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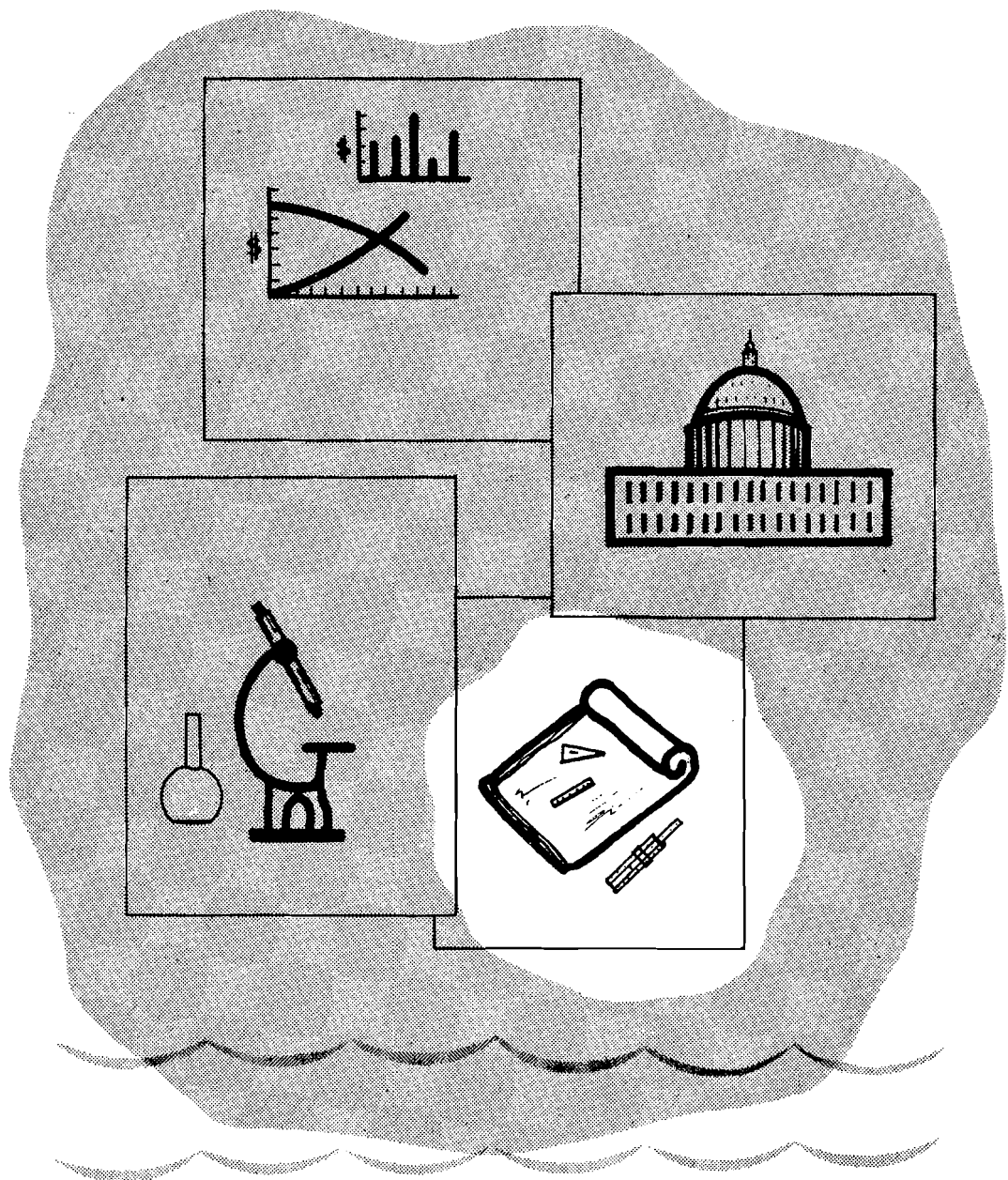


Logan, Utah 84321

Proceedings of a Summer Institute in Water Resources

VOLUME IV - GENERAL PRINCIPLES OF WATER
RESOURCE PLANNING

CIVIL ENGINEERING DEPARTMENT SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION



99939

PROCEEDINGS
of a
National Science Foundation Supported
SUMMER INSTITUTE IN WATER RESOURCES

VOLUME IV
GENERAL PRINCIPLES OF
REGIONAL WATER RESOURCES PLANNING

Civil Engineering Department

Utah State University

April 1966

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Logan, Utah

FOREWORD

Recognizing the need for training of individuals to meet the rapidly rising problems connected with water resources development, Utah State University, with National Science Foundation support, organized a Summer Institute in Water Resources for college teachers. It was hoped that participants carefully selected from all regions of the country would receive additional insight and stimulation to improve and enlarge water resources training programs at their own institutions. Thus, the accelerated dissemination of such knowledge on a national scale could be facilitated.

Realizing further that the key to a successful institute of this nature lay in the excellence of its staff, efforts were made to obtain instructors with intimate knowledge and broad experience in the subject matter area they were asked to present. In nearly every case those selected willingly accepted the invitation to participate, although this meant considerable monetary sacrifice and major adjustment of busy schedules.

The subject matter treated paralleled regular offerings listed in the University catalog and is considered to be "central" or "core" to a water resources planning and management training program. One course treated the philosophical, historical, institutional, political, and legal aspects of water development. The responsibility for this course was shared jointly by Cleve H. Milligan, Charles E. Corker, and Wayne D. Criddle. The second course considered the principles of water resource economics and was presented by B. Delworth Gardner. The third course dealt with concepts of water quality management and was under the direction of P. H. McGauhey. The final course was on principles and procedures of regional resource planning and was presented jointly by Aaron Wiener, W. R. Derrick Sewell, and Harvey O. Banks.

Having assembled a distinguished and diversified staff to present some of the best current professional thinking in the topics suggested in the preceding paragraph, it was felt most appropriate to attempt to put their lectures into writing. A proceedings of the Institute would have considerable utility beyond the Institute itself. Hence, the instructors were encouraged to prepare written material for the proceedings and were given secretarial and other assistance to aid them. This material has been organized according to the four major courses and is issued in four companion volumes.

Clearly, this has been a prodigious effort which required Institute staff and others to "go the extra mile." Special thanks and recognition are due Mrs. Dorothy Riley who not only typed the entire proceedings but also attended to many details necessary for the successful operation of the Institute.

Jay M. Bagley served as director of the Institute and assumed a **general** coordinating and editing role in the development of these proceedings.

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PART I
THE DEVELOPMENT OF LAND AND WATER RESOURCES
IN EMERGENT ECONOMIES
CE 264

Presented at the
SUMMER INSTITUTE IN WATER RESOURCES
UTAH STATE UNIVERSITY

by
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Director General
TAHAL -- Water Planning for Israel, Ltd.
Tel Aviv, Israel

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PREFACE

These lectures deal with the development of land and water resources in emerging economies, its strategy and tactics. My interest in this subject has arisen from a lifetime's occupation in the planning of water supplies and irrigation works. The stand I will take on the subject is based on the experience gained in the development of these resources in a number of emergent countries, among them my own country, the State of Israel.

The term "strategy and tactics of development" requires definition. For the purpose of this discussion, strategy is defined as the science and the art of employing the political, economic, and psychological forces of the nation in the pursuit of an adopted development policy. Tactics is but the translation of these strategies into rules of operation.

The strategy and tactics presented in these essays are the fruits of actual experience rather than intellectual exercise. Their limitations -- and doubtless these exist -- are the limitations of the lecturer and his environment, stemming from a particular fund of personal and national professional experience.

Development in this context will be confined to the material aspects of the growth in services and production as a consequence of increased, more efficient use of land and water resources and to those socio-psychological and institutional aspects -- corollaries of material growth.

The terms "undeveloped," "emerging," or "developed" will be used here solely to describe the extent of economic maturity of a country. This form of expression is, in actual fact, an over-simplification, for no fully developed or completely underdeveloped country exists in reality. In many countries conditions of underdevelopment in certain regions and sectors co-exist with highly elevated forms of development; "developed" or "underdeveloped" are but theoretical extrapolations of a continuous scale of maturation, on which a number of intermediate

points may be observed. However, in an exposition of basic strategies and tactics, consideration of such distinctions would tend only to obscure main issues, and a black and white representation will therefore be adopted in order better to expose the main lines of our argument.

It should be self-evident from these introductory remarks that every specific set of conditions encountered in real life planning requires specific analysis and calls for a specific set of strategies and tactics. Generalizations, or the uncritical transfer of a planning approach from one case to another, may under the complex conditions of transition of emergent economies be extremely inexpedient.

I should like to conclude the preface to these essays with the customary note of the prudent novelist: any similarity between situations and persons in these essays and those of real life is purely coincidental.

CHAPTER I

DEVELOPMENT SEMANTICS

"A well-made language is no indifferent thing; in order not to go beyond physics, the unknown man who invented the word "heat" committed many generations to error. Heat has been treated as a substance simply because it was designated by a substantive, and has been considered to be indestructible."

H. Poincaré

"All human history shows that the correct structural formulation of a problem is usually as good as the solution of it, because sooner or later a solution always follows a formulation."

Alfred Korzybski

Introductory

The authenticity of analysis of a set of phenomena, and the appositeness of the strategies which we derive from such an analysis to serve as guides to action, will depend upon the fitness of our tool of analysis--language. Different sets of phenomena require different kinds of tools; one can hardly hope to obtain satisfactory results in the construction of a miniaturized computer if plumbers' tools are used for the job. The basic terminology which we use, the abstractions and constructs out of which it is construed, stem from a specific--though often unconscious--representational point of view and imply a specific model. If this model is dissimilar to the structure of the set of phenomena analyzed, language will--unbeknown to us--introduce a distorting bias which will hinder us from asking the right questions, and obtaining the correct answers.

It is for this reason that I have thought it fit to preface the re-evaluation of doctrines of resources development and management by an analysis of the semantic tools now being used in the formulation of

these doctrines, and to review their structural adequacy for the prediction of growth phenomena in emerging economies.

Our analysis will show that orthodox ideology is not adequate to analyze development phenomena in emerging economies and an attempt will therefore be made to specify the requirements of a language that will be structurally adequate. Our analysis of orthodox semantic tools will show three main structural weaknesses:

1. Naive use and objectivation of abstractions and of heuristic fictional constructs.
2. The use of overspecialized single-discipline language.
3. The use of statically oriented linear terminology to describe and analyze dynamic non-linear phenomena.

Our thesis will be that the application of this structurally inadequate semantics to growth phenomena of emerging economies tends to falsify our results and considerably warps our responses. It will be proposed to replace the inadequate terminology by a new dynamic multi-discipline language termed "process language"* combined with the adoption of the unavoidable semantic crutches that we cannot do without, keeping constantly in mind the boundaries within which they are adequate and the extent of falsification implied in their use.

Abstraction and Constructs

Abstraction is the Alpha and Omega, the essence and driving force of language. Abstraction and metaphor are present in the most primitive forms of language; abstractions are the very basis of modern mathematical methodology. The principle of abstraction is even older than language and

* Note: The term "process language" was coined by the American philosopher Launcelot Law Whyte in "The Next Development Man," Mentor, New American Library, 1962. A. Korzybski in "Science and Sanity," The International Non-Aristotelian Library Publishing Co., 4th ed., 1958, has written in similar terms.

underlies the adaptive behaviour of every organism to its environment. An organism subjected to the protean stream of the stimuli spawned by its environment, molds them by its receptory faculties, and ordains the infinite variety of the stream of sense impressions into simplified patterns, "Gestalten," which, imbued with biological significance, underly its adaptive reaction patterns. These are the bottom rungs of the ladder of abstraction. At this level of abstraction, phenomena, though realized and acted upon, are still uncommunicable. With the growth of the nervous system, and the increase in the complexity of its structure, additional rungs are added to the ladder of abstraction: with each rung, simplification becomes more sweeping, identification of similar phenomena more comprehensive, abstractions more general, and classification more universal; on reaching the few top rungs--the point of origin has meanwhile been lost to sight and we come upon a new device--the use of symbols, the use of language.

The invention of symbols characterizes, more than anything else, the genesis of man. Having once attached names or symbols to signify the classes into which we have constricted our world of phenomena, we are free to ply these symbols even in the absence of the originals. We can recall the past, plan for the future, and, further, we can exchange experience with our fellowmen, since these symbols are a social product, shared by other members of the social group. We can thus mobilize the intelligence of the whole group to bear upon a problem; furthermore, we can, by oral and later by written transmission, reach beyond the lifetime of an individual or group and become "time-binders," according to the term coined by the general semanticists.

The development of abstraction has, of course, not been terminated with the emergence of the first symbols, the words of our language; the tendency to classify, generalize, and unify has continued down to the present; additional rungs of abstraction are added continuously to the

ladder, until we reach the mathematical abstractions of modern science, the latest but not the last or highest rung on the ladder.

As language and the semantic disciplines develop, level upon level of abstractions are constructed and recombined into more general abstractions. With time, these abstractions become further and further removed from their original point of departure--our sense impressions of the environment. Some of these high level abstractions are fictional constructs and simplifications, intentionally devised for heuristic purposes within a certain context. The German philosopher Vaihinger has compiled an impressive list of such fictions in his "Philosophy of the 'As If'." As generations of scientists follow one after the other, the fictitious nature of these abstractions is forgotten, the context for which they were devised sinks into oblivion, and general validity is claimed for them. Finally, by a curious but almost universal twist, these fictions are projected back into reality and we begin to believe that they constitute part of our tangible world.

We do not have to look far for living examples of such fictions. Is not "economic man" and the psychology underlying his behaviour such a fiction, conceived within the socio-economic context of Europe, near the point of "take-off"? Indeed, it is doubtful if "economic man" was an acceptable simplification at any place and time, but it is certain that his behaviour bears almost no similarity with that of the traditional farmer in a subsistence agricultural economy. Are not some of the difficulties in development thinking, as applied to emerging economies, due to the blind adoption of the same fiction for a completely dissimilar context?

The transfer of metaphors, drawn from one area of human endeavour and used to illustrate processes encountered in an entirely different area, are similar linguistic pitfalls. Originally, the metaphor is casually introduced to illustrate a point of reasoning; gradually, as it is re-used, repeated, and developed, the metaphor acquires a reality of its own; its origin fades away, and it is unconsciously used in the construction of a model of the phenomenon to be analyzed. The process here encountered is a special

case of the universal process of reification and objectification of words and metaphors, and their projection back into the world of phenomena. The adoption of aeronautic language in the Rostow theory of growth and its uncritical application to development thinking is a current example of such transplantation and objectification of metaphor.

Another example of the danger of transferring metaphors and abstractions from one discipline to another, and of the distortive influence on our analysis of the inappropriate application of structurally inadequate language, is the application of mechanistic terminology to complex development phenomena. Labelled by such terminology, the economy is seen as a machine with a specific "name shield capacity" which requires specific "inputs" to produce specific "outputs." The inputs are seen as controllable variables, independent of each other and of the machine. Outputs are, as it were, algebraic products of inputs and machine capacity. The economic process is considered to be linear and mechanistically determined.

This representation will often prove to constitute an acceptable simplification of the economic process in mature economics, where the human and structural dimensions do not have to be programmed, since we can assume that they will adapt themselves spontaneously to the changes brought about by capital investment. In such a context, a programme can be confined to planning the development of material inputs and outputs.

In emergent economies, in which the human and structural dimensions will be the critical ones, such a model, and the language by which it is expressed, would be inadequate and result in a completely distorted analysis. Here, the critical input streams (human and structural factors) will have to be created and fostered by the priming of the production process proper; they will change, both in strength and direction, by feedback from production and output. The same material inputs applied at different phases of development will result in radically different

outputs. The process is non-linear and the mechanistic model breaks down.

However, mechanistic linear language is all too often transferred to such non-linear problems, and a completely distorted and warped representation obtained which is certain to end up with erroneous strategies and tactics.

Specialized Language

The second principal structural weakness of orthodox semantics is connected with the use of specialized single-discipline language to describe complex phenomena that can be adequately analysed only by the use of a multi-discipline language. This inadequacy is a direct outcome of the development of science and scientific language in the last few centuries.

As we reach modern times we find that individual sciences and disciplines have branched off from the diffuse, amorphous, and unspecialized body of ancient science and lore, and that specialized abstractions and languages have developed according to their distinctive requirements.

As sciences have branched out and have become even more specialized, so the gulf between specialized languages has deepened and they have become less and less compatible with each other. It thus came about that the one, unique world of phenomena evoked numerous interpretations expressed in incompatible languages; this was acceptable as long as these phenomena were simple and specific--one had only to remember which discipline to apply and then to use the corresponding medium. But, when a complex phenomenon such as man was being scrutinized, a confusing number of contradictory interpretations were obtained, no one truer than the other, and each having a certain similarity to the phenomenon under investigation, as well as to the other interpretations: each interpretation resembled a caricature seen from a special vantage point.

The available specialized languages, while adequate to represent

and interpret specific aspects of a complex event as seen from specific vantage points, cannot call into being a unitary, consummate representation of such a complex event as a whole. The usually linear structure of specialized language, though similar to the micro-structure of partial aspects of the event, are still incompatible with its non-linear overall macro-structure, and cannot therefore result in adequate overall representation of the whole event; a super-imposition of caricatures will not yield a true portrait.

The analysis of phenomena connected with resources development in emerging economies involves numerous disciplines; engineering, economics, political science, psychology, sociology, the science of organization and institution, etc. Since phenomena are non-linear and therefore non-additive, a compilation of single discipline interpretation will result in a falsified analysis of the status quo and in wrong prediction of the future behaviour of the system. Adequate interpretation can be achieved only by the creation and adoption of a multi-discipline language, that tries to fashion its structure according to the structure of the actual phenomena investigated and discards the linguistic partitions created by specialized sciences in the past.

The need for the multi-discipline approach has been "in the air" for some time: disciplines, which for ages have not been "on speaking terms," have finally realized that application of a unitary language would yield completely new insights and perspective. Let us quote here only one example--that of psychosomatic medicine--the outcome of the semantic reform that resulted from shedding the semantic partition between "psychological" and "physiological" phenomena, a reform that may ultimately make both concepts obsolete.

Process Language

Development phenomena in emerging economies have many facets: they are of a complex structure; they change rapidly. In order adequately to describe and evaluate such phenomena, the structure of the language

used must be similar to that of the phenomena; to achieve this object the language used must comply with a number of specifications:

1. Since development phenomena may be grasped only by a multi-discipline approach, our language must be a "unitary language,"* integrating all relevant, single-discipline, semantic approaches within a compatible framework of representation;
2. Since the time dimension, long neglected, must become the most conspicuous dimension of our analysis, as will later be demonstrated, our language must lend itself to four-dimensional interpretation, to include the three dimensions of space and the dimension of time; in other words, our language must be a dynamic language.
3. Since, with the accumulation of information and the development of techniques, our analysis will become more complex, our language must lend itself to a parallel escalation in complexity.

In the purely formal field of mathematics, a unitary "process language" has lately acquired prominence--I refer here to system planning and other branches of operations research. The models underlying this approach are capable of comprising and interrelating many disciplines, to the extent that common yardsticks are now available, and it has, theoretically, no limits as to complexity, parameters, dimension, and constraints. Practically, however, the purely mathematical approach will reach its limitation as soon as we cease to be able rigorously to define and quantify the functions of the development equation.

The specialized application of this general mathematical approach to the field of economics has given rise to the fruitful new discipline of econometrics and mathematical programming. While some recent econometric applications have tried to widen their angle of vision by including in their analysis semi-quantifiable factors, such as education and training, econometrics is still

* Launcelot Law Whyte, op. cit.

primarily a discipline concerned with the measurement and quantitative description of economic systems and with the prediction of variations in economic parameters, resulting from various patterns of manipulation of the factors of the economy.

Although the mathematical models, used in system analysis in general and econometrics in particular, come closer to our semantic requirements, they still constitute, owing to their restriction to quantitative analysis, only a partially applicable approach to the extremely complex phenomenon of development, in which many significant factors do not lend themselves, at least at this stage of the art, to quantitative analysis. Furthermore, we have to keep in mind that a purely quantitative analysis will certainly not be applicable to emerging economies, characterized in their early phases of development by scarcity and unreliability of data. Therefore, the analysis of the early development phases will require a language, equally versatile, but more rugged and less quantified than system analysis and econometrics. We shall call this hypothetical language--which still has to be fully developed through practising, dynamic, and comprehensive analysis of project histories and development programmes--a "process language."

The extent to which the analysis in every specific case will utilize descriptive process language and/or quantitative language and models, will mainly depend upon the position our case occupies on the scale of development; with cases at the incipient end of the scale, language will be mostly descriptive, and any model that can be devised crude, and semi-quantitative; when progressing on the scale of development, and with the accumulation of feedback information, quantitative analysis will gradually take over without, however, wholly replacing descriptive language.

Process Language for Resource Development

How can we apply process semantics to the analysis of our specific problem, the development of water and land resources, especially in

emerging economies?

To begin with, let us describe the kind of development phenomena we usually encounter in emerging economies. Development, in its early phases, is not a spontaneous process; it has to be imposed, usually by government intervention, and it often depends upon massive foreign aid in material and human resources. Since forms of underdevelopment usually extend over many phases of human activity and organization, the development effort must necessarily extend over parallel areas. The creation of such an all-comprehensive development effort for a whole nation would involve the mobilization of national and international resources on a scale far beyond those available in emerging economies. Furthermore, such a massive nation-wide development leap-forward would also be beyond the bounds of psychological possibility. Government will usually try to establish growth-nuclei, with a view to generating catalytic action from the nuclei and thus set off, in other areas of the economy, additional cycles of semi-spontaneous or fully-spontaneous growth. The planning and implementation of the growth-nuclei must comprise the whole gamut of human activity involved in socio-economic growth. The correlated catalytic reaction of the growth-nuclei on the rest of the economy will, in their turn, also affect a wide variety of human activity. All these processes have to be seen as interacting and evolving along the time dimension.

This view of development has little similarity with that of orthodox planning. Orthodox programmes, using orthodox development models and languages, imply the naive assumption that the basic difference between developed and underdeveloped countries lies in the existence or non-existence of a certain amount of "hardware," or, to use more formal language, capital investment. Therefore, the analysis is usually confined to capital investment and its potential economic impact conceived without reference to the time dimension. The economy is, at least by implication, considered as being capable of absorbing this capital investment, in all

relevant spheres of human activity, by a kind of economic "induction." The social organism is here conceived as already growth-oriented, able to react integrally to the stimulus of the project, as a maternal organism would to the fertilization of an egg cell.

Psychological, structural, organizational, and social problems in this process, if at all foreseen, are treated as an afterthought on separate "lanes" of analysis, assuming that the phenomena involved (material, psychological, structural) are additive--as forces are in mechanics--and that all such forces can be assumed to evoke immediate reactions. Throughout the process, the use of the time dimension is confined to calculations of present worths of investment and benefit streams. This approach implies that growth tendencies are already inherent in the economy and are sufficiently strong to induce all secondary material and non-material phases of development, required for the maturation and fruition of the project. In the following, we shall use the term "development potential" for these growth tendencies, and we shall subsume under this term all professional, structural, organizational, and institutional capacities of the development authorities in particular and the economy in general that are a precondition towards the creation of sectorial self-sustained growth processes. Since, according to this orthodox approach, a development potential is implicitly assumed to be already in existence, the inducement of the growth of such "development potential" is not among the development objectives; objectives are usually confined to direct and indirect increase of production which are assumed to be a necessary result of the proposed capital investment.

Development is, therefore, not viewed as a non-linear, irreversible process in the time dimension which brings about with every successful step far-reaching changes in structure and organization of the society, with the consequent irreversible growth of the "development potential" vector, but rather as a purely quantitative linear and additive process

in a neutral and directionless time dimension; in such a development model a programme constitutes a sequence of independent project steps that, to facilitate analysis, can be considered separately and later added up to obtain overall results. In this approach, which contains no real directed time dimension, transition states, transients of resources, society, and project benefits hardly exist; project features and their impact on resources and society are seen in their final state only, and phasing, if provided at all, is regarded solely as a convenience in subdividing investment. This model does not lend itself to a dynamic analysis of the impact of every project step on resources and society and of the relation of every phase of change to the following one.

The model evolved by "process language" has a different point of departure and a different working approach. Within the terms of the process language model, development is considered as a multi-parameter, interrelated, irreversible process of growth in the time dimension. Owing to the numerous parameters involved and their continuous interaction, the process is so complex that we cannot conceive simultaneous solutions of the whole matrix (except for general solutions of a very simplified matrix for indications of overall trends), and we must rely on step by step or sequential analysis on multi-parameter lines for our current planning and implementation.

In a dynamic development model, the time dimension gains a new significance: every point of the development curve in the time dimension is fraught with the changes brought about in all its parameters by preceding development steps; every point has a different "development potential;" time has direction, and we can no longer cut up time into equivalent neutral units, treat them individually, and then add up results. We have to treat development as a process, where the point of time at which we propose to intervene is of the utmost importance for the outcome.

If, for the sake of facilitation of analysis, we have to adopt a restricted horizon, we have, as we do in mechanics when we cut a piece

of structure out of a whole for detailed analysis, to introduce the "development potential" into our analysis at the point of the cut-off time dimension; this "potential," at the point of cut-off, represents capabilities developed during the past development process, which can bear fruit only during the period beyond the horizon. Since here we consider development to be a continuously evolving process, gaining momentum with time, an evaluation of the "development potential," created by a development programme, and signifying the impact of the programme under consideration on future development, becomes a new and most important dimension of analysis.

A programme, in such an analysis, will be evaluated not only for its contribution to production but also (and in emerging economies probably principally) for its contribution to the growth of this "development potential," and here the sequence of project steps and their timing gains new importance.

Although the material factors of the "development potential" are, of course, an indispensable precondition to every growth process, it will be the extra-economic factors that will be the decisive ones in emergent economies. In the final analysis, development is done by man for men; man must be prepared to undertake this revolutionary, and--at least in its initial phases--this painful process of transformation of all spheres of human activity and cooperation. Progress in the hardware aspects of a programme has to go hand-in-hand with progress in human motivation and structure. Post-mortem analyses of many programme histories show that propelling the main hardware aspects of a programme without parallel progress in the human, social parameters, and in the supporting hardware, will result in dead-sunk investment; furthermore, the frustration caused by such failures will induce negative conditioning and vicious circles in the motivation of those groups that are most needed for development. Such programmes, instead of developing the motivational and structural parameters, result

only in the weakening or even the maiming of the development potential. A development process will therefore be effective only to the extent that the growth rate of all relevant material, human, and social parameters-- in all their transition phases--will be compatible. There seems to exist no better way to further and develop these human, structural, and social factors of the development potential than by applying and exerting them in properly planned and well-prepared integrated development programmes; success is the best conditioning factor--nothing succeeds like success.

Unfortunately, this most vital part of the development front has often been the most neglected one; to the extent that the development of human resources was considered at all, it was confined to formal or on-the-job professional training, again on the naive assumption that motivation and structure in emerging nations were similar to those of mature economies. The anticipated yield of a programme to the development potential, in general, and more specifically to its human aspects was seldom, if ever, consciously evaluated and adopted as a basic programme objective.

The Time Dimension

The above description by process language of development in emerging economies indicates that the most significant part of a programme analysis will be the study of the transients of the combined parameters entering the development equation along the axis of time. The reasons for the importance of time in the early development phases are numerous; a few are listed in the following:

1. Since capital is scarce, and the extent of previous investments extremely limited, its opportunity cost will be high, and with it the economically significant interest rate, expressing also the "value" of time in the economy.
2. Similar reasoning will apply to the other resources that usually are scarce in emerging economies: human resources and their professional training; structural resources and their institutional

consolidation; natural resources--in our case water and land resources--which may be scarce on a national or regional level.

3. Since prevailing productivities are usually low, small incremental investments will initially bring about very significant gains in productivity; postponement of such gains would involve serious losses to the economy.
4. Actual utilization of human and natural resources, employed in the production process, is low, and any delay in increasing their utilization constitutes another virtual loss to the economy.
5. The population explosion, at present experienced in emergent economies, lends special urgency to the prompt development of the productive potential of a nation.
6. An analysis along the time dimension will result in an evaluation of transition stages or transients, accompanied by a multi-parameter evaluation of the development potential vector at the termination of each transient; the sequential decision process for our development plan will be based on current analysis and evaluation of these transients.
7. The advances in mass communication media make development a political necessity: unsatisfactory timing or delay in instituting development processes may spell doom to a political regime. The political doctrine of today may well be read as "develop or perish."

Orthodox and Process Languages
and the Development Process

Since the basic mathematical semantics for a dynamic development language has been available for some time, the question arises why has such language not yet been formalized, and, above all, why has it not been applied more widely? The answer can be found in the fact that

normalized development thinking, and programme planning based on this thinking, were evolved in the context of mature economies, predominantly by scientists and technicians whose prior education and experience were highly specialized. They were mostly single-discipline technicians, or, at best, teams of single-discipline technicians working concurrently on separate, parallel "lanes" of investigations, finally joining their specific investigations into what they hoped would amount to a true analysis of the programme. In the context of steadily growing mature economies, the orthodox "single lane" or "multiple parallel lane," linear and static analysis often resulted in reasonably successful programmes, whereas its uncritical application to the extremely unstable conditions prevailing in the process of growth of emerging economies often proved disastrous: as pointed out before, the superimposition of "single-lane" caricatures of complex dynamic phenomena does not result in a true process description. The reason for this difference in the extent of success in the application of the orthodox doctrine lies, of course, in the difference between the societies to which they were applied.

In mature economies, the simplifications and distortions implied in the application of the orthodox doctrines will have but little effect upon the programme which spells out only the government intervention part of projects. In any case this intervention is almost exclusively concerned with the major hardware aspects of the programme; the other aspects are either already in existence or they evolve by "economic induction," resulting out of the interlinking of the sectors of economy through the play of market forces.

In emerging economies, however, this interlinking is rudimentary; a considerable part of the economy is stagnant and may not yet be monetized. If government intervention, in analogy to patterns practised in mature economies, remains confined to major hardware aspects, the other features equally important for the success of the programme do not evolve, for economic induction is practically non-existent.

At first sight, the results at which we have arrived seem paradoxical: why should the analysis of development problems in the relatively simple economies of less-developed countries require a complex process language, while a simple, statically oriented language has often proved to be satisfactory for considerably more complex, mature economies? The explanation to this apparent paradox lies in the fact that our analysis does not concern itself with the economy as it is, but with the growth phenomena leading to development; and these, at least from the point of view of the planning and executive authority, require a more comprehensive, and therefore a more complex analysis in emerging economies.

Mature economies are growth-oriented and growth phenomena and transients develop spontaneously around a central development theme like vines around a tree trunk. To the extent that intervention is necessary, it can be confined to the central theme, for all cyclic interlinking is positive. Briefly stated, adaptation to growth is a normal function of such economies. Therefore, a linear static language will not introduce major distortions into our analysis.

Emergent economies, on the other hand, are not growth-oriented; many cyclic links are negative, communication poor, and response to growth incentives sluggish and localized. For them, integrated development is an unnatural process, a dramatic revolutionary change, affecting every aspect of human life and activity. In such a context, the analysis of development cannot any more be confined to a single "melodic" line including the main themes of development; here, the spontaneous processes of the relevant accessory sectors of the economy are inadequate to elicit the vital subsidiary themes. Therefore, all primary and secondary growth strands in all their transients and transient interactions must be subjected to a non-linear dynamic analysis. Outside intervention can be relaxed only to the extent that cyclic interlinking improves and becomes positive and when the necessary

reinforcing growth processes become spontaneous.

Conclusions

Growth phenomena in evolving economies depend upon a great number of intersecting ever-changing factors. These factors evolve along the time dimension through transients towards new equilibria; the transients, again, develop their own transitory fields of forces through which they interact. New capacities, development potentials, are gradually developed which will have a decisive influence on future growth. The analysis and prediction of these complex phenomena require a multi-discipline dynamic non-linear model and a language that lends itself to the description of such a model. System analysis and econometrics come closest to the requirements of such a language, but their complete quantification makes their use often unfeasible in the early stages of development. Partly-quantified language of similar structural properties, termed here process language, will have to be developed to analyse growth phenomena in evolving economies, their transients, their interaction, their trends and progress.

A good artisan, before starting his work, will check his tools, selecting those that are required and discarding the tools that will not assist in expediting the job. Let us act in the same tradition: adequate tools are a precondition of success.

CHAPTER II

RESOURCES PLANNING AND PLANNING OBJECTIVES

"Our Country grows by night
when the politicians sleep."

Brazilian proverb
quoted by A. O. Hirshman

Introductory

The subject of the second lecture is the planning of water and land resources in emerging economies. In this context we shall assume the existence of an overall economic development plan to be implemented within a specified period and defining on the one hand the anticipated contribution of the available land and water resources to the economy, and on the other hand the capital and human resources available for development during the development period.

Planning the development of resources in this context will be understood as an attempt to propose ways and means for the manipulation and utilization of natural, capital, and human resources to the attainment of a series of objectives generally related to the productive capacity of a nation. The plan as formulated should embody an inventory of resources, a survey of existing conditions, and an outline of the measures to be adopted to activate and ensure development of the economic sector under investigation. Planning objectives will relate to the creation of self-sustained growth-potential, as well as to the short-term increase in production; the purpose and *raison d'être* of planning is to lay down guidelines for action and planning may be considered as significant only to the extent that it provokes action along the lines recommended.

In the following sections we shall first survey the scope and depth of resources planning prevailing today in developed economies.

We shall then analyse the type of planning required for emerging economies and seek historic precedents. The relation in developing countries of the planning process to the political decision taking process will then be analysed. The final section will deal with the objectives out of which the political decision-taking level will have to choose a self-consistent set of objectives to serve as a point of departure for planning strategies and tactics.

The Necessity of Planning

Is Planning Rational?

The term planning, in its political and economic context, is often bandied about as a slogan, uttered as the clarion call of extreme political philosophies, while considered anathema to equally extreme but opposite viewpoints. Can we dismiss planning then as a purely political slogan, or should we consider it a mandatory tool for the achievement of development?

Casting our eyes back over remote ages to the birth of man, we find no example of true adaptive planning, since instantaneous reaction to a situation as it poses itself is the very essence of the rule of nature. Delayed reaction is a specifically human and social trait; pooling of experience at a social level leads to the definition of traditional rules of operation that gradually replace the pattern of instantaneous reaction. These rules may be considered as prefabricated plans--they survive unchanged through many generations; they are not always based on the last word of logical reasoning, and what they lack in logic they make up for in dogmatism and tenacity. Except under conditions of exceptional stress or scarcity--and here we refer mainly to planning in the so-called "hydraulic societies" and to wartime planning, to which we shall later refer--little true adaptive planning has been practised until very recent times. In Western Europe, planning has only become legitimate with the advent of the major crises of the nineteen thirties and the acceptance of Keynesian economic doctrines.

Andrew Shonfield,^{*} of the Royal Institute of International Studies, has described early attempts at planning in the West as "concerned mainly with the improvement in control over the business cycle. Indeed, in several countries it was the search for better methods of short-term control over the economic system which led to long-term planning. . . . it is in most countries an activity of very recent origins belonging to the 1960's rather than to the '50's."

In the developed countries of today, planning to a greater or less degree has become more or less accepted, though its objectives, depth, scope, and degree of permissiveness vary from country to country. We may study the whole gamut from the complete mandatory planning of communist countries to the negation of planning of some oligarchic societies.

The introduction of all-embracing planning on a national scale in the communist economies has not made this doctrine politically more attractive to the western world. The communistic approach to planning is dictated by its underlying political philosophy; the economy as a whole, and the human elements forming part of it are seen as wheels and cogs of a complex mechanism whose behaviour is completely predictable and dependent only upon material inputs and political indoctrination. The task of planning is seen in determining these inputs and their interconnection in order to achieve predetermined production and distribution targets. The creation of incentives is considered to constitute secondary factors of planning, and, in fact, their spontaneous growth is discouraged through institutional attitudes. Hence, it is not surprising that those sectors of the economy in which productivity depends less upon individual motivation (such as modern industry) show better progress than those where individual motivation is paramount, such as agriculture.

^{*}"The Progress (and Perils) of Planning," Encounter, August 1965.

In the western forms of planning, the implementation of the material aspects of development is rarely fully spelt out and made mandatory. In the French approach to planning, indications are given as to the bottlenecks of the development front and economic incentives created, e. g., through planned channelling of government funds, to create facilities to overcome them. The American type of planning puts the main emphasis on corrective short-term measures to control the business cycle without, however, losing sight of indicative long-term planning.

The repudiation of the desirability of planning, or the drawing up of spurious plans without the true intention of implementing even a part of these plans, as exemplified in some oligarchic societies, would probably constitute the very antithesis to the communistic approach to planning.

Since sufficient case histories of planning in developed countries of every scope, depth, and nature are now available, one might think that it should have become possible to determine the extent of planning required under every set of conditions. However, a cursory examination of the extent of planning and its relation to rates of growth shows an almost complete lack of correlation between the two; apparently more factors are involved than meet the eye.

Despite the spread of general economic planning in the West, development histories are fraught with instances of resistance to long-term planning of natural resources, even where its benefits were obvious. This fact has been noticed and aptly described by Professor Abel Wolman who has drawn the conclusion that long-term planning of national resources in the West is adopted only if really dramatic needs are demonstrated. This resistance stems basically from a deeply rooted mistrust in government intervention, especially in areas so "charged" with vested interest tensions as land and water development.

In emerging economies, the national planning approach has now been generally accepted as a prerequisite to adequate growth. This prerequisite arises out of the existence in the new economies of vicious circles,

prevailing in almost all areas of economic activity, circles that can be broken or transformed into "positive, circular causation" (Myrdal) only by government intervention. Such intervention must necessarily be a complex operation, touching upon numerous economic and social parameters and such a complex operation cannot be successfully implemented without planning. It is also becoming more recognized that the planning process and implementation in emerging economies require a far more comprehensive scope and a greater depth than in the developed countries.

Unfortunately, however, in most developing countries, although these facts are fully appreciated, the necessary know-how is still lacking--and the political motivation often deficient--to enable adequate plans to be drawn up and their implementation organized.

Planning and Scarcity

Basically, the necessity for planning arises from the existence of stress or scarcity: the more numerous the scarce parameters, the more comprehensive the plan; the more serious the scarcity, the greater the depth of planning. Since dimensions of scarcity in developing economies are numerous, the planning process will have to take in a wide field of activity and must penetrate to great depths. Unfortunately, relatively limited comparable planning experience is available from the development history of developed countries. Only two major historic classes of phenomena exist where recurring situations of stress and scarcity have led to far-reaching planning on a national scale--the so-called hydraulic societies and war.

The hydraulic societies* arose out of the necessity to control and manage major rivers on which the subsistence and survival of whole nations depended. These stress situations gave rise to elaborate planning and highly organized implementation of nation-wide engineering, administrative, and political operations. In these societies the trial was

*This term was coined and the phenomena described by Professor Wittfogel in his book "Oriental Despotism," Yale University Press, New Haven, 1957.

made--perhaps for the first time in human history--to achieve the comprehensive planning covering most areas of human economic activity on a national scale. This planning exercise was sufficiently successful to enable the construction of major engineering projects and their successful operation over centuries. These planning efforts were, however, based on an extreme autocratic political philosophy which could certainly not be repeated in modern times. Hence, the lesson of the hydraulic societies for modern underdeveloped countries will be extremely limited.

The other class of phenomena, war, producing chronic conditions of scarcity, has led in modern times to widely-accepted full-scale planning. In fact, success in the prosecution of war has been shown to depend in no small measure on planning the deployment of maximum forces against the enemy, stepping up the production of war material in the hinterland, without denuding the country of the elements required for physical survival. In order to effect this mobilization of resources in a short time, massive government intervention, based on comprehensive multi-parameter dynamic planning, has proved to be necessary; wartime planning concerned with the lightning conversion of the economy from a peacetime to a wartime basis contains the essentials of the type of planning required for the transformation of a subsistence to a modern economy. The main manifest difference lies in the disparity of the time-scale and time horizons, in that planning for war is devoid of long-term goals.

Many of the processes connected with planning in emerging economies are essentially present in wartime planning: dynamic inventorying of resources; definition of overall objectives and strategies; optimization of the allocation of resources with a view to achieving these strategies; employment of every means known to psychology to increase motivation in relation to the plan objectives; an all-embracing reorganization of the economy, tailored to the requirements of the plan; intensive analysis of all these along the time axis. All these activities are seen as interconnected

and are planned by the multi-parameter approach. Extent and depth of planning have probably been among the significant factors contributing to success in war.

The necessity for comprehensive national planning in wartime has never seriously been contended, largely owing to the willingness of the individual temporarily to surrender freedom, to make sacrifices in the face of the peril to the national existence, and in face of the dramatic circumstances under which a number of serious scarcities develop overnight in economies of affluence: scarcity of material as well as human resources; deficiency in the social micro-structure; and scarcity of time. With the passing of the emergency, the importance of such scarcities--so fundamental to the conduct of the war--is eclipsed and planning is promptly discarded.

In underdeveloped economies, and here I refer to a hypothetical economy where underdevelopment prevails equally within all sectors, the dimensions of scarcity may be even more numerous, the depth of scarcity more serious than in a modern wartime economy. In the field of material resources--infrastructure, capital formation, and often natural resources are inadequate; in the field of human resources--population growth uncontrolled; the number of professionally trained men--insufficient; general educational levels--low, and motivation deficient. In the field of social micro-structure--traditional law and institutions seriously handicap development, and the organization of the economy is predominantly on a local subsistence level, with insufficient interlinking between sectors. Vicious circles exist in all these areas holding the economy stagnant. Planned government intervention extending over all these dimensions of scarcity is a necessity if positive circular causation is to emerge and the development process primed. The planning underlying such intervention must take into account the necessity of spreading growth processes from sector to sector, in order to achieve interlinked expansion along the axis of time.

Planning--A Status Symbol

The necessity of planning is today fully recognized by the emerging nations, though unfortunately the organization and political motivation required for planning is often inadequate. However, since planning has become a kind of status symbol, a "plan-or-perish" attitude now seems to prevail, and planners occasionally feel that even if, for no fault of their own, they cannot come up with the real article, they should at least produce and present to the political level the trappings of a plan. Real planning is an uphill job; not only because it involves considerable technological and organizational efforts, but mainly because from the political point of view it is often very delicate. Before one can embark on planning proper, the main socio-political objectives and strategies have to be squarely stated and this, in a true development plan, will include "... a pervasive social transformation;... a wholesale metamorphosis of habits, a wrenching reorientation of values;... an unweaving and reweaving of the fabric of daily existence itself;... in any society such a transformation is a profoundly dislocating experience."*

From the chronically short-term point of view of the politician, such basic long-term measures will not look too attractive. The politician will therefore usually prefer to remain closeted in his world of double-think and triple-talk, instead of committing himself unequivocally to a specific set of values, objectives, and strategies.

Planning, then, must use genuine coin, while in politics counterfeit currency will do equally well, and in time will drive the genuine article out of circulation by the operation of a political Gresham's law; this tactical approach of the political level is not necessarily due to any innate viciousness of politicians, but rather to their pragmatic understanding of the politico-psychological situation in the initial phases of

* Robert L. Heilbroner, "The Great Ascent," Harper Torchbooks, New York, 1963, pp. 53-54.

development. Development implies the sacrifice of possible benefits of today for the sake of the benefits of tomorrow, and is hence a policy of a long time-span. Lifting an underdeveloped economy from its stagnancy and changing vicious circles to positive circular causation involves a painful transformation, a "scandal" according to the definition of the French economist Austruy*; it comprehends the birth of a new society and is preceded by often acute birthpangs. Notwithstanding their ultimate moral justification, it is difficult to sell long-term policies to the public, while subjecting them to initial and painful phases of development.

It is, therefore, not surprising that in emerging economies easily marketable surrogates often substitute for planning. A glamorous list of superlative hardware, well-adorned with economic padding, will from the point of view of political expediency do nicely for a plan. In its political aspects this has often been extremely successful, but in a new economy it has seldom effected true development in a degree proportional to the outlay. The growth bulge created by such a programme in the general front of stagnation will not carry the rest of the front with it due to the lack of "economic induction" so characteristic of developing economies; furthermore, the development bulge is usually implemented by expatriate organizations working practically without any contact with local organizations or professional manpower, and thus the whole effort, while channelling off the major part of the resources allocated to development over one or even two planning periods, remains isolated, leaving the rest of the economy practically untouched.

"Development enclaves" in a sea of underdevelopment are, and have been for some time, very much in vogue: they have the advantage of easily directing the longings and yearnings of a poor nation into easily

* J. Austruy, "Le Scandal du Developpement," Editions Marcel Riviere et Cie., Paris, 1965.

accessible channels; a dam or a large basic industry are examples of such diversion channels. They become status symbols, appealing to that section of public opinion to which the existence of a true plan would have little appeal; they become the chthonic symbol of national aspirations for development, as such have considerable psychological importance, as is instinctively realized at the political level. While exhibiting all these major political advantages, "development enclaves" still demand no change in the traditional structure of the society or the economy; they cause no major upheaval of vested interests, and, in short, they involve none of the "scandal" of development proper. Such a pseudo-development may result in such psychological and political enchantment, but cannot lead and in actual experience has not led to the development of self-sustained growth.*

A Pragmatic Approach to Planning

What then is the realistic approach to planning? If the proper approach--that of grass-roots change in social and psychological structure is destined to run aground on both political and popular resistance, even before being afforded an opportunity to launch itself--and, if on the other hand, the easy way of creating development enclaves does not lead to real development, is the problem then at all capable of solution?

Development, nevertheless, has occurred; continues to occur, and some modus vivendi must exist. The solution--as other real-life solutions--should not be sought at the extreme ends of the scale; generally workable solutions are found somewhere in between.

