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SYSTEMS RESEARCH INSTITUTE, POLISH ACADEMY OF SCIENCES
ИНСТИТУТ СИСТЕМНЫХ ИССЛЕДОВАНИЙ ПОЛЬСКОЙ АКАДЕМИИ НАУК

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# INTEGRATED RURAL/SPATIAL DEVELOPMENT: ELEMENTS OF SYSTEMS ANALYTIC APPROACH

Edited by

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WARSAW 1982

The present volume contains papers presented at the Seminar organised by the Systems Research Institute of the Polish Academy of Sciences together with the Personnel Bureau of the Polish Academy of Sciences, with financial assistance of the UNESCO. 1981
The Seminar took place on October 19-23rd in Jablonna near Warsaw.



Integrated Rural/Spatial Development: Elements of Systems Analytic Approach, edited by Andrzej Straszak and Jan W. Owsinski

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# I. SYSTEMS ANALYSIS AND RURAL/SPATIAL DEVELOPMENT

## ABOUT THIS VOLUME: AN INTRODUCTION

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This short introduction is meant to highlight the following items:

A. orgin and purpose of this volume,

B. some notions related to system analysis as well as rural and spatial systems,

C. organisation of the volume.

A. Papers constituting this volume were presented at the Seminar held in October 1981 in Jablonna near Warsaw, organised by the Systems Research Institute of the Polish Academy of Sciences in cooperation with the Personnel Bureau of the Academy, and with financial assistance of UNESCO. The main focus of this Seminar was gathering of basic experience of applications of systems analysis to rural and spatial systems. Hence, mainly these scientifically justified approaches were considered which could be readily, or are already, transformed into the real-life planning and policy-making tools. It was hoped that this Seminar and the present volume shall constitute a starting point for a longer-term effort through which knowledge of practical application of system analysis to rural and spatial systems could be spread and at the same time gradually synthesized to form a coherent scientifically based area of planning and policy-making methodology.

Such methods are needed not only, although primarily, by countries striving for qualitative and quantitative development, where rural areal are often not able to produce enough food for everyone and where they provide most of the country's labour force, but also for those quantitatively developed, where environmental, fertility and efficiency problems arise. Hence, it was deemed appropriate to make an effort in gathering and furthering these methods.

B. Throughout this volume some notions shall appear quite often, such as: system, systems analysis, model, optimisation, actor, development or resource. These notions shall now be explained in more detail, although quite shortly, for purposes of this volume. It is not considered wise to go too deeply into discussion of these notions, since some of them are analysed in hundreds of publications, and this is not meant to be a theoretical epistemological treatise anyway. Brief, operational quasidefinitions should suffice.

A system is a set of distinguishable elements, together with their interrelations, arranged according to a certain purpose or goal.

Systems analysis is an approach meant to define and solve problems for objects perceived as systems. This approach emphasises the need and utility of formal representation of systems, together with their purposes and/or goals, leading to construction of models, which could be explored with the aid of computers.

A model is a representation of a system allowing easier and less costly manipulations than can be performed on the system itself. The models are constructed in order to analyse various possible configurations and behaviours of real systems, which, in case of socio-economic systems is not feasible at all with the systems themselves. The facility of operation with the model is paid for by simplifications of reality which are necessary to arrive at a workable model. The representation can be quite an abstract and formal one and then we speak of a mathematical model or a computer model, if it is implemented on a computer. In the latter case a great variety of hypothetical system configurations and behaviours can be easily represented and analysed.

By optimisation a choice process shall be meant guided by purposes or goals external or internal to the system. The purposes and goals are two specific categories of a more general one, namely that of values. Various degrees of specification and various natures of values makes them appear under such names as: purposes, goals, objectives, criteria, standards, norms etc.

Resulting from optimisation is one, or a set of, particular, optimal, configurations or behaviours of a system, which, in some cases, whould imply a plan or a policy for attaining the optimum, and a set of measures therein.

Since the optimum may as well be represented through a model, this reflection would become "a model" in the more common meaning, i.e. a pattern or a mould for desired system's state or development course.

If a system contains segments which are guided by their own values, and operating their own measures, these segments being, for instance: authorities, farmers, food processing industries, construction industry, local consumers, trade establishments etc., and these segments must be seperately, together with their values, accounted for in modelling, then they are referred to as actors. Thereby their active role in shaping system's state is emphasised.When speaking of individual economic entities the word actor is substituted for by agent.

