COST	IMPORTATION LEADS TO LOW LOCAL PRODUCTIVITY AND HENCE POVERTY AND HENCE COST	LOSS OF FOOD PRODUCTION AS URBANISATION ENCOURAGED
EMPLOYMENT	BENEFIT DUE TO LABOUR INTENSIVE PLANT	LOW PRODUCTIVITY LEADS TO IEFFICIENT EMPLOYMENT PRACTICES HENCE COST	MAY GENERATE EMPLOYMENT HENCE BENEFIT
INCOME DISTRIBUTION	BENEFIT DUE TO EMPLOYMENT OF LOW INCOME WORKERS	INSUFFICIENT DATA	INSUFFICIENT DATA

NOTE:-

COST -NOT QUANTIFIED

BENEFIT - NOT QUANTIFIED

QUALIFICATION INSUFFICIENT DATA

NO DATA AVAILABLE FOR THESE CELLS

FIGURE 8.6 SUMMATRIX 1.2

TECHNOLOGY i = 1 / NORTH SOUTH DISPARITY j = 2	PLANT	MATERIALS	SERVICES
Investment size	18.7 M. U.	92.5 M. U.	119.8 M. U.
Trade	90% imported	80% imported	61% of expertise imported
Transfers	Money exported goods imported	Money exported goods imported	Money exported expertise imported
Welfare	increased dependency + debt	increased dependency + debt	increased dependency + debt

NO DATA AVAILABLE

COST INCLUDED ELSEWHERE

NOTE: OTHER COSTS NOT QUANTIFIED

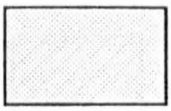
FIGURE 8.7 SUBMATRIX 1.3

TECHNOLOGY i = 1 / ECONOMIC CRISIS J = 3	PLANT	MATERIALS	SERVICES
DEBT CRISIS	FOREIGN EXCHANGE TRANSFER COSTS	FOREIGN EXCHANGE TRANSFER COSTS	COST OF THE FOREIGN EXCHANGE TRANSFER IN RETURN FOR KNOWLEDGE AND EXPERTISE
RISK AND UNCERT-AINTY	COST CONTINGENCIES 18.7 M.U	COST CONTINGENCIES 92.5 M.U	COST CONTINGENCIES AA9.8 M.U
RESOURCE UTILISATION	HARDLY ANY LOCAL TECHNOLOGY	SMALL PROPORTION OF LOCAL MATERIALS	SOME USE OF LOCAL SERVICES

NO DATA AVAILABLE

FIGURE 8.8 SUB-MATRIX 1.4

J = 4 ENVIR-ONMENTAL CONSIDERATIONS \ I = 1 TECHNO-LOGY	PLANT	MATERIALS	SERVICES
DISRUPTIONS AND DEGRADATION	PLANT USAGE LEADS TO RELEASE OF GASES IN AIR LEADS TO AIR POLLUTION AND HENCE COST OF POLLUTION	COST IMPLICATIONS OF POLLUTION CAUSED BY TRANSPORTATION, HANDLING AND STORAGE OF MATERIALS	INSUFFICIENT DATA
DEPLETIONS	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA
ACID POLLUTION	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA
CLIMATE	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA



NO DATA AVAILABLE

FIGURE 8.9 SUB-MATRIX 1.5

GLOBAL INSECURITY j = 5 / TECHNOLOGY I = 1	PLANT	MATERIALS	SERVICES
INTER-STATE CONSIDERATIONS	IMPORTATION	IMPORTATION	IMPORTATION
SOVEREIGN ISSUES	COSTS TO SELF-SUFFICIENCY AND DEVELOPMENT	COSTS TO SELF-SUFFICIENCY AND DEVELOPMENT	COSTS TO SELF-SUFFICIENCY AND DEVELOPMENT
HAZARDS	RESOURCE DEPLETION COSTS	RESOURCE DEPLETION COSTS	RESOURCE DEPLETION COSTS
DEPEND-ENCE	COST OF INCREASED DEPENDENCE	COST OF INCREASED DEPENDENCE	NONE

NO DATAA AVAILABLE

COVERED ELSEWHERE ALSO

FIGURE 8.10 SUB MATRIX 1.6

TECHNOLOGY I = 1 / POPULATION J = 6	PLANT	MATERIALS	SERVICES
STATIC POSITION	NO DATA	NO DATA	NO DATA
DYNAMIC TRENDS	NO DATA	NO DATA	NO DATA
MANPOWER IMPLICATIONS	LARGE UNSKILLED LABOUR FORCE	LARGE LABOUR FORCE, LOW PRODUCTIVITY	OPPORTUNITY COST

NO DATA AVAILABLE

FIGURE 8.11 SUBMATRIX 1.7

TECHNOLOGY i = 1 / RESOURCE UTILITY j = 7	PLANT	MATERIALS	SERVICES
FOOD	COST OF DIVERTING WATER FROM AGRICULTURE	INSUFFICIENT DATA	BENEFIT TO HEALTH SERVICES
ENERGY	PART OF ENERGY COST ELECTRICAL ENERGY COST	NONE	PROVISION OF ENERGY TRASSMISSION LINE
MINERALS	COSTS INCLUDED ELSEWHERE	COSTS INCLUDED ELSEWHERE	INSUFFICIENT DATA

NO DATA AVAILABLE

FIGURE 8.12 SUB-MATRIX 2.1

ECONOMIC I = 2 / HUMAN CONDITION J = 1	TARGETS	IDENTIFICATION	MEASUREMENT	VALUATION	CRITERIA
POVERTY	PER CAPITA SUPPLY HIGH INCOME 100 U MED INCOME 58 U LOW INCOME 25 U TEMP SETTLER 7 U	NUMBER OF PEOPLE IN EACH CATEGORY HENCE QUANTIFI-CATION	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA
NUITRITION	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA
EMPLOYMENT	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA
INCOME DISTRIBUTIION	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA

NO DATA AVAILABLE

FIGURE 8.13 SUBMATRIX 2.2

ECONOMIC i = 2 / NORTH/SOUTH DISPARITY j = 2	TARGETS	IDENTIFICATION	MEASUREMENT	VALUATION	CRITERIA
INVESTMENT SIZE	1. SUPPLY 60,000 m3/d OF WATER 2. MIN RATE OF RETURN 6% P.A	COST BENEFIT	QUANTITYY (M.U) SELL AT 0.013	2270 M.U 700800 M.U	N.P.V COST = 5080 M.U BENE =473 M.U P.A I.R.R = 10.1 %
TRADE	1. ONSHORE 2 OFFSHORE 3 TAXES	COST COST COST	QUANTITY QUANTITY QUANTITY	820 M.U 1337 M.U 112.1 M.U	36 % 59% 5%
TRANSFERS	IMPORTS EXPORTED	PLANT MATERIALS SERVICES OTHERS MONEY	% OF TOTAL % OF TOTAL % OF TOTAL % OF TOTAL % OF TOTAL	6.7 % 30 % 6.2 % 15.8 % 59 %	90 % IMPORTED 80 % IMPORTED 61% OF EXPERTISE IMPORTED FOREIGN EXCHANGE
WELFARE	INCREASED WATER SUPPLY FOR:- TIME PERIOD CAPACITY	BENEFIT BENEFIT	QUANTITY QUANTITY	12 YR LIFE 60000M3/D	FORECAST 159,787M3/D EXISTING SUPPLY = 84,465 M3/D

FIGURE 8.14 SUBMATRIX 2.3

ECONOMIC i = 2 / ECONO-MIC CRISIS j = 3	TARGETS	IDENTIFICATION	MEASUREMENT	VALUATION	CRITERIA
DEBT CRISIS	FOREIGN DEBT	AID	COST IN M.U	UNKNOWN	ECONOMIC GROWTH
RISK AND UNCERT-AINTY	ALLOWANCES	COSTS OFF SHORE ON SHORE TAXES	QUANTITY (M. U)	108.2 119.9 10.2	10 % 20 % 10 %
RESOURCE UTILISATION	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA

NO DATA AVAILABLE

FIGURE 8.15 SUBMATRIX 2.4

ECONOMIC i = 2 / ENVIR-ONMENTAL j = 4	TARGETS	IDENTIFICATION	MEASUREMENT	VALUATION	CRITERIA
DISRUPTIONS AND DEGRADATION	INSUFF-CIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFF-CIENT DATA
DEPLETIONS	INSUFF-CIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFF-CIENT DATA
ACID POLLUTION	INSUFF-CIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFF-CIENT DATA
CLIMATE	INSUFF-CIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFF-CIENT DATA

NO DATA AVAILABLE

FIGURE 8.16 SUBMATRIX 2.5

GLOBAL INSECURITY j = 5 / ECONOMIC i =2	TARGETS	IDENTIFICATION	MEASUREMENT	VALUATION	CRITERIA
INTER-STATE CONSIDERATIONS	MINIMISE TRADE	COST OF HIGH IMPORTATION	MEASURED IN % OF TOTAL	595 OF TOTAL COSTS OFF-SHORE	ECONOMIC INDEPENDENCE
SOVEREIGN ISSUES	MAXIMISE SELF SUFFICIENCY	LEVEL OF SELF SUFFICIENCY	QUANTIFIED AS % OF TOTAL	ONLY 41% COSTS LOCAL	EFFECT ON DEVELOPMENT
HAZARDS	MAXIMISE SAFETY	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA
DEPEND-ENCE	MINIMISE DEPENDENCE	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA

NO DATA AVAILABLE

FIGURE 8.17 SUB-MATRIX 2.6

ECONOMIC i = 2 / POPULATION j = 6	TARGETS	IDENTIFICATION	MEASUREMENT	VALUATION	CRITERIA
STATIC POSITION	YEAR 1970 ESTIMATES	EXISTING POPULATION	QUANTITY	507,573 HDS	PROJECTED AT 5.6 % P.A
		WATER DEMAND	QUANTITY	77,782 M3/D	PROJECTED AT 5.4 % P.A
DYNAMIC TRENDS	UPTO 1982 FORECASTS	FUTURE POPULATION AND WATER DEMAND	QUANTITY	981,408 HDS	PROJECTED AT 5.6 TO 5.9 % P.A
				145,472 M3/D	PROJECTED AT 5.4 TO 5.7 % P.A
MANPOWER IMPLICATIONS	NO DATA	NO DATA	NO DATA	NO DATA	NO DATA

NO DATA AVAILABLE

FIGURE 8.18 SUB-MATRIX 2.7

ECONOMIC i = 2 / RESOURCE UTILITY j = 7	TARGETS	IDENTIFICATION	MEASUREMENT	VALUATION	CRITERIA
FOOD	COMPENSATION FOR CROP DESTRUCTION	COST	QUANTITY (M.U)	2.6	UNKNOWN
ENERGY	TRANSMISSION LINE FOR ELECTRICITY	COST BENEFIT	QUANTITY QUALFICATION	24.6 M.U DEVELOPMENT	INCLUDED IN I.R.R. UNKNOWN
MINERALS	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA	INSUFFICIENT DATA

NO DATA AVAILABLE

8.4.5 Step 4 : The Analysis (see section 7.4.4 of the manual)

a) Presentation of information available

The final stage in step 3 of the proposal methodology, requires that the information available for the submatrices should be sorted out and presented in a suitable form. This has been done in accordance with step 2c. Accordingly costs, benefits or qualification for every element of the submatrices for which this information is available, is shown in figures 8.5 to 8.18. Figure 8.19 contains the results obtained from the analysis of each one of the submatrices.

b) Interaction Matrix

In accordance with step 4c outlined in the typical manual (chapter 7) and section 6.6.3, the interactions between the elements of the main matrix have to be analysed using figure 6.7, using the economical and technological systems as the major element in turn. Figure 8.20 overleaf shows the outcome for the analysis for the case study under consideration.

8.4.6 Step 5 : Presentation of Output

a) Results of detailed analysis.

The results of each cell analysis are transferred to output matrix 1 having the format shown in figure 8.19.

b) Results of the interaction analysis

These are contained in figure 8.20 by transference to the output matrix 2.

8.5 Comparison of Results

The actual appraisal of this project limited itself to economic considerations only. Thus the final decision to proceed with the project was based on the understanding that a return of 10.1 % p. a would be obtained from this project. It had been decided earlier that the project could not be accepted if the return was less than 9% p.a.
It is evident from the analysis shown in this section that even when carried out to the most fundamental level, the data available is insufficient to produce more than an outline analysis consisting mostly of quantities statements particularly the interaction analysis, which appers sketchy at best.