The planner should realize that the society for which he is planning has a particular social, economic, and political structure which, except for revolutionary transformation, may be changed only very gradually. He must realize that his task is not to wait until society has sufficiently changed so as to make it fit his plan, but rather to design a plan for an existing society,

* See Heilbroner op. cit. p. 53

If in his society the chemically pure stuff is unacceptable, he will have to water it down until it becomes palatable to his political level. Under conditions of developing countries, the basic choice will seldom be between two alternatives of optimum utilization of resources, but rather between a plan of action in the right general direction that will still be acceptable to the political decision-taking level because it compromises with what is euphemistically called the "realities of political life," and between a "chemically purer" plan that would never be acted upon. In other words, it is a choice of the lesser evil, where the greater evil is "unrealistic" planning equivalent to postponement of action. When making these painful choices the resources planner should keep in mind that successful action will lead to new action, that the best road to development is by initiating development, and that, with time, development implementation may convert even the political level to a "purer" line of development thinking.

Major structural changes often required for significant development should be brought about by gradual and subtle modification of existing structures, effected as by-products of the implementation of a programme, rather than by making major change a prerequisite or sine-qua-non of development. Compulsive tactics rarely breach the structural and institutional front or even gain temporary beach-heads for later deployment.

We must conceive the extent of inertia and resistance to change of institutional patterns and their underlying rationalizations as points on a continuous scale: at one extreme end of the scale we encounter societies with relatively less-developed institutional structure, having low resistance to change (e. g., the societies of the authoritarian type which, however, have their own brand of mental blocks), while at the other extreme end of the scale we have firmly entrenched traditional societies, with extensive vested interests and formidable mental blocks active against change.

The planner and the political authority responsible for sanctioning planning strategy must first evaluate their own particular situation and determine where and to what extent resistance, both active and passive, is likely to be encountered. Accordingly, the programme must consider certain institutional patterns as constraints in the development equation (at least in its initial decision sequences), while others might--within certain limits--be considered as accessible to change and thus as controllable variables. As development progresses, institutional patterns considered as constraints in the initial phases may gradually, as a consequence of the structural changes brought about by the development process, become amenable to change and thus controllable variables in subsequent phases of development.

Every socio-political condition has areas of least resistance, likely to yield to pressure or attack. The starting momentum available at the outset of the plan, if first applied to such areas, may obtain the necessary leverage to prize open a first series of vicious circles and transform them into positive circular causation, and from this first nucleus change processes may sustain further opportunity of propagation, supported by a momentum invigorated by the process of growth.

So far, we have touched only upon the tactics connected with the initiation of the planning process; the time has now come to consider the objectives of planning.

Planning Objectives

The basic objectives of a society play a similar role in the development equation that axioms play in algebra. They are choices stemming from a set of political and social values prevailing in that society and, once adopted, they determine general and operational strategies and the choices of the plan proper. Though basic objectives can be counted among the less changeable parts of planning, they nevertheless change with time: as an ideological product of society they change with that society. Society

creates values; values result in objectives; objectives in strategies; strategies in programmes; programmes in development and change of society; and finally, the changed society gives birth to new values and new objectives.

Since in political decision-taking our practical choice will always lie somewhere between the extreme points of a scale of values, we can, perhaps, best visualize a range of objectives by describing the extreme points of the various scales of possible choices; without pretension to completeness; a few recurring scales, relating to resources development are listed in the following:

1. True development versus prestige programme

Do we intend to put the main emphasis on basic social and psychological and institutional transformations, that are the precondition to self-sustained true growth, or do we choose the establishment of development enclaves as a prestige programme?

2. Timing of benefit

Do we prefer to maximize benefit for the immediate future or for future generations, or do we take an intermediate position?

3. Conservation of resources

Do we choose utilization patterns which would significantly jeopardize or diminish potential use of resources by future generations, or do we insist in preserving utilization levels proposed for the use of the present generation also for the use of future generations; or do we take an intermediate position?

4. Choice of economic parameter for optimization

Do we intend maximizing by the budgeted capital investment the value of the product, the improvement of the balance of payment, the volume of employment, the ratio of consumption

to saving, or any combination of these parameters?

5. Distribution

Do we aim to maximize the absolute volume of the product; or do we prefer to optimize the distribution of income; or any combination of both?

6. Relief to distress areas

Do we single out for intensive development those areas that for capital invested will yield the highest product, or do we give priority to areas of distress, even if investment in such areas will prove less rewarding?

7. Demographic policy

Do we consider measures to control population growth justified or do we consider it our duty to provide means of subsistence for an unplanned population growth?

8. Conservation of traditional ways of life

Do we consider that the preservation of traditional ways of life overrides the necessities of economic growth, or do we consider economic growth bought at the cost of fundamental social changes to transcend such considerations?

Theoretically it would be up to the political decision-taking level to choose a point on each of the above (and on other similar) scales, and to define an internally consistent set of objectives to serve as ground-rules for the planner. In actual fact, such a clear-cut procedure will not always be possible: firstly, because the political level is not always sufficiently analytical, and secondly, because in political double-think the impossible feat of uniting the extremes becomes possible. The planner, however, has to think algebraically, and double-think will not carry him far.

In order to make the choice of a consistent set of objectives amenable to the political level, and further to get over to them the social cost of their choice, the planner will often have to translate alternative sets of objectives into corresponding project mixes and point out the approximate

economic and social costs and the benefits of each alternative. This will enable the political decision-making level to attach a price tag to each set of objectives before the choice is made. Both the political and the planning authorities must bear in mind that objectives change with development and that it will often pay not to be too pretentious in setting up one's objectives in the initial phase of development; a gradual elevation of objective and target, attendant on the rise in development consciousness and morale of the public, will have a better chance of success. Let us consider two examples demonstrating this gradual approach.

The first example concerns the choice of "time span;" time span here refers to the length of period that motivation for the implementation of a certain policy can be sustained in an individual, a group, or a nation. With individuals, time span increases with age, whereas with societies time span will depend mainly on the extent of development; in traditional societies it will be relatively short; as the economy develops time span will become longer. Objectives for individual action in the initial phases should therefore be predominantly short-term, whereas medium and long-term policies should be undertaken by the State. With the growth of the economy, time span will increase and objectives can then progress to medium-term and later long-term; furthermore, with the lapse of time, medium-term programmes may be picked up by private initiative.

The second example concerns the question of institutional change, already mentioned. Here, again, it will pay initially to treat traditional patterns with great respect and to effect change by introducing only gradual modifications to existing institutional patterns. The continued use in a development programme of such gradually modified traditional institutional structure might make it possible to initiate the first steps of implementation of a new programme without excessive resistance.

Conclusions

While in developed societies the choice of planning approach will be mainly dependent on political doctrines and considerable variety of scope and depth of planning will therefore prevail, true growth in emerging economies will be conditional upon nationwide comprehensive planning of resources development, extending over all areas of economic activity, human structure, and institutions. The closest historic parallel of such planning approach is modern wartime planning.

While the necessity of comprehensive planning is today recognized in developing economies, actual planning performance is found to be guided by short-term political considerations. The resources planner must determine to what extent he will have to water down his optimization in order to ensure its acceptance by the political decision-making process. The choice of planning objectives on which the planning process will be based will depend upon the political philosophy of government. Within the various scales of objectives, optimum points will be selected, harmonizing with the prevailing political value system, and these optimum-points coordinated and modified into a self-consistent set of objectives.

CHAPTER III
PLANNING STRATEGIES FOR RESOURCES DEVELOPMENT

"The mere laying-in of a core of capital equipment, indispensable as that is for further economic expansion, does not yet catalyse a tradition-bound society into a modern one. For that catalysis to take place, nothing short of a pervasive social transformation will suffice."

R. L. Heilbroner, "The Great Ascent"

Introductory

In the last lecture we have reviewed the place of resources planning in the political decision-making process related to development and alternative basic values and objectives, on which to base such plans.

If all the factors entering into the "development equation," i. e., the physical, psychological, social, and economic parameters, their interrelationship and the functions governing their growth, were fully known to us, and once the basic objectives were settled, an optimal plan could be drawn up by mathematical analysis, determining which parameter, or combination of parameters, we intend optimizing and under what constraint.

In reality, the development equation in developing economics is too complex to lend itself to formalized expression and the data on parameters and functional interrelationships inadequate to admit of an overall formalized representation and subsequent solution of the development equation. However, the study of successful case histories in land and water resources development indicates a number of typical strategies whose application will often lead to rational utilization of resources, reasonable growth rates, and priming of the development process.

In the present lecture I shall outline a number of strategies derived

from successful case histories. The strategies described will fall into two main groups:

1. strategies aiming at short-term growth of production and its distribution,
2. strategies aiming at long-term growth by increasing the development potential of the nation.

This first group of strategies will again be subdivided into two sub-groups: The first sub-group will include the conventional growth strategies relating in an abstract way to the usual short-term economic parameters, without reference to the special conditions of emerging economics. The second sub-group will include those strategies that deal with optimization of short-term economic parameters, with special reference to conditions prevailing in emergent economics, i. e., analysis of the all-important time dimension, conditions of uncertainty, and institutional constraints.

The second main group of strategies will be aimed at the gradual transformation of society. The psychological, social, and institutional structure of society (the fifth dimension of our universe of discourse, to be added to the three dimensions of space and the dimension of time) must be transformed by adopting suitable development tactics so as to step up the development potential of the economy and to reach that stage of capacity for self-sustained growth.

When drawing up an effective resource development plan in an emerging economy, proper weight must be given to both these groups of strategies. Consideration of the first main group is relatively easy, since such strategies can be expressed in quantitative terms. The second group does not lend itself easily to quantification, though considerable progress can be expected in the future in this direction. Evaluation will therefore have to adopt the difficult approach of combining fully quantified, partly quantified, and qualitative criteria. We can now approach the description of the two groups of strategies.

Short-Term Strategies

Optimizing Production Function

The first and paramount target of a programme will usually be to maximize the production function (in the widest sense of the word) resulting from the investment of the available budget. In emerging economies, where the analysis along the time axis is usually decisive, investment and benefit streams, rather than static budget figures without time dimension, should be adopted. The opportunity cost of capital and the other value dimensions of time can be expressed by interest rates applied in the computation of present worth of programmes; without involving ourselves in the complex question of the determination of appropriate discounting rates, it can, nevertheless, be stated in general terms that (1) interest rate decreases with development, (2) in determining interest rates additional socio-political factors should be taken into account, in addition to the opportunity cost of capital. In long-term programmes, a decrease of the discount rate with time might be indicated. The function that we shall endeavour to maximize will usually be the surplus of the present worth of benefit streams minus cost streams, discounted at an appropriate rate of interest. McKean has proposed the use of the marginal internal rate of return.* The benefit streams to be maximized can be the direct production volumes, improvements in the balance of payment of the country, employment, or any combination of them. The bearing of proposed programmes on consumption and saving might also be of importance.

In certain kinds of projects (e. g., water supply projects) non monetary "service units" may be used, and there our endeavour will be to optimize the present worth of service units in actual use that can be obtained for a certain budget, allowing, of course, for the present worth of unutilized capacity that had to be incorporated for engineering and

* R. McKean, "Efficiency in Government." John Wiley & Sons, New York, 1958.

economic reasons. The relation of investments in direct means of production to those in infrastructural features will also be an important consideration. Premature investment in infrastructure in emerging economies will not accelerate the development of productive capacity, in contrast to the effect of such procedure in developed economies. It will be justified only to the extent that the current cost of using existing inefficient infrastructure will have become higher than the current cost of new infrastructural features, when operating at the partial load predicted for the date of completion.

Spreading Investment

A successful programme requires both the creation of means of production and their absorption within the production process. In view of the fact that absorption is gradual, capital investment should be induced parallel with, and not in advance of absorptive capacity, or in other words, growth processes in the means of production should be consonant with growth of absorptive capacity. However, investments in means of production are not given easily to subdivision; "development quanta" will emerge which, for economic and/or engineering reasons, cannot be further subdivided. As a consequence investments will necessarily be of a spasmodic nature, and the cost of the development quanta will determine the lumpiness of investment. In order to ensure the optimal use of our budget, we should try to spread investments, in space and time, as closely as possible in parallel with the growth in absorptive capacity of the economy for these investments. This spreading will, of course, be constrained by the inherent "lumpiness" of investment, on the one hand, and by the diseconomy of using smaller instead of bigger quanta on the other hand. If, for the purpose of evaluation, we subdivide a project into its quanta and evaluate project mixes consisting of project quanta, instead of entire projects, a realistic evaluation according to our first strategy above, giving proper weight to anticipated limitations in the growth of the absorptive capacity for new means of production, will already include evaluation of the economic effect of spreading the investment.

Manipulation of Demand

Some projects unavoidably involve large development quanta and are therefore lumpy in investment. Construction of dams or canals are examples of lumpy projects, where phasing is not generally worthwhile. In such cases, one should build up demand where this is feasible, ahead of the construction of main projects--the over-utilization of existing resources, by recourse to temporary palliative measures, or by other available means, in order to minimize the cost of idleness of the capital that must be invested in the indivisible large project quantum. Such manipulation of the demand function will result in production even before investment has started and it will reduce the real cost of interest during construction and the loss of income during the development period of the project. Such measures often make it possible to reduce accounting costs considerably, and, in addition, serve to predevelop an area, facilitating later, more rapid absorption of new means of production, after initiation of project operation.

Flexibility

Ideal planning situations, with all parameters and constraints of the development equation disclosed, would allow us to draw up a firm programme without running the risk of misinvestment. Such ideal situations, however, never exist (though, in mature economies we sometimes imagine their existence until society or nature calls the bluff), and we must therefore make allowance in planning for factors of uncertainty: our resources data are incomplete and their reliability limited; our demand forecasts--subject to factors beyond control and computation; our evaluation of the socio-political and institutional aspects--fortuitous speculation. To defer development for lack of data would be both absurd and contrary, for compilation of complete data is also part of the feedback process of a programme. Initial diagnosis--as well as therapy--may often rest on insufficient analytical or clinical evidence; however, this limitation should not be allowed to defer initiation of treatment. In order to avoid mistakes likely to

prove fatal or incorrigible, our initial therapy will be of a probing, exploratory nature and its continuation shaped by responses to initial therapy.

Dimensions and depth of uncertainty are especially serious in emerging economies and, hence, flexibility of planning should be one of the prime strategies for such economies. The response area of our solutions must be evaluated for the full uncertainty range in our basic data and the programme adopted to fit the entire range.

Programmes lacking flexibility will, under conditions of uncertainty, necessarily result in a relatively high percentage of mis-investment, and provision of flexibility has consequently real value, the extent of this value depending primarily on the extent and depth of uncertainty. Our analysis must compare the cost of flexibility against its probable value, and adopt at least that degree of flexibility warranted from the purely economic aspect. It is characteristic of human nature to overestimate our knowledge of the future and flexibility therefore usually pays off better than originally assumed.

Application of flexibility strategy to projects may take any number of forms; some of the more obvious are enumerated here:

1. The strategy of phasing (to be discussed in the next paragraph);
2. The strategy of project generations. Alterations in the programme necessitated by revisions of the resources inventory or of other parameters may be made in a later project generation.
3. The strategy of the flexible basin. This strategy allows us to draw on the resources of a wider basin concept, if and when the estimate of the resources of the original basin proves to be scarcer than originally anticipated.

Phasing

Phasing will, in some contexts, be a special case of a flexibility strategy; in other contexts, it will be a special application of the spreading strategy. A special aspect of the phasing strategy is the avoidance of the "diseconomy of scale." We hear a lot about the economy of scale, but

a hind sight type of analysis shows that such a "paper economy" often results in an actual diseconomy. Analysis of benefits often neglects the time dimension and the effect of partial load that will usually prevail for extended maturation periods; these partial loads will result in higher unit costs by reducing the scope of benefits without at the same time diminishing current fixed costs. Analysis of actual project histories shows that, due to this factor, average unit costs are often higher by 30 to 50 percent and more than anticipated in the static economic evaluation.

The extent of such diseconomy of scale will mainly depend on the length of the maturation period (or more exactly on the product of unutilized capacity and time) and on the real rate of interest of the economy. The impact of both these factors will tend to be heavier in emergent economies than in developed ones. Therefore, phased solutions, palliatives, and similar tactics will often prove to be economically more attractive in emergent than in developed economies.

Long-Term Strategies

Contribution of the Programme to Development Potential

Development should be viewed as a continuous process. Our evaluation of alternative programmes cannot, therefore, be confined to the production impact of a programme within the period of planning but must include the contribution of alternative programmes to the development potential, which will become effective only beyond the planning horizon. Two alternative programmes, while having the same production effect within the period of planning, may yet materially differ in their contribution to the development potential for self-sustained growth, and therefore in their long-term contribution to production. The short-term production impact represents the increase in productivity that can be obtained by making available capital and other inputs within the existing structural framework of society, assuming only minor modification of this framework resulting from the incidental effects of the programme.

Since this modified structure will constitute the structural input for the subsequent phase of development, and since the structural input constitutes the most critical bottleneck in the development of emerging economies, the growth of the development potential and the long-term growth of production depending upon it will depend upon the extent, depth, and orientation of the structural changes achieved by the preceding programme. The paramount importance of these structural changes for the emergence of self-sustained growth has recently been recognized, and stated most convincingly by both Austruy and Singer.* In quantitative analysis, the benefits accruing from increments to the development potential of alternative programmes can be evaluated by comparing the present worths of the additional production that can be achieved in the future planning period. This may be done by applying a reasonable capital input, and the various potentials obtained in the alternative programmes as structural inputs.

A number of tactical criteria related to the development potential are listed below:

1. Does the proposed programme provide sufficient opportunity for on-the-job professional training of the development group of professional and sub-professional men, and what micro-organization of the group will optimize such training?
2. What micro-organization, what placement of expatriate staff, what type of division of responsibility and authority between the national and expatriate personnel will ensure an increase in motivation and structure?
3. What kind of formal organization would best fit 1 and 2 and how should its relation to other government organizations be defined?
4. Does the programme incorporate those operations and trends that we wish--in the long run--to demonstrate?

* J. Austruy, "Le Scandal du Developpement," Editions Marcel Riviere et Cie, 1965. H. W. Singer, "International Development Growth and Change," McGraw Hill, 1964.

5. How should programme nuclei be located and organized so as to obtain the maximum catalyzing effect upon the programme utilization group, e. g., the farmer?
6. What expatriate, professional, and sub-professional manpower is necessary, and what input of national professional and sub-professional manpower must be made available by national, educational, and vocational systems?

Data Yield

The data yield of a programme is a neglected strategy, a neglect that stems mainly from the lack of awareness of continuity of the development process. The data yield aspect of a programme becomes significant with process continuity, especially when dealing with emerging economies. If action becomes necessary before adequate data become available, flexible solutions have to be selected and generous safety factors applied. In this respect, data and data improvement could find economic expression and the data yield of alternative programmes thus becomes one of the long-term benefits to be considered in programme evaluation.

It will seldom be possible to express the value of data yield in exact quantitative terms, though often it will be possible to evaluate the importance of data feed-back for future programmes in qualitative terms. Theoretically, the principle of diminishing returns should apply and the value of data yield in the initial phase be higher than in the later phases. In fact, however, a counteracting principle takes effect: as utilization increases, at least under conditions of scarcity, the data sophistication required for efficient management also increases.

Spill-over Effects

So far we have not considered any spill-over effects from our resources sector to the rest of the economy. This simplification is justified for a first evaluation. However, as we proceed to more detailed phases of evaluation and planning, we should consider the direct and indirect impact of our programme on the rest of the economy.

Scarcity Strategies

We have already mentioned that wherever acute scarcity develops in any dimension of a mature economy, planning and allocation develop almost spontaneously, even in political regimes with an aversion to planning or state intervention. Since emerging economies are usually already "sold" on planning, we do not have to enlarge here on its blessings, but rather on the kind of strategies necessitated by scarcity in natural resources. The type and scope of scarcity strategies will, of course, depend on the type and scope of the scarcity; we shall attempt to exemplify appropriate strategic patterns by describing a set of strategies, as adopted in Israel under conditions of serious scarcity of water resources; this set of strategies included the following main items:

Water resources

1. Projects planned and designed in a manner that will ensure optimum conservation and minimum loss of resources.
2. Resources appraisal to be developed to increasing depth and sophistication as the programme progresses.
3. Resource management planning of yield and quality to be increased in scope and depth with increasing utilization of the inventory.
4. Water resources to be upgraded by proper management measures, pertaining to mineral and sanitary quality, to variations of flow, and to the point of occurrence.
5. Less conventional water resources to be included in the inventory, among them:
 - (a) reclaimed municipal and industrial waste waters;
 - (b) one-time surpluses available as transients of groundwater development;
 - (c) reclamation of coastal groundwater outflows.
6. Research to be undertaken into the application of promising, non-conventional conservation methods, among them:
 - (a) reduction of evaporation from open water surfaces and high groundwater;

- (b) control of phreatophytes;
 - (c) changing the non-beneficial cover vegetation of hilly areas in order to increase water harvest;
 - (d) artificial rain by cloud seeding;
 - (e) increasing the water harvest by treatment of soil in uncultivated areas.
7. Artificial man-made water resources to be introduced by desalting sea water and brackish water to the extent that the inclusion of this expensive water may be justified from the point of view of increasing the volume of supply and improving its mineral quality.

Water use

1. Water use efficiency to be increased by the following means:
 - (a) industrial use--re-circulation of water used, application of drier processes and adoption of air-cooling methods;
 - (b) domestic use--employment of water-saving devices in plumbing and elimination of leakages;
 - (c) agricultural use--installation of water-conserving irrigation systems; economy of water use in crop planning and cultivation in accordance with agro-climatic conditions; artificial reduction of evaporation and evapotranspiration.
2. Sub-standard water resources to be put selectively to less salt sensitive uses and possible upgrading, after treatment, for unrestricted use.
3. Water use to be reduced by the following means:
 - (a) all water supply and consumption to be measured;
 - (b) allocation of water to agriculture to be determined in accordance with farm unit size and agro-climatic conditions and in accordance with annual water yield forecasts;
 - (c) waste to be discouraged by disincentive rate structures.

Synthesis

After having reviewed planning in general, planning objectives, and planning strategies, the question now arises how can all these measures be integrated into one overall policy. The planning objectives and strategies, as expounded in the purple passages of political programmes, do not lend themselves easily to such integration. They are more in the nature of Platonic ideas, than of well-thought-out targets; they comprise everything that is and sounds good; they have, however, two drawbacks: (a) they are not realistic, for they disregard scarcity and the real state of the society, often intentionally; (b) they are not internally compatible for, in their obvious desire to kindle hope among all, they embrace incompatible targets.

For our policy synthesis, we must compile from objectives and strategies, developed on and propounded by the political level, an internally compatible set of objectives and strategies that makes due allowance for the dimensions of scarcity of the economy and for the real structure and potential of the society. This set, while taking political doctrines as points of departure will, nevertheless, comprise inventory and structural constraints and make allowance for factors of uncertainty; it will, in short, embody all the parameters entering into the development equation.

Through the implementation of development, far-reaching changes will be effected in productive capacity, in structure, and, with time, also in the political doctrines of society, and thus the "development vector," and the policies and strategies expressing it, will change. In other words, formulation of objectives, strategies, and policies has also to be conceived as a dynamic process; due allowance should be made for this fact, especially in long-term planning.

Since planning has significance only to the extent that it serves as a guideline for action, and since planning is here considered to be a continuous process, requiring periodic re-thinking and reviewing, detailed

policies, as laid down in a programme, will remain effective only for limited periods; major policies, however, much less affected by change, will continue to serve as guidelines for long-term action. The process resembles the routing of a mountain climb from the valley: general direction, or general strategy, is clear and will not change throughout the climb; the short first section is the only part of the detailed route actually visible and may be predetermined, while the next section of the detailed route is determined only when the climber reaches some intermediate point on the first section and is in a position to overlook an additional stretch of his route--keeping his overall general strategy well in view.

Dynamic development planning thus becomes a curious kind of game: it resembles a four-dimensional relativistic chess game with visibility so poor that we cannot clearly see beyond a few moves. The inventory (material and human) is our chessmen; our status quo, the original distribution of the chessmen; our planning strategies, the operative rules of the game; our objectives, the winning rules of the game. In this elusive, relativistic chess game, everything changes--chessmen, squares, operative and winning rules--consequently, a sequential decision type of methodology, guided by a general overall strategy, is the only approach adapted to the problem that will carry us forward to our goal.

CHAPTER IV
A TACTICAL APPROACH TO RESOURCES DEVELOPMENT
IN EMERGENT ECONOMIES

Introductory

The general strategies related to the development of land and water resources in emergent economies have been reviewed in Chapter III. These strategies were subsumed under two headings:

1. Strategies concerned with optimizing the utilization of investment within the planning period, with a view to maximizing immediate production.
2. Strategies connected with the contribution of the programme to subsequent development, or long-term development potential.

The first group of strategies operates within the dimensions of space and time and within the economic parameters. The second group introduces a fifth dimension, the human dimension, that of man, his society, and institutions.

Importance of Long-Term Strategies
for Emerging Economies

In developed economies, only the first group of strategies needs to be considered, with the exception of cases where completely new technologies are introduced. In such economies, development potential is already well-matured, and further expansion, if desired in one area or the other, occurs spontaneously as a by-product of growth. However, in emerging economies, existing structure is not growth-oriented, and development potential, the measure of growth orientation, is inadequate; this inadequacy may be considered as the most important single limiting factor in the evolution of self-sustained growth. In such economies the rate of growth related to a certain sustained capital input will depend upon the extent to which we can improve

the development potential. Singer^{*} has coined the term "capacity to create wealth;" a term close to, although narrower in scope, than the term development potential used here. He refers to the capacity to create wealth as a key factor in the development of emerging economies and states that "the fundamental problem of development is not to create wealth but to create the capacity to create wealth;... additions to the capacity to produce wealth mutually fructify, support, and stimulate each other." Consequently, the basic operational strategies for development and growth in emerging economies result from analysis of factors that control development potential and of ways and means to increase it. Some relevant comments are made in the following paragraphs.

Project Development and Utilization

Development of land and water resources, its scope and rate, is entrusted to two distinct social groups--the project development group--"the builders," and the project utilization group--"the producers." The builders are government officers or officers of regional authorities responsible for drawing up, implementation, and supervision of the programme. The producers--the immediate project beneficiaries--are entrusted with the use of the project facility to enable them to achieve greater production; in an irrigation project the producer groups are the farmers.

Development potential depends on the competence and motivation of both builders and producers to perform concurrently their respective functions, and the competence and motivation of the government machine through which they operate. Only the builder and producer groups fall within the scope of our analysis. The qualifications necessary in each group to fulfill the tasks imposed upon it are listed below:

1. Builder Group Qualifications

* H. W. Singer, Op. cit.

- (a) Formal technological training in its broadest sense to acquire the "latent" stock of knowledge required for the job.
- (b) Job-training in the application of technology in order to obtain "operative" or "active" knowledge.
- (c) Sustained drive or motivation sufficiently strong to carry the group throughout the required time span over the difficulties and temporary frustrations usually encountered in programme implementation.
- (d) Ability to organize informally into groups and teams as required for carrying out the inter-disciplinary tasks of development. Such a group requires a leader, an individual endowed with leadership qualities capable of making decisions, bearing responsibility, inspiring confidence, creating motivation in the co-members of the team, and able to bring about the organizational differentiation necessary for the execution of a complex job.
- (e) Ability of the builder group to motivate and guide the producer group to perform its part of the work.

While the task of the builders is most definitely group-oriented, leaning heavily on team spirit, structure, and social stratification, that of the producer group is only partially group-oriented and the success of the producers will turn more on individual drive, achievement, and qualifications. The principal job qualifications of the producer group are listed below:

2. Producer Group Qualifications

- (a) Technological experience: although some technological experience exists it is generally of a traditional nature-- and associated with inefficient production. New technological experience is required.

- (b) Motivation and sustained drive to discard traditional technology and adopt newly demonstrated techniques; this transition requires readiness to undertake the risk of untried, unfamiliar practices and should be encouraged by incentives and professional support from the builders.
- (c) Motivation to change micro-agro-structure to the extent necessary for initial implementation of technological change. Existing micro-structure is usually of traditional pattern imbued with deeply-rooted emotional association, and offering considerable resistance to change.
- (d) Ability to cooperate with other producers in those phases of the task that cannot be successfully accomplished individually.

We do not have to look far to recognize vicious circles operating both in builder and producer groups. The members of the builder group have had little opportunity to acquire practical active knowledge of the complex methodology of true development of emerging economies--for the simple reason that in their own country no such development existed within their particular sector of activity. Furthermore, any applied training which they may have obtained in foreign countries is generally lacking in many of the elements of paramount importance for development planning within their own society. Improvised efforts of their own to start a development process will have met with the resistance of the rest of the established organization and run aground on the general structural and institutional inadequacy of the economy; the drive behind such efforts gives place to frustration and gradually the builders become conditioned to inactivity, passiveness, and apathy by the working of a vicious circle: burst of activity, failure, frustration, conditioning for passiveness and inactivity, and finally, ultimate apathy and inaction.

Similar vicious circles, though on a different plane, develop

amongst the producers. Here, basic conditioning is that of imitation, and through imitation, repetition of traditional routines of production, marketing, etc. The members are from childhood conditioned against departure from traditional routines; attempts may have been made in the past by government agencies to change these routines--attempts which for one reason or other were ineffective. Such failures have only served to strengthen the conditioning of traditional approaches. In the case of the producer group, one additional decisive factor exists--the risk, and the adequacy of the incentive to take risks. Improvements of agricultural techniques are usually connected with initial additional inputs; additional inputs involve additional costs, and, since the risks of a bad harvest and other fears, apprehensions, and misgivings are ever present in the mind of the producers, the feeling is prevalent that an increase in stakes--and risks--may not be sufficiently rewarding. Consequently, if we wish to break these vicious circles we shall have to bring about a change in the mode of thinking and attitudes of both the builder and the producer groups in preparation for the development task; we shall have to convey to them and have them absorb the job qualifications that we have outlined above.

Development Potential and Learning Theory

All the listed job-qualifications--formal, technological, as well as emotional and social ones--must be acquired. All habitual, obsolescent practices must be blotted out and "job-learning" of adequate approaches initiated. The process of adding to the development potential is, therefore, basically a teaching and conditioning process; it consists in acquiring the capability to do a task by the very act of carrying it out properly--first under supervision, and subsequently by strengthening the motivation to repeat the performance, through gratification experiences. This problem is related to learning psychology. Research and experimentation with the application of learning psychology to our specific problem should be

undertaken, and is likely to prove beneficial to our operational tactics. It is strange that the methodology of the psychology of learning has been so little applied to the problems of resource development in emerging economies.

Development Islands

The translation of this approach into working tactics differs from case to case, but it will often consist in the establishment of successful nuclei of development, both among the builders and producers.

The approach of development nuclei is recommended because the resources available for development (material, human, structural, institutional) in emergent economies are usually inadequate for massive attack along the whole development front; if a full-scale frontal attack were attempted, resources would be too thinly spread, their effect would be subliminal, and the threshold of catalization would not be reached; development would, therefore, not attain fruition. Such a subliminal spreading of resources would be barely sufficient to support a few selected aspects of the development front, and these salients would remain fragmentary due to the poor interlinking prevailing in emerging economies, and would fail to draw with them the rest of the front. Such a subliminal spreading of resources tends only to deepen and consolidate already existing vicious circles, and thus retard, rather than stimulate, development potential and sustained growth.*

If, instead of the subliminal spreading, we choose to apply available resources--from the national inventory and from foreign aid--for a concentrated attack on a number of strategic areas or projects,

* H. Leibenstein in his book "Economic Backwardness and Economic Growth," John Wiley and Sons, Inc., New York, 1963, p. 16, calls this threshold value "critical minimum effort." According to Leibenstein "in order (to reach) the transition from the state of backwardness to the more developed state where we can expect steady secular growth, it is necessary, though not always sufficient, that at some point, or during some period, the economy should receive a stimulus to growth that is greater than a certain critical minimum size."

and if this attack is so planned as to ensure a full coverage of all development parameters, human and material, for the chosen area or project, the chances are that active development nuclei will be successfully created.

The two main objectives of these nuclei are to serve as training projects in the widest sense of the word for the builder group, as well as demonstration projects for the producer group. Through these training and demonstration effects, the development potential may be increased to such an extent that, within a short time, it could transcend the limits of the original development nuclei. If the location (geographic and within the economy) of the development nuclei is so chosen as to ensure maximum leverage, the national development potential will be considerably invigorated, and the catalyzing effect of the development nuclei on the sector as a whole will be most significant.

In the pursuance of such a development task, planning and implementation should cover every detail in all phases of activity so as to ensure that the whole programme can be carried to a successful termination without the occurrence of any crippling mishaps or bottlenecks. Since it is of utmost importance to ensure success, and thus initiate circular causation created by success, it will often be desirable to create an artificially controlled environment, especially auspicious for development, and carried way beyond what might be considered feasible for later action on a larger scale. Once positive circular causation is created in the development nuclei, it will spread to neighbouring organizational and geographical areas; such spread can be encouraged by planned "seeding" of the new doctrines to new areas.

The creation of the controlled environment to facilitate positive circular causation may, in some cases, involve relatively high unit costs in scarce material and human resources, costs not justified by an economic analysis confined to the immediate production benefits only. However, these development nuclei are undertaken for their impact on the development potential rather than for their immediate production contribution to the economy.

Provided the evaluation takes this into consideration, it will be found that development nuclei have greater value for the creation of capacity to produce wealth (and through this capacity for the sustained creation of wealth) than less far-sighted projects with immediate production targets. It is hoped that a standard approach for a rigorous quantitative evaluation of the impact of programmes on the development potential will, in time, be elaborated, and that it will then become possible to arrive at a fully quantitative comparison of the combined impact of the two main aspects of projects: production and development potential.

The political implications of development potential and its growth are also of paramount importance in emerging countries. Frustration and despair, created in people whose hopes are constantly thwarted by the operation of vicious circles, will not remain confined to purely professional and economic spheres, but will spill over into other areas of thought and emotion and infect them with the same blight. People thus injured adopt negative political ideologies and social attitudes. By the same token, once transformation of vicious into positive circular causation is achieved, it will invade other mental spheres, create positive attitudes to work and development, and, in time, colour political ideology. The impact of initial success achieved in the development nuclei upon the decision-makers at the political level constitutes a further important political aspect, likely to lead to far-reaching catalytic effects upon the whole development front: nothing succeeds like success. The spreading or generalization effect here described is well known from our knowledge of experimental psychological phenomena, and further study of this effect is certain to lead to improvement of tactics specifically aimed at such generalization.

Multiplication of the Development Islands

Once a positive circular causation is established in the builder group of one project, a mechanism comparable to that of cell division may

be set up. As the original development cell matures, it may be divided into two independent cells; each comprising a part of the original catalyzing agent, and each consisting of staff trained and conditioned in the first cell "generation," with the addition of some new local still "unconditioned" manpower. One of the two cells, the "daughter" cell, may now be entrusted with the creation of a new additional development nucleus; the daughter cell could for some time be supervised from the parent cell until fully independent, when contact would be confined to coordination and exchange of experience. After another maturation period of approximately two years, a new cell division could be organized; new, yet unconditioned, staff incorporated into the cycle of sustained growth, and the growth process thus seeded into new areas. Growth, according to this cell division model, would develop according to a geometric series: if, for example, initially four development nuclei were established, eight would be in existence by the third year, sixteen by the fifth year, etc. This growth rate would, in addition to material inputs, necessitate, of course, the provision of basically trained professional and sub-professional personnel at the same rate, and should this prove impossible the maturation period should be extended.

Training Tactics for Programme Development Groups

We may now attempt to translate the strategies of development nuclei into operational tactics applicable both to the programme development group, the builders, and to the programme utilization group, the producers. The slow rate of progress that prevails in both these groups is proof of the existence of deadlocks and vicious circles, and some outside element must be added before they can be catalyzed into growth. The groups by themselves cannot pull themselves up by their own bootstraps; these missing elements are not the same from country to country and from organization to organization in the same country, and differ for the builder and producer groups.

The missing elements in the builder group usually comprise the following:

1. Capacity to analyze situations, take decisions based on such analyses, and act upon these decisions.
2. Conditions auspicious to blot out malconditioning and prevailing vicious circles--correlating action with failure and frustration--as well as the lack of opportunity to create new positive correlations between planning, implementation, and successful fruition; in short, adequate sustained motivation.
3. A micro-structure, conducive to the creation of a development oriented esprit de corps, and a formal organization as required by the project.
4. Liaison with, and support and encouragement by, government level.

If time were of no essence, spontaneous growth nuclei and reconditioning of the group might in time develop, leading to further growth both within and without the sector and, ultimately, to self-sustained development processes. However, since time is of the utmost importance, the slow natural process must be speeded up by adding to the existing set-up those deficient elements, i. e., by adding a catalyst in the form of a nucleus of trained, motivated, and structured manpower to initiate a process of positive circular causation. This catalyzing agent may be made up of expatriate or of local manpower; under conditions of underdevelopment the inclusion of some expatriate manpower will be the general rule. The basic task of the catalyst consists in setting up within the builder group a well-organized process of project planning and implementation. This process, if successful, will contribute towards the reconditioning of prevailing vicious circles and the establishment of new positive conditioning. The time period necessary for such reconditioning need not necessarily be protracted, and a two-year

period will often prove adequate for massive outside intervention, assuming that some of the catalyzing leadership elements will continue to operate within the group until adequate indigenous leadership elements emerge and take over. If, on the other hand, the development thrust is for some reason discontinued, extinction of the new positive conditioning is most likely to occur, leading again to the strengthening of negative attitudes and vicious circles.

Training Tactics for Program Utilization Groups

The tactics to be adopted for proper motivation of the programme utilization or producer group will differ from builder group tactics. The reason for this difference lies in the relative lack of social organization involved in the work of the producer group; though, of course, influenced by his social environment, the producer usually makes his own analysis of the situation, arrives at his own decision, and implements this decision individually. His work behaviour is conditioned by traditional village work patterns, and is largely conformative and ancestral. He responds as farmer and villager to social and occupational situations in a preordained manner, and he is generally content to follow pre-established paths of minimum resistance. If the farmer is to adopt new responses, new paths of minimum resistance must be established, and adequate motivation created to take the new paths. Without these two pre-conditions for change in the attitude of the producer group, the farmer remains confined to his limited repertoire of responses, even when faced with the entirely new conditions created by new development projects. Trapped by tradition he will not be able to utilize new opportunities, and the project will fail in its last and most important phase, that of the actual exploitation of the resource for full production fruition. Under these conditions, up-to-date project technology will be thwarted by inferior exploitation and production approach.

In order to achieve the two basic pre-conditions for development, i. e., the creation of new paths of response and of adequate motivation to take these new paths, the tactics to be adopted should again be based on the psychology of learning processes. The demonstration or development nuclei approach should again be chosen in the initial phase. Detailed planning and organization for all phases of the operation, coupled with adequate incentives, should, as recommended for the builder group, again be used in order to create the controlled conditions necessary for successful implementation of new production methods for areas where traditional agriculture had previously prevailed. The proper application of new methods should be taught by motivating the learning person to apply correctly--at first under control--the very methods to be taught. The artificiality of controlled conditions and induced motivation serves as a driving force, moving the producer out of the rut of the traditional into new desired paths; the continuation of the induced motivation will ensure that the new paths become sufficiently well established so as to be retained, even when the artificiality of the production conditions will be gradually replaced by normal levels of support and supervision.

To anyone working under conditions of emerging economies it is, of course, obvious that a knowledge of the correct production approach will not by itself lead to improvement at the level of the producer group. The discrepancy of what can be achieved within the fence of an agricultural research station and what is actually achieved on the other side of the fence is a forceful indication of this. In order to achieve the desired reconditioning, demonstration and incentives will be necessary. The demonstration effect will be achieved within the framework of the development nuclei. This effect will have to be supplemented by a system of effective incentives and continuous support in the organization of the micro-structure of agriculture.

In order to avoid a relapse into inefficient traditional production

methods and to sustain the process of growth started on the development nuclei, local structure and organization must gradually be established and induced to take over from the project group one area of intervention after the other. Cooperative organizations at local or regional level seem best suited for this purpose; they should supply a number of services, such as credit, procurement, marketing, mechanization, etc. The take-over from the original organization established by the builder group should be gradual and the degree of independence achieved provides a valuable yardstick of the extent of maturation of the project at the level of the producer group.

The catalyst initiating change at the level of the development nuclei of the producer group will, in the first phase, be the extension branch of the builder group; with the spreading of the development process, the producer group that will have become retrained and reoriented will both directly and indirectly take over more and more of the proselyting effort. A sprinkling of expatriate specialists may be required for the start. The number of expatriate personnel may gradually be reduced, but care should be taken not to do so prematurely in order to avoid a dangerous relapse into traditional practices.

Summary and Evaluation of Programme Contribution to the Development Potential

Summarizing our comments on the tactics to be adopted for the promotion of the development potential, we should like to set forth a set of criteria for evaluating the contribution of alternative project mixes to the growth of development potential.

1. What extent of participation and involvement of local builder and producer groups does the programme entail? The higher the participation, the greater the contribution to development potential.
2. What extent of spreading of such participation does the programme

comprise? The wider the spreading, the more significant the demonstration and spreading effect.

3. How gradual is the rise in the requirement of professional men to be employed in extremely complex operations? The more gradual the rise, the better the chances for success.
4. Does the project mix go the whole way from plan to production and marketing to ensure successful fruition and the important psychological effects of such success? Is the programme sufficiently comprehensive?

Once a programme is adopted, we should ask ourselves a number of additional questions connected with the tactical approach to be chosen in order to promote the growth of the development potential. Some of the more important criteria are listed below:

1. What important aspects of the programme need demonstration and conditioning measures?
2. What organization will best ensure the success of such measures?
3. What inputs of capital and human resources (local and foreign) will be required for such measures?
4. To what extent are these resources available and to what extent must they be created during the planning period?
5. What additional measures for the formal and informal development of human resources should be taken during the planning period in order to ensure smooth continuation of development in the next period?

CHAPTER V ELEMENTS OF A WATER RESOURCES PROGRAMME

Programme Components

Basic Components

The land and water resources programme seeks to optimize the use of allocated resources with the object of satisfying short-term demand and increasing development potential. The planner must base his programme on the following factors laid down in the overall development plan.

1. Specified demand function--requirements of the economy in goods and services, as defined for the scheduled plan period.
2. Allocated capital and human resources--capital resources are generally well-defined, whereas human resources are taken for granted on the assumption that the supply of trained manpower in government service will meet demand.
3. Defined planning horizon--the scheduled planning period is generally defined in the overall plan.
4. General objectives--often the planner will find that general objectives have not been fully defined in the overall economic plan and that alternative distribution patterns for investment, each with a resultant benefit of its own, may exist. The usual dichotomies encountered relate to contesting areas or sectors of benefit--present or future generation? rich or poor regions? immediate production or sustained growth? equal investment spread or maximum return per unit investment? production volume, improvement in balance of payments or the increase in employment opportunity?

Strategies and Tactics

The components taken over from the general economic plan on the one hand, the general development strategies and dimensions of scarcity applying to the economy on the other hand, may

now be welded into a set of compatible operational strategies and criteria to guide actual investment choices. These operational strategies vary from one economy to another; change with time even within the same economy, and hence must be reconsidered with every plan revision. Strategies of water and land development must also be consistent with overall economic plan strategies, as outlined in Chapter III.

The Demand Function

The demand function of water resource development is based upon agricultural production targets and domestic water supply needs of urban and rural areas. The general aspects of interdependence between demand function and other parameters will be referred to elsewhere in this chapter.

Inventories

It will be necessary to process inventories--land, water, capital, human, and institutional resources. These resources are all interdependent, but, for the sake of simplicity, they will be first analysed individually, and their interconnection considered later.

Resources inventories are not constant stock lists. They are, rather, dynamic processes, changing with time along a number of dimensions, such as scope and depth of exploration; extent of exploitation and its pattern in time and space; technological progress; development of the economy; training and structure of the professional inventorying group; institutional framework; or any combination of these.

These aspects of inventorying, with specific application to the field of water resources, will be dealt with elsewhere in this chapter.

Alternative Plans and Their Evaluation

Alternative plans may now be drawn up for the use of resources, according to strategies adopted, with a view to achieving the objectives of the overall plan. For the purpose of evaluation and possible recombination of parts of alternative plans, projects may be subdivided into self-sustained, benefit-yielding sub-units and phases. These sub-units and phases may be re-combined into various project mixes; disposing the sub-units along the time axis gives a further dimension of variation. Evaluation

of the alternative project mixes may now be undertaken, by using criteria evolved from the adopted set of strategies; part of this evaluation may be in quantitative terms, part must often remain in semi-quantitative or in purely qualitative terms. Hence, ultimate ranking will seldom be the straightforward outcome of calculations but will depend to a considerable degree on weighing semi-quantitative and qualitative factors. Project mixes and their evaluation will be dealt with elsewhere in this chapter.

Programme Implementation and Continuity

A programme will comprise planning of high priority projects, as well as investigation, data collection, and planning for long-term development. It should include all provisions necessary for the continuation of planning beyond the planning horizon. The planning of water and land resources development is often a long-term process and it is not generally feasible to adopt the shorter planning horizons of general economic plans. Furthermore, our plan must provide all the data required for action to be taken during the scheduled planning period, as well as to outline all operations connected with data collection, survey, planning, and design, to be conducted during the planning period under consideration, in order to ensure continuity of implementation in subsequent planning periods. Thus, our programme must case often detailed projections beyond the planning horizon of the overall plan, and, in order to be able to do so, must make general long-term assumptions for the entire economy, even before the general economic planners are prepared to make such predictions. Further reference will be made to this subject later in this chapter.

The Demand Function

Water fulfills four distinct functions in human society:

1. biological - consumption of water is necessary for human survival
2. hygienic - use of water is necessary for preservation of personal hygiene and sanitation

3. industrial - water is necessary for individual industrial processes, although generally in only minor quantities
4. agricultural - precipitation or irrigation is necessary for plant growth

The demand function of water resources must, therefore, be considered in accordance with its particular function.

Domestic Water (biological and hygenic demand)

The demand for domestic water cannot be readily expressed in economic terms for market forces are generally not operative in this context. Decision as to scope and timing of provision of domestic water supplies usually depend upon general social and health considerations, on the one hand, and the availability of funds, on the other hand. This does not make the demand for potable water any less real than the demands resulting from the operation of market forces, whether internal or international. Water is a basic commodity and should be made available in the earliest stages of development for two reasons:

1. It takes precedence over any other commodity in sustaining life and health;
2. By conditioning health standards, it improves man's productive capacity, both physical and mental.