Development is a change in system's state which is distinguished from e.g. growth or decline through its definitely qualitative neture, in addition to quantitative. Development is a positive change in terms of values applied, and it may be brought about by conscious intervention, through plan or policy, just as it may be with growth.

Development is perceived through states of individual elements of a system, but it occurs through functioning of their interrelations, primarily through use and production of various forms of matter, energy and information flowing among elements. These precisely are the flows of resources. In modelling of systems for purposes of their development it is therefore of primary importance to represent these flows of resources through appropriate accounting and balancing.

C. The course of reasoning presented by organisation of this volume is as follows:

First, system analytic approach is presented, in this short introduction and in the subsequent paper. Then, a short paper on modelling of agricultural resources follows, with special emphasis on soil and water problems. This is justified insofar as agriculture is assumed to be the economic basis of rural societies, even there where it does not employ a majority of rural population. Third chapter is therefore devoted to planning of agricultural activities, specially on a regional scale. A number of models and approaches are presented, based mainly upon linear representation of agricultural system, yielding optimum plans. Since such optima are sensitive to conditions for which they are defined, they tend to be risky. Hence, subsequent chapter analyses risk and risk-decreasing in agriculture. Agriculture does, in fact, develop in a broader socio-economic context. Location and allocation of other activities and resources is therefore taken up as a more spatially oriented question. Finally there is a chapter devoted to regional analysis and planning as a framework within which e.g. rural planning would often take place.

This volume requires preparation equivalent to a graduate agricultural, land-use, physical planning or similar course.

# SYSTEMS ANALYTIC METHODOLOGY FOR INTEGRATED DEVELOPMENT WITH SPECIAL EMPHASIS ON RURAL AND SPATIAL CASES

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Abstract The paper presents a systems methodology concept for integrated development, as well as its emergence. It is a scientifically founded construct originated by several national and international scholarly communities. The International Institute for Applied Systems Analysis, IIASA, has played crucial role in the development of this concept. Essential aspect of the concept is extensive modelling and systems research.

## 1. Introduction

Development presents increasingly complex task for decision - and policy - makers, as well as planners, throughout world. There are undoubtedly a great - indeed,far too many - things that developers, whether of business or of non - business public service institutions, cannot do, are not able to do, are not allowed to, are impeded in doing.

During the 1950 s and 1960 s it was believed that everything has to grow, that tomorrow will be an extension of today, that development is a matter of time, management and resources.

Today , after 1970 s, in the turbulent times policy makers and planners cannot assume that tomorrow will be an extension of today, that "well - designed" today development programs could reach their objectives tomorrow.

Development became today much more difficult, as well as needed, than ever. Interest in development problems has grown very rapidly in recent years - both among "hard", "soft" and "org" sciences, policy makers, planners as well as societies as a whole. Technological, political, economic, social and environmental factors together with local, regional, national and global perspectives must be taken into account when seeking solutions to problems in this area. Economics and management,which have had powerful in fluence upon the theoretical, methodological and analytical approaches to development issues for many years,are too narrow for finding the c o m p r e h e n s i v e and *integrative* solution of development problems. Other of practice and sciences should be involved as well as multidisciplinary research.

Due to international importance and conditioning of the development problems the international research in this field has been established. The creation of International Institute for Applied Systems Analysis, IIASA, as well as other national research units in the follow-up action made a great contribution into the advanced form of international cooperation in the research on different development problems. Many of the speakers at this seminar take active part in this ambitious scientific undertaking and try to contribute to the methodology of applied systems analysis with special emphasis on rural and spatial integrated development |2,14,15,16,26,27|.

In identifying the problems of modern society that it should work on, IIASA found it useful to distinguish between two major areas: world - wide, i.e. global and intranational, i.e. universal. Global problems cut across national boundaries and cannot be solved without interational cooperation. Universal problems lie within national boundaries and, therefore, are subject to national or intranational authority. However, because many nations share them, their solution within nations can benefit from the exchange of analysis and experience among nations, especially among those that have different economic, social, political or analytical approaches to ther solution.