FIGURE 8.19 INTEGRATED OUTPUT MATRIX 1

ISSUE \ DISCIPLINE (i / j)	j	TECHNOLOGICAL (i) 1	ECONOMIC (i) 2
HUMAN CONDITION	1	Costs: Automation, ,increased poverty and malnuitrition, loss of food production,low productivity, increase in poverty Benefits: Better water services, some labour intensive methods and income distribution	Lack of information in case study material was insufficient to even establish this portion of the costs, benefits or even the qualitative aspects. Uneven distribution of benefits as this is based on icome distribution
NORTH/SOUTH DISPARITIES	2	Costs: due to effects of import-ation, decrease in self sufficiency, development, management and increased dependency Benefits: Increased capital assets	Costs: onshore = 820 m.u i.e 36% offshore = 1337 m.u i.e 59% taxes = 112.1 m.u i.e 5% benefit: revenue = 473 m.u p.a Internal rate of return = 10.1% p.a
ECONOMIC AND OTHER CRISIS OF UNCERTAINTY	3	Risk and uncertainty:- Costs: contingencies -plant 18.7 m.u -materials 92.5 m.u -services 119.8 m.u others:Debt interest, no develop-ment of local technology or materials.	Costs: Total contingency allowances 10 to 20 % Qualification: Based on insufficient information
ENVIRON-MENTAL PROBLEMS	4	No information available hence not possible to appraise.	No information available hence not possible to appraise
INSECURITY	5	Costs: Resource depletion, dependency increases, loss of sufficiency and limited development, high importation, trade costs	costs: redardation of economic growth and development through resource depletion, high import-ation and dependency levels
POPULATION EXPLOSION	6	Benefits: exploitation of large unskilled labour force Costs: Low productivity and opportunity cost of services used in manufacture	Qualifications: Check on accuracy of past population and consum-ption estimates. Might have additional costs due to uncertainty.
RESOURCE UTILITY	7	Costs: diversion of water from agriculture to industry and urbanisation. Energy implications not investigated fully.	Costs: crop damage =2.6 m.u electricity = 24.6 m.u Benefit: introduction of electrical power for development

DATA OBTAINED FROM ACTUAL ANALYSIS

FIGURE 8.20 INTEGRATED OUTPUT MATRIX 2

Minar System / Major System	Techno-logical	Economic	Human condition	N/S disparity	Environ-mental	Economic crisis	Global insec.	popul-ation	Resource
Techno-logical		increased dependency	increased poverty	increased disparity	higher energy consumption	increased debt	none	automation reducing employment	wasted manpower resources
Economic	development		none	none	none	none	none	none	none
Human condition	ease of access	clean water		none	none	none	increased poverty	uncertainty in estimate cost	none
N/S disparity	none	none	none		damage to nature	none	increased insecurity	increased disparity	inefficient resource exploitation
Environ-mental	none	?	healthier life style	none		none	none	none	none
Economic crisis	none	none	none	none	none		increased insecurity	none	little local resource exploitation
Global insec.	none	none	none	none	none	none		none	none
popul-ation	modern development	none	greater access to clean water	none	cleaner water hence less pollution	none	none		none
Resource	none	rise in std of living	gain in capital assets	increase in resource via imports	none	none	none	none	

BENEFITS

COSTS

NOTE: The diagonal elements are non interactive.
by virtue of the symmetry of this matrix, costs and benefits are easily split into two sets of values.

Figures 8.19 and 8.20 contain the results of an appraisal performed using the proposed methodology.

A number of points can be made about the results obtained using the proposed methodology namely:-

i) The proposed method of analysis does not exclude the use of existing appraisal methodologies. In so far as these existing methods can be used to analyse a part of the proposed appraisal process, this methodology can be regarded as a logical extension of the existing methodologies.

ii) This methodology shows very clearly the fragmentary nature of the actual analysis that was performed in the appraisal of the case study project.

iii) The proposed methodology draws the attention of the appraiser to the issues involved, and therefore serves as a powerful tool in ensuring that a complete analysis is carried out.

iv) The results obtained by using the proposed methodology definitely provided a greater insight into the costs and benefits involved although it proved to be a difficult and in some instances an impossible task to evaluate all of these in a common numaire.

v) The flexibility built in to the appraisal process in terms of the extent and comprehensibility of the analysis is clearly demonstrated by the case study application.

vi) Since it is impossible to express all the results in the same format, the results are presented in the form of two separate matrices which have to be presented to the decision makers. If it were possible to measure all the benefits and costs in the same unit, it is easy to see that a single set of overall figures would result by adding all the elements of the two matrices together.

8.6 Conclusions and discussions

A number of difficulties were encountered in applying the proposed methodology practically. In the main, these consisted of:-

i) A major hurdle in the data handling stages when it was discovered that the data was simply insufficient for the type of analysis being suggested. Having produced the numerous sub-matrices to be analysed it was found that the case study material was very limited in context. For the greater portions of the matrices there was no information available .

ii) Even when an attempt was made to carry out a detailed analysis, it was found that guess-work could not really be relied on.

iii) Accordingly, only the most fundamental level of detail was attempted in the present illustration.

iv) A number of simplifications were thus applied in this illustration , at the expense of not fully impressing the reader with the comprehensibility that the proposed methodology is capable of incorporating.

iv) In actual presentation and manipulation of the available information it became apparent that:-

-this is a tediously long process requiring a great deal of organisation.

-it requires a systematic handling of data

-it is extremely difficult to express the outputs in the same format for all the cells.

-the interpretation of the data is a very subjective exercise so that the importance of rationality in decision-making cannot be over-emphasized.

v)It was decided that in the absence of data an attempt would be made to predict the likely consequences for each cell as best as they could be predicted. It was also decided that monetary values would only be given where these were available.

vi) The interaction matrices proved to be extremely complex to handle and were perhaps too wide in scope. The complications were increased manifold by the need to handle a number of aspects simultaneously . However by exploiting the fact that all the diagonal elements were zero (or non interactive) elements and recognising the essential symmetry about the diagonal of the interaction matrix, the interactions were ultimately brought under control.

v) The final output matrices were fairly easy to handle and proved definitively to be much wider in scope than the method used in the actual

appraisal. In fact the actual appraisal contained information that could only provide an analysis of four of the fourteen cells appraised in the case study. In three of these cells the information still remained only partial at best.

vi) While lack of data proved to be a major hurdle in the case study application it can also be concluded that consistency in data collection and analysis would contribute greatly to the practical viability of the suggested methodology.

CHAPTER NINE

CONCLUSIONS AND PROPOSALS FOR FUTURE WORK

CHAPTER 9

CONCLUSIONS AND PROPOSALS FOR FUTURE WORK

9.1 Introduction

The main issues addressed in this research related to the production of an appraisal/evaluation methodology which would incorporate technological considerations into the decision -making process.

A study of the concept of technology led to the conclusion that in order to appraise it, the role of technology in development would have to be clearly defined. Accordingly, a study was carried out of the concepts of development and technological development. An analysis of all the three concepts of technology, development and technological development studied as a whole showed that the following would have to be incorporated into the appraisal process if technological considerations were to be taken into account adequately:-

i) A global and human context would need to be included in the process.
ii) The process would require a multi-disciplinary approach.
iii) The process would need to be integrated, comprehensive, interactive, continuous and flexible.
iv) An analysis of the existing technological status would have to be included
v) An analysis would have to be included of the mode of transmission of new technologies to the relevant societies.

A method was developed (which used a systems analysis approach as a basis) for appraisal/evaluation that incorporated all the requirements described above. This approach also included the use of multi-level matrix methods and dynamic programming.

This method was then applied to a case study of a major water supply project in a developing country to check its practical viability.

The method was found to be practically applicable and when compared to the actual appraisal of the water supply project under consideration, it was found to:-

i) offer a greater insight to the costs and benefits involved.
ii) force the appraiser to consider in a systematic fashion many of the aspects which had been ignored in the actual analysis.
iii) highlight the limitations imposed on the appraisal process due to insufficient or lacking data.
iv) highlight the fragmentary nature of the existing appraisal methodologies.

9.2 Preliminary Findings

9.2.1 General

A review and analysis of the key concepts forming the basis of this work namely :-

- technology
- development
- appraisal evaluation

led to a number of preliminary findings which were used ultimately to define the framework for a new approach to appraisal / evaluation of civil engineering projects. These findings consisted of the following :-

9.2.2 The Role of Technology

It was clear from the review and analysis contained in chapter 2 of this report that :-

i) to ensure improvement in the human condition, the role of technology in human development needs to be defined more clearly.
ii) in making decisions about technology, it is necessary to understand that :-
-many problems cannot be solved by the present technology
-unanticipated consequences can and do arise from the use of technology
-it can inappropriate to use certain technologies in given circumstances
-the benefits of technology must be maximised
-the disadvantages of technology must be minimised and if possible eliminated

- there must be a fair and equal distribution of the benefits, the disbenefits, participation and control of technology.

9.2.3 Development

A detailed study of the history of development contained in section 3.3 led to the following conclusions :-

i) the concept of development is continuously evolving so that it takes on a different meaning at different points in time.
ii) future trends in development will require inclusion of a human and global context into the development process.
iii) recents trends call for consideration within development thinking of all the dimensions of the present society that act in an interlocked and inter-related way.
i.e. the multi-disciplinary nature of development.

9.2.4 Technological Development

The case study approach adopted in reviewing and analysing the history of technology in linking it with development, contained in section 3.6 to 3.7, revealed a number of conclusive ideas including the following :-

i) understanding and control of the role of technology in development, demands consideration of :-
- the existing technological state of a society
- the mode of transmission that will be adopted in introducing new technology to that society.

ii) technological development is an interdisciplinary process so that in decisions on technology, a more comprehensive perspective than has been adopted until the present time is definitely necessary.

9.2.5 Appraisal / Evaluation Methodologies

A number of appraisal / evaluation methods were studied in detail. A review and analysis of these methods resulted in figure 4.9 from which it can be seen that :-

i) the appraisal process has gone through a number of stages of development including :-

- informal accounting
- conventional cost/benefit analysis
- innovative cost/benefit analysis
- impact approaches and assessments
- social and environmental health impact analysis
- undergirded approaches
- energy methods

ii) the integrated approaches tend to emphasise the multi-disciplinary facet of the process.

iii) the present trends in this area tend to encourage the development of integrated, multi-disciplinary approaches to development.

The main conclusions reached in this chapter were that :-

i) consideration of multi-disciplinary nature of the process must be ensured

ii) that the non-neutral character of an appraisal exercise should be taken into account in a suitable way.

9.3 Main Findings

9.3.1. Linkages

(dirived directily from figure 1.1, section 3.7, figure 5.1, section 4.8 and section 5.5 of this report)

i) A review of the concept or technology led to the conclusion that in order to evaluate a technology, it is necessary to define clearly, the role of technology in development.

ii) Accordingly a study of technology was carried out and this shows that " development " as a concept is not a static concept so that it takes on different meanings at different times through a process of continuous evolution. Recent trends call for the consideration of the multi-disciplinary nature of development. An attempt to analyse likely future trends reveal the need to include a global and human context into the thinking on development.

iii) In establishing a link between technology and development, contained essentially in figure 3.2 , showed clearly that :-

- The mode of transmission of new technologies to a society had profound effects on the developmental directions of those communities.

- The existing technological and resource development states of the society determined the evolutionary direction of development in that society.
- From being a secondary activity necessary for the survival of the primitive man, it has reached a level where it has become so integrated into man's lifestyle that it affects almost every aspect of his life so that it is multi-disciplinary in context and impacts.

iv) A review of the existing appraisal/ evaluation methodologies reinforced the need to introduce into this process:-

- the concept of the multi-disciplinary
- decision-making as an integral part

9.3.2 The Framework

i) In drawing together the preliminary findings described in section 9.1 (see figure 5.1) and those outlined in sections i), ii) and iii) of section 9.2.1, it was concluded that the appraisal process should :-

- be inter-disciplinary and interactive in approach and context
- include for a global context
- place human condition at the centre of the process
- analyse the existing technological state of the society in which the instrument is to be made
- allow for an analysis of the introduction, in particular the mode of transmission of new technologies to the society
- be comprehensive in content
- be integrated
- be flexible

ii) A review of existing methods led to the conclusion that to meet the requirements outlined in section i) above (each of which was analysed in detail on its own, see section 5.3) two methods were particularly attractive namely :-

- dynamic programming
- systems analysis

iii) Drawing together, the main findings outlined in i) and ii) above and the need to make decision-making an integral part of the appraisal process (see section 9.2.1 iv), a framework has been derived for the proposed approached. This integrates into a single process the requirements, the analytical methods and the decision processes and technologies as shown in figure 5.2.

9.3.3 The Approach

i) After initial attempts to produce a computer programme in the form of an expert system, it was concluded that a systems analysis approach applied in a suitable manner should be treated as the first step towards evolving the proposed approach.

ii) The application of a systems analysis approach resulted in the conceptualisation of decision criteria as a matrix incorporating the many elements that needed to be considered before a decision could be made.

iii) Further development of the matrix methods led to the conclusion that multi-level matrix analysis would provide the most suitable approach to appraisal from a continuity point of view (discussed in greater detail later on).

iv) Accordingly, a multi-level matrix method was adopted. The description of this method however was complicated to describe.

v) To overcome the difficulty of avoiding complexity in descriptive terms, a suitable format had to be adopted for the practical applications to be clearly understood.

vi) Consequently, a manual format has been adopted which lays out the procedures to be followed in the proposed method in a simple and straightforward manner step by step.

9.3.4 Illustration of application of proposed methodology

i) A case study approach has been adopted to illustrate the applciation of the proposed methodology to a major water supply scheme in a developing country.

ii) Data was collected from the consultants for the water supply in the relevant country. Included amongst the material collected were the loan justification report and the feasibility report for the project.

iii) The aim was to compare the actual appraisal carried out by the consultants for this water supply project with the proposed approach.

iv) As a first step, the actual analysis were studied in detail . It was concluded that an attempt had ben made to apply a social cost/benefit analysis approach. The focus throughout this analysis remained on the economic returns which were likely to be attained from the project. However as can be seen from the reproduction of these analysis in chapter 8, it was clear that only the fundamental principles of economic returns had been employed for the project.

v) It was found, during the study of the consultant's method of appraising, that data on approval tended to be limited to economic and monetary values. Little consideration was given to any consideration outside the technical and economic feasibility domain.

9.4 Methodological Findings

9.4.1 Practical Application

It was found in applying the proposed methodology to the case study project (water supply for a major city) that :-

i) Data handling could :-

- be a tediously long process.
- require much organisational effort.
- require a very systematic approach in collection and analytical stages.

9.4.2 Data Analysis

It involves the use of a large number of considerations and that :-

- data was not always available.
- it was not always possible to make assumptions about missing elements of data.
- qualitative statements had to be used to highlight the possible

outcomes of missing elements of quantitative data.
- data was not always quantitative.