The planner should appreciate the urgency of demand for domestic water and should take full cognizance of the time value dimension in planning domestic water supply. The inability to express the benefits of water supply projects in monetary terms does not diminish the reality of these benefits.

Industrial Water

Water in industry may be considered as an infra-structural service, rather than a significant input. There are very few industries in which the cost of water constitutes a significant part of overall production costs. Industrial demand will, therefore, usually be controlled by the type and scope of industrial development included in the overall economic plan; in other words, water cost elasticity of this demand will be very low.

The exceptions to the rule are large water consuming industries in arid areas or exceptionally "wet" industries, like pulp and paper. In such conditions, methods of reducing water requirements should be considered, such as recycling, air cooling, and drier or other processes.

Under conditions of scarcity, industrial uses may compete with agricultural uses. In modern economies a clearcut preference is indicated for industrial use, due to the fact that the return per unit of water is 25 to 50 times greater in industry than in agriculture. Industry also provides--generally--greater employment opportunity and the efficiency of industrial production is considerably higher than in traditional agriculture.

Agricultural Water

The nature of agricultural demand for water differs basically from that of domestic and industrial demands. In agriculture, water is one of the most important inputs of production, and its cost will often have a decisive influence on the type of crops grown and the volume of production marketed. Preliminary planning should be carried out, based on assumptions of demand, in order to evaluate the influence of water costs on the location, type, and volume of agricultural production. These water costs should be entered in the input column of the economic evaluation of agricultural development. This evaluation will yield new demand figures for water, and hence a revised plan must be prepared; if the water cost figures of the revised plan differ considerably from those originally entered into the economic evaluation, the process will require repetition.

The volume of water required for irrigated agriculture is generally large and the development of the water resource requires heavy capital investments; these investments tend to be lumpy, with the bulk of funds required in the initial phase. Due to budgetary limitations, this results in protracted construction periods and late maturation of the project; often ten, twenty, or more years may pass between initial investment

and fruition, and the early phases of fruition will often be disappointing, since the farmer reacts to the new means of production put at his disposal by the project by taking paths of least resistance in continuing traditional agricultural practices.

A number of other factors should be taken into account and added to the original calculated capital cost. Such factors include interest during construction, loss of considerable parts of the fixed charges during the maturation period, loss in benefits due to delayed use of water, and the time-lag in adopting more efficient farming methods. This additional cost may constitute a very heavy burden and in extreme cases, considering the high opportunity cost of capital in emergent economies, may as much as double the original cost; the planner should make full allowances for these factors. This may have an important bearing on the extent of spreading of investment and the degree of phasing to adopt in the programme, and it may lead him to attempt management and manipulation of the demand parameter.

Manipulation of the Demand Parameter

The objective of demand manipulation will be to create, foster, and develop the demand function for water (mainly, but not necessarily, in agricultural use), and to promote efficiency in the use of water, ahead of the major and usually lumpy project investments in order to ensure full and efficient utilization of the project as soon as it is feasible. This probably sounds like putting the cart before the horse, but some action in this direction is almost always possible, and there are numerous cases where pre-investment demand manipulation can be carried out on a large scale. The pre-investment development of volume and efficiency of demand may, depending on local conditions, take many forms; some of the more obvious approaches are given in the following:

1. Initial partial manipulation of the micro-agro-structure, e.g., improvement of land tenure, including reduction of fragmentation; creation of cooperative organizations for marketing, procurement, credit, etc.

2. Improvement of cultivation by pilot projects within the area and encouraging the spreading effect of such demonstrations.
3. Development of demand for water, initially through the development of local resources up to sustained yield levels, and, consequently, by relying on "overdrafts," i. e., by taking local water on a credit basis with a view to discontinuing this credit with the implementation of the project or even, in extreme cases, to "pay back" later with imported project water some of the local water withdrawn in the pre-investment phase.

The implementation of pioneering projects of such or similar nature, ahead of the main bulk of investment, has numerous direct and indirect advantages:

1. It creates full, or at least partial, demand before the completion of the project and thus shortens the period required for the absorption of project water.
2. It increases efficiency in the use of water even before project water becomes available.
3. It creates new paths of minimum resistance in the farmer and generally makes him development-conscious.
4. It creates added annual income. Through this income, financial resources for participation will be created both in financing the project (taxes) and its corollaries (farm investment from savings).
5. As already pointed out, it considerably reduces the development and maturation costs of the main project, i. e., the interest during construction, loss of fixed charges, and loss of benefit through low initial efficiency.
6. In certain cases, it makes it possible to delay the main investment over a considerable period.

The Inventory Process

The inventory parameters, directly related to the development of land and water resources, are numerous and their evaluation is difficult due to their interlinking in space and/or time. These direct parameters are, in addition, linked to and dependent on other parameters of the economy that have only an indirect bearing upon land and water resources. All these direct and indirect parameters change and interact along the time axis; in order to describe adequately this constant change and interconnection we must abandon the static listing of resources, to which we are accustomed, and adopt instead a dynamic model in which we can predict only short-term trends. The study of the inventory process will, therefore, be in the nature of gradual approximation rather than of simultaneous solution of an extremely complex matrix. The first predictions will serve as a basis for a first generation of project solutions, fortunately relatively insensitive to the wide scatter of data predictions which, at this stage, is unavoidable. This first generation of projects will feed back new data to the inventoring process, making it possible to construct and evaluate less simplified resources models and reduce the possible scatter of predictions due to uncertainty. A third project generation will follow and contribute, as a by-product, its share in the gradual elaboration of the resources model.

The principal external factors that have a bearing upon the inventory process are listed in brief in the following; they will be treated later in greater detail.

1. Extent of exploration;
2. Extent of exploitation of resources;
3. Technological progress;
4. Scope and trends of the economy;
5. Training and structure of human resources;
6. Institutional and legal framework;
7. Any combination of the above factors.

All these factors are, to a certain extent, interconnected, but for the sake of simplicity, we shall treat them separately.

The resources relating to land and water development which enter into our inventory are as follows:

1. Natural resources, primarily land and water;
2. Capital resources, internal and foreign;
3. Human resources, including the builder group (to construct and implement projects) and the producer group;
4. Structural resources, including informal organization, motivation, cooperation;
5. Institutional resources, including formal organization, legal, political, and social institutions.

Inventory procedure for these five elements will be discussed later in this chapter.

Parameters Affecting the Inventory Process

Extent of exploration. The scope, depth, and reliability of exploration of the resource is an extremely important factor in the inventory process. In emergent economies, exploration will rarely be very elaborate due to scanty data and some aspects will be dependent on feed-back data from exploitation.

Initial development phases can be based on rough data, as they are not oversensitive to the unavoidable scatter of early data projections.

Extent of exploitation. Any form of resource exploitation involves a disturbance of previously established and generally natural equilibria; this unbalancing may have far-reaching effects upon the sustained yield of the resource, upon its quality, its quantitative and qualitative variability, and sometimes even upon its location. Since, in the utilization of water and land resources we deal with rather sluggish equilibria, changes are usually gradual, and transients develop which are often of the highest significance in the effective planning of resources management and

utilization. Since this subject will be covered in some detail in a separate chapter, we need not enter here into any more detail.

Technological progress. Technological progress will have a decisive influence on the inventory process, and may affect items, such as

1. data accumulation and evaluation;
2. development, e. g., water drilling;
3. extraction, e. g., pumping;
4. manipulation of resource parameters, e. g., storage for flow regulation;
5. reducing resource losses, e. g., reduction of evaporation.

A new technology may even create serviceable resources where none previously existed, e. g., desalting of sea or brackish water, or directly influence the hydrological cycle by cloud seeding and other attempts at manipulation of climate. Such basic changes of technology may have a revolutionary impact upon a whole civilization and countries doomed to aridity may become fertile and productive.

Scope and trends of the economy. Within certain limits the economically-utilizable part of the inventory depends on the price the economy is ready to pay for this resource; thus, the size of an inventory will very much depend on the market prices of the products for which water is a significant input, i. e., mainly agricultural products. In addition to its dependence on the market price, the payment ability of a certain agricultural product for water depends on the yield per unit of water, on the cost of other inputs, and on the efficiency of use of the product and its by-products, if any. The volume of water which the agricultural economy may be ready to absorb at a specified water unit cost also depends on the composition of the crop mix and the inclusion of high value crops. With the general development of the economy, crop mix may improve, leading to an increased ability of the agricultural sector to purchase water. Similar but less explicit relations will apply to municipal and industrial

water supplies.

The above comments show clearly the dependence of the economically utilizable inventory of a resource upon the status and growth of the economy which it is intended to serve.

Training and structure of human resources. Exploration, inventorying, conservation, and development of resources is a complex process requiring highly trained manpower, sustained motivation, adequate informal and formal organizations, and last but not least, considerable expenditure. All these resources are extremely scarce in emergent economies and numerous programmes will compete for the use of these scarce resources. The scarcity will, in one way or another, affect the inventory at least in its initial phases, and development of human resources will, by the same token, also expand inventory potentials.

Institutional and legal framework. Land and water were among the first resources for which laws and institutions were established in ancient times; these laws and institutions are today among the most resistant to change. Every programme for the development of natural resources requires a specific legal and institutional framework for its implementation. In the ideal case, the planner will optimize his quantified solution and then define the institutional framework needed for its implementation; in reality, such an ideal framework will be wishful thinking; there is no frictionless society, operating according to optimal rules, since society does not operate in an institutional vacuum. On the other end of the scale of institutional flexibility and mutability, stands the traditional society with an absolutely immutable institutional framework. Extent of flexibility of the legal and institutional framework will certainly affect the extent of utilization: the more immovable institutional constraints the lower the extent of utilization and the further we shall be from our ideal optimized operational rules, the lower the efficiency of the system, the greater loss

and waste. Institutional factors are among the most serious and recalcitrant factors contributing to waste and abuse of resources, even under conditions of scarcity.

Due allowance for the institutional constraints and a realistic appraisal of the feasibility of their gradual relaxation will therefore be among the most important considerations in the determination of a serviceable inventory for a development programme.

Combination of factors. The above analysis of the influence of the individual isolated factors on the programme inventory is, of course, a purely theoretical abstraction; in real life, all the above factors are inter-dependent and all concurrently affect the inventory and the inventoring process.

Inventoring of Resources

We have seen that the inventory of a programme depends on a number of interconnected factors, all constantly changing their own strength and direction and that of their interconnections; these factors are either connected with the inventoried resource itself and the extent of its utilization; with the interrelationship between a number of inventoried resources, or with external factors of the economy and the society. Since all these factors and their changes are predictable only for a short range, it will usually be impossible to solve simultaneously the whole complex inventory matrix and its interlinking with the rest of the economy. Simultaneous solutions will certainly be impossible in emergent economies, where data are often scarce and unreliable.

A serviceable approach would consist in a step-by-step iterative procedure. In the first round, environment and technology are considered constant, and every resource evaluated separately, with links cut to other resources and to the rest of the economy; the individual resource is considered as an independent process along the time axis; the influence and constraints of the links are then considered and superimposed on the original evaluation, and

anticipated short-term developments of environment and technology may then be added. In the second round, values obtained in the first round may be entered into an identical analysis, yielding better figures.

With time, additional data and additional insights become available, and additional changes occur in environment, technology, etc.; this makes it necessary to repeat the inventory process. Some inventorying process will continue throughout the project, and comprehensive re-thinking of the inventory will be required at least once for every planning period.

Resources inventories (especially those prepared in the early phases of development) should not be confined to most probable average figures, but should include estimates as to the range of possible deviations of future, more exact, estimates from the present average figures. Such deviations may be caused by the unpredictability of natural conditions (e. g., climate) during the planning period, by the limitations in our understanding of the natural processes and equilibria, and by the inadequacy of our statistical data.

An estimate of the range of these deviations will, in the early phases of planning, be sometimes almost as important as estimates of average figures. Various project mixes will have different sensitivities to variations in resources data. By analysing alternative programme mixes as to their sensitivity to deviation within the estimated range, we shall be able to choose a mix not oversensitive, involving less risk of misinvestment. Where, for one reason or the other, a sensitive project must be included, we should, at least, estimate the cost involved, if resources vary within the limits of the range of deviation, and appraise this risk against the inherent advantages of the project.

Water resources. The basic objective of the inventory process of water resources is to estimate maximum yields that can be achieved in dimensions of space and time without running the risk--at any point of space and time--of

quantitative of qualitative deterioration beyond what may be considered as acceptable in the programme. To achieve this aim, the inventory process cannot be confined to a static listing of sustained yields of resources, based on the anticipated final steady state that will ultimately develop with a certain pattern of utilization; it must adopt dynamic appraisal procedures that make it possible to analyse and predict all transient stages that will develop in the extended period between the first stages of interception and use of water and the convergence upon the ultimate steady state. Rivers and flowing water are often used as symbols of change. Herakleitos, the first propounder of a philosophy of the dynamic, uses the river metaphor in one of his most striking fragments: "you cannot step twice into the same river; for fresh waters are ever flowing in upon you."

Objections may be raised that this kind of analysis is not feasible in emergent countries, since these countries do not generally possess the comprehensive body of data that a dynamic analysis requires. However, rough and ready models can usually be compiled even with limited data, and the results obtained from such an extremely simplified model accompanied by an estimate of the range of possible deviations may, nevertheless, be sufficient for the initial steps of development.

As development proceeds, and the utilization percentage of the resource increases, a more elaborate model and a closer range of deviation may be required; this will become possible with the accumulation of additional data from the implementation and exploitation of the initial phases of development. Generally, it may be said that with the adoption of proper planning procedures, an inherent adjustment mechanism will be created between extent of utilization and degree of sophistication of evaluation.

We should also bear in mind the inverse relation existing between the reliability of inventory evaluation and the flexibility of a project. In the initial phases of development, inventory reliability (as expressed

by the range of deviation) is low, but, on the other hand, project flexibility within the framework of a comprehensive and dynamic programme of sufficient range along the time axis is still relatively inexpensive; gradually, inventory evaluations become more reliable while the cost of flexibility increases. In the final phases of development, flexibility becomes negligible, but reliability has, in the meantime, increased to such a level that flexibility should no longer be required.

Land resources. For reasons connected with my professional limitations, I shall confine my treatment of the inventorying process of land resources to some general comments.

Land resources seem much less of a "flowing" and changing resource than water. To the unarméd eye, land would not appear to be in a state of flux or have the flowing characteristics of water, but a closer analysis shows that land resources nevertheless are changing; that their potential depends upon an interplay of all the factors already enumerated. Even the time scale of change is not, in reality, slower than some groundwater resources. The potential of land resources may change basically by the application of irrigation water, of fertilizers, and soil conditioners, and other aspects of cultivation. It may also change under the influence of natural phenomena of wind and water erosion.

With land, as with water resources, the eternal battle of conservation versus destruction or over-exploitation continues, and all efforts should be directed toward development with full regard for conservation and amelioration practices.

The influence of the human, structural, and institutional elements on land resources will probably be even more decisive than we have found in the case of water resources; hereditary techniques and the responses of farmers are decisive factors in the productive potential of land resources and vicious circles and deadlock, related to land use practices are almost universal in underdeveloped countries. Improvement of these techniques

and practices will probably be one of the most essential points in the improvement of the development potential at the level of the producer group, i. e., the farmer.

Inventorying of land resources is thus part of a process rather than a static listing. The quantity and quality of the land inventory will, to a considerable extent, depend on a number of changing parameters. Improvement of the development potential by the development process will have a decisive influence on the land inventory.

Capital resources. We have assumed that the overall volume of capital investment for the development of land and water resources during the planning period has been determined within the framework of the overall economic plan, and the same applies to the general objectives of the programme. It thus depends on the programme planner to determine how best to achieve these objectives with the capital resource at his disposal.

Unfortunately, prevailing procedures differ widely from this idealized outline. The planners of the national capital budget programmes generally receive from the ministries responsible for the development of resources politically ranked lists of installations and facilities accompanied by cost tags; somewhere the list must be cut, somewhat arbitrarily, in accordance with budget allocations. The sectorial programme planner has then only to detail the engineering of the hardware aspects of the programme, and it is no wonder if he secures only a small part of the potential productivity from the investment.

A recommended procedure would be the inclusion in the general plan of general sectorial objectives, and to earmark capital resources of sufficient volume to reach these objectives. The sectorial planning team could then draw up a detailed development programme by optimizing the use of the capital resources at the planner's disposal, ensuring a uniform development front, with the occurrence of a bulge only where lumpiness of investment makes it unavoidable.

A complication often arises from the fact that major sectors of development programmes often fall within the jurisdiction of more than one ministry. Furthermore, supporting features of the development programme overlap different spheres of government activity. In order to achieve an unbroken development front that would seem to be a precondition for growth in emergent economies, and in order to ensure a consistent programme, allocations must be coordinated both by the general economic policy group, and later by the planning groups of the various ministries. Full coordination is seldom achieved, since the ideologies and capabilities of various ministries differ and are subject to the short-term vagaries of politics.

Most financing institutions are fully aware of the paramount importance of a unified organization for effective allocation and use of capital investment. They often require proof of the adequacy of organizational aspects of the programme before granting loans for a programme, which, from the economic point of view, may appear attractive.

Frequently, the apportioning of capital investment does not maintain a correct balance between basic programme investment and the incidental but essential investments of a programme. Investments in human, structural, and material infrastructure are either completely ignored or inadequately endowed; working capital and funds to subsidize initial operating costs in the development and maturation period are generally deficient.

Human resources. Of all development resources, the human resources are the most elusive and least amenable to planning. A carefully thought-out programme, giving proper weight to increasing development potential, can revolutionize the capacity of a human resource. This resource, therefore, more than any other, requires a dynamic, process-inventorying approach.

Inventorying should commence by drawing up a list of professional and sub-professional personnel available, the extent of their structure and organization, and the vicious circles and deadlocks that maim its

effectiveness and efficiency; it should, furthermore, try to estimate the anticipated increments to professional and sub-professional manpower during the planning period.

The inventory should then turn to the requirement of the programmer in human resources, its structure and organization. Available resources, if inadequate, will have to be supplemented by recruiting national or expatriate manpower. The structural, organizational, and motivational aspects of manpower are almost always deficient, and the minimum requirements to make these aspects adequate for a "take-off" must be estimated. The programme planner should evaluate alternative project mixes for their contribution to the structure of the builder and producer groups.

Manpower for the development programme must be allocated for the following functions:

1. data collection and evaluation,
2. overall resources planning,
3. planning and design of short-term projects,
4. construction and/or supervision of contract management for short-term projects,
5. agricultural extension,
6. legal, institutional, and administrative problems.

All these functions should be developed concurrently in order to ensure a continuous development front, although, with regard to pre-investment infrastructure, isolated thrusts at selected aspects may be of value, scarcity can be alleviated for a time and to limited extent by bringing in foreign manpower and by hiring consulting services for some aspects of the programme. Basically, however, the problem of scarcity of human resources will force us to concentrate our resources for full deployment of all the development aspects of limited pilot areas, the development islands; it is better to penetrate on a small front than to fail on a long one!

Already at the stage of allocation of manpower, we come up against the problem of overall scarcity of resources on one hand, and against that of the relative pull of the various functions on the other hand. Some service aspects of development, such as data collection, are not particularly attractive. These functions usually are removed from the main stream of development and their work programme is seldom coordinated with the main programme group; there is also poor contact and feed-back between the main development group and the service groups. The service group usually feels left out and frustrated. In order to create motivation and enlist participation, the work programme of the service groups should be correlated with that of the main development group, and current contact maintained. They should be encouraged to feel that their work is essential and that they are directly connected with immediate issues, not just the dead end of the programme, involved in collecting and filing data for some possible future reference.

I have commented on internal allocation of manpower at some length, since the fate of a programme is often decided at this phase of the effort. Planning, beyond the scope of local and foreign human resources, lack of balance in the distribution of the force, neglect of some less glamorous aspects of development planning; all these can lead to awkward bottlenecks and spell ruin to programme implementation.

Institutional resources. Institutions are formalized consolidations of repetitive human contacts within a framework of society. Some institutions have developed spontaneously over the years out of living contacts, while others have been created by administrative decision. The social and legal institutions of the first group, with their venerable history and deep-rooted traditions, often represent a petrification of ancient human relations; a carryover to an age for which these relations have become meaningless, preventing, by their very survival, the evolution of new institutions adapted to the problems of the day. The second group, including mainly governmental and semi-governmental organization, is

generally, in emerging economies of more recent origin, often a foreign graft and more amenable to change. Even so, such existing institutional and organizational patterns are intertwined with political, tribal, class, and vested interest patterns, and form a complex and tangled web.

The inventorying process of institutional resources should begin with a thorough stocktaking of the status quo; of discernable tendencies of society to change institutional patterns; of motivating political doctrines and forces; of the determination, as well as the ability of these forces to bring about change. These change tendencies, slight as they may be, are often proper points of attack for those initial institutional changes which are mandatory for development. They may be the only point at which proper leverage can be developed for the initial breach of a deadlocked society on the way to creation of positive circular causation.

The next phase of the inventorying process will consist in formulating those changes in the existing institutional framework which are mandatory for the programme. A step-by-step approach, which may hopefully lead to a chain reaction, will often be chosen. A study of institutional requirements in the subsequent planning period and an outline of the necessary measures will follow.

The determination of a realistic programme for adaptation of the socio-legal institutional framework of spontaneous origin to the requirements of a development programme is not an easy task. Tradition, political doctrines, and vested interest loom so large that the planner may see no way to climb this unsurmountable barrier; in most contexts his success depends on his ability to induce the political level to support his measures and to rally additional allies to his aid.

The job of planning the adaptation of the formal organizations of our second group to programme requirements is less formidable, though, nevertheless, considerable. The ideal solution will usually be an authority established by the government with full powers to

implement the programme. It is not always possible to obtain approval for such an approach and compromise solutions are often unavoidable. The moot question that generally crops up in this connection is the measure of authority and responsibility to be invested with the programme organization and the scope and depth of control to be exercised by the ministries. Compromise is acceptable, provided it does not cripple freedom of action of the programme authority as related to strategic aspects. Authorities and their programmes are often doomed to failure, due to interministerial frictions and all that remains of them is a fine sounding name plate!

Solutions pertaining to institutional development should not be transferred from one society or context to another. Rather, such development should be indigenous, based on local socio-psychological, and political custom. Institutions are, in reality, only the skeleton of living relations within the social organism, at all its levels of activity, and the change of the skeleton, without prior or concurrent change of the living tissue, will not give birth to a viable organism. It is often attractive--both uncontroversial and painless--to adopt the organizational trappings of an entirely different socio-economic context without concerning ourselves with the inner matter, its micro-structure, but this can be no substitute for natural institutional growth. Fifth Avenue cannot be created in the desert by putting up a signboard. The danger of substituting signboards for real development is acute in political regimes which advocate change for the sake of change. Under the conditions of such a regime, the planner should exploit tendencies and plan his institutional and organizational reconstruction in a more comprehensive way than the planner operating in a more conservative regime; he should, however, avoid recommending external changes beyond what he feels can be concurrently accomplished at the micro-structural level. He should bear in mind that abortive reorganization is worse than no reorganization, and that existing institutional patterns will, as a result, become more

deeply entrenched. Any attempts to reshape or recast these institutions will raise an outcry; accusations of iconoclastic tampering with institutions, hallowed by time and custom, will only succeed in aiding their perpetuation.

Evaluation of Alternative Programmes

Alternative project mixes should be evaluated for the optimal benefits, both tangible and intangible, that will accrue from the development of the available resources during the period of programme materialization. The synthesis of benefits and the respective weight attached to each, are dependent on programme objectives, conditioned in turn by the socio-political values of society. Programme objectives must themselves be formulated into operational strategies and criteria in order that they may serve as the yardstick of evaluation procedures.

We have stated that development strategies fall into two main groups:

1. Maximization of short-term production benefits and benefit distribution.
2. Maximization of development potential and long-term production benefits.

The first group--the short term policies--concerns itself with maximizing benefit streams, while manipulating demand for best absorption and utilization; adopting flexible projects to minimize risks and optimizing utilization of capital investment by phasing. In the final analysis, the decision will be taken on the basis of the discounted value of the surplus of benefit streams over cost streams, after due allowance has been made for possible handicaps and bottlenecks and to the possibility of deviation of actual data from original data in the preparation of the plan.

The second group of strategies--strategies of development

potential--are concerned with the less tangible benefits that will not materialize within the immediate planning period under consideration. Quantitative analysis of these benefits will, at this stage, often be impossible or at best the analysis can be only approximate. The strategies included in this group relate to the human and institutional structure, to the catalyzing effects of development, to the conservation of scarce resources and to the data yield of programmes.

The difficulty of quantitative evaluation of this group of strategies is probably one of the main reasons for the almost complete neglect of development potential strategies in programme evaluation, for it requires the summation of unlike factors--the quantitative results of short-term policies and the semi-quantitative and qualitative results of long-term policies.

Our scientific technological training has conditioned us, in the face of such dilemmas, to concentrate on the quantified criteria and to consider semi or unquantified criteria as pure speculation to which we, the representative of exact sciences, may allow ourselves to pay no more than lip service. However, the fact that a parameter is difficult to quantify does not in itself belittle its importance and actual project histories give ample proof that programmes which neglect the second group of criteria will not succeed in bringing a developing economy nearer to "take off."

Development programmes must therefore satisfy both sets of criteria in order to become effective instruments of growth; the relative emphasis will depend on where the economy or economic sector lies on the scale of underdevelopment maturity and on the length of time span for programme realization that may be acceptable both to the political level and to the public.

A programme that meets only the first set of criteria would bring about a measurable but not really decisive increase of production without significantly catalyzing any self-sustained growth processes. A programme based entirely on the second set of criteria would be politically unacceptable

and, if adopted, it is most likely to be abandoned prior to fulfilment because of its few tangible benefits. Thus, a combination of both sets of criteria with sufficient stress on both long- and short-term benefits, and making full allowance for the degree of maturity and time span of society, will provide the correct overall yardstick for evaluation of resources development programmes.

Every situation then calls for its own evaluation procedure though certain similarities between programmes of countries on comparable points of the scale of development will, nevertheless, emerge; details and tactical approach will usually differ; outline and strategy will remain similar. In the following, we shall try to delineate the typical phases for a development programme of land and water resources for a country at subsistence level.

Typical Development Phases

A development programme in emerging economies, to boost production and potential, may be achieved in three phases:

Phase one. Better use of existing means of production by the addition of intangible inputs--human, structural, and institutional--as well as material inputs.

Phase two. Improvement in the existing means of production.

Phase three. Creation of new means of production.

From the point of view of marginal analysis, these three phases should be implemented chronologically. However, without departing from basic acceptance of this chronological order of phasing, it will be found that there will be much overlapping or intermingling of phases. Phase one will generally contain some elements of phase two or even first steps of Phase three. This dilution of a programme based on a purely economic analysis by elements not warranted according to such analysis, nevertheless, becomes justified if we allow for the necessity to lay the structural and institutional foundation in each phase for the coming phase, and if we keep in mind political and psychological desiderata.

Phase one. This phase is concerned with the better use of existing means of production. Generally, utilization of the means of production in emergent economies is inefficient and a relatively small capital investment is sufficient to bring about a significant increase in efficiency--hence, this aspect of growth will be the obvious initial choice from the point of view of marginal analysis. It will remain the preferential approach for a considerable time, since diminishing return tendencies and the bottlenecks of later phases will be encountered only after a certain time.

The difficulties that crop up in the first phase lie mainly in the fields of human and institutional resources. Some of these difficulties arise from the fact that the measures which we take are in the nature of an initial attack upon a firmly entrenched but stagnant subsistence economy. The extent of the front requires both powerful zones and dauntless perseverance if a successful attack is to be launched and a breach made in the front. As a result, many planners despair and choose the easy way out by concocting a glamorous "hardware package." However, without at least a partial breakthrough on this front, sustained growth cannot be achieved in any later phase and the production effect of such a break-through will by far exceed that of the much more expensive third "hardware phase." Over-enthusiastic, large-scale adoption of first phase measures that are not based on a realistic appraisal of our forces of development may be no less dangerous than the hardware escapism: our forces would be spread so thinly along the vast front of resistance that their impact would remain subliminal, and resistance would only be strengthened.

The implementation of growth nuclei seems to offer a possible way out of this impasse. Sub-nuclei will, if properly planned and successfully implemented, be a tremendous morale builder for the development group and at the same time they will help to prize open the most recalcitrant vicious circles in the producer group; they will create foci of positive circular causation and will, by their very existence, tend to catalyze, radiate, and spread growth tendencies to adjoining areas. The importance

of these breaches in the front of stagnation does not constitute the only effect of the proposed procedure; the gradual change brought about both in the development and producer groups, and indirectly also at the political and government levels, will create the necessary pre-investment social and institutional structure for phases two and three, both of which involve large-scale investments that would remain only partially utilized or wholly idle without preparatory structural transformation.

We have already stressed more than once that to choose the alternative way and start with the hardware is like commencing the construction of a building from the roof. We know that an emerging economy cannot be classified as that type of organism that spontaneously grows foundations to an extraneous roof. The very existence of such structural and institutional foundations will give the development group the necessary self-confidence to plan further massive growth and will engender trust in the financial institutions and encourage them in their support of the programme. The successful launching of growth nuclei further leads to partial transformation from subsistence agricultural patterns to rudimentary monetary economies, with creation of new supply and demand functions.

The first-phase attack is the most important part of our development campaign; the success or failure of the whole campaign depends to a considerable extent on the outcome of the struggle. It will therefore require our utmost efforts in planning and marshalling of forces in all its logistic aspects. The human resources, both local and foreign, required for success, as well as the strength of the forces of resistance should not be underestimated. Eligible first phase programmes generally include improvement of cultivation and irrigation methods; crop and seed selection; pest control and fertilizer application; livestock improvement; provision of home semi-industrial supporting facilities; improvement of the agrico-micro-structure in relation to tenure, and fragmentation; improvement of operational and sanitary standards of

potable water supplies. Implementation of such measures, simple as it looks on paper, nevertheless involves the creation of major new structural and institutional capabilities, and it is this aspect which will constitute the "piece de resistance" of the first phase programme. The necessary dilution with second and third phase aspects already mentioned will be an intrusion into the programmes described in more detail in the following.

Phase two. Means of production in emergent economies are rarely fully developed. Tactics for the second phase will therefore be based mainly on completing the development of resources to their full capacity. The structural and institutional involvement, though less all-pervading than in the first phase, will still be commanding.

Stepping-up and improvement of the conservation and utilization of water resources in partial use will often be among the more important programme features of this phase, including full development of water resources in partial use and making available additional water by conservation measures at intake, by conveyance structures and by improvement of existing irrigation methods and introduction of new methods; improvement of seasonal and overall availability by storage and other manipulative measures; adding new facilities to increase the withdrawal and conveyance capacity of the water resources in use to their sustained yield. Ranking of measures will be governed by economic, institutional, and technological considerations.

In the field of agriculture, this phase might include agricultural and institutional development, among others: crop planning; more basic methods for the improvement of cultivation; increasing the cropping area; introduction of new crops; more rational use of fertilizers and irrigation water; seed improvement and seed propagation for local soil and climatic conditions; establishment of production incentives; cooperative organization for storage, transport, marketing of produce, and for credit procurement; provision of supporting industrial facilities utilizing agricultural products.

Some of the aspects of phase two will have already been initiated in phase one and an initial impetus obtained which can be utilized in the much larger application of phase two; most aspects of phase one will be carried over to phase two, and those of phase two to phase three.

Phase three. The third phase is the actual project phase, and is usually the exclusive concern of planners. It is the capital-intensive; less sub-divisible and therefore the more lumpy, lower in marginal benefit, and more dependent for these benefits on a developed micro-agro-structure than the two phases discussed so far. It will be effective only if the proper structural and institutional conditions have first been created by prior implementation of phases one and two, and to the extent that marginal benefits per unit of investment of these earlier phases fall below those of the project phase.

The third or project phase will need no defenders: for the technocrat, it is the planning phase for which he has been trained; for the politician, the programme that both looks and sounds fine in election manifestos.

Choosing a programme mix. Programmes should from the beginning be made up of elements of all three phases. Development should be initiated with a programme embodying mainly constituents of phase one, followed by elements of phase two and including aspects of phase three only to the extent that they are necessary to create structure, potential, and the development group for the later phases of the programme. Subsequent programmes should be based mainly on phase two features but should also include, in addition to some carry over and continuation of phase one features, a much larger proportion of phase three features. The later stages will be composed mainly of constituents of phase three.

Application of a progression of programme mixes ensures maximum growth in every stage of development by exercising development leverage at points most strategical for growth; further, these mixes

can be improved upon at a minimum of cost, and, at the same time, the ground prepared and subsequent growth phases pioneered. In real life, the optimizing of such mixes will not be easy; techniques of evaluation are partly controversial, partly in status nascendi; we shall therefore confine ourselves to a general description of evaluation approaches.

Programme Evaluation and Ranking

Evaluation and ranking procedures will usually take the following course:

1. Compilation of alternative programmes consisting of project mixes;
2. Evaluation of cost and benefit streams, in monetary and other terms, semi-quantitative or qualitative terms;
3. Comparing the quantitative and qualitative evaluations and ranking of alternative programmes.

The existence of capital rationing for the whole sector is assumed, as well as the definition, within the general economic plan, of objectives and the demand function.

We have already commented on the compilation aspect and can therefore turn directly to evaluation. A vast literature exists on this subject; the major development and financing agencies have in addition their own rules on evaluation and ranking.

It would be far beyond the scope of this presentation to undertake a detailed discussion of the approaches at present in use, and I shall, therefore, confine myself to a review of the basic differences between the existing and the ideal evaluation procedures as applied to developing economies.

The present procedures, which have evolved from legislative procedures of mature economies, generally take single projects as units of evaluation. Some theoretical work has been done on the evaluation of comprehensive programmes by McKean and others*, but practical

* R. N. McKean, "Efficiency in Government." John Wiley and Sons, New York, 1958.

application of the programme evaluation approach has been initiated only quite recently. In emerging economies, under conditions of capital scarcity and capital rationing, the programme evaluation procedure would certainly be of greater significance than the evaluation of single projects.

The present procedures confine themselves to the evaluation of the production function. In older work, analyses totally lacking in time dimension were adopted; more recently, benefit and cost streams along the time axis have been used. Four strategies may be mentioned:

1. the spreading strategy--to keep means of production within the absorptive capacity of the producers and thus minimize idle sunk capital;
2. flexibility strategy--to minimize risks of misinvestment;
3. phasing strategy--to minimize idle capital and increase flexibility;
4. demand manipulation--to minimize cost of maturation of a programme.

All these strategies are very rarely considered and almost never quantitatively evaluated, although all lend themselves to quantitative evaluation. The more long-term strategies connected with the growth of the development potential, including also data yield, spreading, and general scarcity strategies, are almost wholly neglected.

It appears to us that under conditions prevailing in emerging economies decisive weight in programme evaluation should be attached to neglected production and the development potential strategies. Such an evaluation approach would, it is true, involve a truly multi-discipline dynamic process analysis of alternative project mixes. In the initial phases of development, such an analysis would only partly be fully quantified; partly, it would be semi-quantitative analysis incorporating, *faute de mieux*, some rough and ready assumption; partly, it would be purely qualitative. With the accumulation of better data the evaluation would gradually become more quantified. With all its limitations under

conditions of emerging economies, process analysis is still the evaluation approach best fitted to determine the optimum mixture to be adopted for setting a country on the way of self-sustained growth.

The ranking procedure of a programme, as here recommended for emerging economies, will probably never be fully quantified, though quantitative approaches will in time be elaborated for many aspects that at present can be evaluated only qualitatively. To the extent that quantitative methods are applicable, time streams rather than static values should be used. McKean* states "one of the most significant partial tests--presented here as the 'right' criterion for determination of the economically efficient set of investments--is the maximization of present worth for a given investment budget, where the streams are discounted at the marginal internal rate of return. The basic idea is to keep high-valued capital from being put to low-valued uses. Under the conditions of capital rationing that confront government agencies the use of the above test can help to accomplish this objective." McKean then considers the possibility of using other discount rates with special time preferences and recommends a "practicable procedure," to prepare "a schedule of the best proposals at various discount rates and then to select the set that exhausts the budget." He recommends to choose "at least two rates, separated by a fairly wide interval."

This or similar procedures could be employed for the quantitative and semi-quantitative part of the ranking. A set of qualitative evaluation results for each mix would have to be considered in conjunction with the quantitative ones. Some rough quantifying of the qualitative results might be an aid in attributing weights. Nevertheless, a great deal depends on subjective judgement.

* R. N. McKean, "Efficiency in Government." John Wiley and Sons, New York, 1958.

Programme Implementation and Continuity

The drawing up of a programme does not end with the determination of an optimum project mix, and the optimum project mix is in reality only the starting point of programming including the following:

1. A plan of operation for the planning period relating to the detailed planning, design, construction work to be accomplished, including inventorying activities, organization, manpower requirements, etc.
2. A plan of operation on how to link up with the past, i. e., how to initiate positive circular causation on the difficult institutional front.
3. A plan of operation linking the present programme to subsequent programmes by conducting, during the programme period, such inventory activities, investigations, planning and design activities as may be required before the start of the next planning period, in order to ensure a smooth continuity of development.

All phases of the plan should from time to time be reviewed and reconsidered and part of the plan recast if necessary.

A programme, as here advocated, a "process approach" type of programme, would be based on a planned manipulation of the natural resources and their transients, demand and demand transients, quality and quality transients, institutions and institutional transients, human resources and their structural transients. It would be integrated to a considerable extent in the space and time dimensions. It would be planned to such an extent that public intervention could be implemented to a degree sufficient to make up for the gaps resulting from weak interlinking of the sectors of the economy.

The programme would be based on the concept of successive project generations, where each project generation, in addition to meeting adequately the requirements of the present, prepares the

ground (in every sense of the word) through catalizatory and manipulative processes for subsequent project generations, while continuing to operate at the later phases of development in a context that will change through integration of old with new project generations.

This type of integration, commencing growth at the "grass roots," does not require construction at the outset of very expensive integrating features; it will be based on growth where growth is required for today's production and tomorrow's catalization, but it will, nevertheless, as a consequence of the built-in integrating features, become in time more integrated physically to the extent that such an integration constitutes an economic asset.

CHAPTER VI
WATER RESOURCES MANAGEMENT--
GENERAL PRINCIPLES AND CASE HISTORIES

General--Parameters of Water Resources Management

Management of water resources is a planned intervention into natural equilibria or equilibria established by prior development with a view to intercepting water for human uses while causing a new equilibrium to be formed in the resource. This new equilibrium will not necessarily be stable, and in extreme cases water resources management leads to conditions of "no equilibrium." Utilization of a resource by necessity involves intervention through interception of natural flows or stocks, with resultant disturbance of the original balance.

A water resources basin is an extremely complex and only partly predictable dynamic system. The natural processes underlying the hydrological cycle are extremely involved, variable, and (at least at present) unpredictable. The media through which water flows are extremely unhomogeneous, usually assessable only by statistical analysis, and often only partly investigated. The interconnection between various types of resources is known only in principle and will therefore not be amenable to full quantitative analysis; the quantitative parameters of water resources, their distribution in space, and their changes along the time axis cannot usually be fully assessed, and, consequently, prediction of trends is generally unreliable.

A dynamic process approach will, therefore, have to be adopted for the study of management measures and their impact on resources equilibria and utilization capacities. A programme for management of water resources must analyse alternative management measures by considering the following principal parameters.

Scope of Management Planning

The planner will first have to decide upon the scope of his

management planning; the choices will be national planning, as against the planning of selected regions; the dichotomy facing the planner in relation to these choices will be to plan on a national scale and wait with implementation until results are available, or to choose areas of urgency and draw up regional plans for immediate implementation.

Boundaries of Individual Management Basins

The choice of the boundaries of a management basin will often be a decisive factor in moulding water resources development policy and determining efficiency in the exploitation of the resource. Management boundaries need no longer be considered as static constraints; they are changeable, and their position in space and time will depend on management decisions.

The Time Horizon

Every analysis is limited by some time horizon; beyond this horizon there is no purpose in planning due to the uncertainty and the widening scatter of predictions. The planning of management of water resources requires relatively long planning periods, since many hydrological processes are both slow and sluggish. A combination of a somewhat narrower time horizon for action and a wider one for guiding policy might here be the preferable approach.

The Choice of the Parameter to be Maximized

Parameters to be maximized will vary depending on the extent of quantitative, qualitative, or combined scarcity of resources. Such eligible parameters may be:

1. Minimizing cost to conserve and convey a given quantity of water;
2. Maximizing yield for exploitation--with conservation constraints and/or cost ceilings on marginal quantities conserved;
3. Minimizing water losses--with cost ceilings to marginal quantities saved;
4. Optimizing quality aspects--with cost ceilings;

5. Optimizing a combined parameter--expressing quantitative and qualitative aspects with cost ceilings.

Dependability of Data and Hypotheses

The quantity and reliability of data, the depth of our understanding of the flow mechanisms of the resource, the extent of simplification that we have to introduce because of lack of better data--all these will be decisive factors in water resources management. The extent of uncertainty controls the extent of flexibility required to minimize risks, and the limitations imposed on the scope of decisions.

Management Constraints

Constraints will be mostly related to the human element of the development equation: they may be connected with the professional, motivational, and organizational limitations of the project development groups, with institutional and legal problems, and, last but not least, with limitations of funds.

In the following sections, the above parameters and their influence on management planning of water resources will be described in more detail.

Scope of Management Planning

There exists no generally valid answer to the question whether to plan on a national scale before initiating development of a resource or to start the management planning at the regional level by sub-optimizing management conditions on such a level, and by giving priority to those regions which urgently require development. If the responses of nature and society to management intervention were instantaneous, we would endeavour to have the largest possible management unit; the nearer the unit would be to the total area, the closer would our sub-optimization be to the national optimum. Choosing smaller units for sub-optimization would involve the acceptance of partial autarky and the waste involved in it. Conditions prevailing in the natural, social

environment do not allow us to ignore the time dimension. We must therefore look for intermediate solutions which are closer to the optimum under actual conditions, although somewhat removed from the theoretical optimum. There are a number of factors that would tend to orient us to words "thinking big," and others, and would suggest an opposite approach. The main factors for management thinking on a national level are:

1. scarcity of water--national and regional;
2. high present utilization as expressed as a percentage of utilization potential, national and regional, and the small percentage of water still remaining for development;
3. great disparity of resources availability and dependability between regions;
4. special topographical configurations;
5. small overall area of country;
6. rapid demand development;
7. uniform distribution of demand growth;
8. considerations of financing image;
9. political and psychological attraction of national plans;
10. alibis for postponement of development;
11. availability of trained manpower.

The main factors that would tend to influence us to start management planning on a basin (or similar) level are:

1. absence of scarcity;
2. uniformity in the distribution of resources and demand;
3. small percentage of actual utilization;
4. lack of data;
5. large area;
6. slow rate of demand development, as compared with overall potential;
7. inadequate professional human resources;
8. last but not least, the necessity for immediate action.

Conditions of emerging countries usually fall into the second group of factors, except for these countries that labour under conditions of scarcity on a regional or national level. An attractive pragmatic strategy will consist in starting management planning on a regional basis, giving priority to regions requiring early development and among them to regions with scarce, undependable or otherwise problematic resources. Concurrently with the regional planning, over-all national thinking could be started and general development concepts developed. With time, two adjoining management regions could, if required, be integrated and thus gradually regional planning would merge into larger interregional units. Hand in hand with this planning "from the grass roots," nationalizing planning concepts could be deepened and broadened and in due time the planning from the top and that from the bottom would meet and coalesce into one national plan.

The proposed solution has the advantage of providing sufficient basis for early urgent management decisions without prejudicing the larger decisions that can be made only on the basis of an interregional or national plan. In emergent economies, the percentage of utilization of the potential is usually small, even if it can be predicted that the resource will be scarce in the future; therefore, management decisions made at an early phase and on a regional basis are not liable permanently to jeopardize major overall management policies, because of the flexibility inherent in the still undecided management decisions of the undeveloped part of the resource. As the country develops, and scarcity becomes more pronounced, management will, in any case, become more and more integrated until it takes in the entire country.

Postponement of development decisions, due to lack of data, cannot, under any circumstances, be justified; for it causes loss of production many times larger than the gain one could hope for potentially from additional planning data, and it furthermore diminishes the catalyzing effect of development on society.

The approach proposed has an additional justification: it serves to develop the professional and structural potential of the development group on smaller scale tasks, and thus prepares them for the larger and more complex tasks of national planning.

There are many cases where the same country has regions of water surplus as well as regions of relative or extreme scarcity. In such cases an "expanding" interregional plan may be adopted for the scarce region, with interconnection to adjoining surplus areas, while the areas of ample supply are left for later management planning.

Management planning must be given priority in all cases where the water resource constitutes part of an international hydrological system, in order to ensure full preparation for any negotiations to be carried out on an international level. The provisions of any bipartite or international agreements serve as constraints in the management equation of the resource.

Boundaries of Individual Management Basins

The determination of the optimal boundaries of an individual management unit (which we shall term a management basin) is an extremely difficult task, especially if we bear in mind that we are not here referring to static boundaries but to boundaries changing, and generally expanding, with time. No wonder therefore that planners have often preferred to circumvent this difficult task by adopting what I would call "arbitrary management units," without even feeling the necessity to justify their choice. The choice usually falls on units determined in completely unrelated contexts, such as administrative units and water user's cooperative organizations, etc. Natural, geographical, or hydrological regions are sometimes given preference, and though these "natural" units have greater justification than political units, they are, nevertheless, based on the completely unfounded assumption that nature is a good planner of water resources management. How then should the boundaries of a management unit be chosen?

There is no hard and fast rule for such a choice, and, furthermore, the choice will not be permanent, requiring revision from time to time. A trial and error approach will usually prove a useful procedure.

A hydrological basin may be selected for the first trial step: the demand projected resources management rules chosen, their application simulated, and the optimum management regime established; projections would have to extend over considerable periods; as we progress on the time axis, uncertainties will increase, and alternative assumptions will have to be made on the scatter between minimum and maximum projections. Should the resources of the assumed management basin prove insufficient to meet the demands of the basin, a wider boundary would have to be chosen from some point on the time axis, and the optimization procedure repeated. If the resources prove to be more plentiful than required within the planning horizon, the management basin could possibly be divided into smaller units.