9.4.3 Investment Analysis

It was found that :-

-the methodology was easy to apply.
-the step by step analysis created a systematic approach to the appraisal process.
-because each viable had to be considered in turn, the appraiser was forced to consider its implications hence ensuring comprehensive consideration.
-the interpretation of effects due to each variable had to be interpreted so that a strong element of subjectivity was present.
-the process was tediously long if too many cells had to be analysed within any matrix.

9.4.4 Presentation of Results

-his proved to be the weakness in the methodology as no standard method could be found to present the results from both the sub-matrices and the interaction analysis. A workable presentation was however found in the end.
- the results did however provide a mare comprehensive picture of the likely consequences of the proposed investment.

9.5 Comparative Assessment

9.5.1 Requirements

Essentially, this chapter contains a review of the proposed methodology against the requirements listed in section 5.3 namely :-

i) Multi-disciplinarity
This objective is satisfied by the introduction of infinite number of disciplines by adopting the matrix approach.

ii) Global Context

By introducing global issues as a dimension within the main matrix, a global context is ensured in this approach process.

iii) Human Context

Since the global issues and the disciplines considered revolve around human systems (and all aspects of these systems if possible) the human element becomes central to the whole methodology.

iv) Existing technological system

The incorporation of an analysis of existing technological status of a society is achieved by introducing existing technologies as a variable to be considered under the technological system cells in the main matrix.

v) Mode of Transmission of new technologies

Again, this aspect is introduced as one of the main considerations for the technological system cells.

vi) Comprehensibility

This is achieved by the introduction of varying levels of detailed indicators to be measured. Hence the extent of the analysis is, as it were, established by the level to which each aspect is explained.

vii) Integration

This is achieved by the following approach :-

- the coalition of all the systems into a single matrix
- introduction of any number of dimensions into the matrix
- introduction of any number of sub-matrices in any cell of the main matrix

Hence, it does not matter which variable is to be measured, as all of them are included in the main matrix which defines the system. Thus total integration is achieved.

9.5.2 Actual and Proposed Methodologies

The actual appraisal was based on social cost/benefit analysis. In applying the proposed methodology a number of observations can be made about the proposed methodology in relation to the actual appraisal. These include :-

i) the actual appraisal tended to be limited to economic and technical feasibility of the project. While the wide range of aspects covered by the proposed methodology highlights the narrowness of the range of considerations covered in the actual analysis.

ii) the proposed methodology followed a logical sequence of steps that ensured proper formulation of the purpose of approval. While the actual appraisal tended to be fragmentary and unsystematic in approach.

iii) the proposed methodology created a much greater flexibility on the manipulation and presentation of data while the actual method tended to rigidly defined and limited to economic criteria.

iv) the actual appraisal tended to be fragmentary in nature (separate economic analysis with little or no consideration to institutional, social, cultural, etc aspects). Every aspect considered tended to be looked at separately from the others. The proposed methodology tended to consider all aspects within the same framework thereby creating a more complete picture.

v) the actual appraisal led to absolute decisions while the proposed methodology left a lot of room for dissatisfaction at the solution that had been adopted.

vi) the proposed methodology tends to bring out the indicators against which the investment had to be measured while the actual appraisal was based on indicators that had been defined previously.

vii) the criteria for a problem indicator tended to be chosen for a particular aspect from within the framework of the proposed methodology rather than using conventional criteria.

viii) Interaction between the variables is appraised by performing an interaction analysis subsequent to an analysis of each cell in the matrix.

ix) Probably the greatest strength of the proposed system is the flexibility to choose any number of elements in any direction so that there are an infinite number of dimensions in every aspect. Described in a clearer manner this means that:-

-any number of disciplines can be used in the system
-any number of global or other issues can be used as a basis of judgement
-any number of variables can be used to define a particular discipline or issue
-The methodology proposed does not lend itself to any particular school of economic or other thought. Human development always remains the central theme. In this sense it is an absolutely neutral device to appraise any investment.
- The output can be produced in any form required (based on cost/benefit , impact, effect or other approaches)

9.6 Summarised Conclusions

9.6.1 Preliminary conclusions

These include the following:-

i) The role of technology in development has to be clearly understood to control it.
ii) Technology results in benefits as well as costs.
iii) Future developmental trends require inclusion of a global and human context into the process.
iv) The multi-disciplinary nature of development must be recognised.
v) In considering technological development it is necessary to understand:-

-the existing technological state of a society
- the mode of transmission of new technologies to that society

vi) Multi-disciplinary nature of the appraisal process must be incorporated into the appraisal exercise

vii) The non-neutral character of an appraisal exercise should be taken into account in a suitable way.

9.6.2 Main conclusions

9.6.2.1 The requirements

These include the following:-

i) An improved appraisal methodology would require that:-

-it includes a global and human context
- that it is multi-disciplinary
-that it is integrated, interactive, comprehensive and flexible

ii) To allow for the appraisal of technology, considerations must include:-

- an analysis of the existing technological state of society
- an analysis of transmission of technologies to that society

9.6.2.2 Methodology

These include the following:-

i) The proposed methodology was based on a multi-level matrix method using a systems analysis approach

ii) This method was found to be practically viable

iii) The results obtained from application of the suggested approach tend to provide a greater insight to:-

-the actual costs and benefits
-the costs and benefits left unaccounted for
-limitations of available data
-significance of the issues involved

9.7 Further Work On The Proposed Methodology

Although the proposed methodology has been developed within this research and the concept shown to be practically applicable, this work is seen only as a start toward solution of the problems concerning appraisers in the face of current issues and problems.

In evolving this methodology, it was considered sufficient to improve on existing methods. To the maximum extent possible, individual parts of it were developed after careful consideration and research. In spite of this, however, there are a number of refinements that can be made to the suggested approach. These include:-

i) A clearer definition of the systems to be considered in that they could be more than have been accounted for

ii) A clarification and refinement of the global issues as more knowledge about these becomes available

iii) An enormous improvement in the suggested method could be achieved if the variables could be defined in a more accurate way.

iv) The tabular form in which the variables are presented may quite possibly expressed better

v) The manual methods used to draw up the matrices make the handling of data and analysis quite complicated. It may be possible to handle these more efficiently

vi) The output presented in figures 8.22 and 8.23 may be presented in a more refined manner

vii) On the whole, it may be possible, as new technologies and analytical methods become available, to decrease the length of time involved in the analysis of a project using the proposed methodology.

9.8 Future Directions

9.8.1 Artificial Intelligence

The availability and manipulation of data was seen to be the worst difficulties encountered in the use of the proposed methodology. It is possible that a data bank could be created using artificial intelligence as the basis of creating a greater and easier access to data.

9.7.2 Expert System

Given that a data base (knowledge base) could be set up, it is only one step to convert the whole methodology into an expert system if a set of rules can be established that can be used to analyse each cell of the submatrices and the interaction matrices.

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APPENDIX A

A SHORT DEVELOPMENTAL HISTORY OF BRITAIN UNTIL THE COMING OF THE INDUSTRIAL REVOLUTION: A TECHNOLOGICAL PERSPECTIVE

APPENDIX 1A

A SHORT DEVELOPMENTAL HISTORY OF BRITAIN UNTIL THE COMING OF THE INDUSTRIALREVOLUTION: A TECHNOLOGICAL PERSPECTIVE

1 Introduction

The United Kingdom (U.K.) is characterised according to data available for the mid - eighties (Cole,1987) by a high gross national product (about 9,050 U.S. dollars per capita), a high percentage of urban population (approximately 76% of the total) and a low population growth rate (in the region of 0.1% p.a.). Between the beginning of the twentieth century and the mid 1970`s, the annual output of goods in the U.K. rose by almost 250 per cent, personal consumption increased by about 100 per cent, the average working week fell from 56 hours of work to 41 hours and annual holidays increased from 1.4 to 4.7 weeks (Haigh,1985).

In spite of these positive economic achievements, the economic history of the U.K. has been one of disappointment. The reason for this is that the U.K. is best at its past. The twentieth century economic performance of the first industrial nation has been worse than all the leading industrial nations of Western Europe as well as Japan.(Haigh,1985)

Nor does the examination of social structure based on political institutions, distribution of wealth, class and status, sex roles, religion and education present a clear picture of significant social progress and transformation. Indeed, the present understanding of historical literature and material, leads one, upon scrutiny towards recognition of distance traveled upon too long a road to permit easy return(Bentley,1985).

In the U.K. today, in common with other advanced industrial countries, technology is affecting not only the physical production of goods and services but the intellectual and organisational activities as well. The widespread access to radio and television served to distance the scientific elite not only from the majority of the population but from fellow intellectuals as well as limiting power of the written word so that at the end of 1950`s it became fashionable to talk of "two elite cultures," the itinery and the scientific. The real root of this cultural problem lies in early specialisation in secondary schools and to bridge this gap between the two cultures, in a period of increasing financial stringency, was the central issue of the 1970`s (Sutherland,1985) and continues today.

Until recently, British governments have given top priority to maintaining high levels of employment. The cost of this policy has been a substantial reduction in productivity and competitiveness as well as slowness in introduction of new technologies into the production process and the United Kingdom has been faced with a downturn in their share of world trade started in the nineteenth century. A change of policy since 1979 has been directed at reducing manufacturing costs and improving competitiveness but only at the cost of increased unemployment (Caldecote,1983).

If advantage is not taken of new technology, the U.K. will not be competitive in quality, price or service. This will result in a drop in world trade, lower standards of living and unemployment. If new technology is applied, dramatic increases in productivity will lead to fewer and fewer people being employed in the manufacturing industry making unemployment a permanent feature of life for an increasing number of people.

At the same time, U.K. in common with the rest of the world is faced with a whole new series of global problems, including pollution of its atmosphere and oceans, depletion of its natural resources and growing energy consumption. So long as the range of weapons remained limited so that wars remained regional conflicts, a state could imagine it was master of its own destiny. Today in the age of global economic warfare, intercontinental missiles, sattelites and radar systems, every regional dispute could plunge mankind into a world catastrophe. The sudden and dynamic growth of transport and communications and intensification of world economic interdependencies have put the world into the position where the slightest upset anywhere on the globe can spread with devastating speed to the rest of the world. The realisation is slowly but surely percolating through to the public at large that governments are becoming increasingly impotent, that international organisations in their present state have no panoply of measures to impose international order and that the emergence of new nuclear powers and incalculability of technical innovation threatens to undermine all order . In this age of the test - tube, and genetic engineering, man can tamper with human life. New life can be created or transformed.

Thus, evolution of the scientific and technical civilisation has placed the U.K. and the rest of the world in the way of stepping into a terrifying age. The pursuit for control over the sources of power in nature started by the industrial revolution has placed man in the position to start conquering nature itself. But what of the quality of life? Has this development, in the final analysis, then, created a man, who is less free in his thinking and behaviour, who lives in permanent insecurity, has a better chance of access to a

greater quantity of goods, in a society that has as much injustice as ever, and who as machines replace man will be condemned to a week of sundays in a civilisation of permanent leisure?

There are for the industrialised world, only two ways forward, total nihilism which is already threatening it with the choice either of the robot or an atomic explosion, or the rediscovery of a new meaning to life. If the western man is to resume advance through history, technology must be put back in its place and a reappraisal of past experience carried out . That is the purpose here, to review the technological past of the U.K. in search for a better future so that the role of technology in human development may be defined more clearly.

2 Technology and Human Development Until Coming of Iron

The most fundamental way in which human beings differ from animals is in their ability to add new scope to the capacities of their physical being through a history of continuing societies with a material culture. The continuity of tradition in the primitive man is indicated by archaeological records to begin with the actual implements resulting from the extension of human limbs, made by the primitive man himself.

The primitive man of the stone age in Britain is much the same as the primitive man all over Northern Europe which is not unexpected as Britain was a past of the continent until its last link, a marshy belt across the shallow southern part of the North sea broke. The earlier primitive man of the island thus formed were probably from the mid stone age and hence Mesolithic in technology. They were wanderers and gatherers who used flint tools. Those at the coast knew how to catch even deep sea fish, made bone harpoons and other implements. They could make fire but had no pots. Camp-sites have been discovered indicating that during warm seasons the game hunting and gathering was done on high ground. The winters were probably spent in caves. (Clapham,1957)

Around the year 2400 B.C. migrants brought into Britain the neolithic (new stone age) culture(Clapham,1957) which covers essentially, the period of the early river civilisations of Egypt, Mesopotamia, India and China(Bernal,1969). The importance of these people lies in the fact that they brought with them a knowledge of agriculture and of managing cattle as well as improvement of implements. These arts had probably been carried from the near east, where great civilisations already flourished. Because of exhaustion of soil caused by lack of fertilisers and rotation of crops, the spread of the

neolithic culture was rapid. There is reason to believe that at each stage of migration the new arrivals absorbed or enslaved the natives as and when they met both teaching them and learning from them how and when necessary. From Sussex Downs westward into Devon settlements of these first farmers have been examined. They were mainly cattlekeepers, but also kept goats, pigs and sheep. They also cultivated little plots of wheat probably using some sort of digging stick to turn the ground or a pick made of a dear`s antler to furrow (Clapham,1957). For defence and enclosing of cattle they fortified their camps with trenches about them in concentric circles enclosing areas upto fourteen acres. They learnt to mine for good flint.

The earliest farmers probably crossed a narrow channel into a country just like the one they were leaving in France. Later a more developed civilisation (called the Big Stone Culture) affected Britain from the South and West, immediately from Britanny but ultimately from the Mediterranean. This was a sea - bourne culture and these were fine seaman but their agricultural life differed little from the first known farmers. About 2000 B.C. the `Beaker Folk` with their arrows tipped with barbed flint, the flint daggers, stone battle axes and copper daggers imposed themselves as overlords on older stocks and mingled or absorbed the existing peoples (Childe,1940). The life of these people was migratory with subordinate agriculture.

The outstanding technical achievement of this period around 2000B.C. is the erection of greater stone circles such as Avebury and Stonehenge. These suggest a knowledge of perspective, high intelligence, wealth and organised servile labour. These required handling of enormous blocks upto 30 feet in height, skilful shaping and tendon and mortice attachment to them of curved horizontal blocks. An amazing requirement of organisation must have been the transport of the inner ring of huge "blue stones". Certainly from Pembrokeshire by sea and river as well as rollers overland. The origins of the type of man who made these are not known in great detail (Clapham,1957).

Between 2000 and 500 B.C. wheat and barley are known to have been cultivated. Although the digging stick was in use, there is no evidence of the plough although it is known to have been here by the time man learnt to work iron. The period from the second millenium and the first quarter of the first is the age of bronze. This is followed by the iron age but this is really effective until about 500 B.C. There is no sharp division between the bronze and the iron ages (Clapham,1957). Besides bronze, copper and gold were also important in these metal ages. Trade seems to be the outstanding feature of this somewhat 'misty'age. A trade connection between Ireland and Cornwall was constant and ultimate in the early bronze age when Ireland exported

bronze wares and gold. However although trifling in totality, the active trade of the late bronze age (1000 to 500 B.C.) is known to have been carried over great distances. The origins of the metalsmiths is however a matter of speculation. However outsiders or not, these people were highly skilled, having a whole range of tools - hammers, chisels, tongs, gouges, ornaments, round shields, cauldrons, general purpose knives razors and sickles.

At the end of the bronze age around 500 B.C. Britain was a predominantly agricultural economy with a handful of bronze smiths among cattle - keepers, corn growers and women spinning and weaving at the homes of the tribes they dealt with (Clapham,1957). In terms of the developmental trends - before coming of the iron age, the primitive man had moved from a hunting economy of the Neolithic age to the agricultural economy of the Neolithic-age and was beginning to develop skills in handling metals. By making tools and using them, the primitive man had learned to use natural resource according to his own will and had thus laid the foundation for rational and usable science, if this is defined as the manipulation at will of the environment, through a knowledge of its inner workings, to the advantage of man. But the interests of this primitive man were severely limited being confined to the provision of necessities of life -food,clothing and shelter. The origin of agriculture is at best conjectural. However the limitation of the plants and animals used in agriculture to a few related kinds points to its having arisen in a definite period probably in the Middle-East (Bernal,1969). Evidence (Childe,1939 Collingwood,1945 Sambursky,1959) points to crops and domestication of animals always being associated with each other. The implication of this change that effected greatest influence lay in the creation of communities. The new techniques in growing crops - sowing, hoeing, reaping, threshing, storing, grinding, baking and brewing etc gave rise to other ancillary techniques like weaving made possible by ample supplies of wool and flax, pottery and hutbuilding. This was the concept of fixed goods evolved by requirements of permanent occupation. The rule of share and share alike regulated by custom, ritual exchanges eventually gave way to the barter system and individuals began to emphasize ownership, with the inevitable result that inequality of wealth was born. Agriculture also introduced into life, the concept of work which in the hunting cultures was not distinguished from other aspects of life. Pottery gave rise to greater control of fire, weaving resulted in the introduction of geometry and arithmetic (Childe,1939 Weltfish,1953) and spinning created the concept of rotation. It became important to know how animals bred and grew and the smelting of metals started a study of chemistry. Thus science which originated in old stone age, expanded in the Neolithic and Bronze ages.

3 The Iron Age

The age of iron for Britain begins about 500B.C. or slightly earlier. Britain south of the Forth and Clyde had reserves of iron - ore. It is likely that during the early iron - using times, the specialists were people who came in a train of conquerors such as the Parisic who overran the East Riding of Yorkshire in the third century B.C. But very quickly the smelter and blacksmith spread over the regions where various iron ores were located.(Clapham,1957)

When Caesar came in the first century B.C. wrought iron bars were being used as currency in South Britain, and had probably been in use for the two centuries before this (Clapham,1957). These bars had been properly graded by weight.

The coming of iron steadily ousted flint and bronze as materials for weapons, implements and tools but bronze utensils, ornaments and horse trappings continued. The iron shod plough came into use. The connection between Britain and the continent became close as movement of goods and people between Gaul and Britain increased. However the Celtic speaking tribes of Gaul and Britain were constantly at war with each other and hence skills in self - defence gave rise to the building of many hill - top forts in Britain especially in the third century B.C. Coins were issued in the eastern Kingdom and a second Belgic state whose centre was in Hamphire and frontier in Somerset, but these were first struck on by Belgic princes. Gaulish coins had been in circulation two generations earlier (Clapham,1957).

The effect of abundance of iron was that it opened up a whole new continent to agriculture by making clearance of forests easier. It was possible to drain swamps and the resulting fields could be ploughed. The advent of money, as a measure of every other value changed all established social relations into those of buying and selling. By bringing rights without obligations, money enabled power to be concentrated in the hands of a few and destroyed immemorial customs in a few generations. Thus began the feudal system.

Contact with Rome carried Britain from prehistory to history. It was in these important respects that Britain reached a stage of development that made them suitable for incorporation into the Roman empire (Birley,1985) namely :-

- they were producing their own coins, with latin alphabet on the coins indicating a degree of trading activity and the beginnings of literacy.

- capability in building hill-forts indicating political organisation and engineering skill.
- efficiency in agriculture with cereal production.

For much of the period of Roman rule a relatively large garrison of the army was provisional from Britain, and since soldiers were the only significant body of the wage-earners in the ancient world, their spending power must have been a major factor in the enrichment and development of Britain. Initially Britain was governed as a single province until the early third century. In about the year 213 it was divided into two provinces for political reasons (mainly to prevent rebellion). Around the end of the third century, it was further sub-divided into four provinces and a fifth was created later in the century. Three colonies for legionaries were founded in the first century at Colchester, Lincoln and Gloucester. York was given an honourary status of colonia in the third century and London probably by the fourth century. In the second century elaborate private houses began to appear, although majority of the population continued to live in the countryside. Agriculture was the main source of wealth although extensive mining of gold, lead (from which silver was extracted), copper, tin and iron was being undertaken. Pottery and industry was widespread and British textiles began to be exported (Birley,1985).

4 Britain 409 to 1150

From the time of Roman withdrawal following the rebellion of Constantine, which led to Britain taking up arms in self defence in 409, Germanic (anglo-saxon) warriors, chieftains and adventures began to come to England. The English History from Anglo-Saxon settlements to the Norman conquest represents a development from the " Heroic Age " to the state. In the sixth and seventh centuries the most highly prized arts were those of bards and the goldsmiths or skilled workers in precious metals. Books came from Britain in the context of Christianity and mainly for the purpose of worship, and were brought in by the Anglo-Saxons who had received it from the Romans.

Following the Norman conquest in 1066, the cultural development continued and English textile weaving, influences of German metalwork, use of the vernacular introduced by the Anglo-Saxons continued. They introduced however in addition, castles, churches (in full scale grandeur of Romanesque architecture), the notion of architectural sculpture as well as French.

By the eleventh century, Anglo-Saxon England was a rich country. However the remainder of England was largely unaffected by the growth of the North Sea and the Channel trade until the twelveth century. After 880, there was a rapid expansion in the the number of towns from about ten in 880AD to about seventy in 1000AD. By 1066 at the time of the Norman conquest more than a hundred places could claim to be regarded as urban. The towns were however very small covering about 100 to 150 acres of land for the largest towns with the populations rarely exceeding 5000 people. However by the eleventh century only one tenth of the population seem to have lived in towns.

Coins ceased to be used in Britain in the fifth century but reappeared in the mid seventh century. The quantity and management of coinage also reveals the wealth of England by comparison with the rest of Britain. There is clear evidence from the seventh century indicating the association of coins and coining with coastal and riverine trading places. Southampton for instance was laid out with a regular arrangement of streets and workings of metals,wood, bone and antler was carried out there. Other activities taking place there included, together with the minting of coins,the making of pottery and textile weaving. Imported finds include among other things, glassware, pottery and Lava millstones from Germany, and pottery from many parts of France (Biddle,1985).

Production however remained overwhelmingly agricultural in Britain as a whole as well as Anglo-Saxon England. Archeological and pollen analysis indicates that there was no major ecological change or increase in the amount of arable land, fitting as it were the picture of " new topography ", indicating exploitation of a land system of estates and fields taken over in fluctuating order from Roman Britain and gradually modified as opposed to reorganisation and recolonisation of an abandoned wasteland. The beam ard, involving cross ploughing in square fields seems to have remained the normal agricultural tool until the ninth century when the heavy wheeled plough was introduced. This allowed ploughing in one direction only and hence encouraged the adaptation of the strip field. The main crops consisted of wheat and barley. Oates were used more as fodder and rye was an insignificant crop. Edible wild foods played a small but significant role,beef cattle, followed by pigs were the main meat components of diet. Poultry was insignificant while sheep were probably kept for wool production on a scale far exceeding continental practice (Biddle,1985).

Essentially then, Britain (Anglo-Saxon and in the whole) was an agrarian society until 1150, and other than geographical fact, which made it an island, was by culture, religion and territorial authority joined to Europe by the second half of the twelfth century.

5. The British Economy 1150-1625

The economy of Britain in 1150 was on the eve of expansion and the population increased from about two million in 1100 to five million in 1300. The thirteenth century seen by many historians as the high point of the middle ages saw major changes in farming, the growth of towns,of trade (local and international) and the realisation by great landlords that rich profits were to be made from farming for the market as opposed to leasing out their lands. As a result, their incomes rose and they spent lavishly on building, on luxury goods, on hospitality, and ostentatious living. Towns of all sizes expanded and by 1325 the number of towns in England had doubled. In spite of this, however, there no growth, no per capita increase in wealth, no major industrial development to absorb the manpower surplus to agriculture so that even though flourishing tin and lead mining and building brought prosperity to a few areas, for peasant smallholders in manorial England, life was grim. War with Scotland followed by a failure of harvest between 1315 and 1325 led to economic change, population decline, falling prices and rising wages so that landlords were forced to abandon farming for the land and to return to leasing of land. This was followed by the " Black Death " (plague) in 1348 and resulted in an end to expansion, a return to subsistence farming, decline in trade and industry, impoverishment and contraction for the towns. By 1450 manorialism had collapsed and landlords forced to become rentiers. However by the 1430's the cloth manufacturing areas of the South-West and East Anglia began to flourish and new towns developed from existing villages and England had become a the leading supplier of fine and medium quality broad cloths. Exporting finished goods rather than raw material brought more profit, employment and spending power to the South-West (Palliser,1985).

1450-1625 saw the first phase of the " pre-industrial " period, the transition from an underdeveloped, primary producing economy to an industrialising one. 1450-1520 saw gentle change, with population, prices and most production stable. By the 1520's the population began to increase and prices as well as output increased more rapidly. Two major developments stand out in this period :-

i) balance was stuck between arable and pasture, and middling tenant farmers increased their holdings at the expense of both the manorial lords and smallholders

ii) cloth became the largest export as the home and overseas markets expanded.

iii) manufacture of other goods such as crafts, leather, pottery, cannon, gunpowder, paper, sailcloth, and drinking glasses also expanded in this period (Palliser,1985).

The British economy underwent consolidation and development between 1625 and 1783 which laid the foundations for industrialisation. Industrial innovation resulting in raised productivity included such developments as Derby's coke smelting process in the iron industry (1709), Newcome's and Watt's steam engines (1712, 1763) as well as Hargreave's Jenny (1768), Arkwright's waterframe (1769) and Crompton's mule (1779) in the cotton textiles industry. An international commercial network evolved into which Scotland and Ireland were integrated. In the 18th Century, it has been suggested, agriculture accounted for 45 per cent of output in 1700 and only 33 per cent in 1800, while industry and commence rose from 30 to 40 per cent over the same period (Beckett,1985).

6 The Pre-Industrial Period

Britain emerging from the feudal system was a predominantly agricultural economy with very few large towns and many villages existing throughout the country. Although no sharp division existed between manufacturing on the one hand and agriculture on the other, 75 per cent of the urban labour force was employed in industries consisting of textiles, clothing, leather, metal working, building, and processing of food and drink. The basic unit of production was the craftsman who manufactured on a small scale basis, using labour intensive methods and little capital. The largest employers of labour were the manufacturers who " put out " work to employees in their own homes mostly in the woollen, metal working and leather goods industries (Lee,1984).

Growing population and expanding markets, as well as the emergence of new technology requiring bulky plant and power driven machinery requiring close supervision and flow of work from one stage to another without interruption, led to the use of specialised premises for manufacture leading to the rise of the late 17th and 18th Century manufacturies. The first genuine factory was put up in Derby in 1719 by Thomas Lombe andwas a silk throwing mill producing yarn for weaving and giving rise to the factory system (Lee,1984).

7 The Industrial Revolution (1750-1850)

Over a period of 50 years from the mid-eighteenth century the predominantly agricultural economy gave way to an industrial one as Britain became the first " industrialised nation " of the world. The development of more efficient methods of agriculture began to feed a growing population while the factory system superseded its earlier rivals to become well developed by 1815, with the development of new technologies providing cheaper and more efficient methods of production (Lee,1984).

The factory system separated home from work, and availability of plentiful labour made it cheap so men, women and children toiled hard to scrape a living at the premises of their employers. The absence of trade unions and the prevailing " Laissez Faire "economic doctrine of the day, assisted this condition. The fundamental units of business were the sole proprietorship and partnerships (Lee,1984).