Once such optimum boundaries have been established, the marginal benefits and costs of further manipulative measures may be calculated: if, for instance, the analysis has proven that at some point of time the supply of a hydrological basin must be supplemented by relatively expensive import from an adjoining or more distant basin, we should investigate whether it would not pay to make one of a number of measures or any combination of these measures.

1. To mine underground water formations until
 - (a) the quality of the mined supply is endangered,
 - (b) the marginal costs be greater than those of imported water,
 - (c) the supply exhausted.

The shortest of these periods will, of course, be decisive.

2. To increase storage by artificial recharge of the storage basin from surplus surface water, if present, during the build-up period of demand.

3. To build up demand and payment capacity for more expensive water through (1) and (2), and by trying to pilot high-valued uses into the area.

Analogue considerations would also apply to the relative timing of the development of the resources within a single basin. An optimized basin policy could, for example, provide initial development of groundwater and local surface water near the points of demand, provide some recharge from unregulated winter surpluses when groundwater levels start dropping, continue the utilization of the reinforced local resources, including some mining, until it becomes necessary and justifiable to import water from a distance, first without, and later with storage.

Such four dimensional optimization (including time in addition to the three space axes) will result in optimum use of the resource over the whole planning period. Although it will necessitate a certain duplication of supply capacity, first in relatively low-cost local installations, then in higher-cost installations for water imports, yet, if properly planned, the overcapacity created will not, at any time, be a wasted investment; the local facilities will work throughout the year according to the requirements of the load curve, provided imports are not yet available; this capacity will, of course, be considerably above the perennial yield. When imports become available, the utilization of the local resource will have to be pared down to perennial yield levels and this will be effected by moving the entire local production capacity to peak operation, letting the imported resource take the base of the load curve. This would enable us to reduce the capacity of the conveyance and distribution facilities for the imported water to a minimum, minimizing overall costs.

The above description is, of course, highly schematic and actual operation rules will deviate from this outline. The rules, nevertheless, indicate some of the basic policy approaches that can be taken in the selection of boundaries, in the establishment of expanding management

units, and the benefits accruing from such procedures.

The Time Horizon

The factors entering upon the equilibria equations of water resources are numerous and their interlinking most complex; therefore, dependability of projections beyond a certain time horizon will rapidly decrease, and predictions based on such projections become meaningless. This will certainly be the case where data and hypotheses are inadequate. If, on the other hand, the time horizon we choose is too short, we shall, owing to the sluggishness of hydrological processes, not be able to foresee the ultimate results of the proposed management measures.

In order to extract ourselves from this dilemma, we may choose a relatively short time span of perhaps 5 to 10 years for detailed analysis and planning of immediate measures, and retain a longer span of some 10 to 20 years for analysis of the boundary conditions of our problem, including the extent of possible divergence due to variations in input data. Since evaluation processes of management measures, and their impact on the resource, must be continuous, time horizons also move continuously, gradually increasing the time spans as data and hypotheses become more established.

The Choice of the Parameter to be Maximized

The choice of the parameter to be maximized is one of the most important, and at the same time one of the most crucial, decisions in water resources management. In making this decision, we must consider not only the relative scarcity of the principal parameters entering the management equation of the present, but, also, the anticipated shift in relative scarcities that can be predicted as a consequence of a certain management policy, and of the general economic development of the nation. If such shifts are not correctly predicted and allowed for in management planning, our policy may lead to the creation of

irreversible management facts, which, though justifiable by the relative scarcities prevailing at the time of decision, may preclude the establishment of a reasonable management policy based on tomorrow's scarcity relationships. Under conditions of changing relative levels of scarcity--and these will be the rule wherever resources can be expected to become scarce on a regional or national level--management measures adopted in the early stages must have sufficient built-in flexibility to make a later shift feasible.

The principal parameters entering the management equation are resources conservation, cost, quantity, and quality. Let us analyse the role of each parameter in the management equation.

Resources Conservation

Most social and political ideologies are very insistent on the necessity of passing on to future generations an undiminished and undeteriorated stock of water resources. Though such an attitude might, within certain limits, be justified for the overall national management policy, no case, moral or economic, can be constructed for this form of management of a regional resource: the next generation will be more developed, richer, and have at its disposal a more advanced technology; it should therefore be in better position to solve its problems with the same relative effort.

The conservation policy chosen for a certain resource will depend on the extent that the resource is considered as renewable. Renewable resources will usually (we are here neglecting transients, and these will be treated in a separate chapter) be utilized at a rate that, while ensuring maximum yields now will, nevertheless, allow maintenance of such, or similar rates on a sustained basis. Non-renewable resources, on the other hand, will often be utilized on a mining basis, leaving their future substitution to the better technology and investment capacity of future generations. Occasionally intermediate policies might be indicated.

Cost Parameter

The cost parameter may appear in two roles in the development equation: as a parameter to be minimized as long as capital resources are the parameter of greatest scarcity, or as a constraint of other parameters, such as quantity and/or quality, in the form of a cost ceiling. In the initial development phases of emerging economies, cost will usually make its first appearance as a parameter to be minimized, except under conditions of acute water shortage; under humid climatic conditions, as well as conditions of limited demand, this first role may be permanent; where resources will, with time, become scarce, the cost parameter will become subsidiary to quantitative or qualitative parameters, assuming for itself the secondary role of a cost constraint on the latter parameters.

Such cost constraints or cost ceilings will, in turn, depend on the costs of alternative water management measures and on the payment ability of the prospective users (as viewed from the point of view of the national economy and not from that of the user himself). Both these functions will change with time: management alternatives will change mainly with improvement of technology; payment ability with changes in production efficiency, shifts in water application from low-valued to high-valued uses, etc. No difficulty will, as a rule, be experienced in allowing for the improvement of technology; however, predicting shifts in the application of water will be difficult due to the unpredictability of resistance to change.

Quantitative Parameters

These parameters will be chosen for optimization where the scarcity factor is the controlling one. The quantitative parameters for optimization will usually be expressed in seasonal or annual quantities; where it is essential to express time preference of earlier supplies; this can be done by applying a discounting procedure. The cost ceiling, applied as a constraint, will change as a function of time. This

optimization is not necessarily identical with minimizing losses; however, it would lead us too far to enter into details here.

The optimization of quantitative parameters will be closely related to that of regulation by storage, whether surface or underground. Extent, distribution, and type of storage facilities, and their interconnection, are among the independent variables.

Qualitative Parameters

Qualitative parameters will be related to the sanitary and/or the mineral quality of water. Whereas sanitary quality can be improved by direct treatment or incidental improvement through management measures, mineral quality is much less amenable to change. The total quantitative balance of the most important mineral components will remain practically unchanged by any internal management measures. Management can influence only their distribution in place and time, and through mixing of waters of various mineral contents, achieve a redistribution of minerals in the formation water. External measures that change the mineral balance include selective discharge out of the basin of highly mineralized waters, and reduction of salinity by desalting processes, with subsequent discharge of the concentrated brine.

Mineralization will enter the management equation either as a constraint in the form of a salinity ceiling, or as a function relating salinity to productivity of water. In urban and industrial uses, the ceiling approach usually applies, although the functional relation may be more appropriate in certain industries; in agricultural uses, the functional relationship is the more logical, since the reduction in production with increase in mineral content will be gradual, but, due to the lack of data, a flat ceiling is generally adopted, at least until the functional relationship has been satisfactorily quantified.

Water may be used within one distribution system for both agricultural as well as non-agricultural purposes. In such cases, the more salt sensitive major--usually the agricultural--uses will be decisive in establishing quality constraints.

Combined Parameter for Optimization

An ideal procedure would be to establish a single parameter for optimization, expressing in a single function both the quantitative and qualitative aspects of a management unit. As long as data and hypotheses will not be sufficiently complete for such a combination, the quantitative parameter can be optimized for a number of quality constraints and the most attractive pair chosen for implementation.

Dependability of Data and Hypothesis

The dependability of resources management predictions will depend on the extent and dependability of the data collected about past performance of the resource and on the correctness of the hypotheses constructed (on the basis of such data) for relating to hydrological functions and their interrelationship.

Management planning is warranted for any amount of data. Even where no dependable observational data exist, one can always fall back upon some unquantified indication or construct synthetic data based on observations from similar watersheds. Hypotheses based upon such rudimentary data and management planning using such hypotheses will give at least some rough range for our predictions, and such predictions may be sufficient for the first development phases.

Management measures implemented in the initial development phases do not restrict our freedom as to the future continuation of exploitation of the resource to any major extent. The scatter of possible predictions stemming from the low dependability of input data and hypotheses need not, therefore, concern us too much. As utilization increases, flexibility as to future action diminishes; our predictions must become more dependable if we wish to avoid wrong decisions, and our data and hypotheses must improve. The very process of resource development, fortunately, offers us a means of improving data and hypotheses: initial implementation, and observation of the response of hydrological parameters to such an implementation, can be viewed as

a large-scale experiment for the verification of the adequacy of the originally assumed hypotheses; the feed-back from this experiment will enable us to improve gradually our original assumption.

Data collection requires the use of scarce human and capital resources that have valuable alternative uses. Dependability of predictions is of economic value, since flexibility of solutions, beyond certain levels of utilization, involves additional investments. The value of data will increase with the extent of the utilization of the resource. Consequently, for every phase of development there exists an optimum proportion of allocation of human and capital resources between development and data aspects.

Management Constraints

Management measures must be implemented in the four dimensions of space and time, as well as in the fifth dimension of society. Management is planned by man for men, in an institutional and man-created legal environment.

A planner, too much immersed in the elaboration of optimization mathematics, may completely neglect this fifth dimension; when faced ultimately with actual reality he realizes that his perfect theoretical solution has only one minor disadvantage: it just does not fit into the fifth dimension.

The most important constraints related to water resources management can be subsumed under three headings:

1. Constraints due to limitations in planning capacity;
2. Constraints due to lack of legislation and/or power to implement necessary management measures;
3. Constraints due to lack of legislation and/or power to prevent unplanned, inefficient, or in extreme cases detrimental exploitation of resources.

The first constraint can be mitigated and ultimately removed by the catalyzing effect of the development and planning process itself; in order to achieve the necessary starting momentum, foreign personnel or trained

local personnel from other sectors can be obtained. An early start of management planning, even if data are extremely scarce, will tend to make the development group management conscious and impart to it the training required for later, more complex, operations.

The second constraint. Solution of a management equation comprising only physical inputs will indicate how to convert the natural system, having a certain distribution of quantitative and qualitative flows in space and time, into a new system with a distribution prescribed by demand. When we try to impose this solution upon society, we come up against numerous legislative and institutional impediments: these impediments will usually be so serious that the solution will have to be reworked, with the legal-institutional factor entered as constraint into the original equation. Legislation and institutions, however, lag far behind the times, and are extremely resistant to change. It will therefore be realistic to propose changes in the first phases of management only to the extent that they are absolutely mandatory for the implementation of even a modest management policy. Spreading effects upon the political level from initial successful implementation of management measures will pave the way for the further gradual improvements. Fortunately, we can, as a rule, start management with a minimum of institutional changes, and delay major changes until the spreading effects of implementation will make the introduction of innovations easier.

The third constraint will often require a more active policy from the beginning, especially where, due to local or overall water scarcity, unplanned development might result in the deterioration of the resource, or would seriously interfere with its efficient utilization. Ad-hoc legislation to protect water resources will, in many cases, be more acceptable than comprehensive national water legislation; further, it will constitute a pioneering operation for later all-embracing national legislation. The extent of effort that management authorities will invest

in legislation for the protection of resources will depend on the gravity of the situation.

Case Histories

The importance of the correct choice of the size and the boundaries of the management unit will be demonstrated in three synthetic case histories. These case histories, while not representing any specific set of conditions and solutions give, nevertheless, a composite image of a number of real case histories. The first case history will juxtapose political-administrative management units to hydrological ones; the second, hydrological basins to wider management basins; the third will outline the most comprehensive scope of planning, the national management unit.

The Hydrological vs. the Administrative Management Unit

Description of prevailing conditions. A number of major, medium, and minor towns, as well as numerous villages, are distributed over a relatively narrow river basin. Geologically the basin consists of basement formations and groundwater is not available on a significant scale. The annual yield of the river is ample but in the season of demand the flow is insufficient or the river runs dry. The climate is either tropical or semi-arid. Few of the major towns and none of the medium size or smaller towns or villages have any water supply systems, and the few systems that exist are completely inadequate. Our problem consists in how to provide adequate water supply to the communities of the basin with minimum cost and delay.

Existing management approach. As the water supply situation becomes more acute, internal pressures build up; requests for water supply projects are forwarded to the government, each request backed up by political pressure. The responsible ministry has a certain capital budget at its disposal for water supply development, and will prepare a politically ranked list of projects for the whole country, cut off at the budget limit.

Among the communities selected for water supply development during

the budgetary period, one or two might be located within the basin of our case history. A consultant will be asked to design the project, and subsequently, implementation will start. In the following budgetary planning period another community in the basin might be selected for water supply development, engineering commissioned, and a separate scheme constructed. Over the years a considerable number of individual schemes will be constructed, each with separate dry season storage structures, treatment works, pumping station, conveyance system, storage tanks, etc. Sometimes a few minor communities may decide to pool together and construct a regional system.

Planning data are completely inadequate: flow data are non-existent or short-term and unreliable; consequently, practically nothing definite is known of minimum flow, length of the dry season, maximum flood, long-term average flow; further, the demand forecast cannot be firm, since the extent of urbanization, industrialization, and modern-type housing is not predictable.

Economic analysis of approach. The main storage structures, such as dams, spillways, etc., are the most expensive single cost item, accounting for 30 to 50 percent of the total cost; treatment plant and pumping station account for 15 to 20 percent of the total cost; the remainder is divided between conveyance and distribution pipe, tanks, etc.

A closer analysis of the cost of storage facilities shows that increasing storage capacity results in only a slight rise in total cost: cut-off costs do not depend on dam height, and foundation costs only increase slowly with the height of a dam; the increase of the cost of the body of the dam is, likewise, not proportional to the respective increase in storage volume. The cost of the spillway, possibly 25 to 35 percent of the total cost of the dam or more, will hardly change with the size of the reservoir. We see, therefore, that, as the size of the reservoir increases the parallel increase of cost will be very slight.

The cost of treatment and pumping facilities depends to a greater degree on the increase in capacity, but, here too, there will be a considerable economy of scale. Similar considerations will apply to conveyance facilities.

Separate water works for individual communities, each based on an individual storage structure must, under the conditions described, allow for considerable safety margins in their planning and design in order to compensate for possible erroneous assumptions in hydrological data, demand forecast, etc. Since there is a wide range of uncertainty, the safety margin will be considerable. Furthermore, each project must provide stand-by units to ensure supply in case of failure of an operating unit. Each plant and station will require a separate connection to the available power system or separate prime movers. All the systems will compete for scarce, trained and skilled manpower to design and later to operate and maintain the works, and due to the scarcity of skilled manpower the standard of operation and maintenance will often not be satisfactory.

Proposed change of management boundary. We have concluded that the prevailing approach has a number of economic and engineering disadvantages, the principal being the high initial cost and the lumpiness of investment of storage facilities. The expansion of the size of the management unit will therefore be an obvious way to avoid the repetition of this high and lumpy investment for every major community or group of smaller communities. The recommended management basin will here be identical with the hydrological basin. One dam and spillway will be built on the upstream reach of the river of sufficient size to regulate the flow of the river to an extent that will satisfy all possible demand during the dry weather season along the whole course of the river for a period of, say, 10 to 15 years. The water stored behind the dam in the wet season will be released in the dry season in order to sustain throughout the year a flow that is sufficient for water supply needs; thus, none of the municipal or regional projects would need any additional storage facilities. Regarding the other

facilities, i. e., pumping stations, treatment plants, pipes, separate systems could be constructed for every town or a number of communities could preferably combine into one regional scheme. The extent to which it would be economical to pool a number of communities under such a regional scheme would depend on the comparative cost of fewer and larger pumping and treatment facilities as against that of longer conveyance pipes. When making such comparative studies, the lack of trained manpower and the unavoidable lowering of operation and maintenance standards that will result from multiplication of plants should be allowed for.

The proposed solution has the following major advantages:

1. The cost (per capita) of the most expensive single cost item-- that of storage facilities--will be considerably lower.
2. Safety margins related to storage functions must be allowed for thus reducing overall costs.
3. Once the river flow is regulated, the cost of individual water works based on this regulated flow will not only be significantly lower, but it will be less lumpy, more phaseable, and, therefore, more flexible, and will involve less risk of misinvestment.
4. To the extent that communities agree to combine their efforts into a regional scheme, fed from the regulated river, the cost of the safety margin and stand-by services, the quality of operation and maintenance, the quality of service, and, therefore, the life of the project, will improve.

Institutional aspects. The proposed management solution need not involve any major organizational or institutional difficulties or friction: the task of regulating the river flow could be part of the duties of a central or regional government, while the individual water projects that obtain their water from the river may, after construction, be handed over to the municipality or group of communities. No new institutional set-up would be required, for major cities and smaller communities would have had to pool their resources in any case.

Management Basin vs. Hydrological Basin

Description of prevailing conditions. Case history II concerns a densely populated and cultivated coastal region comprising a large number of communities of all sizes. A number of rivers drain the area to the coast; the major rivers have adequate dry weather flow, whereas most of the other rivers do not flow at all during the dry season. Water supply systems exist only in the major communities but have become inadequate due to the rapid process of urbanization and industrialization. An optimum way is sought to provide the maximum number of people with an adequate water supply service as soon as possible within the limits of a predetermined budget. No groundwater is available. Data are as inadequate as in case history I and for the same reasons.

The conventional solutions. Each municipality or group of communities will stake out its claims to a specified, though usually exaggerated, quantity of water from the nearest river, as well as their claims for the largest possible chunk of the budget. Each project will start with costly and lumpy investments in storage structures. Each project will incorporate safety margins and provide facilities capable of generating an adequate supply for the next 15 to 25 years. Each project will have to provide for power connection or prime mover, for stand-by capacity of treatment and pumping facilities. Since each project will be able to grab only part of the required money, construction will be protracted. This approach will result in high per capita capital investment, very long maturation period with a large percentage of sunk capital remaining idle, or expressed differently: less people will be served for the available budget and those served will have to pay more for the service.

Economic analysis. We have already pointed out the main economic disadvantages of the conventional solution as follows: large per capita investment, idle capital; repetition of investment in safety factors, and stand-by capacity; relatively low quality of operation and maintenance, and therefore, shorter life.

The criterion for an improved solution would be the maximization of the number of service units (water supply service per man and year without differentiating the per capita demand) for a given budget; the time preference being expressed by a discounting procedure of the service units; concurrently, due allowance has to be made for the potential contribution of the proposed facilities to future service.

The proposed solution. An overall general plan is drawn up for the whole region which should provide for all the needs of the region for a period of, say, 15 to 20 years. This overall plan will be based on a number of river intakes; some with, some without, storage structures. A conduit system will connect the intakes to the communities. This plan is subdivided into phases, each sufficient to provide service for a five-year period. In consecutive phases, the source for a town might change; the flow in the conduits might change in direction and quantity. Intakes, storage structures, treatment and pumping plants, conduits, distribution facilities are provided only to the extent necessary for the immediate phase; capacities are increased as new resources are developed and fed into intermediate points of the conveyance system.

In such a system every dollar outlay is spent for immediate service; there is practically no idle capital, the number of people served will be at a maximum without, however, resorting to temporary investment; investment in safety margins of every description is minimized; data are accumulated for the later phases; the whole region is opened up from the point of view of water supply for industrialization. The facilities requiring the big lumpy investment, e. g., dams and other headworks, are constructed full scale, but only those included in every phase are required to supply the area they are planned to serve during the forthcoming phase. In such a regional approach it will matter little if we have mis-estimated demand, since correction, one way or the other, can be made in the next phase. This approach also has considerable advantages from the funding point of view: firstly, because the regional

solution has a much higher economic justification than a limited number of local ones, with a necessarily much more limited benefit range, and secondly, because there will be more communities, industries, and individuals to participate in repayment of the loan.

Institutional aspects. The approach advocated here will require, in addition to the adoption of a regional plan, also the establishment of a regional authority, or at least of a limited number of cooperating authorities. Concerted and well-planned action is a necessity. The question of participation in investment and operating costs will not be an easy one, since it will, at least theoretically, change with time. A simplified approach, based on a per capita or quantitative basis, might be a good short-cut to avoid protracted squabbles.

Regional vs. National Management Basin

Basic problem. New dimensions of scarcity, e.g., water scarcity, if added to those of the first two case histories (capital, human, data scarcities), compel us to reconsider our approach. Under such conditions the use of the scarce resource, i.e., water, can be optimized only if we continue to expand the boundaries of our management unit beyond the region until it comprises either the whole country or considerable portions of it, or, in extreme cases, a number of countries.

Sub-optimization of regional autarkic units will lead to inefficient use of the scarce resource. Detailed planning on a national scale and, still more, implementation on such a scale will, on the other hand, not be feasible for lack of time, human resources, data, and capital. A realistic approach under such conditions will, therefore, be to plan the optimization of the main features of the plan on a national scale (where the scarcity is national), and use the results obtained from such natural analysis as inputs and constraints in more detailed regional analysis. By taking this approach, we will avoid delay and be able to embark on intensive development from the outset without, however, creating any irreversible facts that would be contrary to the overall plan and jeopardize its future realization.

Generation of projects follows generation: the earliest generation at a local level; subsequent generations on regional and interregional levels; the final, on a national level. They would, however, all be planned in such a way that they will fit ultimately into one overall national pattern, like pieces in a jigsaw puzzle. The integrating features that will, to a lower or higher extent, be built into all project generations will be partly physical and partly of a management nature; they will refer to integration in space as well as in time, in quantity as well as in quality.

The planner will use a dynamic process approach in inventorying and scheduling, and will utilize transients of the system to the fullest possible extent; he will operate with direct and indirect, positive as well as with negative storage. He will endeavour to propose the legislative and institutional framework that is mandatory for the implementation of the programme. This programme will extend not only to the development phase but will also include the exploitation. This also will be planned on a national scale and be based on optimization procedures.

All this seems a pretty tall order especially in the framework of a developing economy; we should be aware of being overambitious; on the other hand, we cannot afford in developing economies to deviate too far from the optimum use of the scarcest resources without endangering growth. No effort is required by the poor to remain poor or for the rich to get richer. Poor people, poor nations are called upon then to use their brains even more so than rich, in order to bring about a change in their condition.

CHAPTER VII
THE APPLICATION OF WATER RESOURCES MANAGEMENT

Natural Equilibria and Human Intervention

Water, a renewable resource subjected to the influences of a climatic cycle, is in its undisturbed state at natural quantitative and qualitative equilibria. These equilibria oscillate in response to climatic functions between long-term average values; the quantitative equilibria with slight variation; and qualitative with an even narrower range.

Man's entry into new areas is almost always accompanied by immediate exploitation of existing resources, through interception of natural resource flow, and leading to a disturbance of these natural equilibria. Though such disturbance is an unavoidable corollary of exploitation, care should be taken to avoid embarking on a programme of exploitation without first evaluating the short and long term implications of such disturbance.

States of equilibria react to disturbance through processes of self-adjustment, leading through various transition stages into new, lower level equilibria; the resource thus arrives at transients, which represent gradual stages of flux from the original to the new equilibria. Changes in equilibria of groundwater resources are extremely sluggish, as a consequence of the slow rates of flow of water in porous media, and transients are therefore long lived. This longevity of transients increases their importance, especially in the initial development phases, for it will be the transients, rather than the ultimate steady state conditions, with which we shall have to deal over a period of many years. In a dynamically managed basin, in which rates of utilization wax and wane as the boundaries of the management basin expand, the prediction of transients becomes even more important. In fact, the analysis along the time axis of quantitative and qualitative transients, and the prediction of final values as they approach ultimate stability is one of the prerequisites of dynamic resources management.

The optimization in space and time of the utilization of a groundwater basin is possibly the most important example of such a dynamic management procedure. In the original state of equilibrium the formation receives a certain annual recharge, within the range of variation from rainfall, and discharges the same amount to the sea or other base levels. Average groundwater levels enabling this flow to be sustained are thus created. However, the interception of water and its utilization at an increasing rate will result in a lowering of groundwater levels, even if maximum utilization is less than the annual recharge; this lowering of the driving head will reduce the outflow to base levels. The fall in groundwater levels will continue until these levels have settled to a steady state when the discharge of groundwater to base levels will equal the average annual recharge minus withdrawals. The time period required for the establishment of the new equilibrium may be in the order of 10 to 30 years. During this protracted period the outflow from the formation to base levels will continue at rates well above that of the ultimate steady state: in the initial phases the rate of discharge will be close to that of the undisturbed outflow; it will diminish only gradually until the final steady state rate of discharge is reached with the passing of a complete transition period.

These continuous discharges to base level constitute losses of the system and occur in conjunction with withdrawals for utilization. The volume of water that will be thus lost by discharge to base levels equals the volume stored between the original and ultimate groundwater levels or between original and ultimate equilibria. In our simulation we have assumed that this volume, available only on a one-time basis during the transition period between the commencement of the withdrawal and the ultimate steady state, will not be utilized. We may, however, adopt a different policy of increasing withdrawals from the formation during this transition period by an additional amount of water than, over the entire transition period, will equal the above

one-time storage volume without in any way endangering the resource or jeopardizing its future use.

This pattern of utilization enables utilization rates to be increased substantially for extended time periods beyond sustained yield levels. Moreover, due to actual slow maturation of the demand function, withdrawal rates will not reach sustained yields or even the higher levels in one single leap but will gradually increase from very low to assumed maximum levels. As a result, maximum withdrawal rates may be increased still further, or, alternatively, the time period of pumping may be extended.

We could possibly continue to overdraw the resource for some time beyond the date when the ultimate equilibrium is reached, provided that we can later restore the overdraft either by reducing pumpage by an equivalent amount to below sustained yield levels or recharging into the underground formation that same amount of surface water.

Such a regime of exploitation can be implemented only after careful planning and scheduling of the location of the well fields and the individual rates of withdrawal. In order to avoid losses to base levels, some of the wells must be located at the downstream end of the formation and the schedule of pumping must give priority to these downstream wells. Since the withdrawal rates resulting from our wish to minimize loss to base levels, and those determined by actual demand will not necessarily be identical, some internal transfer of water from the downstream end of the formation for temporary upstream storage may be required in the early development phases. In reality, recovery of the above one-time storage will never be complete, since for one reason or the other real implementation can never be in full accordance with theoretical schedules; the increasing marginal costs of the last increments of recovery will also influence the actual recovery of smaller quantities than theoretically possible.

Where the formation is located along a coast line, the boundary line

or interface between the salt and fresh water must be taken into consideration. At the original equilibrium, the toe or the point where the boundary line hits the impermeable formation, the aquiclude, will generally be situated some distance out into the sea. With increasing interception and subsequent lowering of groundwater levels, the interface will be drawn inland; its ultimate steady-state position will be determined by the rate of outflow to base levels and the groundwater level controlling this rate at the steady state. The higher the percentage of interception, the deeper inland will the toe of the interface move before it reaches a steady state. This movement of the interface will follow the lowering of groundwater levels with considerable sluggishness. This sluggishness is caused by the wedge of fresh water that is stored in the formation between the original and the ultimate position of the interface and which must be withdrawn by pumping before the interface can progress inland. This wedge constitutes another one-time stock of water available for utilization, in addition to the above-mentioned regime of withdrawal during long transition periods. The existence of this temporary fresh water wedge will, of course, also influence location of wells and pumping schedules.

As a next step, we must visualize the connection between a groundwater formation managed according to the dynamic approach just set forth and the remaining water resources of the management unit. For the sake of simplicity, let us assume that the unit is a hydrologic basin draining into the sea, with an upstream surface water source with very irregular flow, and a downstream groundwater formation located near the principal areas of demand, assumed to extend along the coast. Let us further assume that the structure required for regulating the erratic surface flow and conveying this regulated flow to downstream areas of demand is costly and investment practically indivisible and, hence, lumpy. How then would the above pattern of groundwater utilization fit into the overall management plan of the basin?

Utilization of groundwater should certainly be the initial step, since it can be effected with least cost, least delay, and least risk. Groundwater withdrawals would gradually grow to sustained yield levels and then continue beyond such levels until one-time stocks stored in the formation will have been exhausted. While the initial regimes of utilization might have to be based on approximate calculations, with time our knowledge of these resources will increase and our flow models will resemble actual conditions. Further, during this initial period of groundwater development, we have time to collect flow data of the surface source, conduct investigations, and prepare our designs to ensure adequate conservation and regulation. Extended use of groundwater on a scale significantly greater than sustained yield levels enables the local agricultural as well as the non-agricultural economy to be strengthened and broadened to a position where they can bear the cost of imported water when the local groundwater yield will no longer suffice.

With the approach of a state of exhaustion in our one-time stocks, unregulated surface water may be used for recharging the formation in order to extend the period of groundwater use and enable the construction of costly storage and conveyance structures to be postponed for a further period. When the time arrives for construction of storage and conveyance facilities for expensive imported surface waters, the demand function and its capacity for future growth will have developed considerably and the period required for absorption of the new water will have been cut short, thus minimizing the cost of maturation of the import project. Groundwater installations may then be shifted from base to peak load use, leaving the base load to be supplied from the surface water scheme. Long expensive conveyance structures can therefore be designed for relatively low base load flows, at costs considerably lower than that of an equivalent structure in an independent surface water scheme. A comparison of the present worth of such a dynamic development programme with that of a conventional, statically oriented programme indicates the very significant advantages of such dynamic development programmes.

So far we have dealt only with the quantitative aspects of resources management and its transients; however, a full analysis requires also the evaluation of the qualitative aspects of transients. Qualitative equilibria are usually a concomitant phenomenon of the quantitative. Let us consider a simple case of the salinity of coastal groundwater formations; in undisturbed natural equilibria, coastal groundwaters contain quantities of salts originating from wind-borne coastal salt spray, as well as from normal leaching processes during percolation. The salt equilibrium in the formation is maintained by a continuous discharge of salt to base levels (as a result of the outflow of groundwater) which, on the average, equals the average salt input.

Withdrawal of groundwater for consumptive use reduces the outflow of water to base levels and with it the discharge of minerals from the formation, without, however, reducing the salt input. This disturbs the natural mineral equilibrium and causes a gradual build-up of minerals in the formation water until a new equilibrium is reached at which, again, the average annual discharge of minerals to base level equals the average mineral input. Since this discharge of minerals will, as a rule, be effected through the residual outflow of formation water, the latter must, at final steady state conditions, reach a salinity at which the annual average discharge of minerals at the highly reduced residual outflow rates again equals the original mineral input. A simplified numerical example will illustrate these qualitative implications of water utilization: an 80 percent rate of utilization of the average annual recharge to the formation will result in a 20 percent residual flow to base levels. To regain mineral equilibrium, the original salinity of the water would have to rise to 500 percent of its original value: only when this salinity level will have been reached will the salt discharge, now diluted with only 20 percent of the original undisturbed discharge, equalize the salt input.

Human intervention into nature's hydrological equilibria has,

moreover, additional qualitative implications. Municipal and industrial wastes seep underground, or, under conditions of scarcity, are induced to seep underground, carrying with them considerable quantities of salts; chemical fertilizers, pesticides, and herbicides applied in agriculture are ultimately carried down in varying quantities to the formation by rainfall or irrigation water.

Finally, the lowering of groundwater levels connected with exploitation may cause an influx of substandard water from adjoining brackish formations or from the sea. These secondary salt inputs will also increase with the water exploitation, and the ultimate salinity of water at the steady state will be considerably higher.

Fortunately, the qualitative changes of water in groundwater formations are more sluggish than the quantitative ones. Huge volumes of water are stored in the formation above and below base level, and the new mineral content must spread throughout the water mass before the change can become significant. Apparently, other processes also slow down the leaching of agricultural minerals into the formation. Owing to this slow response of groundwater formations to qualitative changes, transients of qualitative aspects will become even more important than those of quantitative aspects. In actual analysis, the two aspects of transients must, of course, be considered together.

Let us now stop to consider to what extent the simulated management pattern has changed the original basin regime and its natural equilibria: by planned manipulation we have succeeded in changing completely the flow regimes of groundwater; we have adjusted the availability of rate of flow water in space and time to meet our needs; we have changed the relation between ground and surface water, and through such changes increased the availability of surface water according to the requirements of the demand function; as a by-product of the quantitative changes, qualitative changes of water were brought about that will continue in their course for many years to come.

Management Parameters

The management equation of water resources will generally include five basic parameters and some outside constraints. The five basic parameters are:

1. The space-time parameter; the three space coordinates and the time coordinate of the point at which a certain flow will occur at a certain time;
2. The quantitative parameter, expressing the cumulative quantity of water over a certain period, usually one year;
3. The flow rate parameter, expressing the variability of the flow within season and cycles;
4. The mineral quality parameter, usually expressed as total dissolved salts (TDS);
5. The biological quality parameter.

All these parameters are, to a certain extent, interrelated; they can be influenced by measures within the management basin and by including the basin within a wider management context. A certain set of values and a set of functional relationships will express the status quo, as well as inherent change trends of the resource parameters at the outset of development. Usually, a different set of values and relationships will express the parameters of demand. The constraints relate to conservation issues, the capital and human budget, inclusive of their growth potential, available for development. Resources management is concerned with establishing the quickest and least expensive way for changing the parameters of the resources, as existing at the outset, into those prescribed by the demand function, while considering conservation and budgetary constraints. Dynamic management must not confine itself to studying initial and final steady states but must also investigate and endeavor to predict all transients between these two states.

Since the parameter set of the demand function constitutes the series of our management objectives, we may consider any process that brings the original parameter closer to that desired as an upgrading. Thus interpreted, it will depend from our point of view upon which process will result in significant upgrading; e. g., improvement of the biological quality of water may constitute a more significant upgrading measure from the point of view of potable water demand, yet be of no importance from the point of view of irrigation demand. By using the upgrading concept, we arrive at the following definition of water resources management: water resources management is a method of optimizing upgrading processes of water resources with due consideration to prevailing constraints.

Resources Conservation

In earlier chapters we have considered the constraints related to the budgeting of capital and human resources, and we shall therefore confine ourselves here to the analysis of the management constraints related to conservation issues.

In his paper "National Sources of Economic Growth: The Qualitative Problem"* Chandler Morse of Cornell University has analysed lucidly the main issues involved in the conservation controversy. He has exposed the conventional conservationist viewpoint, which is usually implied by the engineering approach to resources conservation as a static simplification unwarranted in a dynamic society of expanding technology. He has shown that a "changing resources spectrum" will change the "resources base" of production, and it is therefore not economically, or even morally justified to insist on quantitative conservation of a resource with a view to achieving a continuous and constant sustained yield of the resource. He does not deny the existence of a moral obligation to further generations in

* Read at the 1961 meeting of the Western Resources Conference, University of Colorado Press, 1962.

relation to resources use; rather, he maintains that these "obligations must be framed and discharged in the most sensible manner available to us." His thesis is that this could be achieved by maintaining what he terms "social welfare output";... "social welfare output means the gross output of society values in non-economic as well as in economic terms, full provision being made for the replacement of wasting assets, for research.... Thus we may and should act on the assumption that future generations will welcome, or at least will have no legitimate cause to complain if they receive an unimpaired per capita stock of social wealth." Owing to the variability of the resources base, the share of different resources in the stock transmitted to future generations will also change. Morse concludes that "Regardless of what happens along the way, the aim must be to avoid a final loss of social welfare.... Policy should be framed in the positive terms of optimal resource use, not in negative terms of optimal conservation."

Decision Patterns for the Management of Water Resources

The doctrine recommended by Morse may be applied both to renewable and exhaustible resources; water will usually be placed in the category of renewable resources, although the renewal of some water resources may be negligible. Basically the same doctrines may be applied to both categories of resources.

Policies related to the conservation of water resources may be guided by one of the three alternative ultimate management decision patterns.

1. The stable equilibrium--to attain, after transient stages, a new stable equilibrium, with only minor oscillations representing short-term fluctuations;
2. The unstable equilibrium--to arrive, after transients, at an unstable equilibrium, requiring continuous intervention, in order to avoid "run-away" conditions;

3. The no-equilibrium--to reach conditions of no equilibrium, and ensuring our ability to deal with such conditions.

The choice of decision patterns for a specific case will depend on our evaluation of specific hydrological and socio-economic conditions and their influence on the maintenance of "social wealth" (Morse); each of the three has a place in the overall spectrum of a national management plan. In the following, the three patterns and their combination in space and time will be analysed by applying them to typical management situations.

The Stable Equilibrium

The stable equilibrium pattern, being the most obvious of the three, is implied, at least in its overly simplified static version, in the conventional management approach to water resources: static stable equilibrium models underlie the concept of sustained safe-yield that is used in conventional hydrological analysis.

Standard evaluations refer usually only to the steady-state quantitative aspects and neglect the long-term qualitative implications of the adopted hydrological regime. However, where the "stable equilibrium pattern" is applied to closed groundwater basins, quality aspects will not converge upon an equilibrium, and where it is used for a quasi-closed basin (i. e., a basin in which, by hydrological management measures, the discharge to base level has been reduced to a small percentage of the original rate), the ultimate equilibrium quality will often be unacceptable. Owing to the extreme sluggishness of qualitative changes in groundwater formations and the various mechanisms that cause delay in the initiation of such changes, such neglect will hardly matter in the short run; however, if carried over into long-term planning, it would lead to dangerously optimistic qualitative predictions.

Switching from static to dynamic interpretations of the stable equilibrium theory, the quantitative and qualitative transients become available for temporary exploitation in addition to sustained yield; the quantitative for 1 to 2 decades, the qualitative for even longer periods.

Quantitative changes will not usually be decisive during the period of exploitation of quantitative transients, for in such dynamic management thinking the utilization of the quantitative transients will, in time, be discontinued and other water resources substituted for it. When the quantitative equilibrium is reached, qualitative changes have not as yet become too significant in most cases. In the event that the cumulative quality changes ultimately reach objectionable levels, the management planner will have two patterns of decisions open to him; he may either aim at a stable equilibrium in relation to the qualitative aspects, or choose our second basic approach of the unstable equilibrium of quality management, requiring continuous intervention into qualitative processes, in order to maintain the equilibrium at a certain level. We shall return to this question in a separate section.

In closed or quasi-closed basins, the stable equilibrium doctrine would involve the reduction of the rate of utilization that has been practised during the stage of transient utilization to a level, usually well below even the conventional sustained safe yield; it will therefore be chosen only where resources are ample and easy to develop. Where water is scarce or expensive, the unstable equilibrium approach will be chosen, coupled with the adoption of continuous remedial measures to hold the mineral content of the water within acceptable levels. This procedure would doubtless result in passing on to future generations a water resource of lower quality than that originally existing in nature. However, the cost of future remedial measures will certainly drop with technological development, so that the cost of these measures to future generations will be no higher than the cost of the development of alternative resources to our generation. This approach therefore does not run counter to the conservation policy proposed by Morse.

The management of a coastal groundwater basin, including the exploitation of the transients connected with its early phases, as described in some detail in the first section, is another example of the

management doctrine of stable quantitative equilibria. In this case, management planning must also consider the movement and ultimate position of the sea water--fresh water interface. The steady state position of this interface will depend on steady state groundwater elevations near the coast, and these, again, on the extent of utilization. The higher the utilization, the lower the groundwater levels; the further the inland interface penetration, the more involved the complications in the utilization of groundwater above the interface. Optimizing the relationship between the rate of utilization, the groundwater level, and the interface position may be counted among the more difficult management operations often requiring a step-by-step, and trial and error approach.

A further important application of the stable equilibrium approach is the manipulation of the surface-groundwater relationship; we shall here elaborate only upon one representative example: the manipulation of spring flow. Spring discharge is usually controlled by storage levels (or pressures in the case of confined formations) of the groundwater formation sustaining the spring. These levels (and the spring flow controlled by them) are highest in the rainy season or during humid cycles when the demand for water is lowest; on the other hand, they are lowest in the late summer or in dry cycles, when demand is at its peak. Availability of spring water along the time axis is therefore at variance with the requirements of the demand curve and dependent on the vagaries of climate; it will be the objective of management measures to upgrade availability by making it fit the demand curve. This upgrading of flow availability may be effected by lowering the groundwater level, controlling the spring flow to an elevation at which the flow would be completely under control. The lowering will be produced by interception of all the groundwater flow feeding the spring by pumping from wells.

The drop from original to ultimate levels will extend over a considerable period of time and the quantity of water stored between these two levels will again become available for mining, as a one-time stock, during the protracted transition period.

The upgrading of the flow parameter of springs can sometimes be supplemented by upgrading operations of the qualitative parameters: some springs pick up minerals as they flow through mineralized formations, and the water becomes brackish. Wells can be so located as to ensure interception of the flow before it comes in contact with the mineralized formations. A combined operation of this nature will result in upgrading both flow and qualitative parameters.

The Unstable Equilibrium

The unstable equilibrium approach is most often encountered in the analysis of manipulative measures to control the qualitative parameter. It is seldom adopted exclusively, but is usually part of a diversified approach, with stable equilibrium and no-equilibrium decision patterns as component parts. In the following, an attempt will be made to analyse the approaches available for the manipulation of the quantitative parameter, with special emphasis on the unstable equilibrium approach.

A purely quantitatively oriented management policy might result in acceptable quantitative equilibria, though it may often produce qualitative equilibria which will be objectionable for many uses. Lowering of qualitative levels can be prevented, and the resource held at a chosen higher qualitative level, by one of four methods of intervention, or a combination of such measures.

1. Artificial abstraction of minerals and discharge of concentrated brine out of the basin;
2. Recharging groundwater with high-quality imported water, in order to reduce the salinity of the formation water by dilution;
3. Dilution of pumped groundwater of high mineral content prior to use with imported high quality water;
4. Selective diversion out of the basin of highly mineralized water.

These methods will be dealt with in the following paragraphs.

Artificial abstraction. In order to reach qualitative equilibrium by artificial abstraction of the minerals and subsequent discharge of the concentrated brine, it will be necessary to abstract at a rate that, together with the continued discharge to base level at the specified salinity, would equal the average salinity input. Suitable processes for this purpose are the electro-dialysis or reverse osmosis methods. At present, these processes are generally too expensive for large-scale application at the present state of technology, but these or similar processes may prove to be economically feasible with future technological development.

Underground recharge with imported water. The application of this method will not, in effect, create a real equilibrium condition. The process of mineralization of the groundwater is interrupted by recharging the groundwater reservoir with imported low salinity water.

This approach assumes that the importation of the water is needed for quantitative reasons in addition to the qualitative need, and that the imported water will be assigned to consumptive uses within the basin. As a consequence of the interruption of the mineralization process, the salinity of the residual discharge to base level will be much lower than at equilibrium condition, and the salt discharge will therefore be less than the salt input. It is the purpose of the recharge operation to compensate for this salt build-up by providing the proper amount of dilutants corresponding to mineral accumulation. It will be necessary to increase the rate of recharging in accordance with increases in mineral accumulation. Further, the requirements of the dilution operation must be coordinated with those dictated by demand growth, and as no final equilibrium will be reached, the dilution must be a continuous process.

Dilution of groundwater after pumping with imported water. This method does not attempt to change the normal processes of mineralization of the formation water, and the mineral content is allowed to increase to a selected equilibrium level, at which the average salt discharge to base level equals salt input. The dilution to required salinity levels will be achieved

by mixing the pumped formation water, before use, with imported low-salinity water. This method must ensure the supply of the diluting water to all areas of groundwater use.

Diversion of highly mineralized water. This method is more in the nature of a palliative measure and by itself will, seldom if ever, bring about a solution of the quality problems of a closed or quasi-closed basin. It usually consists in collecting and discharging the highly mineralized industrial wastes and agricultural drainage water out of the basin. If combined with one of the three other approaches, it will contribute toward the reduction in their scope or allow delay in their timing.

A combination of two or more of the above approaches will usually be adopted in management of the qualitative parameters of a basin, implemented simultaneously or consecutively. Owing to the sluggishness of the processes involved and the built-in delaying mechanisms, transients, and their incorporation into a dynamic management plan, will be even more important than in the case of quantitative parameters.

When the more comprehensive management phase is reached, and the narrow hydrological boundaries are replaced by wider regional or national management boundaries, the salt balance need be no longer planned for a hydrological basin as a closed unit, but for the management basin as a whole; this wider approach will open new avenues for the manipulation of quality balances. The combined use of the formation with mineralization problems, as an underground storage reservoir for imported low-salinity water and as a mixing basin, can solve its salinity problems without causing any serious deterioration of the quality of the stored water. The imported water will, while flowing through the formation, mix with indigenous formation water to an extent that can be set to a predetermined level by proper planning in space and time, rate of recharge, and withdrawal operations. The combined use of the mineralized formation as an underground storage reservoir for imported

low-salinity water and as a mixing basin can solve the salinity problem of a formation without necessarily causing any serious deterioration in the re-exported water temporarily stored in the formation.

Quality management may also set different levels of quality equilibria for different sections of the management basin. The higher salinity water may be selectively allocated to less salt sensitive uses, such as municipal, industrial, or even agricultural uses, or for restoring the unavoidable discharge of the formation to base levels. Quality differentiation may also be practised in the time dimension: where summer irrigation is the most salt sensitive use, the basic salinity of the formation may be kept at a level considerably above that permissible for irrigation; at such salinity, the water would be used directly or via storage, for municipal and industrial uses; the winter flow of the dilutant could be stored, possibly underground, and reused together with its summer flow for intensive dilution of the formation water during the dry season, predominantly for irrigation; dilution could again be selectively varied for various parts of the basin according to the salt tolerance of the principal crops.

Numerous alternative approaches or a combination of approaches may be worked out in such a comprehensive management plan. Ultimately, we would have to broaden our analysis and consider the introduction of drainage and special cultivation measures that would create conditions permitting the growth of crops in more saline waters: a comprehensive optimization procedure would have to include all these factors.

As management measures become more comprehensive, we shall require more elaborate models for our optimization; these models, in turn, will require more data input which should be obtained as a by-product of earlier phases of management implementation.