The major sectors to develop were cotton, iron, coal, copper, glass, paper and building. Cotton was the first major industry to replace hard methods of production with machinery, and when power was harnessed to the machines, the factory system expanded rapidly. By 1815,cotton had replaced wool as the major export from the U.K and by the 1830's formed over half of the total value of the export trade. The main factor contributing to this growth of the cotton industry was the opening up of new markets in the colonies, and tropics, as well as the availability of raw materials in cotton plantations of the southern states of America (Lee,1984).

The transport network roads and canals was improved as the cotton industry required. Improved shipping and internal transport as well as building of factories and " textile towns " to house workers near remote sources of power made demands on the construction and engineering industry as did the construction of machinery and steam engines to power them. Because all these industries required iron and steel production, which in turn required a thriving power generating industry, all these also developed. By the beginning of the 18th Century the timber forests had been so heavily exploited that timber was in short supply. Thus it was that coke from coal was discovered, although it took almost half a century for widespread use of coke smelting methods to come into being (Lee,1984).

APPENDIX B

A SHORT DEVELOPMENT HISTORY OF KENYA UNTIL THE BEGINNING OF THE NINETEENTH CENTURY - A TECHNOLOGICAL PERSPECTIVE

APPENDIX B

A SHORT DEVELOPMENT HISTORY OF KENYA UNTIL THE BEGINNING OF THE NINETEENTH CENTURY - A TECHNOLOGICAL PERSPECTIVE

1. Introduction

During the last hundred years, Kenya has witnessed radical transformations in 'its' environment caused in no small measure by the effect of mathematical and physical services on the development of technology elsewhere in the world. Today, Kenya is characterised by a low per capita gross national product, high rural population (over 80% of the total population) and a high population growth rate in the region of 4% per annum with more than 50% of her population under fifteen years of age in spite of an economic growth rate of 2.8% per annum between 1960 and 1982 (World Bank,1984).

In effect, when judged against the development criteria (Fryer,1965) of per capita national product, occupational distribution and age structure of it's population, rural-urban population ratios and the rate of economic growth, Kenya is classified as a 'poor' or, in parlance of the day, a 'developing' country. Poverty is not, of course, a new circumstance in human affairs. Nevertheless, this poverty has seen Kenya being placed increasingly at a disadvantage, in recent years, due to the unfavourable terms of its relationship with the 'rich' and 'highly developed' nations of this world.

To understand the gap existing between Kenya and the 'highly developed' nations, it is necessary to venture outside the boundaries of economic theory and to turn to history in search of causes of 'underdevelopment' and 'antecedents' and 'preconditions' for development. This article will review the role that technology has played in the development of Kenya, up to the beginning of the nineteenth century, covering essentially, the period before the advent of modern industrial technology, as we know it today.

The purpose of this article is to stimulate new thoughts on the technological beginnings and importance of technological expansion of the Kenyan people. The historian has his choice of starting points and I set mine in the stone-age.

2. The Stone Age, Technology and Human Development

The technological significance of stone-age lies primarily in the notion that man is a 'tool-making' animal and that his inordinate mental development is due to this ability.

It is now almost certain that 'Australopithicines' who have been grouped with the 'hominid' family represent a stage in man's family tree (Cole,1963). Remains of the 'Australopithicines' who probably lived over a million years ago have been found in abundance in the Transvaal (Cole,1963). Oakley (Oakley,1957) suggests that these 'early men' were probably " .... occasional users of ready to hand tools and weapons ..." though they may not have been tool makers. However Gregori (Gregori,1969) states of the 'hominids', that they are generally believed to have existed by scavenging but without tools. The hominids are generally accepted to have assumed the erect position of modern man (Cole,1963).

Nothing much is known earlier than the 'hominid' group although, the limbs of the 'Proconsul' were of a form that could have given rise to those suitable for an erect posture or the extreme kind of brachiation seen in the modern apes (Cole,1963). The 'proconsul' were an unspecialised genera of apes of which three species existed. The earliest known remains of the skull of the 'Proconsul' were found on Rusinga Island in 1948 (Leakey,1948).

Recent discovery of fossils in East Africa, and factors such as seriological similarities between man and African apes have caused practically all experts to reconsider Africa as the place of man's origin (Cole,1964) as originally suggested by Darwin. However the data available is very little. Attempts to infer the skills, the technology and range of habitable environments, therefore result in theories that are very tentative. Despite this lack of detailed information however, the dynamic character of tool development, tool use and the resulting creation of new environmental frontiers is evident from the archeological data available for East Africa.

In outline the following significant archeological finds have been made in East Africa as a whole and Kenya in particular.

-Discovery of the hominid fossil in Kanapai, Lake Rudolf, Kenya dated as being 2.9 million years old.

-The first stone tool industries known to man, discovered in the oldowan and Kaffuan pebble tool cultures of East Africa (Tanzania) (Gregori,1969).

-The discovery of fossils of the Chellus-Archeul culture in abundance in Olorgesailie in the Kenyan rift valley (Oakley,1957). The pebble tool culture is thought to have evolved into the Chellus-Acheul culture named after the Chellean and Archeulean hand-axes.

-About 50,000 years ago, the hand-axe culture was replaced by several regional variants of which the Fauresmith culture was associated with hand-axes, cleavers and stone-balls etc while the Sangoan culture after an initial degeneration in stone-working techniques includes long delicately flaked lance-heads and tranchets. The Fauresmith culture has been discovered on Mount Kenya and the Sangoan culture in Nyanza province of Kenya (Fryer,1965).

-Regional variants of the hand-axe culture also include the Stillbay and Protostillbay cultures which started slightly later than the Fauresmith andSangoan cultures. Both of these later cultures are associated with triangular and leaf-shaped points on their implements. Evidence of these later cultures is particularly common in the Kenyan Rift valley (Cole,1963).

-These cultures were succeeded by the Kenyan Capsian of which there were two classes. The lower Kenyan capsian and a more advanced upper capsian. From the finds at Gamble's cave, Elmenteita in the Kenyan rift valley, it is concluded that these people worked bone, leather and wool, that their stone tools included backed blades, engravers, microlithic crescents or lunates and end scrapers and were made of obsidian which they mined and traded over great distances, that their main food was fish although they hunted and were probably among the first people to use bows and arrows. They were able to make pottery and decorate themselves with ochre, beads and pendents. It is in the Capsian culture that we see the first evidence of the modern homo sapien in Kenya (Cole,1963).

-The very localised upper capsian culture was followed by the Elmentaitan culture which was even more restricted in its distribution. The equipment of these people included long two-edged blades and potsheds (Cole,1963).

-The upper Kenyan capsians were followed by still more settled communities of the stone bowl culture. The earliest makers of this culture have been discovered to have lived at Hyrax hill in the Kenyan Rift valley. They have been classified as neolithic mainly because they lived in villages which presupposes some form of food production. Four variants of this culture namely, the Hyrax hill, Gumban A, Gumban B and Njoro River variants have been identified in this culture. The Hyrax hill variant is presumed by discoveries at the Hyrax hill site to have been in existence before 2500

B.C. (Cole,1963). The Gumban 'A' variant associated with traces of iron and beads of Egyptian origin (Leakey,1936) was dated by it's discoverers to have started about 850 B.C. The Gumban 'B' variant was found on the North-Eastern slope of Hyrax Hill; near Nanyuki on the slope of Mount Kenya. An industry resembling this discovery and dated by carbon 14 to about A.D. 1600 was found at Lanet near Hyrax hill. By the time of the North-East village at Hyrax Hill, the discovery of beads similar to ones from Zanzibar and Pembe confirms that trade with the coast had been established. The presence of saddle-querns, pestles and mortars apart from the stone bowls makes it fairly certain that the Gumban 'B' people ground grain. The Njoro river cave people resembled the Elmenteitan culture people The stone bowl culture continued in East Africa throughout the Iron Age until the sixteenth century A.D. (Cole,1963).

While it is important that discovery of stone-age remains establishes the presence of tool-making and tool-using tradition of the Kenyan stone-age man, it is significant that Kenya has it's own contribution to make to the story of man's technological beginnings. It is significant that universal principles underlying the technological process, namely, scientific method, free enquiry and extension, modification or combination of existing tools to produce new, often improved tools, were in practice in Kenya in the stone age. It is even more important that people trained and skilled in the art of adapting and evolving new technologies to suit specific environments, have been a part of the Kenyan population from the very beginning of the existence of man as the indisputable climax of the vertebrate line.

3. The Kenyan Interior

According to modern ethnographers, the present inhabitants of Kenya include Negroes, Hamites, the 'Bantu' and the Nile valley peoples.

The first attempt at classification of peoples of North-East Africa was made by Agatharchides of Cnidus (1855) in second century B.C., when he wrote about people living South of Egypt who "... wander here and there without plan, feeding on meat and milk." Huntingford (Huntingford,1963) believes that, Agartharchides of Cnidus was referring to Hamitic pastoralists.

It is known that much of East Africa was occupied by scattered survivors of hunting people, referred to as 'symbiotic hunters' by Huntingford (Huntingford,1963), before the present inhabitants arrived on the scene. These people included the Dorobo of

Kenya and Tanzania. The Darobo were a forest people who spoke various forms of Nandi language and were characterised by ability and willingness to acquire elements of cultures with which they came into contact, to the extent that except for the hunting aspect of their lives, they were often indistinguishable from their neighbours. They also depended on their neighbours for products (such as ironwork) which they could not produce themselves, hence the description 'symbiotic' (Seligman,1945). Huntingford (Huntingford,1963) suggests, that it is possible these people represented survivors of one of the early stocks which may have contributed to the formation of the modern peoples of East-Africa so that while they definitely had a foreign strain in their make-up, they should not be classified as modified 'Hamites' or 'Nilo-Hamites' as has been the tendency with some authors.

The origin of the Negro is uncertain, and though the Negro group has left its mark almost everywhere on the East African people, it does not exist in any 'pure' form in East Africa. Typically, the Negro culture in East Africa was technologically characterised by a concentration on agriculture, use of irrigation works and skill in pottery (Huntingford,1963).

Evidence shows that until a few centuries back, people of the Hamitic type occupied a large part of the East African Highlands. Certainly the Hamitic people were established in the Ethiopian Highlands by about the seventh century B.C. The languages of the Hamites may be divided into the Beja, Agaw, Galla-Somali and Sidama. The only people in Kenya today who are unequivocally Hamitic are the Galla (Huntingford,1963). Remains of structural and other works consisting of dwellings, wall enclosures, agricultural and irrigation works and roads (Huntingford,1926) have been found all over the highlands and are attributed to these Hamitic people. The dwellings consist essentially of circular hollows, with level floors excavated on slopes and having an entrance on the lower side protected by the Banks. Large numbers of these dwellings (hut-circles) have been found in the Nandi and Uasin Gishu areas of Kenya (Huntingford,1963). In 1937/38, Mrs Leakey excavated at the Hyrax Hill near Nakuru, an iron-age settlement consisting of dry-stone walled enclosures and hut-circles of the same type as other sites in the highlands. Among these remains, she also located some material from the coast which could be dated any time between the sixth and sixteenth century A.D (Monod & Toupet,1961). This development certainly iron-age, it has been, suggested should be ascribed to the Hamites.

The use of stone-building suggests a northern origin, which also supports this suggestion. Hence, while something is known about the structure and distribution of these 'hut circles', nothing much is known about their origin. It is uncertain, how extensively, stone-built dwellings were used in the Hamitic area but circular stone sites have also been found in Eastern Galla. Taken as a whole, the evidence suggests a people of Hamitic affinity. In occupation the Hamites were pastoral, with a well developed form of agriculture including use of the plough (Huntingford,1963).

The Nile valley peoples (a mixed group stretching on both sides of the Nile from Sennar to Lake Victoria) consisted of two major divisions namely, the Nilotes and the Nilo-Hamites. The Nile valley peoples were strongly pastoral, with the hoe culture as a subsidiary. Their influence certainly penetrated deep into Kenya (Huntingford,1963).

The Nilotes, included among others the Luo. A pronounced characteristic of the Nilotes was their cattle complex which could almost be called a cattle-cult, although Southern Nilotes - the Luo of Kenya were more strongly agricultural than others, and lived in walled villages.

Most Nilo-Hamites practised some form of agriculture, with the exception of the pastoral Masai. The Nandi and Masai had very distinctive spears and shields, pig-tails and horn arm-ornaments.

A difficult problem in the early history of Kenya and in fact Africa as a whole, is the origin and spread of the Bantu speaking peoples, who cover nearly three quarters of the African continent south of the Sahara. If his thesis is correct, then according to Greenberg (Greenberg,1962), the Bantu were a small group situated north of West African rain forest in the vicinity of Lake Chad, about two thousand years ago. It is possible to support linguistic evidence by certain technological features in relation to the Bantu. For instance, the distribution of a tanged, heart shaped iron hoe, is found in one form or another over a large part of the Bantu area. Secondly there is the distribution of bellows for ironmaking of which two types have been identified in Africa, the drum type (in which a solid chamber is covered with a diaphragm) and the bag-type (consisting of a skin-bag with a solid mouthpiece. The drum type seems to have been favoured in the Congo area Lake Chad and Northern Nigeria, and the bag type occurs to the west and south of Lake Victoria, up the east coast and inland to Lake Victoria with three enclaves where both types can be found together. Is it possible that the drum bellows together with the knowledge of iron-working reached the Bantu from Lake-

Chad via Northern Nigeria before being spread west of Lake Chad reaching Nok in Nigeria by first century A.D.? Is it further possible as suggested by Huntingford (Huntingford,1963) that when the Bantu moved east of Congo they had the drum type bellow which they replaced by the bag type bellows when they occupied Kenya and Tanzania ? At any rate, there are three zones of these Bantu speaking people in Kenya.

-a zone in the region of Western Kenya i.e. the Luhya group.
-a zone in Eastern Kenya along the coast.
-a zone around Mount Kenya.

4. Occupation and Diffusion of Technology in the Interior

Huntingford (Huntingford,1963) suggests that the Nilo-Hamites entered Kenya via two routes, the Nandi branch moving southwards from the west of Lake Rudolf and reaching Western Kenya via Mount Elgon by way of a secondary dispersal centre (Huntingford,1963) and the Masai branch moving South from Lake Rudolf by a more Eastern route. He further states that although the Luhya group claims to have moved from the west, and evidence exists to support this (Dundas,1913) some of the luhya have more affinity with Gusii (Kisii) of South Kavirondo and hence represent a Northern movement from the area South east of Lake Victoria.

The ancestors of the North-Eastern Bantu came from a dispersal centre in Taita Hills near Mount Kilimanjaro according to oral tradition. They migrated to the coast and went North as far as Shungwaya (somewhere between the Tana and Juba rivers) (Grottanelli,1955) and moved away from this secondary dispersal centre when the Galla arrived between the twelveth and seventeenth centuries A.D. (20).

In moving away from Sungwaya, they broke up into groups which became known as, the Pokomo along the Tana, the Nyika from the coast southwards and the Kamba and Kikuyu further inland in the region of Mount Kenya (Huntingford,1963). The Nyika were an agricultural people with cattle as were the Kikuyu and Kamba group and the Pokomo had no cattle.

The Hamites seemed to have formed part of the ancestry of both the Nile valley peoples and the 'Bantu'. Huntingford (Huntingford,1963) suggests that the Hamitic penetration took place in two major series of movements namely:-

-Series A going westward beyond the Nile and resulting in the 'Early Bantu'
-Series B being the cause of the nile valley peoples.

Both these groups would have then impinged on Negro, the stone-age peoples and hunters in the interior.

Summing up, it can be seen that the foundation stocks of the present Kenyan people were the Negro, Hamites, Nilo-Hamites and Nilotes and the 'Bantu' as well as scattered survivors of the hunting peoples of Kenya. Figure B1 shows the distribution of peoples in Kenya at the start of the eighteenth century. Naturally as these people migrated from one place to another, they carried along with them, stocks of their own technological knowledge which over a period of time were 'diffused' into Kenya.

On the whole, it is the Bantu-speaking peoples that seem to have made the greatest technological impact in Africa. Most of the areas into which the Bantu migrated showed a clear gap from indigenous stone-age techniques to the iron-working agricultural techniques of the Bantu. This iron-working technology included skills in finding the right ores, building furnaces, using fuels, fluxes and bellows for temperature control. Depending on the method used, it also required the use of hammers, anvils and casting. When the Bantu reached Uganda, they encountered grains of Sudanic agriculture and acquired irrigation techniques (Jones,1959). According to Gregori (Gregori,1969), the Bantu movement east from Uganda i.e. in Kenya tended to be limited to areas suitable for their agriculture.

5. Trade, Technology and the Coast of Kenya

The first concrete information relating to trade with East Africa is provided by the 'Periplus of the Erythrean sea' (Schoff,1912) dated between A.D. 60 and A.D. 110, in which is described a flourishing trade with the East African coast, in particular at the emporium of Opone, and an emporium further south at Rhapta, which was organised

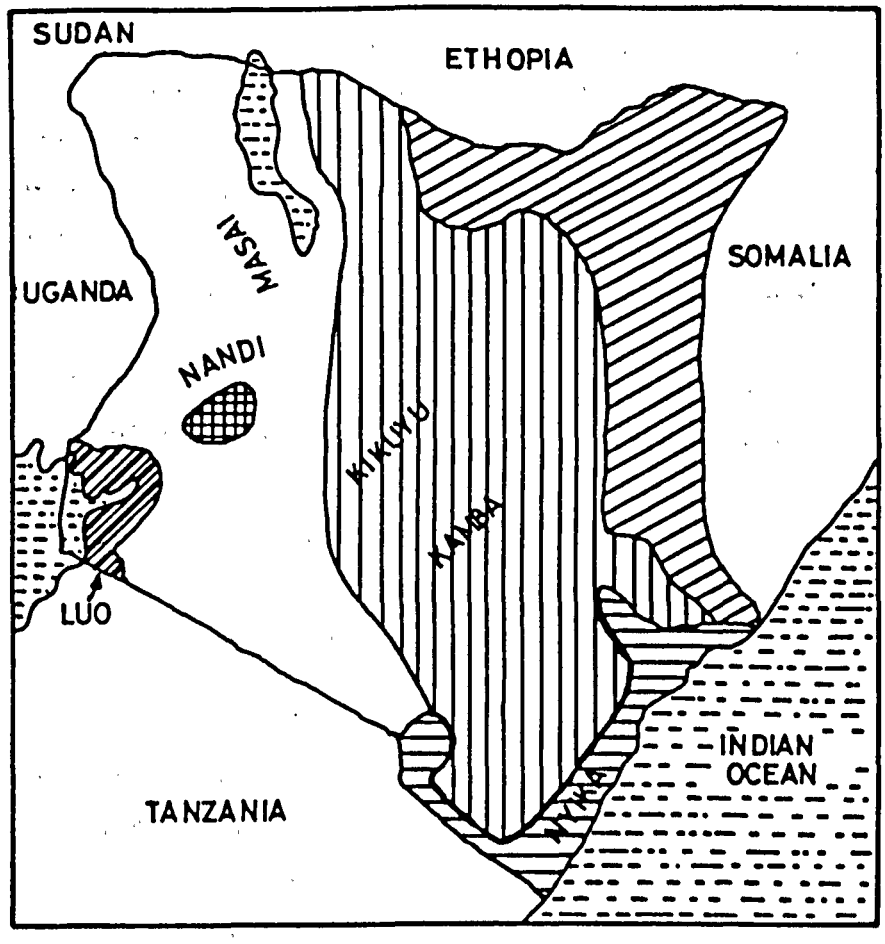

FIG 1. THE DISTRIBUTION OF HAMITES, NILO-HAMITES AND NILOTES IN KENYA, AROUND BEGINNING OF THE EIGHTEENTH CENTURY.

Key:

- HAMITIC (GALLA).
- BANTU.
- SURVIVING AGAW GROUPS (HAMITIC).
- NILO-HAMITIC.
- SUK (NILO-HAMITIC).
- LUO (NILOTIC).

quite differently from Opone. Rhapta, which was probably the Tanzanian coast, imported primarily iron weapons and tools and exported great quantities of ivory. Although it was necessary for the ships to sail south for some weeks to reach from Opone to Rhapta, and a number of places up the Kenyan coast are mentioned, none of these are referred to explicitly as Trading Centres (Mathew,1963). Historians are, as Gregori (Gregon,1969) states, aware that at this time, the Greeks and Romans had learned that they could sail the Sabian lane using the alternative monsoon winds.

The next documentary evidence available is the Geography of Ptolemy (Muller,1963) in which is described the extension of the economically developed northern coast zone to the south towards the Kenyan boundary. The period from the late fourth century to the late seventh century A.D. is most obscure so that very little is known of the history of the Kenyan coast for the first seven centuries (Posnansky,1966). Any technology transferred to the Kenyan coast does not seem to have penetrated far inland during the period.

However for the period from the late seventh century through to the fifteenth century, history of the East African coast is illuminated somewhat by African, European and Asian writings. Unfortunately, these writings contain little information regarding social and economic conditions of Indian or other activity in the area, even though it is known that trade with East Africa eventually extended beyond India to China. Little concrete evidence then is available to explain the phenomenon of iron-working which began in East Africa between 900 A.D. and 1000 A.D. (Gregory,1971). Kirkman (Posnansky,1966) has conjectured that Indians may have been the main cause of the great expansion and diversity of material culture that occurred along the East African coast in the fourteenth century.

With the beginning of a good muslim empire in North-west India in 1206, (Gregory,1971) a profound muslim effect was exerted on the East African coast. All through the twelfth century the crusades had been linking up West and East Mediterranean and the market for ivory and gold was growing in Europe; hence there was good reason for fresh muslim trade interests in East Africa. Thus was Kenya given a place in the network of trade that chaquered the Indian ocean (Mathew,1963).

The process was gradual (Posnansky,1966) beginning with intermittent visits by traders, graduating to scattered settlements here and there at great intervals. The interaction between the Muslims and Africans seems to have been friendly so that the

caost people acquired in course of time a more or less common Afro-Asian character. This however never extended far from the sea. A number of Arab colonies were established at Lamu, Malindi and Mombasa along the Kenyan coast. Slaves ranked high on the list of imports of these people and were exchanged for cloth, metal work and beads from India, Persia and Arabia. It can be said that this was a 'middleman's' trade from start to the end upon which the urban coastal communities supported themselves but manufactured very little for themselves, although Ibn Battuta recorded that he had heard of iron mines being worked in Malindi, when he visited East Africa in 1331 (Batutta,1962) as well as wood construction. By the fifteenth century, stone houses, palaces and mosques were replacing these wooden buildings (Kenneth,1962). The Arabs made no attempt to exploit the agricultural resources of the country but introduced oranges and other fruits from the east and cultivated palms, sorghum, millet, beans and rice in their own towns for themselves. It was the same with livestock, cattle, goats, sheep and poultry (Mathew,1963). The coconut used to build thatched roofs (Batutta,1962) also had other uses, in East Africa such as providing fibres for sewing boats, making up sacking, sails, cordage for shipping, fuel, making rosaries and linen. The weapons in use in this period were bows, arrows, shields made of palm leaves bound with cotton and pikes (Gregon,1969). Among the most important items diffused into East Africa by this trade was paper.

The Arab dominated Indian Ocean trade with Kenya, was based on Persian maritime technology. However in the fifteenth century great advances were being made in maritime technology by the Chinese (Ming Dynasty) and Europeans. Although the Chinese were known to have sent vessels to East Africa, the coming of Superior Portuguese maritine technology prevented them from dominating the Indian Ocean trade. With the voyage of Vasco-da-Gama with 3 ships in 1497, and his visits to the chief Arab settlements one after another in the following year from Mozambique to Malindi began the Portuguese invasion of the East African and Kenyan Coast (Mathew,1963).

Within eight years of their arrival, the Portuguese could claim to have seized the whole of the East African Coast (Freeman-Grenville,1963). However this change was little more than a change of dominion. The portuguese occupation of the Kenyan coast extended very little beyond the Arab occupation and essentially it remained conquest of Arab colonies only.

The presence of the Portuguese for 200 years or more contributed nothing to art, architecture or literature in Kenya. If anything the architecture underwent a change to houses of great simplicity, having no trace of the earlier sanitation and the earlier use of ground Coral and Mortar used traditionally stopped and mud began to be used. The use of stone declined to be replaced by mud and wattle and thatched Mukuti roofing.

The greatest contribution made by the Portuguese included the introduction of certain new crops and trees, namely, cassava, cashew nut, corn, cucumber, avocado, and guava and the use of dung for cultivation. To some extent they contributed to improvements in the rig of vessels and useful household articles, wine, playing cards and snuff-taking (Freeman-Grenville,1963).

The Portuguese were expelled from the Kenyan coast in 1729, by the Omani Arabs, and in 1837, following the piecemeal arrest of the Mazrui Family, Sayyid Said became the undisputed head of the East African coastline. In 1840, Said removed permanently to Zanzibar which thus became for all practical purposes the capital of the Omani realm (Freeman-Grenville,1963). Thus in 1840, with the setting up of his court in Zanzibar and due to his diplomatic ties with France, Britain and United States, the East African coastline was brought into permanent formal contact with Europe and the United States. A consul from the United States in 1836 and Atkins Hameston a British Consul (in 1840) were accepted in Zanzibar by Sayyid Said mainly to confirm support to the Moresby Treaty of 1822 which dealt essentially with abolishing of slave trade throughout Sayyid Said's dominion (Freeman-Grenville,1963). This treaty also included for the confirmation of existing trading conditions within the Omani realm in East Africa. Until the late eighteenth and early nineteenth century then, the immigrants remained trading communities content to let the trade of the interior to flow to them. It wasn't until about 1780 that the first travellers went inland (Freeman-Grenville,1963).

Sayyid Said, can be said to have exercised real and effective power only along the coast of East Africa and parts of South-Eastern Arabia. Although his influence in the interior was stable and continuous along some of the main caravan routes, he ruled essentially a sea-oriented empire. However during the first half of the nineteenth century, Arab caravans traveling from the coast to several hundred miles into the Kenyan interior were increasingly common. Generally quite profitable, they constituted the back-bone of the rich and complex Arab empire.

6. Kenya and Technological Development

Increased specialisation of his central nervous system liberated the stone-age man from automation of his instinctical reflexes and patterns and confinement to his immediate environment enabling him to become a master of self-direction (Mumford,1967). The assumption of the erect posture by the 'hominids' liberated his hands from a variety of tasks. Although it is generally accepted that early hominids existed by scavenging, the Australopithicines, have been linked with the use of tools particularly bones and horns. The discovery by Leakey (Leakey,1959) of the 'Nutcracker man' in East Africa suggests that they could have been pebble 'tool-makers' as well.

The first, stone tool industries known to man are the Oldowan and Kafuan cultures of East Africa. The chellus-Acheul hand axe culture evolving from the stone tool culture also probably started in the Oldowan in East Africa before spreading to the peripheral areas of Asia and Europe (Gregon,1969).

It is also in this historical period that man appears to have developed techniques and skills in group hunting (Clark,1959). As a result, man was able to exploit a greater variety of stone as a resource, leading to improvement in his ability to exploit a greater variety of environments. Naturally, this led to an improvement in his tool-making abilities which evolved into environmental specialisation, so that man expanded into new areas developing distinct tool traditions such as Fauresmith and Sangoan (Gregon,1969). Thus began the art of developing specialised tools for problems of particular environments and the greater exploitation of his environment making it possible for man to develop semi-permanent settlements in caves and rock shelters (Alpers & Ehret,1975). Deeper penetration of forests led to development of wood-making tools, which occurred towards the end of the Sangoan culture (Clark,1962). Fire-working, known in the chellus-Acheul period became a device generally available and used for hunting of animals, tree-felling and protection of campsites (Howell & Bourliere,1963).