The No-Equilibrium

The most obvious example of the third, the no-equilibrium decision pattern, is the mining of a stock of water, i. e., exploitation at a rate that will remain permanently above recharge rates. Such mining will be continued until:

1. the resource is exhausted,
2. groundwater levels drop to depths from which pumping becomes uneconomic or unfeasible,
3. the danger arises of substandard water infiltration from adjoining basins or from the sea.

Conventional analysis has an instinctive aversion to the mining approach which stems probably from fundamentalist water conservation doctrines.

The traditional conservationist ethic, however, cannot contend with an analysis based on the principle of maintenance of the stock of social wealth as set forth in the section on conservation. Mining water could be the precondition for the development of a region and for the creation of production and production capacity that will, in time, warrant importing into the region more expensive water from the outside, and, in extreme cases, even desalted sea water. A region developed by mined water constitutes a more valuable stock of wealth to be transmitted to future generations than an untouched resource in an undeveloped environment, even if expensive imported water will, ultimately, have to be substituted for mining. "Buying time" by mining postpones the heavy investment of importing or even desalting water, and interim technological developments may allow cheaper processes and considerable savings in setting up the ultimate solution. Mining can also be phased according to the growing requirements of the economy, while importing water is much less subdivisible--a fact that is especially important in the early development phases when demand is still low; when inputs will have become unavoidable, a demand will have been fully developed by using mined water and the maturation period for the expensive and lumpy import project will have been considerably reduced.

When mining is carried out within a closed basin, or in a basin that by our management patterns will be transformed into a closed basin, the slow qualitative deterioration of the water by mineral accumulation

or by inflow of substandard water may, in time, constitute a problem. Where conditions are unfavourable it may be necessary to control the extent of the mining even before qualitative limits are reached. In such cases, the mined water may, as an interim measure, be diluted by an initial import of low-salinity water.

Salt accumulation and qualitative dis-equilibria can, of course, occur also as an unwelcome by-product of the quantitative stable equilibrium approach. The utilization of water at sustained yield rates from a closed basin for consumptive use within the basin is a common example. Similar utilization in a quasi-closed basin, though theoretically resulting in an equilibrium condition will, nevertheless, lead to excessively high levels of salinity at qualitative equilibrium.

Management of Intermittent Runoff and Waste Waters

Intermittent Runoff

The parameters of intermittent runoff do not meet with the requirements of the demand function; the location of runoff is usually unfavourable in the relation to areas of demand; its timing, unseasonable; its flow fluctuations, extreme; its annual volume, undependable; its physical and sanitary quality, unsatisfactory; the water is generally of low mineral content, though even this would remain a wasted asset without upgrading of other parameters.

The upgrading of intermittent runoff through underground recharging has much to offer. Although some surface storage will be required for retention of erratic floods, it will usually be confined to an impoundment of one and one-half to twice the flood volume with some reserve for silting-up. The real storage basin, i. e., the storage for seasonal and cyclical regulation, will be underground. This procedure will result in the following upgrading effects:

1. Space-time parameters: the water would be stored at locations that, as a rule, would be close to areas of demand. By storing

it for future use the time parameter would be completely eliminated.

2. Quantitative parameter: regulation cannot by itself increase the average quantity of water; it can, however, by seasonal and cyclic regulation, ensure that this average quantity will be available under all predictable climatic cycles.
3. The flow rate parameter: through underground storage, the source becomes available at call and at a rate that can be completely adapted to the requirements of the demand function.
4. Biological quality parameter: the process of recharging and storage by underground detention constitutes a most effective treatment; under most geological conditions this process, possibly combined with disinfection, may prove sufficient to keep the water potable.
5. Mineral quality parameter: this, the only positive parameter of intermittent runoff, can be turned into an effective asset by underground storage, since in storage it will mix with the formation water. The dilution of runoff water with mineralized water may constitute a most important side-effect of storage.

Underground recharge with water from intermittent runoff thus will effect an upgrading of a "lower rank" resource. The upgrading process is usually rather expensive, and it will be resorted to only after more advantageous resources have been developed.

Waste Waters

Similar considerations will apply to the upgrading of waste water. Ranking waste water according to the same scale will show that, whereas space-time, quantitative, and flow parameters are more favourable than for intermittent runoff, the qualitative parameters, both mineral and biological, are more problematic. Here again upgrading is based on recharging and storage underground. Waste water requires considerable

biological treatment before recharging; the water ultimately withdrawn from underground storage will usually be much more mineralized and may occasionally contain objectionable elements. Nevertheless, this form of waste water conservation will often be most favourable: it grants seasonal storage, bridges over quality fluctuations, furnishes the best available qualitative upgrading, and, provided it is integrated into an overall management scheme, it will almost always supply satisfactory water.

Proper siting of recharge and withdrawal areas in space, as well as in time, allows for a considerable period of grace until quality problems become acute. If and when such quality problems ultimately appear, they may be solved within the overall management plan by dilution, selective use, intensification of initial treatment, and after-treatment, etc. Qualitative problems can sometimes be considerably reduced by installing separate sewer systems to convey the discharge from industrial areas with toxic or highly mineralized wastes, or by confining waste reclamation to residential areas and light industries, while continuing to discharge objectionable industrial wastes out of the basin.

The Role of Underground Storage within an Integrated Management Plan

It has been shown that underground storage is one of the most important methods for upgrading low-ranking water resources within the framework of an integrated management plan. It improves flow characteristics and availability of spring flow and other perennial surface flow, as well as upgrading practically all the parameters of intermittent surface runoff and reclaimed waste water. Where alternative surface storage sites are available the regulative function will be divided between the most attractive surface and underground storage sites.

Underground storage has a number of inherent advantages:

1. Available storage space is usually large and its development does not involve any major investments.

2. The levels representing full and empty storage are not as sharply defined as in surface storage; an empty underground storage reservoir can, without any risk, be overdrawn for a considerable time, and a full reservoir will not immediately overflow; where springs that have ceased flowing due to previous management measures begin flowing again as a consequence of a high storage level, the flow surplus can be re-cycled elsewhere into temporary underground storage.
3. Investment in underground storage space can be phased and developed as needed; no major lumpy investments are required; therefore maturation cost will be negligible.
4. In a properly managed system water losses from underground storage will generally be much lower than in a surface reservoir.

Difficulties naturally arise in the use of underground storage: the recharge operation may prove tricky, and the long-term behaviour of formations, through which the water percolates, is not always fully predictable. If wells are used for recharging, the purity of the water must be high to avoid clogging of the well. Even in spreading operations the quality of water must be carefully watched.

Fortunately, far reaching regulative effects can be achieved by the implementation of indirect storage without having to resort to physical recharge operations proper. In indirect storage, the storage effect is achieved by proper manipulation of the surface-groundwater relationship or the relationship between two or more groundwater basins. In such a management plan, the respective share of groundwater and surface water (this latter either from direct flow or from surface storage) in the current consumption will vary in response to fluctuations of surface flow.

In wet cycles, when there are ample supplies of surface water, a larger share of the consumption may be switched to surface water, allowing groundwater to accumulate in the formation, whereas in dry

cycles when surface water becomes scarce, a larger portion will be drawn from underground formations. Such a management policy, while resulting in all the regulative effects of underground storage, will yet require only a minimum rate of physical recharge.

There is one overriding limitation to underground storage: the rate of recharge is subject to the percolation capacity of the recharge facilities and to the conveyance structures leading to them; consequently, large flows cannot be absorbed. A properly designed regulative system will therefore combine surface and underground storage sites. Surface storage sites serve as a shock absorber between the sometimes highly flash-like flow of the resource and the limited absorptive capacity of the formation; it will also perform part or all of the seasonal regulation. Underground storage will be recharged, either directly or indirectly, at the available capacity; it will serve, in some instances, only as cyclic storage, and in others as combined cyclic and seasonal storage, where the seasonal regulative function often consists in a de-regulation of the relatively regular flow of a major conduit according to the requirements of the demand function.

This division of regulative functions between surface and underground storage gives an indication of the desirable relative location of the two types of storage. Surface storage will usually be located near the water source; underground storage near the area of demand. Where a resource has not only to be regulated for its flow but also upgraded in its other parameters, both surface and underground storage may have to be provided near the source.

The conveyance link between source and demand areas will thus also serve as the connection between major surface and underground storage facilities. This interconnection will make it possible to operate the storage function both as direct and as indirect storage, provided such a management pattern has the necessary legal and institutional backing.

This type of an integrated system has a considerable amount of built-in flexibility, and it can take a fair share of qualitative and quantitative shocks without serious deterioration. As such shocks are usually of local or at most regional nature, their effects can through integration be spread over a much larger area where they will often remain subliminal over considerable periods of time. Even if major unpredictable variations hit the system, the flexibility of underground storage will act as a major shock absorber.

This integration includes the main surface and underground storage facilities, as well as the major water resources basins, whether ground or surface water. The boundaries between adjoining basins can, if necessary, be moved through changing original flow direction by properly planning pumping schedules along the space and time coordinates, and in such and similar cases the formation will serve as a conduit. Integration will, of course, also extend over qualitative aspects. Although no economically feasible method exists as yet to reduce significantly the overall amount of minerals, partial redistribution between resources can be effected, and substandard resources thus diluted to acceptable levels. Sometimes it will also be possible to plan, within certain limits, the storage of objectionable minerals along the time axis, i. e., postpone its impact until additional remedial measures will have become feasible.

The dispersion and the related phenomena of a water of a certain quality, flowing through a formation containing water of a different quality, have until recently not been properly studied, although these phenomena have a decisive importance in management of qualitative aspects of water resources. Only quite recently have experimental and analytical investigations been initiated--one important pilot project is now under way in Israel, under the auspices of the U.N. Special Fund--that will allow us to predict with some confidence these mixing phenomena and plan their manipulation in space and time.

The losses along the boundary conditions between fresh and salt water limit the rate of use of underground storage and a method of overcoming this limitation should be mentioned. Equilibrium conditions require, as already mentioned, the maintenance of a continuous fresh water flow of considerable volume into the sea. Temporary raising of the groundwater levels controlling this outflow, as a consequence of underground storage, will increase this outflow beyond the equilibrium minimum. In order to study ways and means of minimizing such equilibrium outflow, a pilot project, also under the auspices of the U.N. Special Fund, has recently been successfully completed in Israel, for interception of the major part of this outflow through pumping from a chain of shallow wells constructed near the shore line. This interception, while maintaining groundwater levels near the coast at sufficient elevation to keep the salt-fresh water interface at a predetermined equilibrium condition, reduces the loss of fresh water to the sea to negligible rates. This is one of the few cases where you can eat your cake and have it, i. e., use the waters as well as holding the salt water back. Pumping from the narrow wedge of fresh water that floats on sea water is, of course, an extremely sensitive operation that requires great care and constant vigilance.

We have traveled a long way; traversed from one pole to another; from standard, single-discipline, static water management measures to the complex interconnected system that can be understood, predicted, and controlled only by the application of a multi-discipline dynamic process approach. The system is so complex that in order to describe it here we have had to break the phenomena down into specific aspects and describe each aspect by single-discipline semantics, reconstructing the coordinating links by pointing out connections to other aspects and disciplines.

By carrying our exposition to extreme complexity, we do not, as a matter of course, intend to imply that such complexity will be necessary in every case. Every development history must start at the lower range of

complexity; however, the sooner we succeed in foreseeing the later, the more complex stages and make proper provisions for them, the less the ultimate loss in resources and production, and the earlier may we set our emergent economies on the roads we seek.

PART II
ECONOMIC PLANNING OF
AGRICULTURAL DEVELOPMENT

by

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CHAPTER I
METHODOLOGY OF ECONOMIC PLANNING OF
AGRICULTURE AT THE NATIONAL LEVEL

Introduction

General economic plans should set forth in comprehensive and detailed form the economic policies of the government, its proposed lines of action, and the projected time path of the economic system. Agricultural development plans on a national scale should outline general policy measures, lay down a framework for detailed plans of operations within the agricultural sector, forecast the effect of the policy on principal economic variables, and provide basic data and guide lines for economic decisions and programmes in overlapping, non-agricultural sectors of the economy. As an example of the need for such general economic and agricultural economic planning, we may refer to the design and construction schedule of a new harbour to meet export and import projections, provided by the national agricultural plan. Detailed regional development programmes will also be based on consumption forecasts and capital outlays, provided by the national plan.

The scope and degree of refinement of the national agricultural plan depends on the availability of statistical data, the capacity of the planning team, and the time available for the preparation of the plan. Economic plans will tend to develop in scope and refinement as the planning team gains experience and data become more diversified.

Economic planners--planning capacity--are a scarce resource and their assignment to planning missions is in itself subject to optimization. National development plans should therefore not be formulated in great detail, in order to release adequate agricultural planning capacity to detailed project planning at the regional level.

In emerging economies, where subsistence agriculture is predominant and the economic linkages are extremely weak, the price

system is ordinarily ineffective as a guiding and inducing mechanism. In such economies the national plan should be focussed on regional development projects with particular emphasis placed on engineering and agricultural planning, and on administrative and finance organization. In economies more responsive to price incentives, the plan may confine itself to outlining means by which the price mechanism is to be manipulated to promote stable growth. The dualistic nature of many developing countries, where modern and traditional sectors coexist within the same economy, frequently calls for integration of the two approaches.

The Role of Agriculture in National Economic Growth

In setting up a national development programme the particular position and role of the agricultural sector in the growth of the national economy must be considered. The four main contributions of agriculture to a developing economy are as follows:

The Product Contribution

Any rise in agricultural output contributes directly to the gross national product, as well as providing the additional food supply required to meet expanding domestic demand. Development strategies, emphasizing rapid industrialization to the neglect of food supply problems, are bound to encounter severe food scarcities and foreign exchange difficulties that may jeopardize the entire development programme.

The Market Contribution

In its early stages of development, the manufacturing sector of a developing economy caters primarily to the domestic market. Its rate of growth depends, therefore, mainly on the rate of expansion of local demand. Increased agricultural production leads to a rise in farmers' disposable income, which, in turn, encourages domestic demand for manufactured goods. In the less developed economies, there is a certain asymmetry of behaviour between the farm and the industrial

sectors which has important implications for the development policy. Whereas agriculture is an autonomous sector whose output is, by and large, less responsive to variation in demand, industry, on the other hand, is market oriented and its output and investment in productive capacity are ordinarily induced by expanding markets. An increase in agricultural output will have a multiplication effect on industry. As an example of this effect, it may be shown that if farmers divert 20 percent of their additional income, and income earners in industry 40 percent of their additional income to manufactured products, then in a closed economy an increase of one unit in farmers' net product will lead to an increase of .33 units of industrial net product. Industrialization may therefore be accelerated indirectly through public investment in agriculture, while investment in industry does not necessarily induce growth of agricultural production.

Factor Contribution

Economic development is ordinarily associated with the migration of labour from agricultural to non-agricultural employments. The development of the non-farm sectors of the economy draws upon the "surplus" labour existing in agriculture. This usually leads to a decline in the share of agriculture in total employment but does not necessarily involve any reduction in farm output.

In agrarian countries, where at least 30 percent of the national income is generated in agriculture, the farm sector may serve as a source of savings, providing capital funds required for investment in non-agricultural sectors. In countries such as Japan and the Soviet Union, the earlier stages of industrial development were based mainly on savings--largely forced savings--generated in the agricultural sector. In Japan, most of the gains in agricultural productivities were siphoned off through heavy land taxes,* whereas in the Soviet Union,

* W.H. Nicholls. "The Place of Agriculture in Economic Development," 1960. Reprinted in "Agriculture in Economic Development," edited by C. Eicher and J. Witt. McGraw Hill Book Co., New York, 1964.

farmers were forced to deliver to the government production quotas at low prices. The extent to which agriculture may serve as a source of saving will depend on the volume of income generated in agriculture and the rural community's propensity to save.

The Balance of Payment Contribution

In many developing economies agricultural products constitute important export items. As increase in production and export of these commodities provides the country with the foreign exchange needed to finance the import of manufactured capital goods, required for the development of local industries, it also helps to finance service payments on the country's foreign debt. Further, production of certain agricultural products makes it unnecessary to import these products and a rise in their output will save badly needed foreign exchange.

Development Strategies

The objectives of government intervention in developed economies are as follows:

1. To accelerate the rise in productivity through research and extension;
2. To stabilize farm income and assist farmers in adjusting to changing economic and technological conditions--through appropriate price and credit policies, consistent with the efficient allocation of resources;
3. To adapt the existing legal and institutional structure to the new technology and economic relations.

In emerging economies, the government's major task is to transform the traditional subsistence agriculture into a modern market agriculture. This is a fundamental structural change involving great expenditures of material and human resources. In general, these resources are scarce, and in particular skilled and educated manpower are lacking and policies must be devised to make fullest use of these resources. The

transformation of traditional agriculture comprises a wide spectrum of interdependent changes in production techniques, irrigation methods, marketing channels, credit facilities, social organizations, legal institutions, etc. Hence, any agricultural development project requires a certain minimal size team, responsible for planning and implementation. This necessarily limits the number of development projects that can be undertaken simultaneously, and calls for a strategy based on "development foci." Appropriate steps should therefore be taken to increase the availability of technical personnel for development planning and implementation. Furthermore, higher priorities should be assigned to programmes yielding output increments at a minimal expenditure of these scarce resources.

The projected domestic and export demand for agricultural products, and the production possibilities opened by the development programmes, determine the product composition of the increased output. In considering the marketing possibilities one should always bear in mind that increasing agricultural production in itself creates new demand for farm products through the associated rise in income in the farm and non-farm sectors. Since some additional effective demand is always siphoned off in the form of demand for imported goods, the added output should include import substituting and/or export products.

Phases of National Agricultural Planning

Economic planning--though a continuous process--falls into a number of characteristic phases, as outlined in the following:

Preliminary Preparations

Before actual planning can begin, considerable information must be gathered, analyses carried out, and forecasts developed. This applies particularly to the first few plans, for with the accumulation of information and experience the preliminary phase in subsequent plans can be shortened. Data concerning resource availability, production

conditions, final demands for farm products, and various institutional relations are prerequisites for comprehensive agricultural planning.

1. Resource availability concerns land and water, labor and capital resources.

- (a) Land and water resources. Information on land and water resources may be obtained from land surveys and hydrological studies. Land data should be given in terms of land use capabilities, and land diversion to urban uses should be considered in developing land projections. Existing land tenure system and water right relations should be studied in detail, and policy measures formulated conducive to an improved institutional structure. The development of water resources forms an integral part of a comprehensive agricultural plan, and will be based, wherever possible, on water resources development plans.
- (b) Labour resources. The size of labour force in agriculture should be forecast before actual planning is undertaken. This variable, however, is in itself partly dependent on the development plan, since demand for labour within agriculture may affect the direction and rate of labour migration, especially if plan implementation stretches over a long period. Preliminary labour force forecasts are derived from projected rates of growth, age distribution, and participation rates of the farm population in the labour force. Where inter-sectoral labor migration is an established phenomenon, it should be considered in the forecasts. Labour migration out of agriculture depends on employment opportunities in other sectors; these, in turn, depend on these sectors' relative importance in the economy and their rate of growth.*

* F. Dovering. "The Share of Agriculture in a Growing Population." Monthly Bulletin of Agricultural Economics and Statistics, FAO, Rome, Sept. 1959.

Information on the quality of the labour force is an indispensable part of labour force projections.

- (c) Capital resources. Capital requirements are determined as a part of the programme. A general indication as to the availability of capital will, however, be required at the outset. Generally, part of the capital invested in agriculture originates both in the public sector and in other sectors of the economy. The agricultural planner should be supplied with data on capital investment, and, where such data are not available from external sources, it is advisable to forecast capital flows into agriculture on the basis of past experience. In addition, attempts should be made to estimate the propensities of the agricultural sector to save and the proportion of these savings that are reinvested in the farm. The institutional structure of the capital market and its effects on capital supply to agriculture should be examined; in many countries an inadequate structure of the capital market has hampered the flow of capital into agriculture, thus leading to an inefficient resource allocation among the various sectors of the economy. Where such circumstances prevail, agricultural planners are expected to specify and initiate reforms in the capital market.
- (d) Production conditions. For most agricultural plans, production conditions are best expressed in the form of fixed input-output coefficients. While they may add some useful information, elaborate estimates of production functions are ordinarily not required, for price ratios are relatively stable and factor substitution somewhat limited. Depending on the degree of disaggregation in the national agricultural plan, these production coefficients

reflect average conditions. Input-output relations may be derived from statistical data supplemented by information obtained from production experts. For a long-term plan, future changes in technology should be taken into account in developing production coefficients.

- (e) The demand function. In general, three classes of demand functions are of interest, i. e., intermediate demand, final domestic demand, and export demand. The term "intermediate demand" is applied to farm products serving as inputs in agricultural production, such as feed grains, hay, chicks, etc., whereas "final domestic demand" refers to the demand of the non-agricultural sector industries for agricultural raw materials, e. g., textile industry demand for cotton, as well as domestic demand of the population for food and fibres.

Final domestic demand of the population varies with the size of the population, per capita disposable income, and relative prices. The agricultural planner will rely on projections of population growth and anticipated changes in the age distribution and demographic composition, as developed by the demographer. At the preliminary planning stage, disposable income is assumed to be exogenously determined and, therefore, treated by agricultural planners as data, although disposable income depends substantially on income generated within agriculture. Preliminary income projections must, therefore, be based on some general assumptions concerning the overall rate of growth of the economy at large. This first approximation will be developed into a final income projection with the completion of all sectoral plans.

Relative prices are more difficult to predict. In many

cases the assumption of constant price relations is very plausible, since long run supply functions are highly elastic, especially if the commodity is traded in the world market. In short-term plans, domestic production of some farm products that do not feature on the international market may follow an autonomous path; with such products, e. g., perishable fruits, domestic consumption will equal domestic supply, prices becoming the dependent variables. Where relative prices are assumed constant--and this is quite common--income elasticities of demand are the only demand parameters needed, but where relative prices cannot be assumed constant, price elasticities are required in order to obtain consumption projections. Estimates of income elasticities--though often difficult to assess--may be obtained from cross-sectional family budget studies or from time series analyses, whereas price elasticities are ordinarily estimated from the latter.

The main difficulty with estimates based on cross-sectional data lies in the difference in consumers' response to income variation. In family budget studies, changes in consumption reflect differences between income groups, while under the plan changes in income are spread over all groups. Changes in consumption generated by the income variation of given income groups are not necessarily identical with differences in consumption existing among income groups. Another universal difficulty is encountered when projections fall in intervals of the demand functions or Engel curves for which no data were actually observed. Naive extrapolation may then be very misleading.

Export demand projections and analyses are often more difficult to develop, since world markets are, in general, highly complicated and subject to unpredictable fluctuations. (Invaluable contributions in the field have been made by the FAO. The various FAO studies and statistics and especially the "Commodity Review" series provide agricultural planners in all countries with very useful information on anticipated developments in the world markets. Commodity projections for 1970 have also been published.) Small countries may regard world prices of many commodities as independent of their own exports, even though these countries often export farm products for which foreign demand is not perfectly elastic. For these products, attempts should be made to estimate price elasticities of demand. The elasticity estimates will later be used in determining production objectives, where due attention must be paid to the price, and possible revenue reduction caused by an increased output. A study of anticipated economic and political developments and their likely effects on international trade must accompany any export demand projections. The recent growth of regional economic organizations and trade arrangements has had profound effects on international trade, and this development is expected to continue. Any sound plan should take developments in the political arena into account.

2. Preliminary plans. As soon as adequate data have been assembled, forecasts made, and analyses carried out, preliminary plans can be outlined. At this stage plans are highly aggregative, reflecting various general approaches. Performance criteria related to each plan, such as the value of output, farmers' income, employment, etc., are then derived to allow comparison

of the different alternatives. The preliminary plans serve two main objectives. They lay grounds for a comparative appraisal of the different approaches, as well as providing a framework for further detailed programming.

At this stage the approval of the political level for the chosen alternative should be sought. The policy maker should be presented with the recommended programme, as well as with a number of alternatives. Planners must always bear in mind that plans must be approved by politicians before being implemented. The political acceptability of a plan is, therefore, a prerequisite of any practical programme.

3. Detailed final planning can be initiated after acceptance of preliminary plans. At this stage planning should be carried out along several lines simultaneously; regional planners will disaggregate the national agricultural plan into regional plans and each group will occupy itself with formulating plans for its particular field of operation; commodity experts with the detailed commodity programme; irrigation engineers with water supply projects; financial experts with the sources of investment funds and improved credit facilities.

Coordination of the various working groups at this stage is of utmost importance, since the preliminary plan is continuously revised as detailed planning proceeds. Finally, all the separate plans are combined into a detailed final plan. At this stage the consistency of the various policy measures must be established, and the separate plans compiled into a unified plan of action.

4. Plan implementation. With the approval of the final draft by the policy makers, the plan is distributed to the various departments and government agencies to serve as a basis for their respective actions. Planners should follow up the implementation of the plan from the beginning, strive to

avoid misinterpretation of their intentions and ensure intelligent revision as rendered necessary by unforeseen developments or neglected possibilities. Following up the implementation of current plans will have beneficial effects on subsequent projects, for the experience gained will guide planners toward more effective and practical programmes.

Planning Techniques

Economic planning must make use of a variety of measures in order to attain its objectives. These measures may be as follows:

1. Quantitative policy measures, assigning predetermined values to selected control instruments, e. g., tax rates and price support subsidies. In many instances, values of instrumental variables are preassigned for the first planning year alone. In subsequent years these values are determined for the following year according to "decision rules" set up in the plan. This leads to "policy inclusive economic structures."^{*}
2. Qualitative policy measures involving structural change, e. g., change in farm size, marketing channels, and credit facilities.
3. Reforms, e. g., land reform.

Associated with these measures are forecast values of the exogenous and endogenous variables.

The crux of the planning problem consists of determining the policy measures and the resulting values of the endogenous variables, and for this purpose several techniques have been developed. The three principal techniques are:

1. Budgeting,
2. Input-output models,
3. Linear and non-linear programming.

^{*} A. G. Papandreo. "Fundamentals of Model Construction in Macroeconomics," Training Seminar Series, Centre of Economic Research, Athens, 1962.

These techniques are in general most applicable to the quantitative measures, less suited to qualitative policies, and least adaptable to reform measures.

Budgeting

The term budgeting has been adopted from farm management nomenclature and it refers to a broad class of informal planning techniques. The preceding description of the planning process is, in effect, based on budgeting as the predominant technique; the budgeting is itself carried out in similar stages. In contrast to the other techniques, no attempt is made in budgeting to solve simultaneously for all values of the instrumental and endogenous variables, consistency being achieved by successive approximations. The development of the plan is based on some general strategies formed at the preliminary stage, and the plan is worked out with some flexibility, taking into account explicit as well as implicit restrictions. The plan is continuously revised and improved as long as additional efforts are justified by expected improvements, but there can be no certainty that the optimal solution has actually been reached.

To ensure that the plan is itself consistent, resource utilization must be balanced against resource availability; disposition of farm products against supplies. In this context, due attention must be paid to the timing of resource utilization and production, and appropriate measures should be undertaken to mitigate seasonal variation in resource requirements and the flow of output.

Input-Output Models

Input-output models consist of intersectorial flows and stock relations describing the movement of goods and services between various sectors of the economy. The outflow of each sector may be used as an intermediate input to other sectors, for satisfying final demand which consists of domestic consumption, exports, and

investment. The intersectorial flow relations are described by flow tables. Stocks relations are expressed by tables of capital coefficients expressing the capital stocks, by industry of origin, required as productive capacity and inventories per unit output of the using industry. Capital coefficients are used to estimate the investment flows required to sustain certain rates of growth.

There are two ways of applying input-output models in comprehensive agricultural planning. First, they may be used to forecast other sectors' demands for farm products, and second, the output of the agricultural sector may be derived from projected final demands. Input-output models take into account the complex interdependence of the various sectors and this constitutes their principal advantage. These models are, therefore, very useful in determining demand for farm products which serve as inputs in other sectors. They are less valuable in determining outputs within the agricultural sector, since interdependence within this sector is limited.

Empirical input-output coefficients are ordinarily expressed in monetary units; under conditions of varying price relations their use may, therefore, present some difficulties. To obviate such difficulties, input-output coefficients used in agricultural planning must be expressed in physical terms.

Application of input-output models does not involve any optimization. The production plan is in fact determined by the final demand, though the input-output models themselves do not provide any machinery for determining optimum final demands. To ensure feasible solutions, resource use coefficients must constitute an integral part of the model, and any final demand not consistent with resource availability must be rejected. Input-output models may be disaggregated for the purpose of agricultural planning into sectors corresponding to individual commodities, or disaggregated by regions, thereby allowing inter- and intra-regional planning. No optimization of inter-regional allocation of production can, however, be carried out.

By incorporating flow and stocks tables into a single model, investment demand becomes endogenous and is determined by the time path of final demand (consumption and exports). Compared with budgeting, input-output models represent more rigid planning techniques and their practical use in agriculture is somewhat restricted.

Linear and Non-Linear Programming

Mathematical programming methods are formal planning techniques involving optimization. Accordingly, a criterion function or objective is defined and the optimization consists of maximizing or minimizing the criterion subject to various constraints. In national agricultural planning, various criteria may be chosen. Examples of such criteria are the income earned in agriculture, or the receipts of foreign exchange. In these cases, it is necessary to set domestic demands whose price elasticities are finite at given levels and regard these as constraints. If the export demands or import supply functions are not perfectly elastic, these functions must be entered into the criterion function so that net foreign exchange receipts may be maximized. Programmers will then have to resort to non-linear programming in solving the problem. Other criteria are also conceivable. As an example, Chenery and Clark* cite a linear programming model for the economic development of a South Italy in which capital investment is minimized.

The predominant class of constraints on optimization consists of resource availabilities. Other constraints such as crop rotation requirements and various institutional relations are also often included. Conceptually, linear programming models could be formulated and used in any comprehensive agricultural planning. Nevertheless, the size of problem that can be solved is restricted, even if advanced

* H. B. Chenery and P. G. Clark. "Interindustry Economics," John Wiley and Sons, New York, 1959.

high speed computers are available. The model must therefore be highly aggregative so that aggregation errors may be substantial; further, the lack of data is also prohibitive in many instances. Nevertheless, experiments in the application of programming methods to national agricultural planning are being carried out and progress in this field may be expected in the future.

CHAPTER II
STRATEGY AND PLANNING METHODOLOGY IN THE
ECONOMIC DEVELOPMENT OF RURAL REGIONS

The Regional Growth Process

The Rural Region and its
Geographical Organization

A rural region is a socio-economic geographical entity with income mainly derived from agriculture. This definition should not be interpreted to imply the absence of non-farm sources of income within the rural region; rather, a region should be broadly conceived of as an interdependent network of various economic activities, among them farming, manufacturing, trade, transportation, services, local government, and construction.

The geographical organization of the regional economy is ordinarily characterized by certain regular spatial patterns, determined by the technologies employed in the various economic activities, the transportation network, the topography, and various social and cultural factors. The spatial equilibrium is determined by two groups of interacting forces; dispersion and agglomeration.

Forces of dispersion. Agricultural and mining activities are dispersed according to the geographical distribution of the natural resources; processing industries, which transform large volumes of raw materials into relatively small volumes of final products, tend to be located near the source of raw materials and are therefore also resource oriented.

Forces of agglomeration. Economies of large-scale production, high costs of distribution of the final produce, heavy dependence on services, provided mainly in industrialized urban areas, and complementary relation in production and marketing between different groups of industries favour the agglomeration of economic activities and give

rise to market oriented industries. In modern economies, market oriented industries are prevalent, and as will be explained subsequently, this fact bears important implications for regional growth process.

Patterns of Regional Economic Growth

The main features of the regional economy and the interdependence of its various industries may be represented by interindustry region flow tables. Detailed explanation of the use of input-output tables on the regional level are given by Isard.* Three tables illustrating the income and product flows of a hypothetical region at three phases of development will be presented in this chapter.

Phase I. Emergent economies.

Table 1. Interindustry flows of a hypothetical rural region

(All figures are in terms of hypothetical monetary units, MU)

Output of Industry of Origin	Outlay of Industry of Use		Final Demand Outlay			Gross Regional Output
	Industry I (Farm)	Industry II (Non-Farm)	Export	Household Consumption	Gross Investment	
Industry I (Farm)	-	100	200	190	10	500
Industry II (Non-Farm)	50	50	100	80	20	300
Import	100	100	-	75	25	300
Household Income	350	50	-	-	-	400
Total Payments	500	300	300	345	55	

* W. Isard. "Methods of Regional Analysis: An Introduction to Regional Science." Technology Press, Massachusetts Institute of Technology, and John Wiley, New York, 1960.

At the hypothesized stage of development there are only two industries in the region: agriculture (Industry I) and some manufacturing and services (Industry II). Each entry in the table represents the flow of product or income from the sector of the regional economy, corresponding to the particular row, to that sector of the economy represented by the respective column. Thus the non-farm sector (Industry of Use II) spends 100 MU on agricultural raw materials, 50 MU on manufactured goods, and 100 MU on import--goods and services imported from other regions or from abroad. Household income (salaries, profits, rent, etc.) generated in this sector is 50 MU. The gross regional output (GRO of Industry of Use II) is 300 MU, of which 50 MU are purchased by agriculture (Industry I), 50 MU are purchased by Industry II, 100 MU are exported, 80 MU are consumed by household, and 20 MU used for investment.

It should be noticed that the inter-regional trade of the region is balanced and that the total import of 300 MU is fully covered by exports. The regional household income amounts to 400 MU, of which 345 MU are consumed and 55 saved and invested; the average propensity to save therefore equals 0.138.* The largest share of the invested fund will be used to replace worn out capital goods; the rest will represent net addition to the regional capital stock.

Three principal factors contribute to the growth of household income--the only pertinent variable in measuring growth. These factors are: the increase in labour force, accumulation of capital, and technological progress. Per capita income will be on the increase when the joint effect of capital accumulation and technological progress surpasses population growth. Each factor will be briefly considered.

* Average propensity to save = $\frac{\text{Household Income}}{\text{Gross Investment}}$

1. Increase of labour force. Changes in the labour force are due mainly to changes in birth rate, mortality rates of the various age groups, and to migration. The direction and rate of migration depend on differentials in per capita income among the various regions and on social mobility. High education levels, developed communication channels, a younger age distribution, and cultural homogeneity throughout the country are all conducive to higher labour mobility.
2. Accumulation of capital. The rate of capital accumulation is a function of household income, of the propensity to save, of existing investment opportunities, and of the ability of the region's entrepreneurs to invest.
3. Technological progress. This is dependent on the educational level of the local producers, and on their willingness and ability to make adjustments in the entire socio-economic structure in accordance with the requirements of modern technologies. The adoption of new production and distribution techniques ordinarily involves changes in composition and net additions to the existing stock of capital. The speed of technological progress is, therefore, closely linked to the rate of new investment.

Phase II. Post "take-off." The pattern of the regional economic growth may be represented and analysed by constructing the interindustry flow table representing the regional economy at the post take-off stage-- a more advanced stage of development--as illustrated in Table 2.

The basic differences between Phase I and Phase II lie in the considerable expansion in the GRO's of the various industries and the development of a new industry, producing goods that were previously imported, and hence referred to as an import substituting industry (Industry III). This expansion has resulted in a substantial increase in household income. The incidence of GRO expansion and the increase in

Table 2. Interindustry flows of a hypothetical rural region

(All figures are in terms of hypothetical monetary units, MU)

Output of Industry of Origin	Outlay of Industry of Use			Final Demand Outlay			Gross Regional Out- put
	Industry I	Industry II	Industry III	Export	House- hold Con- sumption	Gross Invest- ment	
Industry I	-	200	20	175	340	15	750
Industry II	75	100	90	135	160	40	600
Industry III	30	50	30	165	60	15	350
Import	130	150	110	-	65	30	475
Household Income	525	100	100	-	-	-	725
Total Payments	750	600	350	475	625	100	

Household income is not accidental but is a fundamental trait of growth processes. Economic development is a process in which expansion and structural changes have mutual accelerating effects. Suppose that in our example all three factors contributing to the growth of household income--the increase in labour force, the accumulation of capital, and technological progress--have first led to a mere expansion in the GRO's of existing industries. As a result, regional, final, and intermediate demand for imported goods and services also increased. At a certain point, an economic threshold is attained in which the size of the regional market is sufficiently large to support local production of these commodities at an economically efficient scale and investment opportunity was thus created. Granted the ability of local entrepreneurs to capture and exploit such opportunities, the stage is set for structural change. The development of a new industry gives rise to investment multiplier effects at the initial building phase and adds new sources of employment and income in subsequent phases, thereby providing for a further

expansion of output. Furthermore, the resulting diversification of the regional economy tends to deepen the productive structure of the region, thus reducing the leakages of future multiplier and accelerator effects.

As a quantitative measure of the deepening effect, we may use the ratios of imports to household income. Whereas in Phase I this ratio was $\frac{300}{400} = 0.75$, in Phase II it was reduced to $\frac{475}{725} = 0.65$.

It should be emphasized that the initiation of a new economic activity in consequence of a pure expansionary process, is by no means restricted to expansion in local demand. An increase in the local supply of raw materials may also lead to the development of new industries which use regional outputs as inputs. It should be noted that at the pure expansionary phase, the need for additional markets may become acute and the situation will be alleviated only after the new industry has been fully established.

There is an interesting and highly important corollary to this conception of the growth process. New industries are often market oriented, often because they are induced by the expansion of local demand, but mainly, since ex-hypothesis the new industries involve significant economies of large-scale production, they tend to be centrally located. Urban centres of the rural region are, therefore, the main beneficiaries of the growth process. This tendency is further strengthened by technological progress.

The Role of Government in Regional Development

The Role of Government in a Developed Economy

In developed economies the growth process is self-sustained; social organization, existing capital stocks, regional income, entrepreneurship, know-how, and other factors, have all developed to a degree that inherently supports further growth. In this case, the government's role is confined to the provision of public services in accordance with overall economic

growth and to investment in social overhead (roads, schools, drainage systems, etc.) in order to prevent infra-structural bottlenecks.

The Role of Government in Emerging Economies

In emerging economies the form of government intervention common to developed economies is inadequate. Although the development of infra-structure is a necessary condition for growth, there is much empirical evidence to show that it is seldom sufficient, and it is apparent that the growth process does not function in the same manner as in a developed economy. The government then must intervene in the direct productive activities. This intervention should aim at inducing more investment activity, at providing additional capital funds, at accelerating the adoption of new techniques, and at reforming the institutional system so as to promote growth. The government should always attempt to achieve these aims by activating unemployed and undeveloped resources. The effect of government intervention on the regional flow of product and income may be observed in an interindustry flow table (Table 3) illustrated in terms of our preceding example.

Table 3. Interindustry flows of a hypothetical rural region government intervention in an emerging economy at Phase I

(All figures are in terms of hypothetical monetary units, MU)

Output of Industry of Origin	Outlay of Industry of Use		Final Demand Outlay				Gross Regional Output
	Industry I	Industry II	Export	Household Consumption	Gross Private Investment	Gov. Investment	
Industry I	-	120	190	207	12	21	550
Industry II	55	60	90	93	32	30	360
Import	110	120	-	82	33	39	384
Household Income	385	60	-	-	-	-	445
Total Payments	550	360	280	382	77	90	

Comparing Table 3 to Table 1 it is observed that government investment has had several effects. In the first place, it has raised overall investment, gross private, and government investment, from 55 MU to 167 MU. This has been achieved mainly by channeling public funds into the region, as well as by inducing higher private investment. The resources for the increased private investment have become available through higher regional savings and through inflow of private capital from other regions. The import of private capital has been presumably induced by new investment opportunities created by the speeding up of the economic development. The rise of 8 MU in internal savings deduced, from the gross private investment of Phase I and the phase of government intervention, was generated by an increase of 45 MU in household income, brought about by the activation of unemployed resources through added public expenditures. The inflow of capital investment amounted, therefore, to 14 MU deduced, from the gross investment of Phase I and the phase of government intervention. The increase in regional demand reduced exports to 280 MU and raised imports to 384 MU, resulting in a deficit of 104 MU in the regional trade balance. This deficit is just offset by public and private capital inflows.

The figures presented in Table 3 give evidence of a substantial acceleration of the growth process. There are, however, important governmental activities which do not show up in the table, related to institutional and organizational changes, without which investment in social overhead and in direct productive activities are likely to be ineffective. Although these activities have not been discussed in detail, they invariably constitute an indispensable part of any economic development plan.

The Strategy and Organization of Regional Development

The Transformation of Traditional Agriculture

The major task of the government in the development of rural regions in emerging economies is the transformation of a traditional

subsistence agriculture into a modern market oriented sector. This transformation involves fundamental changes in the socio-economic structure of the region. At the production end of the system the transformation is carried out by the introduction of new crops, as well as the development of new varieties of existing traditional crops; utilization of fertilizers and pesticides; improvement in local breeds of livestock; increased supply of irrigation water; development of drainage and flood control systems; prevention of soil erosion, and by rationalization of irrigation methods and general agricultural practices. Many of these changes require relatively small on-farm capital investment, and may be carried out even if farm units are small and land holdings highly fragmented. However, certain types of tenant-landlord relationships severely impede these changes.

There are three prerequisites for a successful introduction of modern inputs:

1. Farmers must be aware of the benefits accruing from the adoption of the new techniques, and must be taught how to apply them;
2. The new inputs must be made available and be easily accessible, for the new techniques require increased use of purchased inputs, e. g., fertilizer, pesticides, veterinary services, improved seeds, etc.;
3. Increased sales--to pay for the increased use of purchased inputs.

A change in the product mix of the farm is, therefore, necessary. Marketing channels must be adequately developed and outlets found for the additional output. Since this transformation involves an increase in farmers' cash and outlays, farm credit must be extended, even if the overall capital investment is relatively small.

Small farm units and fragmented land holdings may hinder development and modernization. This is particularly so when the

development strategy is based on increasing water supply for irrigation, on the control of floods and soil erosion, and on the extended use of farm machinery.

Although agricultural development projects often involve impressive investments in hardware (dams, canals, highways, etc.), it seems that more emphasis should be placed on developing the "software" by diverting more resources to agricultural research, extension, and education. Although modern research organizations may exist in many developing countries, research projects are not always oriented to actual needs.

In emerging economies, the interlinking between economic activities in rural regions is often weak, and hence it is impossible to concentrate government intervention in just a few sectors of the system, e. g., production, and rely on the spontaneous adjustment of other sectors. To avoid frustration of the development effort, intervention must take place along a wide socio-economic front--production, marketing, farm credit, education, health, legal institution, etc. The scarcity of development resources--particularly of trained technicians and other manpower--may, therefore, limit the number of regions where concentrated development effort may be undertaken.

Regional Organization

What are the requirements then of the spatial pattern of various economic activities in a developed region? Existence of indivisibilities and economies of scale, as well as certain characteristics of social behaviour, dictate a certain hierarchy of the regional organization. A schematic illustration of this hierarchy is presented in Figure 1.

Weitz* has presented the concept of a composite rural community.

* R. Weitz. "Rural Development through Regional Planning in Israel," paper shortly to be published in the Journal of Farm Economics.

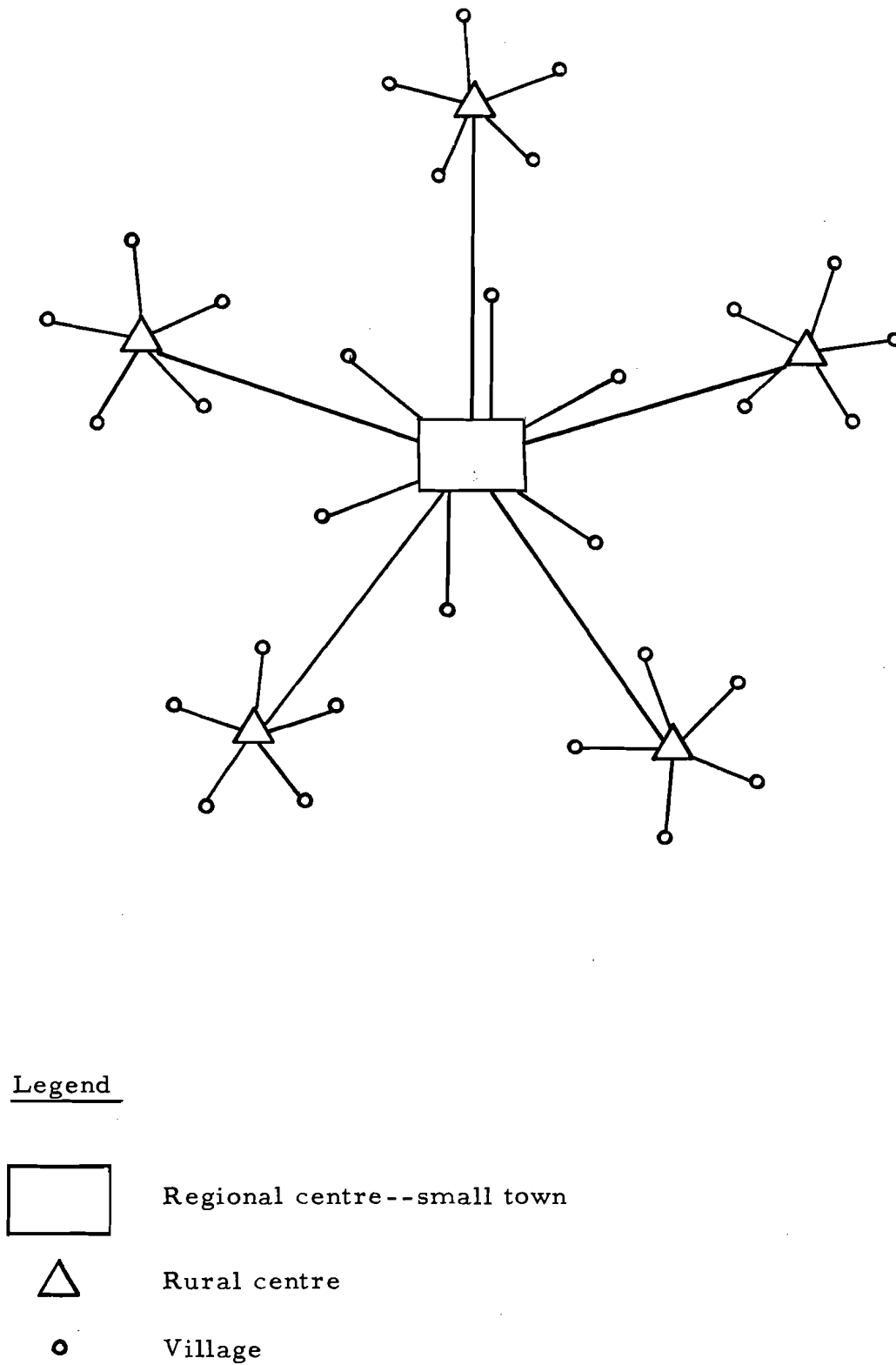


Figure 1. Schematic representation of a rural spatial hierarchy

In this concept, the basic units are the family farms. Individual farms may be organized in villages where certain services, such as a primary school, a retail store selling consumer goods, and certain inputs, etc., are available.