This sequential development of specialised tools adapted to particular environments continued (Cole,1964). With the evolution of microliths, composite tools appeared as did techniques of hafting followed by the bow and arrow in the Kenyan Capsian culture. The lunate translated itself into a bone harpoon, enabling the Kenyan capsians to settle besides lakes of Rift valley and evolve a sedentary way of life (Oliver & Fage,1962). This permanent position by water sources led to man having some control

over animals watering there establishing the 'preconditions' as it were, for domestication (Grottanelli,1955). At the end of this period, there were sedentary communities of hunters and collectors, based on some stable food source, primarily by lakes, water courses, sea coasts and pheripheral regions of Equitorial forests in most areas of sub-Saharan Africa (Clark,1962).

An extra-ordinary pattern of self development thus emerges in the stone-age of Kenya (seen more a part of East Africa as a whole than on its own), beginning with the exploitation of stone resources to make simple tools. The development of simple tools led to an expanded range of foods enabling the 'early man' to leave the forest to live on the periphery of the woodlands, and near water sources or penetrate even deeper into forests. As new techniques were evolved, they were quickly absorbed to make better tools and diffused rapidly. Deeper penetration into forests led to developments of woodworking tools. The first steps that man took beyond animalhood were probably due in part to his reaction to fire, with its threefold implication of light, power and heat.

If survival had been all that mattered to the 'early man', he needed no better equipment than his early hominid ancestor, but some inner need propelled him onto his 'tool-making' and 'tool using' career so that self improvement occupied his time in addition to scrambling for food. That this inner striving, this motivating force which compelled the primitive man to enter the doors opened by each new device should have started, to the best of our present knowledge, here in East Africa is truly remarkable, especially so, since it was a truly self-managed and self-sufficient industry.

Kenya remained pastoral, with sedentary communities of hunters and collectors until it was occupied by the Hamites, Nilo-Hamites, Nilotes and the 'Bantu' peoples. All these peoples were pastoral, with varying degrees of agriculture forming a part of their culture. The 'Hamites' had a well developed form of agriculture including the use of plough, while the 'Bantu' were a technologically advanced people who worked iron and used the hoe. The plough was the first application of non-human power to agriculture but was as seen from history, a technology that was diffused into Kenya and not an indigenous development.

Migrants into or within Kenya's interior have usually been absorbed at least linguistically by the pre-existing people in the areas where these migrants settled. A notable exception were the Masai, whose relations were their neighbours on the west in the seventeenth and eighteenth century seen to have been generally warlike, and to the

east have a dual aspect of inter-marriage between the Masai and the Kikuyu at the same time as Masai were raiding goods of the Kikuyus (Alpers & Ehret,1975). The later dual aspect could persist because of the mutual value placed on the trade between the two peoples. The Masai traded hides which they had in abundance because of their cattle, and which the Kikuyu needed for iron goods, tobacco and ochre. It can thus be concluded that, diffusion of technology by overland routes within Africa had already started taking place in the Kenyan interior by the start of the nineteenth century.

Migrants from outside Africa, only seem to have invaded the Kenyan coast, and seem to have concentrated only on trade. Hence although new types and varieties of materials were made available to the coastal peoples and to a small extent the interior, these were consumer products. Technologically this invasion contributed very little to the development of Kenyan people especially in the interior.

Agriculture then was the most fundamental of all concerns in Kenya in mid-nineteenth century, and the people were all pastoralists practising agriculture to some extent. Unlike the stone-age, the emerging technological development trends, show an almost total dependence on migrants and their technologies as they absorbed the indigenous stone-age peoples of Kenya while the self-development, management and sufficiency characterising the stone-age peoples were being eroded as trading facilities increased. The most astounding feature about this period is the absence of the ability of these people to improve the devices brought in by migrants to produce improved devices due no doubt to the population movements which occurred in Kenya on a scale, never known before this time.

It is possible that if the invasions by other peoples had not occurred, the developmental patterns set in the stone age might have continued and positive dynamical development of the Kenyan people would have occurred. Instead it can be concluded that diffusion of technology and opening up of trade routes to the rest of the world began the process of dependency on other peoples.

Any prosperity resulting from trade with the coast remained in the hands of traders who were forever looking homewards, while in the interior, the migrants were diffusing technologies into the land where tool using and making had been the predominant characteristic before their advent.

APPENDIX C

COMPARATIVE DEVELOPMENT IN BRITAIN AND KENYA - 1850 ONWARD

APPENDIX C

COMPARATIVE DEVELOPMENT IN BRITAIN AND KENYA -1850 ONWARD

1 Introduction

By the middle of the nineteenth century then, Britain had become the first industrialised nation of the world and Kenyan coast had just been brought into formal contact with Europe and the United States, having already gone through the Portuguese and Arab invasion.

In the interior of East Africa, four basic industries supplemented direct agricultural production among many tribes. Iron work was fairly well developed in several tribes. Special clans of these tribes divided their male members into smelters and forgers, producing spears, knives, swords, hoes, wire, jewellery, arrowheads, chains,tongs etc. African women were producers of pottery (mainly for trade), basket-making and tanning of skins for clothing (Wolff,1974).

Britain on the other hand had a thriving industrial economy based on cotton, iron and steel, construction and communication industries, with new markets opening up in the colonies for raw materials. On the whole, it was the " trading " activity in this period that made the greatest impact on both economies.

2 The impact of trade on East African development (1820-1870)

For the thirty years after the establishment of their consulate in Zanzibar, the British authorities remained content to rely on free trade and competition to maintain their merchant's interests in the East African trade despite frustration over American, German and Indian stronghold in cotton cloth importation in the area. However, flow of information from explorers and missionaries in the region and the opening of the Suez Canal began to provide images of East Africa to the Europeans that prompted a more active interest in the area.

The commercial interests of the Europeans increased rapidly and the simultaneous activity there by Belguim, France, Germany invoked a response from the British, so that the period from 1873 to 1887 defined a sharp transition in Britains official and

private behaviour towards East Africa and a progressively more active intervention replaced the earlier relatively freer trade and political relations (Ingham,).

In Britain itself, the partnership system, unable to cope with the large capital investment required for the high cost industries of steel, ship-building, chemicals, brewing etc, began to give way to larger limited liability companies though slowly. Hence by 1885 only less than 10 per cent of all companies were limited liability (Lawrence & Lee,1984).

The cotton industry continued to expand although it lost it's pre-eminence as more foundries began to be established since the world was dependent on Britain for supplies of finished iron for transport equipment. From about 1820 to 1870, the development of the railways integrated national markets and stimulated demand for iron and steel. More powerful ships could be built with steam power and steel. Freight costs dropped enabling remote areas to produce goods for distant markets. Hence between 1820 and 1870, Britain and other European countries as well as U.S.A began to adopt more liberal trade policies. World output and international trade thus expanded enormously and in 1870, the United Kingdom accounted for 32 per cent of the world's industrial production (World Bank,1987).

The opening of the Suez Canal in 1869 drew East Africa inevitably into the network of world trade. In response to increasing European interests in East Africa, the British deepened their involvement in East Africa, after 1869 (Wolff,1974). In 1873, Britain decided to stop the East African slave trade, which " had fostered among some Africans a kind of economic regression from higher levels of development to more punitive self-sufficient economies " (Wolff,1974), while for others it became an economic necessity (Davidson,1965). The consequence of the British anti-slave trade campaign contributed to the establishment of British Legonomy and further reorganisation of the Kenyan population.

British political Legonomy began formally with the declaration of the East African protectorate in 1895. Slave-trading and the anti-slave trade campaigns caused immense damage to the East African people by disrupting the economic structure and activities of the African society and leading to a disarrayed population, agricultural production and trading in a depressed and dismal state (Davidson,1965).

3. Further Advances upto 1950 (Kenya)

When the British first established the protectorate in East Africa they inherited an area which was seen as dismal and hopeless in most parts. Uganda was the only region which showed any signs of prosperity and that also only in the agricultural sector which was well organised in the Buganda state. The first task thus became one of establishing a profitable economic unit in East Africa.

It was this prosperity in Uganda that decided the guiding theme of British policy in the East African protectorate, hence the vision of trade between Uganda and Europe led to the economic rationale of building the railroad between the coast and Uganda. The railroad ,as a purely British owned , financed and run enterprise actively shifted the locus of economic power for the first time from Arabs to Europeans. Thus it was that the existence, growth and direction of economic development came to depend almost entirely on the British (Davidson,1965). Having committed their capital to the Uganda railway, the protectorate's administration was under great pressure to offset the costs of the railway."After many trials and errors, British officials in the East African protectorate evidently came to conclude that there were only two alternatives available in the depressed economic conditions facing them in the Kenyan colony, either to revert to an earlier primitive form of tribal, more or less subsistence economy or to implant non-African settlers in order to organise, invest in and manage agricultural production of cash crops " (Wolff,1974). They chose the second alternative. Hence the British organised entirely new land tenure and use system in East Africa after 1900. "In this process, they dealt simultaneously with the question of who would use the land and how it was to be used " (Wolff,1974). Thus the task of perhaps the highest priority in the colonial administration was the management of agricultural development (agricultural as opposed to industrial that is).

Thus it was, that Britains economic development policy for Kenya from 1890's to 1930, involved a bold reorganisation of land, labour and capital resources. The major transfer of technology involved the construction of the Uganda railway and the main source of income was agriculture. Landowners envisioned grand gains while trade expanded. Official commitment to European settler plantation was the chief cause of further disintegration of the African economy which of course had already been shaken by the impact and abolition of the slave trade (Wolff,1974). But in spite of all these changes, " As of 1930, Europeans cultivated less than 10 % of the white highlands allocated exclusively to them ". It has been concluded by two recent studies that upto

the late 1920's European agriculture was an inefficient and in strict accounting terms even privately an unprofitable use of resources (Wrigley,1902-1945).

It has been argued by Fearn (Fearn,1961) that the traditional land tenure and cultivation methods of the Africans kept them in the low productivity trap, a situation which was made worse by the confinement of Africans to reserve areas. He further argues that the transfer of European technology to the very much smaller African plots was precluded by shear size of the European settlements.

Roads, railroads and other infrastructure were funded by grants-in-aid from the colonial government. Protection was provided against importation by tariffs and differential rail rates. To induce development of processing facilities, investors were given monopoly positions. Technical schools and railway workshops were set up to train African labourers in basic industrial skills. However a domestic market consisting of settlers and wage earners in Kenya was insufficient as a base for most types of industry, even after monopoly rights were given (Westcott,1981).

4. Developments in Britain from 1820 to 1870

Following the great innovations and progress in cotton textiles during the 1700's, the period between 1820 and 1870 saw industrialisation centred on steel railways and steamships. Railways integrated national markets and increased demands for iron and steel. Adopting trade liberalisation policies, Britain, the leader in industrial technology, which had prohibited exports of machinery as well as emigration of skilled workers, removed these legal barriers in 1842 (export of machinery) and 1825 (emigration of skilled workers) respectively. Consequently it also abolished the Navigation acts so that when restrictions on grain imports were repealed in 1846, Britain had moved to free trade by 1850. This led to a boost in international trade helped of course by the transport revolutions wrought by railways and steamships, and in 1870, the United Kingdom accounted for 32 per cent of the world's industrial production.

5. Britain (1870-1913)

During this period, major advances occurred in science and technology, including innovations in electricity, refrigeration, organic chemicals, internal combustion engine and the transatlantic telegraph and radio. The technological advances became more dependent on scientific research that was systematically organised in firms and universities for commercial application. Increasingly raw materials needed for new

technologies and ingredients for new alloys had to be found outside the U.K and so many countries found themselves ushered into global industrialisation as suppliers of raw materials (World Bank,1987).

APPENDIX D

DEVELOPMENT OF EVALUATION CRITERIA TABLES

TABLE 1: ISSUES INVOLVED IN TECHNOLOGICAL CONSIDERATION

SYSTEM (i = 1)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
1. TECHNOLOGICAL	1. PLANT	1. Existing Types	1. Locally made	1. Operation 2. Efficiency 3. Cost	
			2. Imported	1. Operation 2. Efficiency 3. Cost	
			3. Spare parts	1. Availability	
		2. New or advanced types	1. Locally made	1. Operation 2. Efficiency 3. Cost	
			2. Imported	1. Operation 2. Efficiency 3. Cost	
			3. Spare parts		
	2. MATERIALS	1. Locally manufactured	1. Quality 2. Availability 3. Distribution 4. Cost		
		2. Imported	1. Quality 2. Availability 3. Distribution 4. Cost	1. Goods 2. Freight 3. Insurance	
	3. SERVICES	1. Existing	1. Infrastructure	1. Transport & Communication	1. Cost 2. Sufficiency
				2. Water	1. Cost 2. Sufficiency
				3. Sanitation	1. Cost 2. Sufficiency
				4. Energy Supply	1. Cost 2. Sufficiency
		2. New	1. Infrastructure	1. Transport & Communication	1. Cost
				2. Water	1. Cost
				3. Sanitation	1. Cost
				4. Energy Supply	1. Cost

TABLE 2 : ECONOMIC SYSTEM CONSIDERATIONS

SYSTEM (i = 2)	LEVEL 1	LEVEL 2	LEVEL 3
1. ECONOMICAL	1. Targets	1. Quality 2. Time 3. Budget 4. Location 5. Constraints	
	2. Identification	1. Costs	1. Direct 2. Indirect 3. *Spillovers (externalities)*
		1. Benefits	1. Direct 2. Indirect 3. Spillovers
	3. Measurement	1. Quantifiable	1. Monetary analysis 2. Labour value analysis 3. Energy units analysis
		2. Non-quantifiable	1. Quality analysis 2. Willingness to pay 3. Compensation
	4. Evaluation	1. Magnitude	
		2. Place of occurrence	1. Foreign exchange 2. Local exchange
		3. Time of occurrence	1. Discounting
	5. Choice	1. Decision criteria	1. Net present value 2. Annual equivalent 3. Internal rate of return 4. Payback period 5. Benefit : Cost ratio 6. Composite economic and factor profiles.

TABLE 3 : ECONOMIC SYSTEM INDICATORS

SYSTEM (i = 3)	LEVEL 1	LEVEL 2	LEVEL 3
1. CULTURE	1. Belief systems	1. Religion profile 2. Traditions 3. Taboos	
	2. Biases (9)	1. Ineffectual 2. Hierarchist 3. Entrepreneur 4. Sectist 5. Hermit	(Inconsistent electiasm/fatalism) (Ritualism and sacrifice) (Pragmatic materialism) (undamentalism/millcniarism) (Nature and mysticism)
	3. Life styles	1. Education 2. Material - Shelter - Food - Clothing 3. Recreation	
	4. Consumption	1. Local resources 2. Local products 3. Imported goods	

TABLE 4 : SOCIAL SYSTEM INDICATORS

SYSTEM (i = 4)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
1. SOCIETY	1. Population definition	1. Composition	1. Language 2. Ethnicity 3. Age 4. Sex 5. Education	1. Types of schools 2. Years of education
	2. Family structure	1. Parent presence 2. Sibling structure		
	3. Mobility indicators	1. Birth place 2. Length of residence 3. Region of residence	1. Migration levels	
	4. Economic structure	1. Occupational profile	1. Training 2. Age 3. Income	
	5. Poverty	1. Poverty line 2. Income structure	1. Percentage below	

TABLE 5: ENVIRONMENTAL SYSTEM INDICATORS

SYSTEM (i = 5)	LEVEL 1	LEVEL 2	LEVEL 3
1. ENVIRONMENT	1. Quality	1. Pollution limits	1. Land 2. Air 3. Water
		2. Depletion limits	1. Forests 2. Natural resources 3. Other life support systems

TABLE 6: INSTITUTIONAL CONSIDERATIONS

SYSTEM (i = 6)	LEVEL 1	LEVEL 2	LEVEL 3
1. INSTITUTIONS	1. Legal	1. Basis of liability	1. Trespass 2. Negligence 3. Dangerous activity 4. Nuisance 5. Arbitrations
		2. Issues	1. Funds 2. Authorities involved 3. Regulation 4. Liabilities
		3. Legislation & Rules	1. Specific directives 2. Market Modifications 3. Authority constraints & grants
	2. Organisations	1. Formal	1. Statutory 2. Public 3. Private
		2. Informal	1. Parties
		3. Operation	1. Mode
		4. Funding	
		5. Interfaces with other organisations	
		6. Effectiveness	
		7. New	

TABLE 7: POLICY CONSIDERATIONS

SYSTEM (i = 7)	LEVEL 1	LEVEL 2
1. POLICY	1. Perspective or Model	1. Rational (Efficient goal achievement) 2. Institutional (How organisations work) 3. Equilibrium (Power balances) 4. Elite (Preferences of the elite only) 5. Incremental (Muddling through, bureaucracy) 6. Systems (Complementary to incremantal model)
	2. Content	1. Physical 2. Social
	3. Locus	1. Public Private
	4. Sensitivities	1. Political 2. Cultural 3. Social 4. Institutional 5. Environmental
	5. Time	1. Past 2. Short-term future 3. Long-term future
	6. Focus	1. Processes 2. Outputs 3. Implementation processes 4. Consequences
	7. Analytical stance	1. Explanatory 2. Neutral, action oriented 3. Advocacy, action oriented
	8. Information	1. Informal/Specific 2. Qualitative/Quantitative
	9. Investment	1. Market failure 2. Suboptimality

TABLE 8 HUMAN CONDITION CONSIDERATIONS

SYSTEM (j = 1)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
1. HUMAN CONDITION	1. POVERTY	1. Shelter	1. Availability 2. Qality 3. Cost		
		2. Infrastructure	1. Water supply	1. Quality 2. Cost	
			2. Sanitation & Waste disposal	1. Quality 2. Cost	
			3. Health	1. Life expectancy 2. Infant mortality 3. Population growth rate 4. Cost of services	
			4. Education	1. Literacy level 2. Availability 3. Cost	
	2. NUTRITION	1. Food	1. Consumption 2. Productivity	1. Cost	
			3. Distribution	1. Transportation	1. Cost
			4. Storage	1. Availability	1. Cost
		2. Quality	1. Deficiency	1. Calorie count	
	3. EMPLOY-MENT	1. Labour	1. Skilled	1. Education 2. Training 3. Wages	
			2. Unskilled	1. Wages	
			3. Unemploy-ment levels	1. Benefits	
		2. Other	4. Recreational facilities		
	4. INCOME DISTRIBUTION	1. Minimum wage	1. Suffuciency 2. Percentage in this bracket		
		2. Average wage	1. Percentage in this bracket		
		3. Maximum wage	1. Percentage in this bracket		

TABLE 9: NORTH/SOUTH DISPARITY INDICATORS

SYSTEM (J = 2)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
1. NEW INTERNATIONAL ECONOMIC ORDER	1. Investment (magnitude)	1. Local 2. Foreign	1. Private 2. Public	1. Transnational 2. Governments
	2. Trade	1. Government restrictions	1. Import lincences 2. Work permits 3. Embargoes	
		2. Institutions	1. Efficiency 2. Availability	
	3. Money transfers & Cost	1. Exchange rates 2. Inflation rates 3. S.D.R.		
	4. Resource transfer & Pricing	1. Depletion implications	1. Conservation	
		2. Importation	1. Foreign exchange	
		3. Export 4. Scarcity		
		5. Alternative resources	1. Optimisation	
		1. Renewability		
		2. Fuels	1. Natural 2. Renewable	
	5. Food	1. Population	1. Control	
		2. Infrastructure	1. Storage 2. Distribution 3. Imigration	
		3. Agricultural promotion	1. Location	
	6. Labour	1. Exploitation 2. Training 3. Regulation	1. Income distribution	
	7. Justice	1. Balance of power	1. Individuals 2. Nations 3. Regions	
	8. Technology (4) transfer	1. Existing technology	1. Local 2. Other	
		2. New technology		
		3. Development		

TABLE 10: ECONOMIC PROBLEMS INDICATORS

SYSTEM (J = 3)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
1. ECONOMIC PROBLEMS	1. Debt crisis	1. Foreign exchange considerations	1. Trade	
			2. Productivity	
			3. Terms of borrowing and lending	
			4. Transfer mechanisms	
	2. Monetary	1. Risk		
		2. Uncertainty		
	3. Resource considerations	1. Local	1. Efficiency of exploitation	
			2. Availability	
		2. Regional	1. Preferential trade	1. Quality implications
				2. Monetary implications
		3. International		

TABLE 11 ENVIRONMENTAL CONSIDERATIONS

SYSTEM (J = 4)	LEVEL 1	LEVEL 1	LEVEL 3	LEVEL 4	LEVEL 5
1. ENVIRONMENTAL CONSIDERATIONS	1. Disruptions & Degradations	1. Economical 2. Life forms	1. Animals 2. Birds 3. Marine life 4. Field crops 5. Natural vegetations 6. Aquatic plants	1. Threatened 2. Number 3. Habitat caharcteristics	
		3. Abrotic disruption	1. Soil pollution	1. Soil analysis	
			2. Water pollution	1. Ground 2. Surface	1. Quality
			3. Geochemical cycles	1. Quality	
			4. Climate	1. Micro 2. Macro	
		4. Biotic disruption	1. Food webs 2. Carrying capacity		
		5. Degradation	1. Pollution	1. Quality	
			2. Noise	1. Duration 2. Frequency 3. Loudness	
		6. Hazards	1. Nuclear waste		
			2. Toxic wastes & Radioactive wastes		
			3. Solid waste accumulation		
	2. Depletions	1. Soil	1. Erosion 2. Desertification 3. Defforestation		
	3. Acid pollution	1. Sulphur dioxide 2. Nitrogen oxide 3. Hydrocarbons 4. Ozone	1. Techonolgy to combat (fluidised bed combustion technology etc.)		
	4. Carbon - dioxide				

TABLE 12: GLOBAL INSECURITY DIMENSIONS

SYSTEM (j = 5)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
1. GLOBAL INSECURITY	1. Interstate implications	1. Trade implications	1. Debt issues 2. Economic issues 3. Transfer issues	1. Stock exchange 1. Resources 2. Manufactured goods Technologies
			4. Proctective practice	1. Tarrifs and Barriers
		2. Environmental protection	1. Interstate pollution & Degradation	
		3. Human rights		
		4. Law	1. International	
	2. Sovereign issues	1. Self sufficiency		
		2. Resource exploitation		
		3. Income distribution		
		4. Defence	1. Budget 2. Quality	
		5. Legality issues		
	3. Harzards	1. Nuclear	1. Explosion 2. Failure 3. Wastes	
	4. Interdependence	1. Energy	1. Development of indigenous sources	

TABLE 13: POPULATION CONSIDERATION

SYSTEM (j = 6)	LEVEL 1	LEVEL 2
1. POPULATION	1. Static (at known or existing point in time)	1. Birth rate 2. Mortality rate 3. Migration rate 4. Natural growth rate 5. Population structure 6. Categorisation
	2. Dynamic (trends)	1. Forecasted rates.
	3. Labour and Manpower issues	

TABLE 14: RESOURCE UTILITY AND LIMITS INDICATORS

SYSTEM (i = 7)	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
1. RESOURCES	1. Food resources	1. Land (agricultural)	1. Water availability	
			2. Yields (intensification)	
			3. Biosites	
		2. Land (Animal)	1. Yields	
		3. Marine resources	1. Water quality	
			2. Yield	
			3. Mineral extraction	
		4. Distribution	1. Self-sufficiency	
			2. Aid	
	2. Energy	1. Power	1. Consumption	1. Policy
			2. Source (Primary)	1. Coal
				2. Natural gas
				3. Crude petroleum
				4. Nuclear
			(Secondary)	1. Solar
				2. Hydro-electric
				3. Geothermal
				4. Tidal Power
				5. Coke &
				6. Manufactured gas
			3. Other (Natural)	Manpower
				Draught animals
				Firewood, domestic waste, straw, dung, etc.
			4. Synthetic	1. Benzol
				2. Alcohol
			5. Fissionable	1. Uranium
				2. Thorium
				3. Plutonium
	3. Minerals	1. Metallic	1. Abundant	Aluminium, Iron Manganeese, Magnesium, Titanium.
			2. Scarce	Copper, Chromium,Gold, Lead, Tin,Mercury, PlatiniumZinc, Molybedium,Silver, Uranium,Tungsten.
		2. Non Metallic	1. Fossil fuels	Coal, Gas, Oil, Petroleum
			2. Water	Ground, Lake, River
			3. Building materials	Cement, Gravel,Gypsum, Sand, Asbestos
			4. Chemical, Fertilisers, etc.	Nitrates, Phostphates, Sodium chloride, Sulphur, etc.

APPENDIX E

TYPICAL LEVEL 2 ANALYSIS

FIGURE 8.5 SUB-MATRIX 1.1

HUMAN CONDITION / TECHNOLOGY (I = 1, J = 1)		PLANT		MATERIALS		SERVICES	
		EXISTING TYPES	NEW TYPES	LOCAL	IMPORTED	EXISTING	NEW
POVERTY	SHELTER	COST OF ENERGY, WATER AND WASTE DISPOSAL ASSOCIATED WITH PLANT		MATERIAL STORAGE COSTS		NONE	
	INFRASTRUCTURE	PLANT STORAGE COSTS		COSTS RELATED TO USE OF POWER, TRANSPORT, WATER AND WASTE DISPOSAL		COSTS RELATED TO USE OF POWER, TRANSPORT, WATER AND WASTE DISPOSAL	
NUITRITION	FOOD	COST OF INCREASED POVERTY RESULTING FROM INVESTMENT IN PLANT.		IMPORT OF MATERIALS RESULTING IN INCREASED POVERTY.		INCREASED URBANISATION HENCE DECREASE IN AGRI.	
	QUALITY	FALL IN NUITRITIONAL STANDARDS DUE TO POVERTY		FALL IN NUITRITIONAL STANDARDS DUE TO POVERTY		REDUCED FOOD PRODUCTION RESULTING IN POORER NUITRITIONAL STDS	
EMPLOYMENT	LABOUR	COST/BENEFIT DUE TO DECREASE/INCREASE IN EMPLOYMENT		IMPORTATION OF MATERIALS RESULTING IN EMPLOYMENT BENEFITS OFF-SHORE AND COSTS LOCALLY		COST/BENEFIT DUE TO DECREASE/INCREASE IN EMPLOYMENT	
	OTHER	NONE					
INCOME DISTRIBUTION	MIN WAGE	GENERATION OF EMPLOYMENT IN MIN INCOME WAGE EARNERS		INSUFFICIENT DATA		INSUFFICIENT DATA	
	AVER. WAGE						
	MAX WAGE	EXPERTISE IN THIS GROUP IMPORTED.					

NOTE:-

COST -NOT QUANTIFIED

BENEFIT - NOT QUANTIFIED

QUALIFICATION INSUFFICIENT DATA

NO DATA AVAILABLE FOR THESE CELLS