A number of villages, from 5 to 10, should be organized around a rural centre. This centre will consist of a community, a school, a medical centre, a local office of the extension service, a tractor station, various marketing facilities (sorting and packing sheds, grain elevators, etc.). It will also include housing for public service officers, such as teachers, doctors, nurses, accountants, and the technical staff, responsible for maintaining the agricultural technical services. The community served by the center constitutes the composite rural community.

The regional centre is the focus of the region's activities. It should comprise a high school, a bank, a research station, offices of the regional administration, and various industrial and commercial enterprises. It will ordinarily coincide with an existing town.

This spatial organization is not a rigid one, and will vary from region to region in accordance with the local conditions. Its development is closely associated with the general development of the region, and conforms well to the envisaged pattern of intervention. In the earlier stage of development, leading elements of the regional development authority should be established in the regional center to prepare preliminary plans and the recruiting and training of personnel. At the second stage, nuclei of rural centres are initiated and the functions of the regional centre are extended, e. g., beginning of the construction of a process plant. In the following stages, additional rural centres will be set up, and the work on existing centres broadened. The experience gained in the earlier stages guides the revision of the operational plan in its subsequent stages.

Regional and Sub-Regional Boundaries

The question of the geographical definition of a region is often raised when first plans are prepared. A region should be defined--from the purely economic point of view--according to the interdependence of economic activities; all closely linked industries should be contained within the region's boundaries. This approach does not lead, of course, to clear cut borders, but it may remove some of the arbitrariness involved in their delineation. As a general rule: the permissible size of a region may be determined by the ratio of import to household income; regional area may be increased, provided this produces a reduction in this ratio.

However, the economic approach provides us with only one criterion. Other criteria--perhaps more important ones--should always be considered. Thus, in irrigated areas, a river basin may be a more natural unit for development planning. The historic, geographical organization of local and central governments is also a dominant factor in the definition of regional boundaries. This is not an irrational basis for regional organization, inasmuch as the administration of the development programme is a key factor in its success.

A regional plan normally involves disaggregation into sub-regions. Contrary to our approach to the regional boundaries, the breakdown into sub-regions should aim at defining homogeneous productive units; each sub-region should comprise as small a number of interdependent industries as possible and should be characterized by uniform production conditions. This will help in simplifying the planning procedure and will minimize aggregation errors. It may, in some instances, conform better to the internal organization of the regional development authority.

Economic Planning at the Regional Level

Economic Planning as an Interdisciplinary Effort

Having analysed the regional growth process and development strategies, it becomes apparent that in any development plan due attention must be paid to all aspects of economic activities. An

interdisciplinary approach to planning is, therefore, a prerequisite for successful planning. Economists, agronomists, civil engineers, hydrologists, experts in industrial development, architects, public administrators, legal advisers, sociologists, and experts from other disciplines should all join efforts in laying down the development programme. Some of these experts may be full-time members of the planning team, while others should be available for consultation as the need arises--in accordance with the particular problems of the region.

Phases of Regional Agricultural Planning

As emphasized elsewhere, economic planning is a continuous process. A number of phases may be distinguished in their preparation as development plans are formulated at certain time intervals. These phases will now be reviewed with special emphasis on the planning activities that are related to the agricultural sector.

Planning phase I: preliminary preparations. At this phase basic information is gathered and preliminary analyses carried out pertaining to the resources of land, water, labour, and capital. Existing data are compiled and augmented by surveys and research. The data on available land resources should be compiled in maps indicating present land ownership and use and land use capabilities. The existing land tenure systems should also be studied and analysed. Information on water resources should be based on the dynamic inventorying of the various sources and should comprise pertinent data concerning the existing water supply systems.

Other important resources are labour and capital. The surveys should aim at measuring the size of the labour force on farms, its quality, degree of utilization and mobility. Demographic studies are important means in the estimation and evaluation of the required parameters.

There are three major sources of capital funds for agricultural development:

1. On-farm savings;
2. Private loans;
3. Public investment.

Attempts should, therefore, be made to estimate farm income and the saving habits of the farm population to gather information on the credit system and to project available public funds. A thorough understanding of farm organization is a prerequisite for any plan. This is best achieved by identifying the predominant farm types in each sub-region and by analysing the input-output relations, crop rotations, number and types of livestock, annual work and irrigation schedules, costs and returns, financial structure, and other organizational characteristics of the typical farms. The construction of a synthetic farm model for each farm type is a highly useful tool of analysis for this purpose.

The analysis of marketing channels and costs should also precede planning. The demand for farm products, both within and without the region, should be studied in an attempt to develop demand projections and marketing outlets. Projections provided by the national planning authorities may be very useful in this respect.

Compilation, analysis, and evaluation of all pertinent data are a time consuming undertaking and the first plans will, therefore, be based on somewhat scanty information and rather crude analyses. As long as these weaknesses are recognized, they should not deter planners from embarking on the second phase of planning.

Planning phase II: determination of development strategies and preparation of preliminary plans. Having assembled and evaluated the needed information, the planners must now determine the development strategies and lay down preliminary general plans. The adopted strategies should aim at developing those resources which effectively limit growth; at inducing spontaneous economic activities, and at building growth potential. Preliminary plans should reflect basic development strategies; they serve as checks on the consistency of the envisaged policy measures and objectives with available resources, and of the projected rise in output of the various industries with the expansion in intermediate and final demand.

Planning phase III: detailed final programming. Preliminary plans are the basis for detailed programming. In Phase III, balance sheets for the availability and utilization of the various resources, and the production and disappearance of the various goods and services are prepared on a sub-regional and regional basis. Detailed investment and current costs of individual development projects and their financial sources are estimated and integrated in the general programme. A detailed programme of research and extension activities should constitute an integral part of the plan.

The social and economic outcomes of the planned development may now be evaluated. To this effect the expected rate of growth of household income, outputs of the various industries, levels of education, employment, and values of other target variables are forecast for the year constituting the planning horizon. In the light of the projected performance of the economy and the further understanding gained in this planning phase, certain revisions of the plans are unavoidable, and final plans may differ from preliminary plans.

Economic Planning Techniques

The techniques employed in regional economic planning are similar to those used at the national level, discussed in the previous chapter. In the author's opinion, budgeting is still the most useful and practical technique, as it avoids the rigidities inherent in input-output and linear (or non-linear) programming methods. Furthermore, it allows planners to use their judgement in considering the unquantifiable restrictions and imponderable factors that abound in any development programme. The use of formal programming techniques requires access to high speed electronic computing facilities and highly trained personnel--conditions which are not easily satisfied. Even where the technical prerequisites for the application of mathematical programming methods exist, they may serve only as auxiliary planning tools.

CHAPTER III
SOME REFLECTIONS ON ECONOMIC PLANNING
AND DEVELOPMENT STRATEGIES

Introduction

Economic planning has been both expanded and intensified in the past twenty years. Doubtless, this spread of planning consciousness owes much to the dictates of fashion; nevertheless, the necessity for planning is genuine and its importance cannot be denied. This need for planning is a direct result of the increase in governmental intervention in the economic process--in itself both established and necessary.

Economic planning is today extensively practised despite the widespread feeling that planning has failed to live up to expectations. This lack of fulfillment of hopes engendered stems, in our opinion, from a misconception--on the part of planners and public alike-- of the role of economic planning. Economic planning is generally viewed as a discipline related asymmetrically to the day by day process of policy formation. In accordance with this conception, plans are prepared at different time intervals for subsequent periods of time, e. g., a Five Year Plan. During the period of plan implementation, all activities, it is held, should adhere to the blueprint. This approach to economic planning may be likened to the process of aiming and firing a rifle; rather should it be viewed and dealt with as the process of guiding a missile. The purpose of economic planning, therefore, is to provide for rational and far-sighted control of the socio-economic process.

The main objective of this paper is to reconsider the role of economic planning within the framework of the political decision-taking process, and as a basic thesis we maintain that economic planning should be comprehended as a continuous process of policy formulation. This conception of planning involves both organizational and methodological implications. Some of the problems and principles related to the

development strategy will now be outlined.

The Socio-Economic Process and Its Control

The Socio-Economic Process

The socio-economic process is governed by a series of functional relations arising from the behaviour patterns of socio-economic units and from the definitional and technical relations of social and economic variables. As examples of behavioral relations we may quote consumption patterns, investors' response to economic opportunities, and social mobility, whereas input-output coefficients and production functions are examples of definitional or technical relations. Let us designate the set of functional relations as the structure. Given the initial state of the socio-economic system at the beginning of any particular period and given a number of endogenous influencing factors, e. g., climatic conditions, war, etc., the values of the social and economic variables during the period under survey, and hence the state of the system at the beginning of the next period, will be determined by the structure. States of growth, immobility, stagnation, and decline may all occur, depending on the nature of the initial conditions, the exogenous factors, and most important of all, on the functional relations. Although the structure can, for the sake of simplicity, be considered more or less stable in the short run, in the long run this will not be the case. Structural changes are continuously taking place--with the exception of stationary societies--generally through evolutionary process and occasionally through revolution; every real development will be accompanied by comprehensive structural change.

The Control and Function of the Planning Process

The socio-economic process can be controlled to some extent by government; government intervention, by manipulating certain control instruments--"instrumental variables" (Tinbergen^{*})--can affect the time

* J. Tinbergen. "Economic Policy: Principles and Design," North Holland Publishing Co., Amsterdam, 1956.

path of the system. Tax rates, tariffs, subsidies, allocation of public funds among competing development projects; distribution of state outlays to education, health, defence, and other public services--all may be cited as examples of quantitative control instruments. The government may also attempt to affect the socio-economic process by initiating structural changes through legislation, administrative arrangements, education, and other measures.

Government intervention is a continuous process affecting the entire time path of the economy, and the effects of immediate decisions carry over well into the future. Any intervention involves expenditure of scarce resources, and the pragmatic question of economic efficiency may be posed--whether the benefits accruing from the intervention exceed its costs, and whether higher benefits might not have been obtained with similar or even lower expenditure, by the adoption of alternative intervention measures. It is at this point that economic planning enters upon the scene.

Economic planning is essentially a phase in the political decision making process. Its main functions within the political-administrative machinery thus are:

1. To provide data required for decision making,
2. To propose intervention strategies,
3. To evaluate the outcome of alternative economic policies,
4. To coordinate the activities of various government agencies,
5. To propagate economic information and projections so as to improve the coordination of decisions in private and public sectors and minimize the waste of resources due to lack of foresight.

A plan consists, therefore, of a realistic programme of actions to be carried out by the government together with projections of their likely social and economic outcomes. A plan thus defined has only superficial similarity with some economic plans which are little more than lists

of target values for certain economic quantities, such as outputs, exports, imports, and investments. This is not to say that these figures are irrelevant to the planning process, but in a real plan the principal emphasis should be placed on the scope and timing of government intervention required to reach desired targets.

All economic planning programmes are based, by necessity, and will always be based, on incomplete data. This is particularly true of developing nations where many of the country's resources are still unexplored, demographic and social statistics are inadequate, and detailed economic statistics are available mainly for the public sector and the country's foreign trade. Sources of data are primarily studies and specific surveys undertaken in previous years, feed-back material during plan implementation, and the flow of information from abroad. Data from feed-back and from surveys are by far the most important. As the informational position improves, earlier projections are reviewed, and the entire plan must be brought up to date; often, the original plan will be discarded after some time, and a new one worked out. The guiding principle will be: the operational significance of a plan is derived from its potential influence on action. Under imperfect knowledge, only the immediate actions matter, since subsequent actions may be reconsidered and replanned from an improved informational position.

Economic planning is thus comprehended as a sequential process with an ever receding horizon.

Organizational and Methodological Implications

This conception of economic planning has important organizational and methodological implications; some of these we shall now consider.

Organizational implications. The administrative structure of planning requires, first and foremost, close communication with the executive branches of government. Thus, each ministry and regional authority--where the latter is responsible for development schemes--should have its own planning unit. To assure overall coordination, a central planning

authority should be established whose role will be to define overall development programmes, through coordination of the plans of the various planning units. It is vital that the central planning authority participate actively in the formulation of fiscal and monetary policies. This must be assured by an appropriate administrative organization.

According to this approach, any exclusive reliance on outside assistance in developing economic plans should be regarded only as a transitory phase during which the planning organization is set up. This, of course, does not exclude continuous advisory activity in special fields.

Methodological implications. In view of the importance of data for the planning process, planning authorities should initiate research projects, surveys, and studies designed to improve the informational base of planning. Some of these studies should be carried out by members of planning teams and some contracted out to universities, research institutions, engineering consultants, and other appropriate bodies. The high importance attributed to data collection should also be reflected in the development strategy by assigning high priorities to information-yielding projects.

The last implication concerns the problem of the planning horizon, or the duration of plans. In determining the planning horizon, one must bear in mind that plans are needed only to the extent that they serve as guides to immediate action. It is therefore necessary to plan ahead only as far as immediate actions have significant effect. The planner must consider the future only to the extent that it has operational implications with respect to short-term action. Thus, the evaluation of a dam or similar irrigation projects should span several decades, while production plans for annual crops call for a horizon of only one year.

A United Nations group of experts on programming techniques has distinguished three broad categories of plans:*

* United Nations Economic Commission for Asia and the Far East. "Programme Techniques for Economic Development." Report of the First Group of Experts on Programming Techniques, Development Programming Series No. 1. Bangkok, 1960.

1. Prospective plans--covering a span of two to three decades. These plans serve as a framework for shorter term plans, and as a guide for decisions concerning development projects whose gestation period and life expectancy are relatively long.
2. Medium-term plans--extending over 4 to 6 years. These plans involve decisions concerning the majority of development programmes (agriculture, industry, education, etc.), and should be much more detailed than the prospective plans.
3. Short-term plans. Of these, the most detailed and specific is the annual plan which should be closely associated with the government budget.

In concluding this section, it should be emphasized that the duration of a plan should not be interpreted to mean that new plans should not be reviewed during the duration period. The underlying concept is that of a constantly evolving or rolling plan which continuously maintains a horizon of given duration.

The Strategy of Economic Development Planning

Planning Objectives and the Problem of Rational Choice

The policy maker is faced with several alternative lines of action and he is, therefore, called upon to select planning programmes in accordance with objectives and other criteria. A rational choice of policy measures is defined by the degree of achievement of certain objectives. These objectives may be expressed in terms of a finite set of criteria, describing quantitatively the main features of economic performance, such as the value of the national product and its rate of growth, employment, price stability, income distribution, and the balance of payments. Difficulties arise, however, when the choice is between plans with a set of incompatible criteria. As an example of such incompatibility, full employment may give rise to inflation and foreign exchange difficulties, and rapid growth may have undesirable effects on income distribution. The final policy decisions are, in fact,

usually arrived at by political processes, often reflecting the political pull of various sectorial groups. In arriving at these policy decisions, the status quo and past performance ordinarily serve as a point of departure, a fact which often burdens political decision-making with great inertia and sluggishness.

In the subsequent discussion, it will be assumed that the rate of growth of the national product will be the most important, though not the sole objective; this assumption is particularly valid for developing economies.

The Role of Government in the Stationary Economy

Emerging economies are often characterized by stationary socio-economic processes. Thus, the income generated in productive activities may be so low that savings are just sufficient for the replacement of existing but inadequate capital stocks; without an increase in capital stocks, income is destined to remain low. Human capital in the form of education skills, know-how, and social organization are also stagnant. The vicious circle of low capital-low income-low savings-low capital is characteristic of other numerous similar vicious circles in the stationary socio-economic process. Primitive productive processes represent a low level of division of labour and the prevalence of unspecialized technologies, leading to subsistence agriculture, with its singular self-sufficiency and lack of exchange. There is insufficient inducement to develop marketing channels and transportation networks without which self-sufficiency remains as the core of the socio-economic pattern. In the absence of economic exchange, social and cultural communication are hindered, traditional patterns perpetuated, and social mobility maintained at a low level. Thus, the primitive system of production is preserved indefinitely.

Under such circumstances, exogenous intervention is unavoidable, due to the lack of any endogenous mechanisms, capable of breaking up these vicious circles. The role of transforming socio-economic

structures must, therefore, be assumed by government. Such a change is an immense undertaking, extending far beyond the development of an infrastructure and the accumulation of capital. Since the available resources, and in particular trained personnel, know-how, and organization are extremely scarce in new economies, the choice of appropriate development strategies will be a crucial element in economic planning.

Guiding principles with respect to the optional selection of development strategies are still wanting. These could probably be obtained by detailed analyses of the outcome of actual development schemes. Tracing the causes of success or failure to the relation between certain socio-economic attributes and the development strategies may help in developing the desired principles.

Development through Inducement

The principal conclusion of our preceding discussion is that social and economic development should be brought about by inducing the individual units to act in a manner conducive to growth. Both direct and indirect inducements are generated by creating certain economic opportunities which serve as incentives. The development of a proper infrastructure, the provision of improved seeds, fertilizer, and convenient credit arrangements, and market facilities are good examples. They provide peasants with the opportunity to improve their production and income by adopting more modern techniques. These, however, are only necessary conditions and, in most cases, are not sufficient in themselves to induce spontaneous economic growth. In order to induce people to take advantage of opportunities the following circumstances should prevail:

1. Awareness of existing opportunities to increase production;
2. Acquisition of requisite know-how, skills, and managerial abilities to make use of these opportunities;
3. Urge to assume the risks and uncertainties inherent in any attempt to discard traditional social and economic patterns of behaviour;

4. Conviction that the new processes do not contradict existing social norms;
5. Absence of any hampering by existing institutions.

These prerequisites for effective inducement mechanisms are not easily fulfilled. They imply that efforts must be made to communicate to people the existence of opportunities, and teach them the use of such opportunities through the setting up of demonstration farms or similar teaching practices. They also imply the need to educate people in a way that will create aspirations toward social and economic improvement and encourage faith in their own ability to achieve them by exploiting the opportunities opened to them.

Some good examples may be found in the field of water resource development. Numerous costly irrigation projects have been constructed, often with chronic and substantial excess capacity. Opportunity has been created for increasing farm output, yet projects are only partially utilized and little advantage taken of afforded opportunity. This is due, in part, to the failure to satisfy some of the five pre-conditions for successful inducement. Farmers may not be aware of these opportunities inasmuch as they involve a shift to untraditional crops and modern irrigation and farming methods. Granted this awareness, they may lack the necessary know-how and willingness to assume the associated risks. Even more often the existing institutions--the land tenure system, credit institutions, and marketing facilities--are completely inadequate, and, in fact, interfere with the full utilization of the available supply of water. The diversion of some resources from the development of the irrigation system to the creation of the required change in the socio-economic structure may assure more effective inducement.

This treatment of the inducement principle has been rather general and even sweeping; in actual analysis, it should be treated in detail and social and psychological approaches elaborated. All that can be

done in this context is to emphasize the importance and prerequisites for effective activation of inducement mechanisms.

Inducements are generated by the direct or indirect creation of incentives for investments, technological progress, and output expansion. In some sectors of the economy, output and investment are limited by the lack of adequate effective demand, while in other sectors, they are restricted by the scarcity of raw materials. In these cases, growth may be generated in development foci and transmitted, through backward and forward linkages, to the rest of the economy. Multiplier effects constitute the most important transmission mechanism.

The Role of Multiplier Effects

Multiplier effects are means by which income and demand changes are propagated throughout the economy. If, for example, in a certain region an increase in government spending has occurred, the additional expenditure will, in part, be spent on goods and services produced within the particular region--an increase in the regional income; the rest will be paid out for goods and services imported from other regions of the country or from abroad. The income increment within the region will be partly saved, but mostly spent. Again, part of the increased spending will accrue to other regions and foreign countries, and the rest will be spent locally, thereby generating a further increase in income. The process described will continue until the effects of the initial change taper out. Unless the regional productive capacity is fully employed, the income generated in the region will, in its turn, generate increased production. It is also obvious that the beneficial effects will not be restricted to the particular region, but will be transmitted to other regions of the country.

The magnitude of the overall effect within the region, or within the country, will depend on the composition of the initial expenditures, on the marginal propensities to consume of the population in the particular region, as well as in other regions of the country, and on the degree of diversification

of the regional and national economy. Generally speaking, the lower the foreign components of the initial expenditure with resulting high percentage of added value, the higher the regional marginal propensities to consume; the lower the imported components of consumer goods, and the more diversified the regional and national economy, the greater will be the multiplier effect. It should also be emphasized that multiplier effects are important instruments in activating inducement mechanisms and in providing incentives for spontaneous economic activity. They are thus conducive to accelerated growth and should be considered in choosing development strategies.

Linkages and the Interdependence of Economic Activities

The concept of economic linkage is akin to the concept of the multiplier. Two types of economic linkage may be distinguished according to Hirshman:* forward linkage and backward linkage. Forward linkage refers to dependence and inducement relationships that exist between the supply of certain goods and services and the economic activities using them as inputs; cotton production is, thus, forwardly linked to the textile industry. Backward linkage refers to the derived demand for goods or services generated by the development of industries using these goods or services as inputs or by changes in final demand, such as private consumption, exports, etc. Identification and quantification of the economic linkages of the various activities allow planners to trace out the path of the multiplier effects and inducement mechanisms. This knowledge allows the planner to choose certain "growth leaders" for a concentrated development effort. The growth leaders become levers for an overall economic activity and growth. It should be emphasized, however, that in many emerging economies, and, particularly, in rural areas, these linkages

* A. O. Hirshman. "The Strategy of Economic Development," Yale University Press, New Haven, 1958.

are extremely weak. In the early stages of development, it may therefore be necessary to spread efforts over a wide range of activities. In order to achieve any effects at all, it will then be necessary to concentrate the limited resources on an overall effort in a limited number of chosen, strategically geographical development foci.

Other Considerations

The choice of development strategy is obviously subject to many economic, social, and political considerations. Problems of optimum resource allocation, price stability, availability of investment funds, the foreign currency position of the country, and many other considerations are always present. They have not been discussed in this context since our main objective has been to present basic considerations with emphasis on particular development strategies applying to development economies.

I have endeavoured in these lectures to cover the salient features in the economic planning of agricultural development in emergent economies. The treatment of the subject has, of necessity, been short in view of the time limit. I trust, nevertheless, that we have reached an understanding of the purposes and the requirements of economic planning, so that the demands made of the economic planners--and the plan--will be, for the sake of all concerned, reasonable and attainable and that our future disappointments will be fewer and of lesser impact.

PART III
LECTURES IN WATER RESOURCES PLANNING
CE 264

Presented at the
SUMMER INSTITUTE IN WATER RESOURCES
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by
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I
FACTORS CONDITIONING THE APPROACH
TO WATER MANAGEMENT

Throughout history there has been a constant search for more efficient ways of developing and utilizing water resources. Sometimes the search has led to major shifts in the approach to water management. Generally, however, changes have been adopted slowly; the process has been evolutionary rather than revolutionary. Changes come only as a result of a strong motivating force.

At any particular time the approach to water management in a given place will be conditioned by at least four factors: (1) concepts of the purposes of water resource development, (2) perception of the problems and possibilities for development, (3) the available technology, and (4) social guides. These factors are to a considerable extent interrelated and a change in one effects all the others.

Concepts of the Purposes of Development

Concepts of the purposes of water resource development range from the view that water should be developed to satisfy certain specific human needs, such as the provision of drinking water, irrigation water, hydro-electric power, etc., to the view that water resource development is a means to achieving "a better life," measured in economic and social terms. The latter view has been extremely popular in the United States, particularly in the West. It is largely associated with reclamation programs and with multiple purpose schemes such as those undertaken by the Federal Government. Water resource development has been regarded

as a means of stimulating economic development in many of the under-developed countries. A number of the schemes supported by the World Bank, for example, have been based on this concept.

Perception of Problems and of Possibilities for Development

The way in which people perceive water problems and the opportunities for water resource development exert a profound influence on the approach to water management. Perception is conditioned largely by experience, knowledge, technical expertise, and certain personality traits. Kates has shown, for example, that lack of experience leads to imperfect perception of flood hazard. He has also shown that even though a flood plain dweller may be aware of the flood hazards, he may have a very imperfect perception of possible adjustments to that hazard. He may be aware of possibilities for dealing with the problem, but may be unclear as to whether they apply to his situation. In some cases, programs of information dissemination can improve the perception of possible solutions and the adoption of solutions.

Much depends on who the decision makers are. The engineer, for example, has a different view from the economist as to what the most desirable course of action might be. Although economists and engineers may not make decisions directly, they nevertheless exert a profound influence on decision-making through the array of projects which they put forward for consideration. Kenneth Boulding and Ray Linsley discuss the economist and the engineer's points of view, respectively, in their contribution to the book by Stephen Smith and Emery Castle. (See Stephen Smith and Emery Castle, Water Resources Development, pp. 82-103)

Available Technology

The technology which is applicable to a given situation depends, in part, on the local physical conditions. There are major differences,

however, in technologies adopted in similar situations in different parts of the world. Sometimes the adoption of technology is inhibited by cultural factors. The role of technology in water resources development is discussed in detail in the book by Edward Ackerman and George Löff, Technology in American Water Development, John Hopkins Press, 1953.

Social Guides

Social guides are those aspects of human behavior, past and present, that condition water resource development. In some cases, they are given expression in laws, administrative arrangements, and public policies. In other instances they exert a less direct influence and are tacitly accepted in policy formulation. They may encourage or discourage development.

Motivation for Change

The approach to water management is constantly changing. Major shifts in the approach, however, usually depend upon the existence of a major motivating force. Typically, this motivating force follows from a crisis of some sort. For example: (1) period of prolonged aridity, (2) a catastrophic flood, (3) intolerable pollution, and (4) severe economic depression.

There are many examples of effects of crises on water management policies in the United States. The soil conservation programs were born following a period of aridity. The flood control acts have followed major floods. Pollution control laws have resulted from the crisis in pollution. The depression of the 1930's led to a more active federal role in water resource development in the United States. Henry C. Hart in his article on "Crisis, Community, and Consent" in Law and Contemporary Problems, Summer 1957, shows how crises have played a major role in water resource development in the United States.

II
CHANGES IN THE APPROACH TO WATER MANAGEMENT
IN THE UNITED STATES

Characteristics of Water Management in the United States

There is no single approach to water management in the United States; rather, a variety of approaches, varying from region to region and from manager to manager. It is possible, nevertheless, to discern some broad characteristics:

1. The growing influence of government at all levels in water management.
2. The heavy emphasis on law and historical precedent, and the small emphasis on economic considerations in allocations of water between users and between uses.
3. The great emphasis on physical engineering compared with human engineering: This is a reflection of a technologically-oriented society.
4. Comprehensive planning is an ideal which is aspired to rather than one which is achieved in practice. Even the TVA scheme was not completely comprehensive.
5. The growing desire for improved water quality.

Causes of Shifts in the Approach to Water Management

There have been some important shifts in the approach to water management in the United States in the past 100 years, and especially in the past 30 years. Major shifts may be expected in the next 10-20 years. Changes in the approach to water management have followed principally from:

1. The growing seriousness of certain water problems and the emergence of new ones.
2. Changes in possibilities of dealing with water problems,

principally as a result of improved technology.

3. Changes in political philosophy.

These factors have found expression in the four elements which condition the approach to water management; namely, (1) views of the purposes of water development, (2) perception of possibilities for development, (3) technology, (4) institutional guides.

Changing Views of the Purposes of Water Development

The approach to water management in the United States has been conditioned by three concepts relating to the purposes of development.

1. The Key to Development

From an early stage in the history of the United States it has been assumed that economic development is closely associated with the development of water resources. One of the earliest expressions of this notion was in the development of waterways. The federal government has played an important role in this connection. It has also played an important role in policies relating to the reclamation of arid lands in the West of the United States.

The notion of "the key to development" grew in popularity in the 1930's and still has considerable currency. Much of the legislation enacted by Congress in the period since the 1930's appears to have been based on this notion.

2. The Yardstick and the Birchrod

The nature of water resources is such that monopoly is possible. Recognition of this possibility led to the view that the government should compete or threaten to compete, to keep private enterprise in line. This view is most prevalent in policies relating to navigation and hydro-electric power development.

3. The Staff of Life

The view has long been held that everyone should be provided with a certain modicum of water at a nominal charge, regardless of the cost

of production. This view still prevails, especially in certain municipal water supply systems.

Changing Importance of Concepts of Purposes of Development

It is probable that the foregoing concepts were valid when they were developed. They no longer seem to be as important, however, as they once were. Consequently, justification for government action must rest on other factors.

1. The Key to Development

Water resources are now less important as an element in the cost structure of economic enterprise, even in the arid West. There has been considerable diversification in the economy of arid areas. New activities in many cases have not had large water demands. In addition, possibilities of water transfer and improvement in technology of water use have made it possible to solve water scarcities in some instances.

Although water may no longer be regarded as a "key to development," its absence may inhibit certain kinds of development.

An important discussion of this question may be found in Irving Fox's article on "Attainment of Efficiency in Satisfying Demands for Water Resources," which appears in the American Economic Review, May 1964.

2. The Birchrod and Yardstick

One rationale offered for government participation in the development of navigation was that it was an effective regulatory device in connection with railroad rates. It appears, however, that competition from truck transport is today much more influential than navigation in this regard.

One reason given for the participation of the federal government in hydro-electric power development was that it helped to regulate the activities of the private power utilities. Today, however, hydro-electric power is declining in importance as a form of energy. Other means of regulation are now being actively sought. The approach of the National

Power Survey, for example, may be even more effective than direct federal participation. For a discussion of this point see W. R. D. Sewell, "The United States National Power Survey, Water Power, May 1965.

3. The Staff of Life

Advances in technology and the growing affluence of American Society have tended to make the "Staff of Life" concept obsolete. Improvements in recycling techniques and water treatment have reduced requirements for carry-over storage. In addition, pricing below cost seems less necessary today as people are able to pay what it costs to make water available. An excellent discussion of these matters is found in J. W. Milliman "Policy Horizons for Urban Water Supply," Resources for the Future Reprint No. 40.

Implications of Changes in Concepts of Purposes of Development

The main implication of the foregoing changes is that government intervention seems less necessary than it once was. On the other hand, there are powerful reasons why government interest in development in water resources is likely to continue and possibly increase.

1. Institutional Rigidities

Once established in a particular role, government intervention is unlikely to be relaxed, at least not in the short run.

2. New Bases for Intervention

There is a growing concern in the United States over the "Quality of Environment." In the past, concern has been mainly with providing increased quantities of water for various purposes. This concern continues. Added to it today, however, is the desire to improve the quality of water. It has been recognized that certain uses, especially waste dilution, are likely to lead to serious "external" effects. Problems arise relating to the tracing of responsibilities and paying of compensation.

The growing desire to provide for increasing recreational opportunities is also likely to lead to increased government participation in water

resource management. Increased leisure time will probably stimulate further demands for water based recreation. In some cases, the demands for such recreation will conflict with demands for water for other purposes. Demands for recreation and calls for arbitration will multiply in the years to come. It also seems likely that the government will be called upon to provide recreational opportunities, especially in cases where water is involved.

It is probable, therefore, that government influence in water management will grow in the years, certainly in connection with regulation of water use, and, no doubt, in development as well.

Changes in the Perception of Problems and Possibilities for Development

The occurrence of a large number of major floods in the United States in recent years has, no doubt, made people more aware of flood programs. Even so, there appears to be a lag between the perception of the problem and the adoption of an adjustment. In the case of adjustments to floods, it may be 30 years, or even longer.

Experience of water pollution has also aroused a call for action. However, solutions are often narrowly perceived, and generally confined to the treatment of wastes, the provision of increased water flows for dilution purposes, and regulation. There has been relatively little emphasis on the incidental adoption of water quality control measures in production processes, even though these measures might lead to significant economics.

Nevertheless, advances in technology have tended to widen the horizon of possible solutions to many water problems.

Advances in Technology

There have been a number of major advances in the technology of water resource development in the past 30 years, as well as in water

utilization technology. A very comprehensive review of this progress is to be found in Ackerman and Löff's Technology in American Water Development. A discussion also appears in the Senate Select Committee on National Water Resources, Print No. 31.

Certain advances have tended to lead to better design. Computerization of analysis and prognostic hydrology are examples. Other technological advances have increased the range of choice of solutions to problems. The use of nuclear explosives, the development of water pipelines, and increases in transmission line voltages, are examples. In addition, technological advances have made it possible to obtain greater use from given quantities of water. Development of recycling techniques, advances in water-conserving agronomy, evaporation suppression, and waste treatment are examples in this connection.

Such advances in technology have helped to broaden the range of choice. The consequences have been on the one hand to make possible the more efficient use of available resources, but on the other to increase pressure on available resources by bringing to light possibilities hitherto not perceived. It is difficult to determine whether the advances making possible more efficient use have counterbalanced the increased pressure brought about by the development of new uses.

Social Guides

The approach to water management is conditioned by numerous social guides, such as social mores, religion, laws, administrative arrangements, and political ideologies. There have been some important shifts in certain social guides in the past 100 years, and especially in the past 30 years. A discussion of these shifts appears in Irving Fox's "New Horizons in Water Resources Administration," Resources for the Future Reprint No. 51. Fox notes that there has been improvement in procedures for evaluating water development projects. At the same time, there are some important problems still to be overcome in this

connection. These relate principally to the problems of discount rates, secondary effects, intangibles, subnational points of view, and redistribution of income. There has been some modification of agency procedures, but the lack of standardization still persists.

There now exists a vast literature relating to procedures for evaluating water resource projects. A useful summary of some of the important contributions appears in the article by Nobe and Kneese, "The Role of Economic Evaluation in Planning for Resource Development," Natural Resources Journal, December 1962, pp. 445-483. Another useful article is Hubert Marshall's "Rational Choice in Water Resources Planning" in Water Resources Development by Smith and Castle, pp. 403-423.

Fox also notes the establishment of new agencies to deal with emerging problems at the federal and state levels. Such agencies include the Bureau of Outdoor Recreation; the Office of Saline Water Conversion, and the Office of Water Resources Research.

There have also been some experiments in new forms of administrative device to foster coordination of policies and functions. These include the Texas and Southeast River Basin Commissions, and the Delaware River Basin Commission.

Despite these advances, however, there remain major weaknesses in the administrative framework for water management in the United States. Principal weaknesses relate to the lack of leadership from the executive branch, and the lack of an agency to evaluate in depth proposals for development. Fox suggests that research on the administrative side of water management is far behind that on the economic evaluation side, and on the technological side.

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III
WATER SCARCITY IN THE UNITED STATES:
MYTH OR REALITY?

Introduction

In January 1961 the Senate Committee on National Water Resources presented to the President the most extensive study of water resources and related problems ever undertaken in the United States. The studies were undertaken over a period of more than one and one-half years and involved numerous public hearings and detailed studies by various government agencies and private consultants. The Committee's reports provide a mine of information for water resources students.

They are of particular interest, however, for their conclusions and recommendations. The Committee identified the principal water problems in the United States as:

- (a) rapidly growing demands for water, especially in the more arid parts of the country,
- (b) increasing pollution of the nation's streams,
- (c) growing demands for publicly-financed recreation facilities,
- (d) mounting flood losses.

It would be impossible to review each of these problems in detail in the time available here, and such detail can be found in the Committee's reports. This discussion will be focused primarily on the first two problems.

Increasing Demands for Water

The Committee estimated that the demand for water for various purposes in the United States will double by 1980, and will triple by the year 2000. This estimate is based on the assumptions that

...the nation's economy will continue to grow at the same rate as it has in the past, that adequate water supplies will be made available under the present general pricing policies,

that there will be relatively little change in presently known technical methods of water use, and that, with the exception of increased application of techniques for improving the efficiency of irrigation, present inefficient methods of using water will continue.

(Senate Select Committee Report, p. 4)

This suggested that overall withdrawals would increase from 300 billion gallons per day in 1954 to nearly 900 billion gallons per day in the year 2000. Of the latter amount, about 250 billion gallons would be for consumptive uses and depletions. By the year 2000, about 80 percent of the national streamflow will be withdrawn for various purposes. This indicates that there will still be a surplus overall. And in any event, only a small portion of it is permanently removed; most of it is used several times for different purposes.

Severe shortages, however, are likely to arise in several regions. The Committee estimated that the entire available supplies in several regions would be required by 1980. By the year 2000 complete development of water resources in 8 of the nation's major water regions will be called for. These are: (1) South Pacific, (2) Colorado River, (3) Great Basin, (4) Upper Rio Grande-Pecos River, (5) Upper Missouri River, (6) Upper Arkansas-Red River, (7) Western Great Lakes, and (8) Western Gulf.

Among the various water uses, the most rapid increases in demand are expected to come from manufacturing industry and stream-electric power stations: that is, at rates much greater than population increase. A vast increase in irrigated acreage is forecast, but only a modest increase in total requirements is anticipated.

Growing Water Pollution Problems

The Committee report that the condition of many of the nation's streams is extremely poor, and further deterioration is to be expected as population increases and as industry expands--unless a firm attack is mounted immediately:

It identifies these main categories of pollutants:

- (a) sewage and other wastes which demand oxygen as they decompose,
- (b) inert materials which contain phosphorus and nitrogen, and which serve as plant nutrients,
- (c) chemicals, including radioactive substances.

It notes that there will be increases in pollution from each of these sources. Unfortunately only modest advances have been made in technologies for dealing with these wastes. Investment in treatment facilities has lagged, and reservoir capacity for waste dilution is inadequate.

Implications of these Trends

These trends have a number of important implications for water management policies:

(1) Expansion of investment in water facilities

The projected requirements for reservoir capacity, treatment facilities, and distribution systems will result in massive investments in the next 40 years.

- \$18 billion for reservoir capacity
- \$82 billion for treatment facilities
- \$29 billion for municipal water supply systems
- \$60 billion for industrial water supplies

In view of these huge expenditures it is pertinent to inquire whether these water demands can be met more efficiently than assumed by the Committee. The Committee assumed:

- (a) that water would be supplied under present water pricing policies (which are known to be inefficient),
- (b) there will be no change in technology (which seems unreasonable in the light of the experience of the past 30 years),
- (c) that present inefficient methods of using water will persist.

A more objective approach would have been to indicate what difference it would make to capital requirements and total water supply requirements if other assumptions were made:

- e. g. (i) marginal cost policies,
- (ii) improvements in technology and their adoption on a large scale,
- (iii) modifications to existing water laws to encourage water to move into its most efficient uses.

(2) Conflicts in water use

As demands for water for various purposes increase, the number and complexities of conflicts among water uses will multiply. Especially severe conflicts may be anticipated between irrigation and other water uses in the West, and between waste disposal and recreation in most parts of the country. The implications of the growing conflicts in water uses are:

- (a) a need for more objective means of weighing competing alternative uses of water, i. e., take into account rent-earning capability as well as law and historical precedent in making allocations,
- (b) a need for a drastic overhaul of water law in the U. S.,
- (c) a need to encourage water rights holders to pay what water is worth--i. e., make water rights marketable to highest bidder--but within certain constraints to safeguard the broad public interest.

(3) Incentives to reduce water pollution

The present approach to water pollution is a two fold attack:

- (a) increase water supply for dilution,
- (b) enact regulations.

This approach is narrow on many counts.

- (a) Regulations may be circumvented.
- (b) There is a need for an economic rationale--but studies are seldom undertaken in this connection.
- (c) There is a need to augment water supply in some cases, but not all.
- (d) There is a need to investigate other possibilities--e. g., encourage manufacturers to adopt waste treatment as incidental to new construction; might provide subsidies for this.

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Table 1

Total Requirements for Withdrawals and Consumptive Uses
or Depletions from Streamflow
(Billions of Gallons Daily)

Purpose	1954		2000	
	Gross Withdrawals	Net Consump- tive uses or Deple- tion from Streamflow	Gross Withdrawals	Net Consump- tive uses or Deple- tion from Streamflow
Diversions				
Irrigation	176.1	103.9	184.5	126.3
Municipal	16.7	2.1	42.2	5.5
Manufacturing	31.9	2.8	229.2	20.8
Mining	1.5	0.3	3.4	0.7
Streampower Cooling	74.1	0.4	429.4	2.9
<hr/>				
Withdrawals and Consumptive Uses	300.3	109.5	888.4	156.3
On-site				
Watershed Improvement Programs				7.0
Swamps and Wetlands for Wildlife				89.9
<hr/>				
Total Consumptive Uses and Depletions				253.2
<hr/>				

IV

ECONOMIC EVALUATION OF WATER RESOURCES PROJECTS

Introduction

The Senate Select Committee on National Water Resources reached some important conclusions on the nature and magnitude of water problems in the United States. Perhaps the most important conclusion, however, was that water can no longer be regarded as a free good. In his report to the Committee Dr. Nathaniel Wollman states:

The report indicates the status of water in our economic system is rapidly changing. Once water could be regarded as a free good--only pipes, pumps, and treatment plants cost money; water was free for the taking. This view seems destined to disappear from the eastern scene as it did from the West some time ago... and while the country is in no imminent danger of running out of water, no longer is it in the enviable position of having enough water at all times for all conceivable uses. In other words, water is quickly moving into the realm of economic goods. (Nathaniel Wollman, Water Supply and Demand, Senate Select Committee on National Water Resources, Committee Print.)

Water resources projects and allocations of water among competing alternative uses, therefore, need to be subjected to economic analysis. Such an analysis should be able to reveal which projects would achieve given objectives most efficiently, and which water uses make most effective use of the available resources.

1. Classical Economic Theory

Classical economic theory suggests that the operation of the market mechanism will lead to the most efficient allocation of resources:

- consumers will allocate their income to that combination of goods and services that gives them the greatest satisfaction.
- producers will choose that combination of factors of production which brings the highest net return. Natural resources are one factor of production which may be substituted for other factors in the search for an optimum combination.

--resources will move into their most productive occupations through comparison among various alternative opportunities. The highest net return from the use of a given resource constitutes its "opportunity cost."

If the market mechanism is working properly, the whole economic system will be brought into equilibrium through consumers trying to maximize satisfactions, producers trying to maximize profits, and resources trying to maximize returns.

This model of the working of the economic system, and the allocation of resources, is based on the assumptions of perfect competition. These include the assumptions that:

1. Goods and services involved are "packageable," that is, they can be differentiated and sold on the market as such.
2. Goods and services are "appropriable," that is, those who own them can lay a legal claim to them and can exclude the consumption of those who are unwilling to pay for them.
3. Small adjustments can be made to output.
4. There are many producers and consumers, so that the actions of any individual have no important effect on price.
5. The production functions of individual producers are independent of each other. That is, the costs of production of an individual producer are not affected by the operations of other producers.
6. Values can be expressed in terms of market prices.

2. Relevance to the Evaluation of Water Resource Projects

In the case of water resources, there are a number of factors which inhibit the working of the market mechanism. These relate principally to the "common goods" nature of many water derived services; the fact that the use of water by one individual usually affects use by other individuals; the fact that it is often very difficult to make small adjustments to the output of water derived services; and the fact that many water derived services are not offered for sale on the open market.

(a) Common Goods.

There are certain goods and services which if they are to be provided at all must be provided for everyone. An example is flood control. Those who do not wish to pay for flood control benefits cannot be excluded from enjoying them, as this would mean no one would enjoy them. Since such "common goods" are not offered for sale in the open market, surrogate measures of what consumers as a whole would be willing to pay must be derived in order to estimate their value.

(b) Indivisibilities.

It is often impossible to make small adjustments to output because key water management facilities can only be undertaken on a large scale. You cannot have half a dam or half a navigation system.

Many water-derived goods and services can be produced and/or distributed at minimum cost only through natural monopolies because the conditions of production involve major economies of scale. The development of a water supply system is a case in point. The construction of a new water supply reservoir, for instance, may make water available at a much lower cost than an older reservoir. The effect may be to depress the price of water and to impair the repayment capability of the older reservoir. Entrepreneurs would be unwilling to enter such industries unless they were able to gain monopoly privileges to ensure their costs were covered.

(c) Externalities.

Production functions of producers who use water resources as an input are seldom independent. Anyone who uses water affects someone else's use. Sometimes this will result in cost reductions (as in the case of upstream regulation) and

at other times it results in increased costs (as in the case of water pollution). The normal operation of the market mechanism does not reflect these external gains and losses.

3. Welfare Economics

Economists have developed a body of theory to take account of the fact that the market mechanism does not reflect all values involved. This is welfare economics. Welfare economics forms the basis of the analysis used by the federal government agencies in the evaluation of reservoir development projects.

Benefit-Cost Analysis

Benefit-cost analysis has become a conventional tool for the economic evaluation of public water resource development projects. It has its origins outside the United States, but has received wider use in this country than elsewhere. Its most extensive use has been by United States federal government agencies.

1. Basic Principles

Benefit-cost analysis is based on the following principles:

- (a) The goods and services to be produced by a project have value only to the extent that there is, or will be, a market for them.
- (b) A project or program, to qualify as the best scheme for development must be the most economic means of accomplishing the stated objective.
- (c) The first-added, or most economic alternative should be the project or program with the highest B/C ratio.
- (d) Each alternative should be designed to make optimum use of a given development opportunity. That is, its scale should be increased to the point where incremental benefits equal incremental costs.

2. Steps in the Analysis

- (a) Identification of various technical possibilities.

- (b) Estimation of economic benefits.
- (c) Determination of benefits and costs of each project at various scales of development.
- (d) Comparison of projects in terms of B/C ratios.
- (e) Selection of the project with the highest B/C ratio.

(See W.R.D. Sewell, et al., Guide to Benefit-Cost Analysis.)

3. Criticisms of Benefit-Cost Analysis

Benefit-cost analysis has been subjected to several criticisms in the academic field and in the political area. Most of the criticisms, however, relate more to the manner in which the analysis has been used rather than to the underlying concepts. They refer largely to the misuse of B/C analysis as a tool for project justification rather than as a tool for analysis.

Nevertheless, there are some important problems to be faced in B/C analysis. These include:

- (a) The problem of selecting an appropriate discount rate which reflects society's preference for individual investment vs. public investment, and which makes allowances for risk and uncertainty.

This remains an area of considerable debate and no agreement is yet on the horizon. There is agreement, however, that rates presently used by federal agencies understate the opportunity cost of capital. The 2-5/8 percent ratio used by the Corps of Engineers, for example, is far below the rate at which the government can borrow money.

A rate which is more reflective of the opportunity cost of capital, and the rate at which money can be borrowed, should be selected. This is probably about 5 percent for many projects undertaken by the federal government. Applications of this rate, however, would severely reduce the programs of development contemplated by certain federal

government agencies. Fox and Hirfindahl show, for example, that raising the discount rate from 2-5/8 percent to 6 percent would result in 64 percent of the projects proposed by the Corps of Engineers being eliminated.

(b) The problem of taking into account sub-national points of view.

Conventional benefit-cost analysis assumes a national point of view. Many projects, however, are conceived with local or regional goals in mind. Recognition of this fact has led to recommendations in Senate Document 97 for analysis of projects to be undertaken from several points of view. These recommendations have relevance for the consideration of secondary effects, which may be important from a local or regional standpoint, but may be irrelevant from a national standpoint.

(c) The problem of assigning values to goods and services which are not sold in the market place.

These include tangible goods and services such as flood control and certain types of recreations and various intangible items, such as scenic beauty. Much progress has been made in recent years in developing surrogate measures of people's willingness to pay, especially in the field of recreation. Further research is necessary, however, to refine the rather crude methods developed thus far.

(d) The problem of taking into account objectives other than economic efficiency in evaluations of potential projects.

The objective of many public projects is income redistribution (either from one region or another, as from one group of individuals to another). Conventional benefit-cost analysis is focused on the efficiency implications of potential investments, not on their distributional consequences.

It may be possible to take the latter into account, however by:

- specifying an income redistributive objective and then seeking alternative ways of achieving it.
- attempting to find an optimal project, subject to the constraint that a given income redistribution is obtained.

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V

INSTITUTIONAL ASPECTS OF EVALUATION

Introduction

The evaluation of public resource development projects takes place within the framework of administrative agencies which are committed to the achievement of certain specific goals of water management; a congress composed of representatives committed to the support of local interests; and an executive which wields only limited power in connection with the selection and approval of water management projects.

Influence of Executive Agencies

The executive agencies decide upon which projects to recommend for congressional approval. Often the list which is submitted is reflective of support garnered from the agency clientele. Generally it is aimed at ensuring that the prestige and power of the agency will be maintained and possibly increased as a result of constructing the projects involved. Marshall in his article on "Rational Choice in Water Resources Planning" suggests that personnel in the agencies involved are motivated to advance the size of their organization, and may narrow the perspective in project selection. A consequence of this process is that the range of alternatives considered by the decision-makers (Congress) is strictly limited. e. g. :

1. Programs for irrigation in the West do not compare costs and benefits of such schemes with possibilities of obtaining increased agricultural production in the East.
2. Programs of hydroelectric power development seldom contain detailed unbiased comparisons of steam-electric or nuclear power production.
3. Water quality programs focus mainly upon regulation and stream-flow augmentation, and pay little attention to possibilities of modifying processes, etc.

4. Programs related to flood problems have been concentrated upon flood control almost to the exclusion of other possibilities. The review of projects is an extremely time-consuming and costly business, and Congress is not equipped to review each project in detail.

Responsibilities of Congressmen: Local vs. National

Congressional representatives are members of national parties in name, but not in fact--they are closely tied to local areas. They are likely to push for those projects which are likely to provide support in the next election. As Hubert Marshall puts it:

...organized local interests will not ordinarily divide on a public works and cancel each others effective power. The district will ordinarily be united, and the trustee of the statewide orientation will of necessity become a delegate on this issue. And, of course, all the delegates are district oriented. Only the representative who plays the trustee role out of ethical conviction will use his own judgment on a matter of this sort; and he, like Burke, may pay for it by retirement from office.

Control by Executive Branch

The executive branch appears to have relatively little control over water policy formulation and implementation. Congress has frequently overridden Presidential vetoes. The agencies, in turn, by-pass the President in requests for funds and program authorization.

Implications of these Factors

Marshall suggests that these factors seriously hamper rational decision making in water management at the national level. He suggests further that little can be accomplished by way of reform through the conscious manipulation of institutions to create counter-vailing pressures or to alter the constituency orientation of Congressmen.

He proposes two lines of action which would help to improve objectivity of decision making in the federal field.

- (a) improving professional identity of government servants,
- (b) strengthening the Executive Office of the President.

1. Professionalization of Government Servants

He argues that if government servants could be encouraged to join professional organizations, a counter balance would be provided to organizational loyalty. This might lend to the development of standards which would be used in evaluations.

- insist upon fullest possible data
- insist upon review of all relevant alternatives
- evaluate projects according to various criteria: economic, efficiency, income redistribution, etc.

2. Strengthening the Executive Office of the President

Marshall notes the need for impartial evaluation of programs of water development, which will

- (a) be independent of agency goals
- (b) weigh proposals for water development against proposals for other kinds of development.

The Bureau of the Budget has this nominal responsibility but does not, in fact, undertake detailed evaluations of proposed projects.

- The agencies do the valuations and present them for review.
- Bureau standards are fairly loose.
- Projects with negative ratios are never approved, so there is a desire to come up with positive ratios.
- The Bureau is not permitted to go into the field to check agency estimates.

Marshall suggests a gradual strengthening of the Bureau of the Budget, the establishment of more rigorous standards of evaluation, the institution of field checks on data, and the requirement to consider alternatives.

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VI

ADJUSTMENT TO FLOODS IN THE UNITED STATES

1. The Flood Plain as a Focus for Human Settlement

(a) Since earliest times, flood plains have provided a major focus for human settlement patterns. In some cases floods have been used to advantage, as in the case of the River Nile; but for the most part, they have been the scourge of mankind.

-- huge losses in India and China, and other countries in the Far East each year.

-- massive losses in the United States too; often as much as \$1 billion, and averaging over \$800 million per annum. Losses appear to be increasing despite huge expenditures on flood protection to reduce them. The accompanying diagram shows that more than \$300 million per annum is required to keep up with the increased losses.

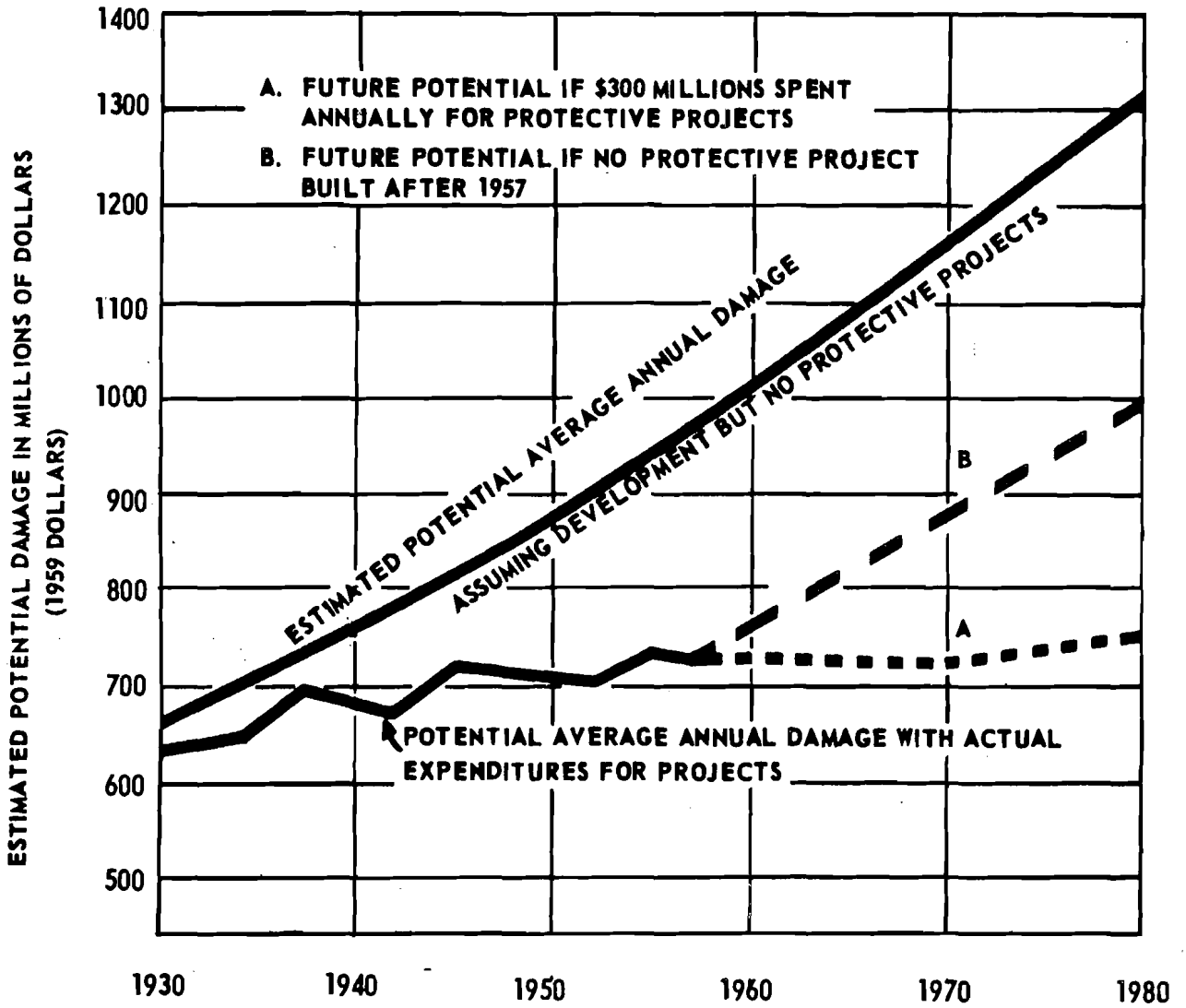
-- losses are increasing especially rapidly in urbanized flood plains. White has estimated that losses in such areas are increasing at least 2.7 percent per annum.

-- losses from catastrophic floods are increasing but losses from noncatastrophic floods are growing even more rapidly. This reflects the fact that occupancy is becoming even more intensive in the sections of flood plains subject to the most frequent floods.

(See G. F. White, Changes in Urban Occupance of Flood Plains.)

(b) In view of these mounting losses, it is pertinent to inquire why people continue to move into flood plains even though major losses have been experienced in the past. At least 6 major reasons suggest themselves: (1) economic advantage, (2) inertia, (3) ignorance, (4) ability of flood plain dwellers to shift the burden of losses onto the public at large, and (5) government policies. An understanding of these factors would

GROWTH OF POTENTIAL AVERAGE FLOOD DAMAGE IN THE UNITED STATES



POTENTIAL DAMAGE - AVERAGE ANNUAL DAMAGE THAT WOULD OCCUR DURING PERIOD OF NORMAL FLOOD EXPERIENCE WITH NO CHANGE IN FLOOD PLAIN USE (NOT ACTUAL DAMAGE IN YEAR INDICATED)

Figure 1

help in the formulation of policies to reduce flood losses.

- (i) Economic advantage. Flood plain lands are often low, flat lands which permit low-cost construction of transportation routes and buildings; they provide access to water for industrial uses; they often provide rich alluvial soils for agriculture. These factors were responsible for much of the early settlement in flood plains in the United States and elsewhere. Technical advances, however, have reduced the importance of some of these factors as locative forces: e. g., it is just as cheap to construct transportation routes outside the flood plain as in it.

Industry is less demanding on locations: there are now many footloose types. In addition, some activities suffer smaller losses per acre--farming less seriously damaged than industry or residential development.
- (ii) Problem of inertia. Once a flood plain is settled, it tends to stay that way. People hesitate to move, and so long as they stay there they encourage others to move in.
- (iii) Ignorance. Many of the people who live in flood plains are ignorant of the flood hazard:
 - especially where there has been no flood in living memory
 - even where there has been flooding in living memory, many may have moved there recently: Kates emphasizes the need to have experienced a flood recently.
 - real estate promoters and local governments may know of the flood hazard but choose to ignore it.
- (iv) Ability to shift the burden to others. Floods cause large direct losses in the flood plain but may also lead to losses outside the flood plain, especially where transportation or communications are involved, and where

there are economic ties between activities in the flood plain and activities elsewhere.

This has provided a rationale for the general public assuming a share of the costs of providing flood protection. It is probable, however, that the benefits to the general public are less than the costs borne by the general public, and the benefits to the flood plain dwellers are far in excess of the costs they assume. Flood plain dwellers typically receive a subsidy to flood plain dwelling.

- (v) Government policies. In general, government policies have encouraged the flood plain dweller to support these lines of action which place the major share of the burden of flood losses on public at large, and have seldom encouraged him to think of ways in which he himself could help to reduce flood losses. Policies have been geared merely to keeping water off the land rather than encouraging optimum use of the flood plain.

On the whole, government policies have been fairly narrowly focused, and have tended to concentrate on the provision of flood protection works, and funds for relief and rehabilitation of flood victims. Provision of protection has tended to engender confidence that floods will not occur again. At the same time, the flood plain dweller has come to regard relief and rehabilitation payments as a right rather than as a charitable gift to alleviate misfortune. The overall effect of both adjustments has been to encourage continued occupancy, and possibly to increase it as well.

2. The Range of Choice

Gilbert White has suggested that the concentration on a narrow range of adjustments is one of the factors responsible for the mounting toll of flood losses in the United States. In reality there are many more possible

courses of action than have been tried so far by agencies responsible for dealing with flood problems. Possible adjustments include: (1) bearing the loss, (2) emergency action, (3) structural change, (4) land use regulation, (5) flood control, and (6) flood insurance.

Together these constitute a Theoretical Range of Choice: Which of these will be selected will depend upon several factors including:

- (a) The perception of the possibilities and their application to a given situation. Flood managers may be unaware of the possibilities, and even if they are aware of them, they may not perceive the application to their situation.
- (b) Institutional constraints. Laws may encourage the adoption of some adjustments rather than others. In the United States, the federal government provides funds for flood control but not for flood proofing. Tradition may encourage the adoption of some measures rather than others. The Corps of Engineers appears to have a bias toward flood protection vs. other alternatives. Division of jurisdiction may also act as an inhibiting factor, e. g., the federal government cannot enact land use regulations.

Over time, various combinations of adjustments will be tried, e. g., (1) initially bear the loss, then (2) emergency action, then (3) flood protection, (4) flood proofing plus protection, and finally (5) land use regulation plus protection.

3. Possible Adjustments

Each of the adjustments has advantages and disadvantages, depending on the flood problem involved. They should not be considered as discrete alternatives, but rather as possibilities which should be used in various combinations. (For a discussion of possible adjustments see G. F. White, Human Adjustment to Floods, and Hoyt and Langbein, Floods.)

- (a) Bearing the loss

--most common adjustment

- arouses public sympathy on a large scale: leads to flood relief campaigns, etc.
- arouses call for government assistance; comes to be regarded as a right rather than a charitable gift to offset the misfortune
- encourages persistent settlement and persistent reliance on public aid

(b) Emergency action

- can be effective by moving people and goods temporarily out of the path of floods
- consists of flood fighting, temporary removal, and re-scheduling of operations

White suggests that in some cases as much as 70 percent of losses could be reduced by such action.

To be effective it requires:

- information regarding flood hazard
- advance planning for removal of persons and goods
- efficient flood forecasting and flood warning

Effectiveness varies: where flood-to-peak interval is greater than 48 hours, it has great possibilities.

Public responsiveness is greatest when flood frequency is high.

(c) Structural change and land elevation

- altering buildings to keep out flood waters; e. g., bricking up windows; sealing valves, etc.
- raising buildings above flood levels
- usefulness limited by nature of flooding: most useful where flood is short duration and level of flood waters is low.
- land fill generally too expensive in old areas, but can be adopted in new ones: a useful 'incidental adoption.'

(d) Flood proofing

- combination of structural change and emergency measures

--raising goods above flood levels, sealing machinery in plastic bags, etc.

--needs effective forecasting service

--used effectively in Pittsburgh Golden Triangle

(e) Land use regulation

--accomplished by ordinances, building codes, urban renewal and government purchase of lands

--purpose is to select those uses which have least flood losses potential, or those which can afford to pay the "natural tax" on flood plain occupancy and still earn higher returns than they could elsewhere.

(i) need to determine potential flood losses to each use with various magnitudes of floods

(ii) need to determine possible earnings of each use in various locations within and beyond the flood plain.

Note: White suggests there may be little difference between earnings within and beyond the flood plain, as represented by land values. However, no intensive studies of this matter appear to have been undertaken thus far.

--opposed are those who feel that personal freedom is impaired by use of police power. (See Allison Dunham.)

--often avoided when the purpose is not well understood and where power of enforcement is weak. (See Francis C. Murphy, Regulating Flood Plain Development.)

--setting of encroachment lines, based on flood probabilities would be a useful way to approach flood loss reduction.

(f) Flood control measures

Two broad groups: (1) land treatment programs, and (2) flood protection.

(i) Land treatment. Changing cropping practices, terracing, gully control, revegetation, and forest fire control. Not effective on its own, despite claims to the contrary.

(ii) Flood protection. Levees and flood walls--most common of all methods. Inherent risks in this method. A useful adjunct to reservoirs. Channel improvements. Floodways and river diversions. Reservoirs. Advantages of reservoirs:

--provide protection away from flood plain by evening out flow

--multiple purpose possibilities

Disadvantages of reservoirs:

--physical separation of costs and benefits: people not aware of flood hazard

--usually require public subsidy

--usually encourage further encroachment

--need to be accompanied by land use regulation

(g) Flood insurance has been little used so far; no appropriation for federal action.

4. Guidelines for Action

Given the present dilemma of mounting flood losses in spite of huge expenditures on flood protection, what lines of action might be taken to overcome this problem?

In his recent monograph on Choice of Adjustment to Floods, White suggests a number of specific courses of action that might be pursued in this connection: these courses of action would be designed to:

(a) make flood plain dwellers aware of the risks they are running,

(b) encourage public agencies to consider the full range of adjustments, and

(c) encourage flood plain managers to consider courses of action that might be taken in the absence of publicly-sponsored projects.

These lines of action would include the following:

(a) Increasing knowledge about the impacts of floods and possible adjustments to them.

- (i) Substitution of synthetic for reported losses from floods. This would improve the accuracy of estimates of losses and would make for better economic evaluations.
 - (ii) Estimate the degree to which losses are reduced by various lines of action. This requires knowledge of human response to various adjustment possibilities. Studies of perception of flood hazard and of possible adjustments to that hazard would help to increase understanding of the way in which flood managers actually make decisions about adjustments, and would, therefore, make possible the prediction of possible responses to given adjustments. (See Kates: Variations in Flood Hazard Perception.)
 - (iii) Refinement of relationships between various flood characteristics, e. g., duration, velocity, volume, depth, sediment, etc.
- (b) Broadening the range of choice.
- (i) Encourage those responsible for dealing with flood problems to consider nonconstruction alternatives as well as construction alternatives in their decision-making.
 - (ii) Provide flood hazard information to those whose policies and actions affect the use of flood plains. Studies of effectiveness of various means of communication need to be undertaken in order to determine which ones are likely to lead to the information being translated into policies.
 - (iii) Provide flood managers with incentives to take individual actions to reduce the impact of floods, e. g., through adoption of flood proofing measures.
 - (iv) Make economic evaluations sensitive to the various factors which enter individual decisions: particularly the perception of the problem and its possible solutions.

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VII

ADJUSTMENT TO FLOODS IN THE LOWER FRASER VALLEY

The Problem in Perspective

As in many other parts of the world, river valleys have provided a major focus for settlement in Canada. In some cases such settlement has spilled over into flood plains, and major losses of property, income, and life have sometimes resulted. In certain instances the occurrence of floods has discouraged further settlement in flood plains. For the most part, however, encroachment in these areas has proceeded unabated.

Until relatively recently there has been little concern expressed over flood problems in Canada. A number of major floods in British Columbia, Manitoba, and Ontario, however, in the past 20 years have shown, however, that catastrophic losses can be sustained from floods and that the national economy can be severely disrupted as a result. No precise figures are available, but limited information suggests that at least 10 percent of Canada's population lives in flood plains. Population in certain flood plains is increasing even more rapidly than population in surrounding areas.

Today about one-half million people in Ontario and Quebec live in flood plains. More than a quarter of Manitoba's population lives in areas which could be inundated by a major flood.

Flood losses in Canada are not very large. They are probably less than \$25 million a year. They are small in comparison with fire losses in Canada, estimated at over \$100 million a year, or in comparison with fire losses in the United States (over \$500 million). Losses assume major importance in some parts of the country, however, especially in British Columbia, Ontario, and Manitoba.

One of the most serious flood problems is that in the Lower Fraser Valley of British Columbia, a wedge-shaped area covering 800 square miles in the southwestern part of the province. In this area is concentrated most

of British Columbia's population, industry, and productive farmland. It is also the major transportation corridor between the Pacific Coast and the rest of Canada. Major floods, therefore, could seriously disrupt the economy of British Columbia and would have important effects elsewhere in Canada too.

The last major flood in the Lower Fraser Valley occurred in 1948, and caused more than \$20 million of compensated damages: actual losses were much higher. Vancouver was cut off from the rest of Canada (except by air). There have been a number of other major floods in the Valley, but these occurred before the present concentration of population and industry took place. Should a major flood occur today, it might cause as much as \$100 million property damages and income losses.

Various adjustments to the flood problem in the Lower Fraser Valley have been tried, but none has been successful thus far in reducing the flood loss potential. Flood losses have continued to mount in spite of huge expenditures to reduce them. The most recent attempt to deal with the flood problem was the establishment of a Fraser River Board, following the 1948 flood, charged with the responsibility of investigating the flood problem, studying the possible alternative solutions. It submitted its final report in December, 1963, recommending the construction of a combined hydro-electric power and flood control scheme, which would cost over \$400 million. Doubts have been voiced, however, as to whether this scheme would be an effective long-term solution. In any event, the scheme has been opposed by certain recreation and wildlife interests. It has failed to win support of either the senior governments or the local governments. Meanwhile, flood loss potentials continue to mount.

The continual failure to find an acceptable solution to the flood problem in the Lower Fraser Valley has several important implications. It suggests that there may be some weaknesses in the present approach

to such problems. It also implies that the causes of the problem are less well understood than its effects. It is conceivable too that the present institutional framework may not foster the search for and implementation of the most effective and efficient solutions.

Adjustments Adopted to Date in the Lower Fraser Valley

The principal adjustments adopted to date in the Lower Fraser Valley are flood relief and rehabilitation, emergency action, and dyke construction. Each of these deals with the effects rather than the causes of the problem. Each of them tends to encourage the flood plain dweller to take risks which he might not do in the absence of their provision.

The Lower Fraser Valley dykes consist of 233 miles of works constructed between Hope and the mouth of the river. They are operated and maintained by dyking districts which charge dyking taxes to cover costs of operation and repair. These funds are, however, insufficient and reliance is placed on the senior governments to reconstruct the dykes when they fail, as they frequently have done in the past 70 years, with varying degrees of seriousness of effects. The dyking system has been plagued with financial troubles ever since the first dykes were built in the 19th century.

The senior governments have handed out several million dollars to assist flood victims to recuperate from losses sustained in major floods. Provincial government expenditures in the province average over \$500,000 for this purpose. Such relief is now regarded as a right by flood plain dwellers in the Lower Fraser Valley.

Various emergency actions have been tried over the years and these seem to have worked well, despite the 'ad hoc' manner in which they have been organized. The Army was placed in charge in 1948. There is no formal organization for organizing, issuing flood warnings, evacuation, and so on.

There are only isolated instances of the adoption of other possible

adjustments, such as structural change (notably the huge land fill project for the Annacis Island Industrial Estate), river diversions (such as the Nechako Diversion to the Kitimat scheme) and land use regulation. No instances of formal flood insurance appear to exist, although some firms do keep reserves to cover possible losses from floods.

On the whole, there has been a gradual shift of responsibility from flood plain dwellers to the public at large, from the individual to the group, and from local to senior levels of government. Reliance on flood control, emergency action, and flood relief has not reduced the flood loss potential; it is possible that these measures may have been partly responsible for its increase, through the increased confidence they engender, either that the floods will not occur, or that the victims will be taken care of if the floods do come.

Reaction to the 1948 Flood

The 1948 flood underlined the need for a new approach to the flood problem in the Lower Fraser Valley. Merely to repair the dykes would be insufficient. This, however, was considered to be only a temporary solution. Provision had to be made for their maintenance and repair. A dyking commissioner was appointed to carry out this task. He is only able to do what the finances of the dyking districts permit. Many of them are too poor to do very much. The poorest ones are also the ones where the problems are most serious. Another line of action was to try to understand the origins of the problem better, and to examine possible alternative solutions. This was to be pursued through an engineering board, known as the Fraser River Board.

The Fraser River Board was given very broad terms of reference, permitting it to study the flood problem within the framework of overall river basin development. Gradually, however, the interaction of a number of institutional factors led to the scaling down of the focus of its studies. The completely comprehensive approach was abandoned in

favor of a small design scheme of hydro-electric power and flood control development. Other uses were taken into account only insofar as they might be affected by the proposed development.

The Fraser River Board's Proposed Scheme

The Fraser River Board's proposed scheme is designed to control floods up to a design flood (equal to a flow of 600,000 cfs at Hope). It would be composed of a number of storage projects, power plants, and a reconstructed dyking system in the Lower Fraser Valley. It would provide flood control benefits estimated at \$75 million. If the power produced by the scheme (785 mw of firm power) is sold at 5 mills/kwh, then the scheme would be self-liquidating, except for dyke reconstruction (estimated at \$15 million). Flood control storage would be provided free of charge by virtue of the power revenues.

Appraisal of the Scheme

The principal emphasis of the Fraser River Board's studies was on the engineering and technical aspects of the flood problem and its solution. These studies added considerably to the understanding of the problem, and the Board is to be commended for their high caliber.

The studies, however, had little to say about the economic and institutional aspects of the problem. Only \$30,000 of the \$4 million spent by the Fraser River Board was devoted to economic studies. The latter were undertaken almost as an afterthought, a few months before the completion of the Board's investigation.

The lack of attention to economic aspects of water problems is typical in Canada, particularly in connection with flood problems. Decisions relating to multi-million dollar expenditures have been based on only the most cursory of economic analyses. Various reasons have been given, such as "the urgency to get on with the job, that there is no time for economic studies," or "human life is involved, so why should an economic analysis be applied."

There are some major weaknesses in the Board's economic studies. Of these, the following might be noted:

- (a) Estimates of income losses were based on personal income per employed worker. No checks were made in the field to determine whether the figures were realistic.
- (b) Crop losses were given an average value throughout the Valley, although there is considerable specialization from one part to another.
- (c) Damages to dykes were considered as losses, even though a basic assumption was that there were no dykes in the Valley!
- (d) No consideration was given to possible changes in land use following the adoption of given adjustments.
- (e) No incremental economic analysis was undertaken to determine the size of the design flood. The latter was based arbitrarily on the largest flood on record.
- (f) No comparison of alternative adjustments was undertaken in economic terms.
- (g) No estimate was made of the economic effect of the limitation of the construction of storage reservoirs and power dams to the headwaters of the basin.

Institutional Aspects of the Problem

The approach to the flood problem in the Lower Fraser Valley has been more in the nature of a series of reactions to successive crises rather than a result of a long-term, broadly based planning. Among the various weaknesses of the past approach to the problem, the following deficiencies appear to be especially important:

1. Lack of Definition of Responsibilities

Responsibilities of the various levels of government for dealing with flood problems are ill-defined. The federal government points out that it has no definite constitutional responsibility for the matter, and

so none should be assumed. It prefers to wait until asked by the provinces to take action. The provincial authorities, in turn, suggest that such problems are not their responsibility and that local authorities should take the initiative to deal with them. The result is that no one takes any action until a major flood occurs.

2. Narrow Range of Adjustments

Only a few of the possible adjustments to floods have been tried so far in the Lower Fraser Valley. Engineering boards tend to concentrate on those alternatives involving construction. Politicians favor flood relief expenditures since they quieten public outcries for action. Neither course of action, however, has been successful. Other adjustments which might be more effective and economically more efficient, such as land use regulation, flood insurance, flood proofing, and so on, have received only scant attention. This follows partly from the legislation relating to floods, most of which appears to assume either implicitly or explicitly that flood control is the most efficient adjustment.

3. Lack of Economic Analysis

Decisions relating to adjustments to floods in the Lower Fraser Valley have not been based on penetrating economic analyses of benefits and costs of various possible alternative courses of action. Generally, there has been an implicit assumption that protection should be provided, and that it should be sufficient to cope with the largest known flood.

The federal government participates in studies relating to flood problems but does not undertake any economic analyses as part of such studies. The rationale offered is that results of these analyses might be used as a bargaining device to obtain federal financial assistance to deal with the problem. A consequence is that the provinces carry out the economic analyses, and the federal authority is left in the position of having to either accept or reject the results, without much knowledge as to their validity and as to possible alternatives.

Possible Improvements in the Present Approach

There are a number of lines of action which might be pursued in an effort to attack the flood problem in the Lower Fraser Valley on a broader and longer term basis. These lines of action include the following:

1. Clear definition of the roles to be played by the various levels of administration in dealing with flood problems.
2. Formulation of national and provincial policies relating to adjustment to floods.
3. Broadening the range of adjustments considered by modifying policies, laws, and agency practices.
4. Coordination of agency functions within and between the various levels of administration through the establishment of committees and commissions.
5. Formal adoption of economic analysis of possible alternative adjustments to floods.
6. Increasing public awareness of flood problems through such devices as information dissemination and flood mapping programs.

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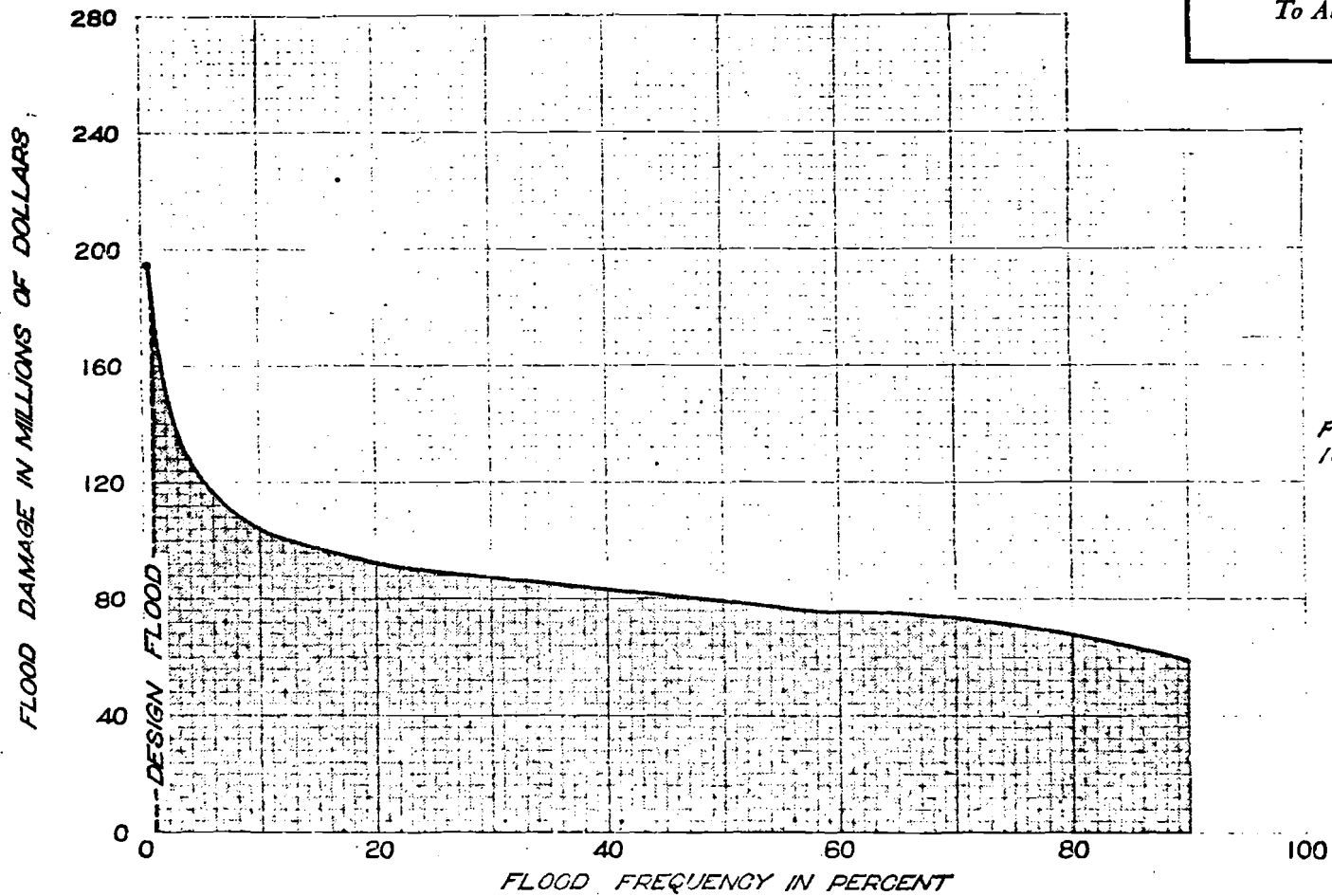
FRASER RIVER BOARD

LOWER FRASER VALLEY
DAMAGE FREQUENCY
CURVE

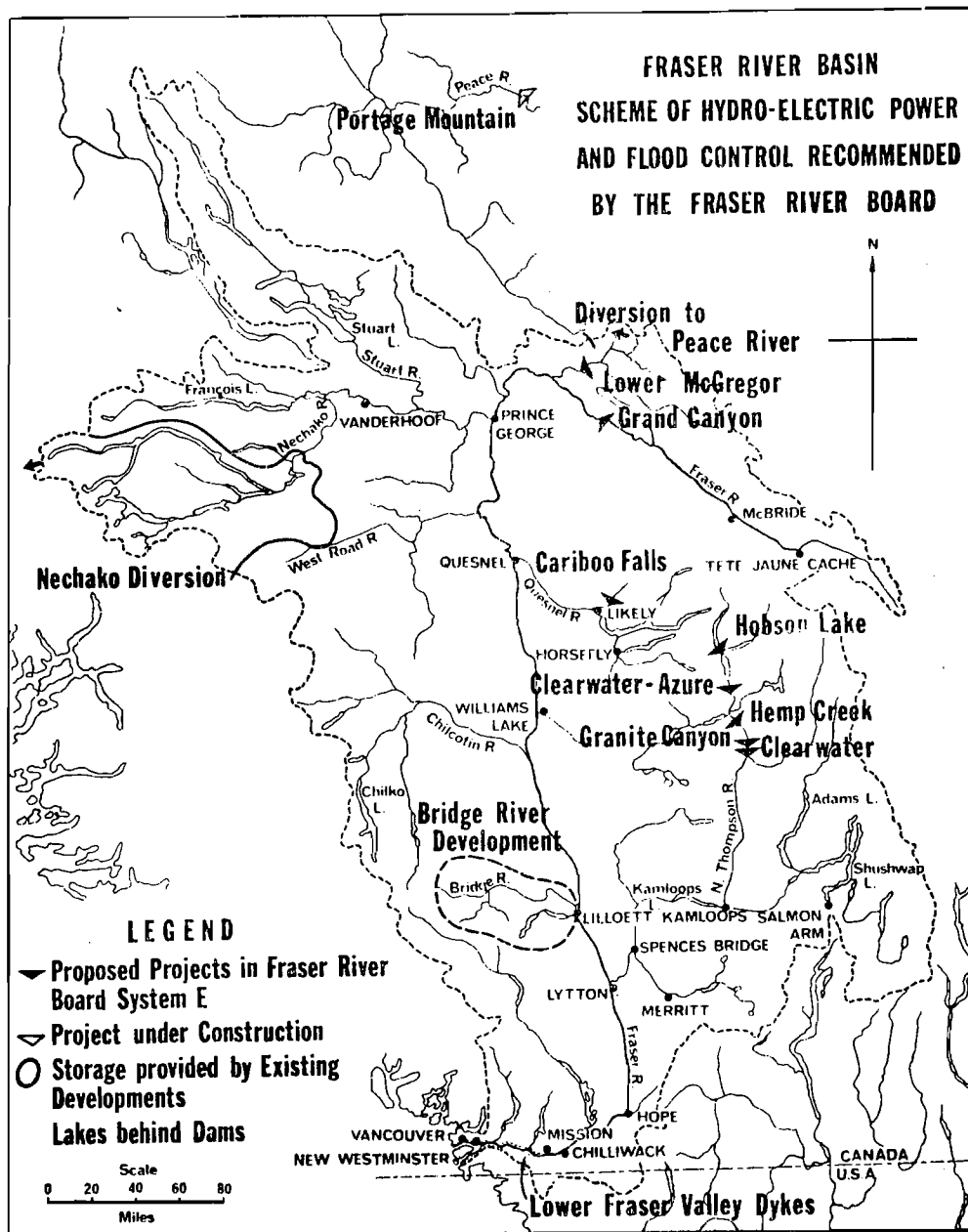
To Accompany Final Report
1963



AVERAGE ANNUAL DAMAGE
BETWEEN 0.8% & 90% FLOOD
FREQUENCY = 75.3 MILLION DOLLARS

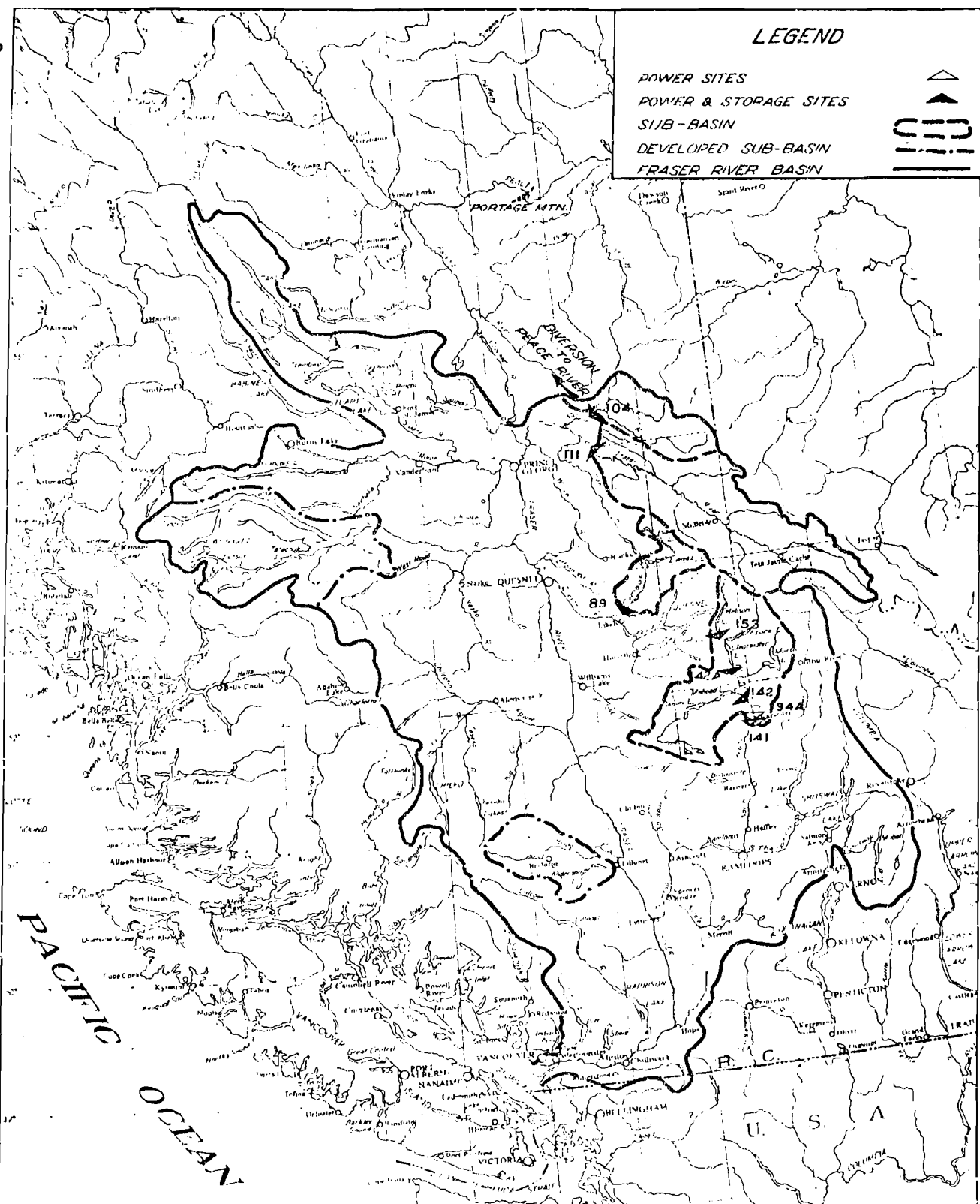


NOTE
FLOOD DAMAGE IS IN
1961 DOLLARS



LEGEND

- POWER SITES
- POWER & STORAGE SITES
- SI/B-BASIN
- DEVELOPED SUB-BASIN
- FRASER RIVER BASIN

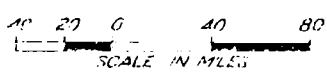


PACIFIC OCEAN

120° 115° 110° 105° 100° 95° 90° 85° 80°

INDEX

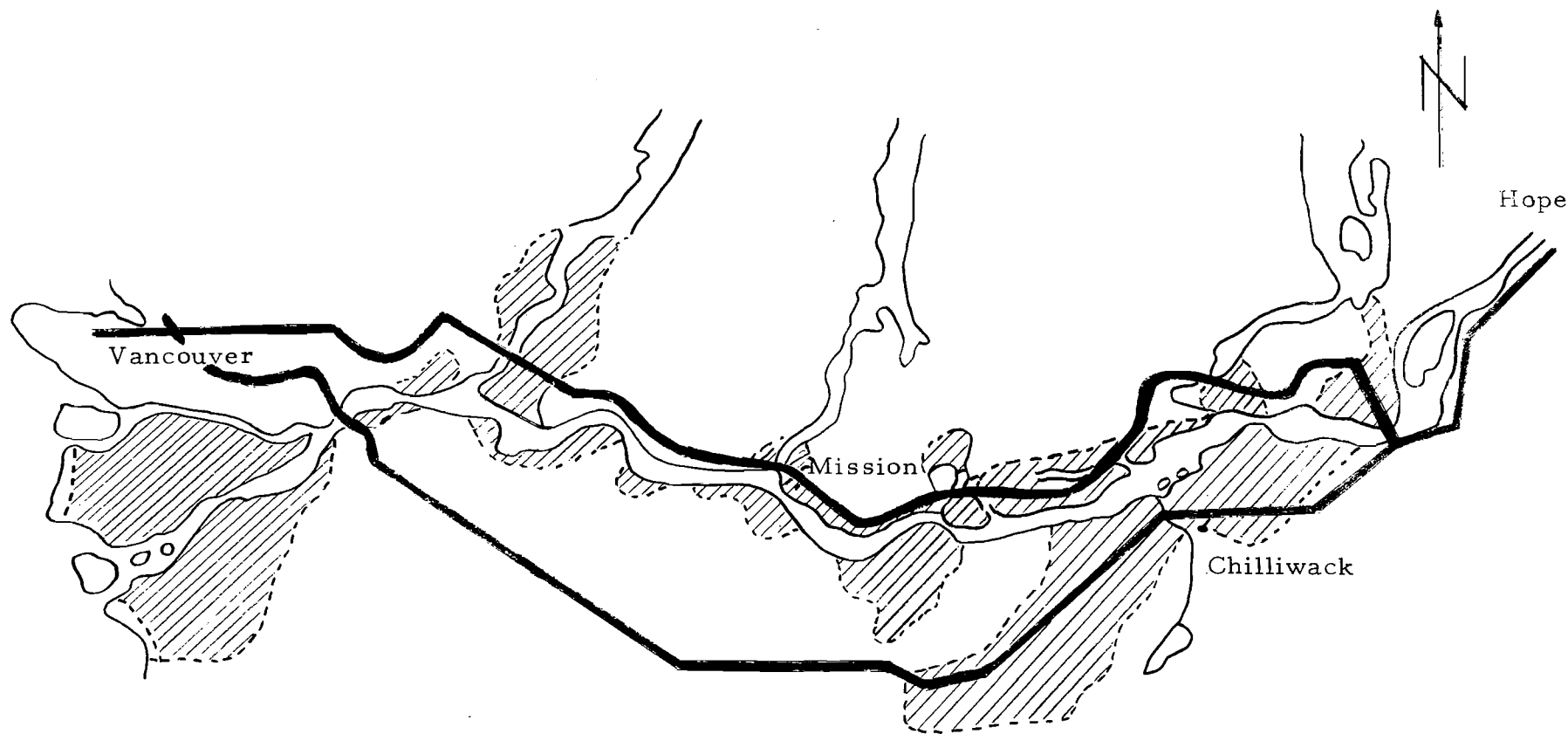
SITE	SUB-BASINS
111 GRAND CANYON	UPPER FRASER RIVER
104 LOWER MCGREGOR	MCGREGOR RIVER
89 CARIBOU FALLS	CARIBOU RIVER
153 HOBSON LAKE	CLEARWATER RIVER
142A CLEARWATER-AZURE	CLEARWATER RIVER
142 HEMP CREEK	CLEARWATER RIVER
141 CLEARWATER	CLEARWATER RIVER
194A GRANITE CANYON	CLEARWATER RIVER
(PORTAGE MOUNTAIN)	(PEACE RIVER)




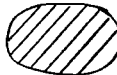
FRASER RIVER BOARD

SYSTEM "E"
LOCATION OF PROPOSED PROJECTS

To Accompany Final Report
1963



POTENTIAL INUNDATION IN
THE LOWER FRASER
VALLEY

-  Roads
-  Areas which would be inundated by a major flood, assuming dykes to be ineffective

Scale: 9 miles to the inch

VIII

THE CONFLICT BETWEEN FISH AND POWER

Origins of the Problem

The competition between migratory fish runs and hydroelectric power constitutes one of the most frustrating problems in the development of major rivers in the Pacific Northwest and in British Columbia. Traditionally, the problem has been regarded as a choice between two mutually exclusive uses of these rivers. Presently they support large runs of migratory fish which provide the basis for one of the major industries in one region. As many as 100,000 people are engaged in activities related to the fishery at certain periods of the year. On the other hand, many of the salmon streams represent important hydroelectric power resources as well. Construction of dams, however, interferes with the migration of the fish runs and, (claim the fisheries interests) if constructed in sufficient numbers, would lead to the extinction of the runs.

The view that these two uses are mutually exclusive alternatives has had some important results.

1. It has given rise to a "preservation at all costs" philosophy among the fishery interests.
2. It has tended to obscure the fact that rivers can be used for many purposes in addition to providing fish migration routes and spawning grounds, and that total preservation may preclude all other uses as well as power development.

Criteria for Evaluating the Conflict

Various criteria may be used for evaluating conflicts in resource use. Among these criteria are the following.

1. Aesthetic and ecological. Such questions as "Will the alternative spoil the natural environment?" or "Will it disturb the delicate

balance of nature?" may be posed. Such considerations are important but they do not provide a basis for relative ranking of alternatives.

2. Technical. Such questions as "Can the fish get over the dams or pass through the turbines without major losses" are posed as one measure of the desirability of competitive hydro-power development. If the biologists appear to agree that fish facilities are technically feasible, they will be installed, and opposition to dam construction is relaxed. Such decisions do not involve an evaluation of the economic benefits and costs.
3. Legal. Often resort is made to legal and historical precedent in deciding conflicts in water use. This has been the case especially in British Columbia in connection with fish and power.
4. Economic. The conflict between fish and power poses the question whether the use of the river for fish migration and spawning is economically more efficient than its use for other purposes. It also raises the question of whether the benefits of providing fish protection facilities exceed the costs involved in providing them.

To date principal reliance has been placed on 1, 2, and 3. There has been little or no attempt to undertake a rigorous benefit-cost analysis of fish preservation expenditures although such analysis has been undertaken of other investments in the water resources field.

Benefit-Cost Analysis of Fish Preservation

Two major questions relating to fish preservation may be posed:

1. Assuming that fish preservation is incompatible with power development, to what extent is the reservation of the river for fish economically more efficient than its use for other purposes?
2. Assuming that fish facilities and other damage mitigating

programs can offset potential fish losses, to what extent can they be economically justified?

1. Net Economic Yield

Both questions involve the estimation of the net economic yield of the fishery: that is, the net return from the use of the river for fish migration vs. its use for other purposes. This requires estimates of:

- (a) The abundance of fish: which varies with the size of the annual catch, etc.
- (b) The catch mix: the number of fish caught for commercial vs. sports purposes vs. Indian fishing.
- (c) The net returns from each type of fishing.

Difficulties arise because:

- (a) Values of each type of fishing have a different basis: commercial, recreational, Indian.
- (b) Values of commercial fishing should be based on net returns to an efficiently organized fishing industry which would seek to increase returns to fishermen by reducing the number of fishermen. The problem is to determine what would be an efficiently organized fishery--how many fishermen? What gear would they use?
- (c) Values of the sport fishery need to be based on estimates of what the fishermen would be prepared to give up rather than forego fishing. Note the product of sport fishing is not fish, but the recreation derived from that pursuit.
- (d) Values of the Indian fishery are not easily assessed when the fish are not sold in the commercial market. However, Indians can fish and sell part of their catch in this way. The price received may be used to establish a minimal value of the fish to the Indians.

The net economic yield may be used in making comparisons of net returns from various water uses and in evaluating the economic feasibility of installing fish passage facilities.

2. Costs of Fish Preservation

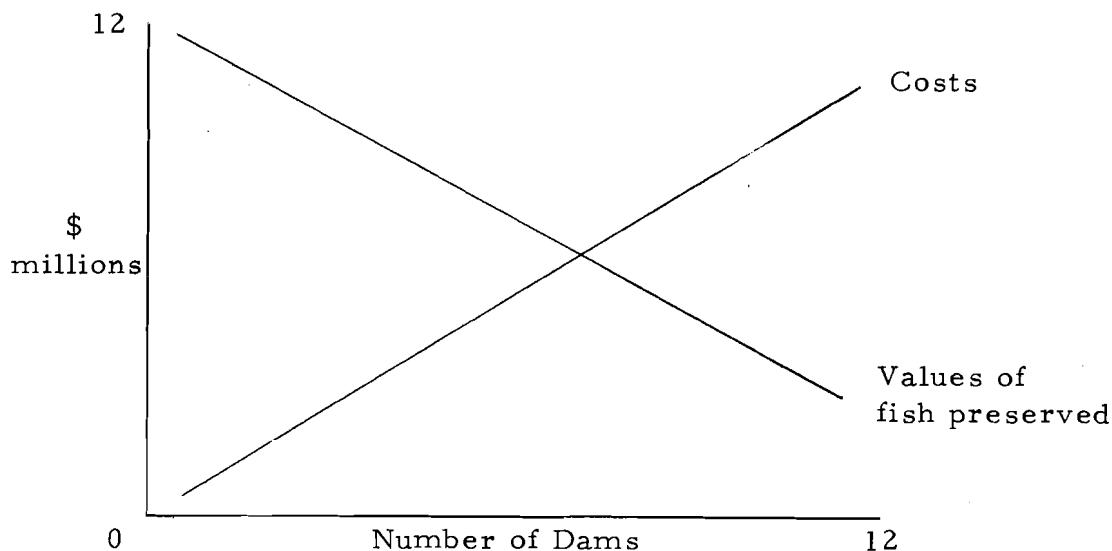
Costs include:

- (a) Costs of constructing and operating facilities
- (b) Costs of power foregone as a result of water releases for fish purposes (45,000 kw on the Columbia)
- (c) Share of joint costs of certain facilities--land, dams, etc.

3. Comparison of Benefits and Costs of Fish Preservation Facilities

The evaluation of benefits and costs of fish preservation facilities must take into account the fact that such facilities are part of a system, i. e., a decision to construct a dam upstream presupposes that fish ladders will be installed at all downstream projects. Some part of the costs of fish facilities at downstream projects is allocable to upstream projects.

It also needs to take into account that fact that fish preservation facilities are subject to diminishing returns. As more dams are added, fish losses increase. More and more money is spent on preserving fewer and fewer fish!



Note: The values-of-fish-preserved curve probably has a different shape, reflecting increasing values as the number of fish decrease. Its actual shape depends on the price of fish vs. other commodities.

No analysis of this kind was undertaken regarding decisions to install fish passage facilities on the Columbia River. None was undertaken in the Fraser River Board studies.

4. An Imputed Value of Fish Preservation

It is often difficult to estimate the values of fish preserved, and the overall costs of preservation. A rough guide to values attached by society to fish runs may be provided from a comparison of costs of a project which provides power (or some other service) most efficiently but does not preserve fish runs, and the costs of the next-best project, which provides power at a higher cost but preserves the fish runs. A case in point was the decision to build the Mountain Sheep project rather than the Nez Perce project. The difference in costs represented an imputed value of society's desire to preserve the fish runs. (See Sewell and Marts reference.)

Possible Solutions to the Fish Power Problem

1. Seek alternatives to salmon streams in provision of hydropower.
This may lead to less economic solutions to the power problem.
It has been tried in British Columbia.
2. Reserve part of the river basin for fish and part for power. The lower Columbia River Fisheries Preservation Plan was based on this. It was frustrated, however, by wrangles over legal definitions and conflicts of jurisdiction, e. g., the Cowlitz River case.
3. Develop hardier species of fish to overcome dams.
4. Develop alternative occupations for fishermen.
5. Encourage the consumption of other types of fish.

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IX

THE COLUMBIA RIVER TREATY AND PROTOCOL

Introduction

In 1961 an extremely important, but little publicized, meeting took place in Vancouver, B. C., Canada. It was a UN Seminar on the International River Basin. It gathered together experts and officials from more than 20 countries around the world to discuss possible reasons why so few of the world's major international river basins have been developed.

In some cases the reasons for the lack of development seemed fairly obvious: they were to be found in such factors as lack of a need for the services which such development might provide; imperfect perception of opportunities for development; limited experience in river development; conflicting political ideologies; and traditional international rivalries. In other cases the reasons were more obscure. The reasons in the case of the Columbia River seemed most obscure of all. There were two countries with a long history of international friendship and cooperation, similar political ideologies, ample capital resources, and machinery to foster international river development, yet they had been unable to reach agreement only after 17 years of studies, investigations, and negotiations. Even then, the agreement which had been reached had not been implemented.

Origins of the Columbia River Case1. The 1944 Reference to the International Joint Commission.

The Columbia River Treaty has its origins in the nature of the regime of the River, and the fact that the river is divided between Canada and the United States. Since it has a snow-fed regime, the Columbia River has major fluctuations in its flows, both seasonally and annually. The average annual flow of the river at The Dalles, Oregon, is about

181,500 cfs or 131 million acre feet per year. The average flow in May and in June, however, is four times the flow in the winter months. Most of the river's runoff, in fact, occurs in a 4-month period, April to July. A consequence is that storage is required to even out the river's flow. The U. S. Corps of Engineers has estimated that some 27 million acre feet of storage would be required to take advantage of the Columbia River's hydroelectric power potential.

Considerable difficulty has been experienced in the search for storage sites in the U. S. part of the Columbia River basin. (See M. E. Marts, "Upstream Storage Problems in Columbia River Power Development," and "The Middle Snake River Controversy.") Such difficulties lead to the consideration of possibilities of developing storage sites in the Canadian portion of the basin.

In 1944 the U. S. and Canadian governments asked the International Joint Commission (IJC) to investigate the possibilities of developing the Columbia River basin on a unified basis, ignoring the international boundary. The Commission established an International Columbia River Engineering Board to carry out the studies, and 15 years later it presented a report. The report outlined 3 schemes which would make possible "the maximum practicable utilization of the water resources of the Columbia River basin." Any of these schemes would produce over 16 million kw of prime power, and would require over 50 million acre feet of storage.

They represent optimum schemes in a technical sense. The Board did not determine whether or not they would be economically feasible. Its responsibility was to determine the opportunities rather than to actually recommend a scheme of development.

The report showed that there are opportunities for storing about 23 million acre feet of water in the Canadian part of the basin. There are few opportunities for head development in that part of the basin, however, and so some incentive has to be presented to Canada to develop the storage sites.

2. Principle of Downstream Benefit Sharing

Various incentives were proposed. At first, the Americans proposed to pay compensation for land that would be flooded by reservoir construction. It was soon realized, however, that the main value of the stored water was in the extra power that could be generated downstream, and the flood control it would provide for communities in the United States. Canada demanded a share of the extra power that would be generated downstream: and so the principle of downstream benefit-sharing was born.

The Americans were unwilling to recognize the principle at first, but a series of events on the Canadian side of the border eventually brought about this recognition. Recognition of the principle in fact came about as a result of Canada's demonstration that she did not have to depend on the Columbia River for power. First, the threat that Canada would divert part of the headwaters of the Columbia River into the Fraser River, and then the announcement of plans to build the Peace River project in northern British Columbia, led to acceptance of the principle of downstream benefit-sharing by the United States authorities in January 1959.

3. Determination and Allocation of Downstream Benefits

The problem then became one of finding a mutually acceptable method for determining the magnitude of downstream benefits and of finding a formula for allocating these benefits between the United States and Canada. None of the studies that had been done thus far offered any guidance on this: the IJC had specifically requested the ICREB not to make any recommendations in this regard--even though the question was bound to be asked eventually!

The IJC set up a committee to look into the question and it brought forward a report in December 1959. The principles it recommended for determination and allocation of downstream benefits formed the basis for the Columbia River Treaty which was signed in January 1961. (See International Joint Commission, Principles for Determining and

Apportioning Benefits from Cooperative Use of Storage Waters and Electrical Inter-Connection within the Columbia River System,
Ottawa, December 1959.)

These principles have been criticized on grounds both of concept and of equity. They recommended, for example, that the countries should share the benefits equally. Such a principle failed to recognize that Canada would be putting three times as much investment into the arrangement as the United States and yet would obtain only half of the benefits. Arguments were raised by the United States that the benefits would result only from the fact that the United States had already built \$2 billion worth of facilities, and that if these were counted, then the U.S. would be putting in five times as much as Canada! This argument, of course, begged the question for it is only the incremental costs that are relevant: historical costs are not relevant in determining the feasibility of a new investment. Difficulties in determining incremental costs on the United States' side of the border, however, led to the acceptance of the 50/50 principle. (Arguments about the principles have been discussed by L. Higgins in "Columbia River Treaty, A Critical Review.")

The Columbia River Treaty

The Columbia River Treaty was signed in January 1961, by President Eisenhower and Prime Minister Diefenbaker. It calls for the following:

1. 15.5 million acre feet of storage to be provided by Canada at 3 projects--Mica, Arrow Lakes, and Duncan.
2. This storage will be operated to optimize power output at U.S. plants downstream, and to reduce flood losses in U.S. communities in the basin.
3. The U.S. will operate its present installations to take maximum advantage of the storage releases.

4. The power benefits will be shared on a 50/50 basis between the U.S. and Canada (amounting to a total of about 2.6 million kw of additional firm power and 13 billion kwh of energy).
5. About 8.5 million acre feet of the storage will be operated for flood control purposes. Canada will receive \$64 million for this, paid in a lump sum. This sum represents savings which will accrue as a result of estimated reduction in flood losses in the U.S.
6. The U.S. has the option to build the Libby project on the Kootenay River, a tributary of the Columbia River. This project will result in benefits in both countries but no formal sharing arrangement was agreed to.
7. The diversion of part of the flow of Kootenay River into the Columbia River is permitted after 20 years, but no diversion from the Columbia River into the Fraser River.
8. The Treaty will remain in force for 60 years. The flood control provisions, however, will remain in perpetuity.

Objections to the Treaty

The Treaty was ratified almost immediately by the U.S. Senate. Ratification in Canada, however, was held up for over four years by differences between the Canadian federal government and the B.C. provincial government over the disposal of the Canadian share of the downstream benefits. The B.C. government said that such benefits were surplus to its immediate needs, especially as the Peace River project would be underway. Sale of the Canadian share of downstream benefits to the U.S. was proposed by the B.C. government. The proposal was flatly rejected by the Ottawa government. An impasse was reached: the federal government was unable to honor the Treaty it had made because the B.C. government owned the water resources and would not proceed with construction of the dams.

Eventually, the federal government relented and agreed to export part of the surplus power to the U.S. (The matter of "export" is one of definition: the power would actually be generated in the U.S., but Canada would have a title to it.)

In addition to the provincial-federal feud over the disposal of the downstream benefits, there were also some major criticisms of various provisions of the Treaty. These are outlined briefly in the article by Sewell, "The Columbia River Treaty and Protocol Agreement," and discussed in greater detail by General A.G.L. MacNaughton in "The Proposed Columbia River Treaty." Arguments for and against the Treaty were weighed by the Canadian government in reaching an agreement with the B.C. government. Negotiations were reopened with the U.S. to clarify some of the points in the 1961 Treaty. A Protocol Note was drawn up by the U.S. and Canada embodying these clarifications.

The Protocol

Briefly, the Protocol outlines the terms of the sale of the downstream benefits, makes clear that Canada can select which projects may be called upon for storage releases, indicates the circumstances under which the U.S. may call upon Canada for additional flood control, and states that Canada can divert water at any time for irrigation or domestic water supply purposes.

Debate in the House of Commons

Even with the signing of the Protocol agreement, however, opposition to the Treaty in Canada did not die down. Some people firmly believed that the Treaty was a sellout to the U.S., and that there were superior schemes for Columbia River development which would yield greater benefits to Canada. One such scheme was the so-called MacNaughton Plan (See Map 2) which would involve a diversion of the Kootenay River into the Columbia River at Canal Flats. This scheme would result in

greater power output in Canada, but would have cost more than the Treaty scheme. Moreover, the Americans would have demanded assurance of similar flood control to that to be provided by the Libby project (which would be eliminated), and compensation for the power output which would result from Libby. These demands would no doubt have made the MacNaughton scheme unfeasible.

Other objections related to the Arrow Lakes project. Some groups wanted to have a low rather than a high dam, to preserve the scenic beauty. Further criticisms were made of the flood control payments. Some suggested that the U. S. could afford to pay more than the \$64 million lump sum since its alternatives would be much more costly. However, much of the flood control is provided as a by-product of power operation, and it could be argued that Canada was being paid twice for storage services! In any event, the value of the storage was not based on an analysis of the value of incremental additions to existing storage. It overlooked the fact that the incremental value of storage diminishes as further increments are added. The value of Canadian storage for flood control, therefore, was probably overstated rather than understated.

The Columbia River Treaty: An Overview

The Treaty represents a major step forward in the development of international rivers. Despite the disclaimer at the end of the Treaty that the arrangements shall not be regarded as a precedent, the Treaty brings a new principle to the bargaining table: that of downstream-benefit sharing. International cooperation is to be sought rather than compensation for damages.

It is impossible to tell whether the Treaty represents the best possible arrangement, or whether the U. S. or Canada got the best of the deal. Both countries are, however, clearly better off as a result. The U. S. apparently is able to obtain storage benefits from Canada more

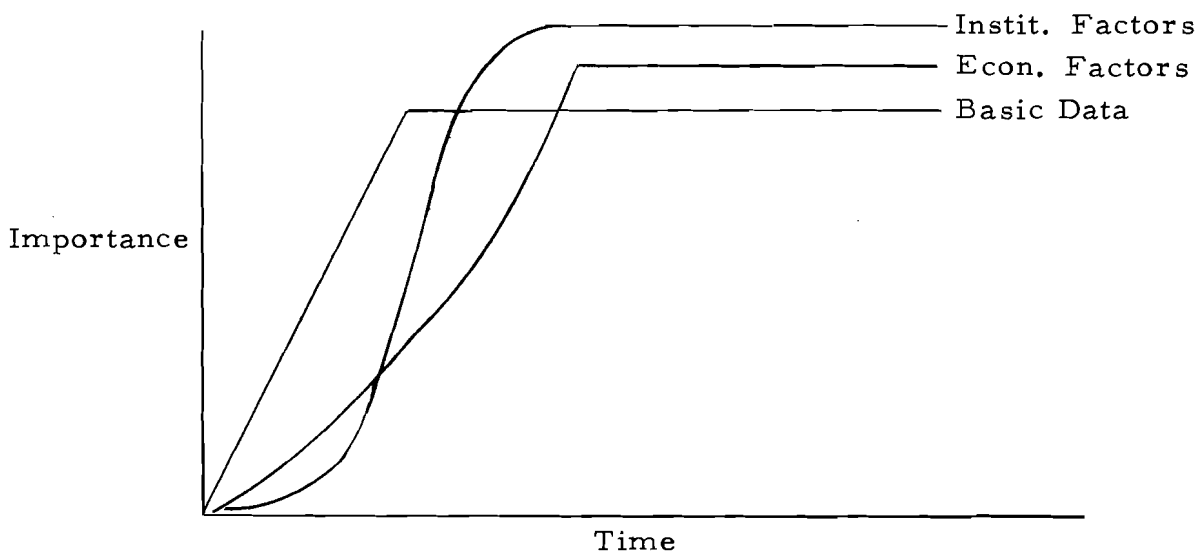
cheaply than from U. S. alternatives. By selling her share of the downstream benefits to the United States, Canada is able to obtain capital for development of the projects now, and enjoy benefits at a later stage, when the B. C. economy has expanded sufficiently to take advantage of them.

Implications for International River Development Elsewhere

The Columbia River experience has several implications for international river development elsewhere:

1. The integrated approach to water management, though attractive in concept, is difficult to put into practice, especially in the case of international rivers. Whereas under this approach, economic criteria should play a guiding role in project selections, other factors assume greater importance at the bargaining table, particularly national prestige. The Columbia River scheme is in fact a compromise, composed of projects which each party involved individually prized very highly; namely Mica (Canadian government), Arrow Lakes (B. C. government), Libby (U. S. government). The benefits of these projects taken together exceed their costs. There may have been economically superior combinations, but this combination represents that with the greatest consensus.
2. The various factors involved in river development vary in their relative importance over the planning period, especially in the case of international rivers. It may be possible to take a very broad view in the initial stages--such as the assumption of no international boundary--but the realities of the institutional factors are brought to bear as the planning proceeds. In the case of the Columbia River, the search for basic data was the most important factor initially. Subsequently, other factors assumed greater importance, until institutional factors, such

as federal-provincial relations, came to dominate the planning. The process is illustrated in the diagram below:



3. Internal politics can assume a dominant role in negotiations relating to international rivers, especially in federal systems of government. The Canadian government miscalculated the power of the B. C. government in this connection. Agreements between subnational units and the central government are essential to smooth negotiations.

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X

DEVELOPMENT OF THE LOWER MEKONG RIVER

Introduction

Several months ago, Gilbert White, in an article published in the Bulletin of Atomic Scientists, suggested that there were 4 possible courses of action that might be considered in the search for a solution to the crisis in South Vietnam:

1. Containment. The United States could step up its military, political, and economic assistance to local governments opposed to the Viet Cong in Vietnam and to the Pathet Lao in Laos. Many observers have argued that this alone would be insufficient to settle the conflict or to stabilize the two governments.
2. Escalate the War. The United States could carry the war to North Vietnam in an effort to cut off support of guerilla activity. Such escalation would be highly dangerous, and probably ineffective in any case in reducing guerilla activity. White suggested that at best it would create another Korea. A new border would be established and create further rigidities in the search for a long-term solution to the problems of southeast Asia. At worst a major world war could unfold.
3. Neutralization of the Area. The area could be neutralized under an international agreement, calling for the withdrawal of troops on both sides of the conflict. The removal of troops, however, would not provide a lasting solution to the problems in southeast Asia. Political instability would no doubt continue.
4. Development of the Lower Mekong River. Gilbert White suggests that a major step toward solving the problems of poverty, population increase, and political instability might be found in the implementation of a scheme which has been in the planning stages for over 14 years. The development of the Lower Mekong River

is suggested as a fourth course of action in Vietnam.

(See Gilbert F. White, Vietnam: The Fourth Course.

Bulletin of Atomic Scientists, December 1964.)

It has been pointed out by several observers that even if the United States, together with the Saigon government, manages to win the present war, the basic problems in that part of the world will remain. These problems are rooted in poverty, population increase, and political instability. All three are, of course, closely interrelated.

Per capita income in southeast Asian countries is considerably lower than that in countries such as the United States. Per capita income in Vietnam, Laos, Cambodia, and Thailand, for example, is about \$100 per annum, compared with \$2500 per annum in the United States. A very large proportion of the population is engaged in agriculture. Illiteracy is extremely high. Added to this is the problem that population is increasing rapidly. It has been estimated that population in the four southeast Asian countries mentioned above will double by 1980. Problems raised by diversity of races, religions, and political ideologies represented in these countries are compounded by the poverty of the people. Political instability inevitably follows.

A successful long-term solution to the southeast Asian problem would have four major criteria or characteristics:

1. It would be a course of action which the people who live in the region want for themselves.
2. It would be a solution in which they would actively participate.
3. It would probably require massive foreign investment, but to be politically acceptable, such investment would have to be provided on a broad multilateral basis rather than from one or two countries.
4. Initiative would probably have to come from countries other than the United States, France, or the Soviet Union, but all three might participate in the solution as members of a cooperative international group.

The Mekong River Scheme

The Mekong River Scheme appears to embody all of these characteristics:

1. It is the one thing upon which most of the people in the region are agreed. They are sharply divided on many other matters, such as religion and political ideologies. The Viet Cong are not opposed to the scheme.
2. The people in the region have long been actively engaged in an international cooperative effort to plan the development of the river. Studies have proceeded despite the fighting in South Vietnam, and differences in opinion between the various countries in the region. The Mekong Coordinating Committee has continued to meet even though some of its member countries may have temporarily severed diplomatic relations with each other!
3. The Mekong River scheme has been planned from the beginning as a cooperative international effort, sponsored by the United Nations. Over 20 countries have contributed funds and technical assistance to the studies that have been undertaken thus far. No one country has dominated the investigations, even though some have made large financial contributions.
4. Offers have already been made to provide financing of the scheme on an international basis. An Asian Bank, for example, might be established to underwrite the scheme with funds provided from countries from all over the world.

The Mekong River is one of the world's largest rivers. Rising in Tibet, the river drains parts of six countries. It drains a total of 422,000 square miles. The lower part of the Mekong basin, however, an area covering about 300,000 square miles, is the focus of interest in the studies. In volume of flow the Mekong ranks with the Irrawaddy of Burma, and is several times larger than the Indus and the Yellow Rivers. Today it flows largely unharnessed to the sea. Apart from a few small dams on some of

the tributaries; a number of irrigation and navigation channels; and small sections of levees, there has been relatively little development so far.

Details of the physical characteristics of the Mekong River basin may be found in the United Nations Economics Commission for Asia and the Far East Report on the Development of the Lower Mekong River. Political and cultural factors are described in Schaaf and Fifield's book on the Lower Mekong. The latter also provides a useful bibliography. The main focus here will be on the origins of the international approach to the problem, and the appraisal of benefits which the proposed scheme might provide in terms of their contribution to the solution of the major problems in the region.

Origins of the Scheme

It has long been known that the Mekong River possesses considerable potential for the development of hydroelectric power, irrigation, navigation, and flood control. It was not until relatively recently, however, that any systematic study of this potential was undertaken. Some studies were undertaken by the French, and data collection programs were initiated. The real impetus came after World War II, under United Nations sponsorship.

- 1949 Establishment of ECAFE Bureau of Flood Control.
- 1951 Bureau of Flood Control instructed to study problems of international river development in Asia and the Far East. The Mekong River was singled out for particular attention, and a report was presented in May 1952. Intensive study of the Mekong River, however, was impossible until the signing of the Geneva Accords in 1954.
- 1955 Following the signing of the Geneva Accords the U.N. became interested in the possibilities of developing the Mekong and ECAFE was encouraged to undertake further studies.

The U. S. also became interested and signed an agreement with the four governments: Laos, Cambodia, Thailand, and South Vietnam. The Bureau of Reclamation sent out a team of experts to study the river in general terms. It prepared a report, recommending further investigations. This report has become a basic document in Lower Mekong studies. The report emphasized that data on many critical aspects of the river and its regime were lacking, and outlined a program of studies.

Side by side with Bureau study, ECAFE, through its Bureau of Flood Control undertook further investigations of the basin, and prepared a report on development of water resources in the Lower Mekong Basin. It noted that there were many attractive possibilities for the development of multiple purpose projects in the basin. It suggested that such development would go a long way toward dealing with some of the serious problems in the southeast Asia region. The report also stressed the international character of the river and the need for international control.

1957 The report was presented to the 10th Annual Meeting of ECAFE. It was enthusiastically received. The outcome was the establishment of the Mekong Committee:

(a) composed of 4 nations: Laos, Cambodia, Thailand, and Vietnam, and

(b) tied to the UN through liaison with ECAFE.

The report was enthusiastically received elsewhere as well. The French made an immediate offer of \$120,000 to support the studies which the report proposed. This gift was the first of many international contributions to the Mekong effort.

1957 (November) The UN was also enthusiastic about the proposed scheme and through its Technical Assistance Administration offered technical aid in further investigations. As a start, it organized a mission under Lieutenant General Wheeler (retired

U.S. Army) to determine what detailed studies need to be done. General Wheeler submitted a report in early 1955, recommending a program of investigations which would cost about \$9 million.

The report was greeted with enthusiasm from all quarters. The required \$9 million was soon over-subscribed, and to date over \$20 million has been spent. The U.S. has provided 10 to 20 percent of this.

Various studies have been undertaken to determine more precisely the hydrology of the basin, its geologic structure, sites for development, etc. In addition, studies of economic, social, and institutional aspects have been undertaken by Gilbert White, John Krutilla, Egbert de Vries, and others.

Projects Recommended

The ECAFE study in 1957 recommended the following projects for early construction:

1. Main Stem:

Priority: PaMong, Sambor, Tonle Sap

Later: Khone Falls, Khemerat, Upper and Lower Luang Prabang, and Thakhek

2. Tributary Projects:

Priority: Battambang (Cambodia), Nam Ngum (Laos), Nam Pung (Thailand), Upper Se San (Viet Nam)

Details of these projects are summarized in the accompanying tables, and their locations are indicated in the accompanying map.

What benefits would these projects provide?

1. Water for 7 million acres of irrigated land
2. 3 million kw of power
3. Improved navigation along the river up to Luang Prabang
4. Flood control for the delta area.

The importance of these benefits is recognized when cast within the framework of the major problems in the basin:

1. Growing needs for food: at present the region is almost self-sufficient but population will double by 1980. Double cropping (which irrigation could provide) would go a long way toward dealing with the pending crisis in food supplies.
2. Growing needs for electric power: costs are very high at present (several times those in the United States). Per capita consumption is very low:

Thailand	7.9 kwh/yr
Cambodia	7.2 kwh/yr
Laos	0.9 kwh/yr

compared with:

U.S.	> 3000 kwh/yr
U.K.	> 1700 kwh/yr

Provision of lower cost electric power would help to stimulate industrial expansion and to raise the standard of living.

3. Floods result in losses of property and lives even though the people are well adjusted to the annual rhythm of floods. Reduction of area under inundation would make more land available for cultivation.

What would the scheme cost?

Various estimates of costs of the scheme have been made. These range upward from \$2 billion, depending on how comprehensive the scheme is intended to be. With all the required ancillary developments--such as education, establishment of demonstration farms, etc.--investment might be well over \$10 billion. The scheme might take several decades to bring into fruition. Much effort will have to be put into training the people in the region to adopt new farming practices, to operate industrial plants, etc.

Lessons to be Learned from the Mekong River Experience

These are some important lessons which may be learned from the Mekong River experience:

1. International river development, especially in some of the less advanced parts of the world, may offer a "key to economic development." This is likely to be particularly so where the lives of the people are intimately affected by the river, as with the annual rhythm of monsoon floods, and where water regulation provides opportunities for increased food production.
2. International river development may also provide a fruitful avenue for promoting international understanding, not only between the countries sharing the river, but between them and other countries which might assist in the planning and undertaking of the development. The United Nations might well adopt it as a major instrument for advancing world peace.
3. Economic criteria are an important but incomplete set of considerations in international river basin planning. Other factors, and especially national prestige, may play a much more critical role in determining which set of projects should be built. It may not be sufficient that all countries benefit from the development but to have a project located in each of the countries involved.
4. The ability to plan the development of the physical works may be much greater than to ensure that the benefits which such works will provide will be fully utilized. It may be necessary to invest even greater funds and effort in education programs than in dam construction. A corollary is that the pace of development may need to be slowed to enable skills in agriculture and industry to be developed. Tributary projects might be started first, followed at a later stage by the larger main stem projects.

5. Experience has been gained in international cooperation of the Mekong Committee. No doubt a different type of organization will be required for the developmental stage of the proposed scheme.

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Table 2. Lower Mekong basic scheme: technical data^a

Project	Purpose	Available head (feet)			Firm discharge (cubic feet per second)				
		Upstream water level msl	Down-stream water level msl	Total and average head	Natural discharge at low water	Increase from regulation of flow at site	Net increase from regulation of flow upstream	Diverted or lifted for irri-gation	Available for power generation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Development of five high-priority main stem projects as a system									
Pa Mong	PNIF	790	560	230/204	23,300	62,600	--	35,300 ^b	77,600
Khemarat	PNI	430	298	132/98	33,000	7,100	47,300	1,800	85,600
Khoac	PNI	270	158	112/102	42,500	--	52,600	1,800	93,300
Sambor	PNI	115	26	89/79	49,600	3,500	50,700	3,500	100,300
Tonle Sap and delta	P*IFD	(0 to 33 ft. reversible)			--	--	--	--	--
B. Development of high-priority projects in the major tributaries									
Nam Ngum	PIF	--	--	131/115	180	6,400	--	1,400 ^d	6,580
Nam Pung	PIF	596	512	84/56	20	1,800	-- ^e	700 ^d	1,820
Stung Battambang	PIF	223	82	141/131	110	1,310	--	1,420 ^d	1,420
Upper Se San	PIF	--	--	230/216	70	2,030	--	350	1,750

P - power generation; N - navigation; I - irrigation; F - flood control; D - drainage

^a This table reflects planning at the end of 1961 and is subject to change.

^b Part of this discharge of 7,000 cfs would run through the turbines and be consumed for lift irrigation downstream of Pa Mong dam.

^c Seasonal power only for Tonle Sap project.

^d Pumping or diversion for irrigation downstream of main dam.

^e Triple increase after Pa Mong built.

PART IV
Outline of Lectures
on
WATER RESOURCES ENGINEERING--PLANNING
CE 264

Presented at the
SUMMER INSTITUTE IN WATER RESOURCES
UTAH STATE UNIVERSITY

by
Harvey O. Banks
President, Leeds, Hill and Jewett, Inc.
Consulting Engineers

Logan, Utah
July 19-August 13
1965

WATER RESOURCES ENGINEERING--PLANNING

by

Harvey O. Banks

1. Some concepts and principles for comprehensive planning for water resource development.
 - A. Planning is only one step in the total process of controlling, protecting, conserving, and utilizing water resources; it is not an end in itself. Planning, to be effective, must encompass much more than simple inventories of resources and potential requirements, and development of a possible system of physical works to meet requirements from available resources. All too frequently, this is the basic concept and extent of so-called "comprehensive" planning.
 - B. In Planning, consideration must be given to the agency or agencies that will implement the plan; each of the agencies at the various governmental levels, as well as private developers, have specific powers, objectives, functions, policies, and philosophies, pursuant to the laws under which each operates.
 - C. Integrated and coordinated development and management of the water resources, involved by or through existing agencies or by creation of some new agency, should be fundamental to the plan.
 - D. With certain exceptions, such as water for direct human use, water development is undertaken only as an adjunct to the development and utilization of other resources. Therefore, investigation and planning with respect to these other resources must precede and underlie water resource planning. Population projections, for instance, should take into account the availability of land and other resources to support the population in accordance with proper economic and social

objectives, proper land use planning, transportation facilities required, and the problem of proper disposition of waste products, among other things. Planning for irrigation should consider the probable need for an increase in the crops to be grown both locally and on a national scale and for export.

- E. Social, as well as economic, goals and objectives should be clearly defined.
- F. All functions and purposes that can be feasibly served should be included.
- G. All feasible alternatives should be fully evaluated, including reclamation and reuse of waste waters, desalinization, and reallocation of resources among uses as new uses develop.
- H. All economic, social, and ecological effects, both beneficial and detrimental, should be evaluated and means provided to mitigate detrimental effects. Efficiency of investment is not the sole criterion to be considered.
 - (1) Ecological changes downstream, as in saline bays and estuaries, are becoming increasingly significant, as for instance,
 - (a) Along the Gulf Coast in Texas,
 - (b) In the Sacramento-San Joaquin delta, California.
 - (2) Potential economic and social dislocations may be very important.
- I. Planning should encompass the conjunctive use of surface and ground waters, and of surface and underground storage, where physically or economically interrelated.
- J. Planning should be done on a regional basis, not necessarily on a river basin basis alone. The needs and problems of the entire region, including the areas of origin, should be considered. The proper areal or regional scope of comprehensive planning cannot be determined in advance in all cases. A river basin is by

no means necessarily the proper areal basis. In fact, the concept of "river basin planning" indicates some confusion as to the fundamental purpose of planning; that is, for the development of water resources as an objective in itself or to serve human needs where and when they arise. The Water Resources Planning Act of 1965 unfortunately tends to perpetuate this misconception of the river basin as the proper geographical basis for planning.

- K. Where water resources are scarce in relation to potential requirements, the proper allocation of the available resources among competing and conflicting areas and uses should govern planning.
- L. Vested water rights should be recognized and, if taken, compensation should be paid.
- M. Within the framework of existing laws and policies, or politically acceptable revisions thereof, the costs should be distributed generally in proportion to the benefits received. In other words, pricing and repayment plans should be developed which will contribute to this end.
- N. Increase in the efficiency of use of water should be encouraged.
- O. The timing and sequence of construction of facilities should be a part of a comprehensive plan.
- P. The responsibilities for financing, construction, and operation of specific units, especially those to be built in the near future, should be assigned to the extent possible.
- Q. Ideally, planning should also encompass the proper level of commitment of capital, materials, and human resources to water development in relation to the demands for other programs. At the present time, this is done at the federal level by the Bureau of the Budget, not infrequently on an expedient basis.

- R. Finally, planning must be conducted as multidisciplinary process involving not only engineers and geologists but also economists, lawyers, geographers, and others.
2. Organization for planning, development, and management of water resources.
- A. It must be recognized that the areal extent and functional scope of interest in water development becomes progressively more limited down through the various levels of government, from national to local. Private developers are generally interested in only one or at most, two functions.
- B. There is a high degree of national interest in water resources.
- (1) Navigable waters
 - (2) Interstate and international waters
 - (3) Waters originating on or flowing across federally withdrawn or reserved lands
 - (4) Federal installations
- C. Likewise, the states have, or should have, a high degree of interest and responsibility.
- D. In considering a particular organization, the following are significant:
- (1) The statutes under which it operates
 - (2) Areal extent of its interest and responsibilities
 - (3) Functional scope of its interest and responsibilities
 - (4) Its objectives, as established both by statute and by administrative directive
 - (5) Its concepts, philosophy, and motivations
 - (6) Its powers and interest in comprehensive planning
 - (7) Its powers to finance, construct, and operate projects
 - (8) Its powers, interest, and capability to manage water resources

E. At the federal level

- (1) There are now more than thirty federal agencies active in one or more aspects of water resource planning and development. The Geological Survey and Weather Bureau are principally concerned with data collection and interpretation. The Agricultural Research Service, Department of Agriculture, is a research agency. Others are largely regulatory. Only the principal agencies actively engaged in planning and implementation on a large scale will be considered here. For each agency, the following are pertinent:
 - (a) Statutes
 - (b) History
 - (c) Powers, functions and responsibilities
 - (d) Primary interests and objectives
 - (e) Activities, and any limitations with respect thereto, in planning, financing, construction, operation, and management coordination with other agencies
- (2) Bureau of Reclamation
 - (a) Reclamation Act of 1902 and acts supplementary thereto and amendatory thereof
 - (b) Small Reclamation Projects Act
- (3) Corps of Engineers
 - (a) Flood Control Act of 1936 and subsequent enactments
 - (b) Marketing of goods and services produced by Corps projects
- (4) Soil Conservation Service, Department of Agriculture
 - (a) Small Watershed Protection and Flood Prevention Act (68 Sta. P. L. 566) 4 August 1954
 - (b) Application to urban flood control projects

- (5) Department of Health, Education, and Welfare
 - (a) Federal Water Pollution Control Act
 - (b) Low flow augmentation, Public Law 87-88
 - (c) Water supply for municipal and industrial purposes
 - (d) Water Quality Act of 1965 (S. 4, 89th Congress)
- (6) Federal Power Commission
- F. Interstate Agencies
 - (1) Delaware River Basin Commission
 - (a) Delaware River Basin Compact
- G. At the state level
 - (1) California
 - (a) State Water Rights Board
 - (b) State and regional water quality control boards
 - (c) Department of Water Resources
 - (d) Other agencies
 - (2) Texas (as reorganized effective 1 September 1965)
 - (a) Texas Water Rights Commission
 - (b) Texas Water Pollution Control Board
 - (c) Texas Water Development Board
 - (d) Other agencies
- H. At the local level
 - (1) Cities
 - (2) Districts
 - (3) River basin authorities--Texas
 - (4) Districts performing management functions in California--
Water Replenishment District Act
- I. Proposed river basin commissions (H. R. 1111, 89th Congress)
- J. Proposed regional commissions (S. 1019, 89th Congress)
- K. National Water Commission proposed by the Bureau of Budget, in
its report on S. 1019, 89th Congress, 1st Session
- L. Western States Water Council

3. Joint Undertakings
 - A. Joint action in the planning, financing, and construction and operation of projects by two or more levels of government has been developed as a means of broadening and expanding the scope of projects to fulfill the interests of each level.
 - B. Federal-State
 - (1) San Luis Unit, Federal Central Valley Project, California
 - (2) Flood control contribution, Oroville Reservoir, California
 - (3) Purchase of conservation storage in federal reservoirs, Texas
 - C. Federal-Local
 - (1) Federal flood control contributions to local projects
 - D. State-Local
 - (1) Davis-Grunsky Act program, California
 - (2) Flood control, California--state reimbursement of non-federal costs on federal flood control projects.
 - (3) Texas Water Development Board
4. Laws and policies--implications as related to planning
 - A. Reclamation Act of 1902 and acts amendatory thereof and supplementary thereto
 - (1) Economic and social objectives--acreage limitation
 - (a) Original
 - (b) Present--comparison with other federal agricultural programs
 - (2) Pricing and repayment policy for irrigation water--economic implications
 - (a) Subsidy--sources and extent
 - (b) Development funds or basin accounts
 - (3) Proposed land purchase fund
 - B. Other pricing and repayment policies under federal projects
 - (1) Municipal and industrial water supply

- (a) Water Supply Act of 1958
- (2) Hydroelectric power and energy
 - (a) Public agency preference--economic implications
- (3) Flood control
 - (a) Flood damage prevented
 - (b) Land enhancement
- (4) Navigation
- (5) Recreation and enhancement of fish and wildlife (S. 1229, 89th Congress)
- (6) Water quality control or low flow augmentation, Public Law 87-88, 1961
- C. Water Quality Control Act of 1965
- D. Pricing and repayment policies under state programs
 - (1) Texas
 - (2) California--statutes and contract provisions
 - (a) Hydroelectric power and energy
 - (b) Water supply
 - (c) Recreation and enhancement of fish and wildlife
- E. Significance of liberal federal repayment policies
 - (1) On allocation of resources
 - (2) On formulation of projects--selection of alternatives
 - (3) On attractiveness of federal development from local financing and repayment viewpoint
- F. Some pricing and repayment policies in foreign countries.
 - (1) Turkey
 - (2) East Pakistan
- G. Water rights
 - (1) Paramount federal power--effect on state and local projects
 - (a) Inverse condemnation
 - (b) Lack of water laws and policies at federal level
 - (2) Rigidity effects

- (a) Riparian rights
 - (b) Appropriative rights
 - (c) Prescriptive rights
- H. Public Land Law Review Commission
- 5. Functions to be considered in planning--compatibility, complementarity
Competition, and conflict
 - A. Municipal and industrial water supply
 - B. Irrigation water supply
 - C. Water quality control and pollution prevention
 - D. Recreation
 - E. Fish and wildlife
 - (1) Mitigation
 - (2) Enhancement
 - F. Flood control; flood plain zoning
 - G. Hydroelectric power generation
 - H. Navigation
 - I. Salinity repulsion
 - J. Land reclamation
 - K. Ancillary problems
 - (1) Drainage
 - (2) Salt balance in groundwater basins
- 6. Alternatives that should be considered in planning
 - A. Saline water conversion
 - B. Reallocation among uses--limitations as related to other
resources
 - C. Replacement or substitution--equitable distribution of costs
is problem
 - D. Reclamation and reuse; possible uses
 - E. Salvage
 - (1) Collateral effects
 - (2) Ownership of salvaged water

F. Increased efficiency of use

- (1) Limitations inherent in present attitudes toward water, and pricing policies
- (2) Economists' views are beginning to have an impact as regards pricing policy

G. Waste disposal

- (1) In-stream treatment
- (2) Regional collection, treatment, and disposal systems; organizational problems
- (3) Stream specialization
- (4) Effluent charges

H. Flood plain zoning

- (1) Danger of freezing land use patterns under present flood control policies

I. Nuclear power generation

7. Role of States

A. Comprehensive planning

- (1) Only agency with sufficiently wide scope of interest
 - (2) Coordination
 - (3) Administration
 - (4) Management
 - (5) Construction and operation--limited role
- } no federal machinery or laws for administration or management

B. States must have a plan and money in order to be able to administer and manage water resources--for own programs and for joint undertakings--to coordinate activities--to ensure comprehensive planning and development--in short, to be able "to sit in at the poker table."

8. Evaluation and critique

- A. Delaware River Basin Compact and Commission
- B. Colorado River Plans

- (1) Report on Pacific Southwest Water Plan, United States Department of the Interior, January 1964
 - (2) Lower Colorado River Basin Project Act, S. 1019, 89th Congress, 1st Session
- C. California Water Plan, Bulletin 3, California Department of Water Resources, 1957
 - D. The Texas Water Planning Program
 - E. A Plan for Meeting the 1980 Water Requirements of Texas, Texas Board of Water Engineers, May 1961
 - F. The Report of the U.S. Study Commission--Texas, 1961.
 - G. Texas Basins Project, U.S. Bureau of Reclamation, January 1964
 - H. Comprehensive Survey Report, Trinity River and Tributaries, Texas, Corps of Engineers
 - I. Report on Master Plan of the Trinity River and Tributaries, Texas, April 1958, and Supplemental Report, December 1960 prepared for Trinity River Authority by Forrest and Cotton, Inc., Consulting Engineers
 - J. Work Plan for Watershed Protection, Flood Prevention, and Agricultural Water Management, Big Creek Watershed, Brazos County, Texas, April 1962
 - K. Master Plan for Water Resource Development in the Neches River Basin, 1960, prepared for the Lower Neches Valley Authority by Freese, Nichols, and Endress, Consulting Engineers
 - L. Indus River Basin Treaty, India-Pakistan, and planning for development of the Indus River in West Pakistan

Editorial Note: In "Evaluation and Critique" Mr. Banks assigned small groups of participants to critically analyze the basin plans outlined above. Brief oral and written reports were presented in class with

discussion and comment in terms of how well the plan met the concepts and principles introduced earlier.