Today , in 1980's, almost all development problems have aspects of both global and universal character. The last decade demostrated that interrelations between global, national and regional problems are so tight that global solutions are not feasible without national and regional ones and that regional, or even local, e.g. rural, problems should take into account the national and global constraints or perspectives.

Energy and food are the most crucial and complex problems of modern society |6,12,19,21|. Since IIASA's establishment in 1972, there have been in 1973 - the first oil crisis, and in 1974 - widespread food shortages and it is not suprising that the first two major IIASA research projects addressed these problems.

It was less obvious, how, according to the report of Dr. R. Levien - the director - to the IIASA Conference 1980 |17| "integrated development" became third major research problem of IIASA.

As the chairman of the consultative session on Regional Development at this Conference I had stressed "... research on regional development problems is not new in Bulgaria, Italy, Poland, or Sweden, or in other National Member Organization countries. However, IIASA has contributed a new concept to this area of research... This new concept - integrated regional development - emerged as a result of generalization of previous IIASA retrospective case studies undertaken in the USA, the USSR, and Japan... The integrated regional development approach is still so complex that no one has enough experience and knowledge to solve this issue alone, and hence exchanges of experience will be fruitful for all the interested parties.." |24|.

In any integrated regional - rural or other - development study, it should not be forgotten that in reality each region is unique, it differs from others geometrically, geographically, historically, culturally, socially and economically, and therefore any experience transfer is limited. But at the same time, the region is a universal eco-techno-economic system where ecology subsystem e.g. environmental habitat interacts with technical as well as socio-economic subsystems, with interactions playing an increasingly important role in the development.

There is a great diversity of development areas and each development task has its own characteristics and problem solving criteria.

Rural and spatial issues of development are of interest not only to scholary communities, but also to policymakers, planners and other practicioners connected with national development.

Dramatic urban growth during the past 30 years with just a slight recent decrease of growth of urban population could produce new picture of the world human settlement system and relations between urban and rural economy. Therefore the efficiency of rural development will play increasingly important role for regional, national and global development.

The increasing prices of rural products which one could observe over the world, together with new technology and knowlegde seem to be a good prospect for the future of the rural development, nevertheless extensive effort should be added if integrated rural development concept is to be realized.

This paper, based on IIASA and Systems Research Institute research and experience, is meant to contribute to the methodology of integrated development. It should be not forgotten, though, that even system analysis with its comprehensiveness and integrativeness can only play a supportive role to any real integrated development problem.

## 2. Emergence of Integrated Development.

Fulfilment of current and future needs of societies requires advanced utilization of all resources such as land, minerals, energy, water, air, capital, labour, information and technology. The complexity of development process has increased rapidly over the past ten years because of the new perception of development and new constraints.

The increase in geographic density of economic and social activities makes the socio-economic and geographical spaces more coupled than ever. Moreover, specialization of these activities reached over huge areas of geographical space and resulting interdependences cut even across national boundaries.Rapid geographical expansion of more and more diverse economic and social activities increase sectorial productivity, at the same time producing geographical, economic and social inequalities, and as the result increase the areas of low productivity throughout the global geographical space.

Productivity is the source of all economic value and all resources can be managed for productivity.

Diversity of resources distributed over the geographical space make it necessary to utilize own crucial physical resources, therefore to-day all resources can and should be managed for productivity. To do that it is necessary to utilize not only physical resources but also human resources |31|, however even that is not sufficient, other resources like knowledge and organization (which have not only human but also societal dimension |30|) should be introduced.

Therefore <u>integrated development</u> should be introduced.

Integrated development of any geographical and socio-ecomic unit encompasses joint <u>utilization</u> of all crucial <u>physical resources</u> as well as all the others including <u>human resources</u>, <u>knowledge</u> and <u>organization</u> (Fig.1)

Integrated development of given geographical and socio-economic unit includes organizational and management arrangements for coordination of current and future processes of utilization of all available resources, (Fig.2). Integrated development includes cooperation of crucial actors involved in the development process: developers, regulators and impactees, Fig.3.

Integrated development of any region requires support by scientific research, computer and communication technology (appropriate hardware and softwone), data and knowledge bases as well as systems research. Many leading regional scientists and economists, such as Professors Aganbergyan |1| and Isard |10| have called for application of systems analysis to solving integrated regional problems, Fig.4.Integrated development requests proper interdependence as well as variety among all resources.

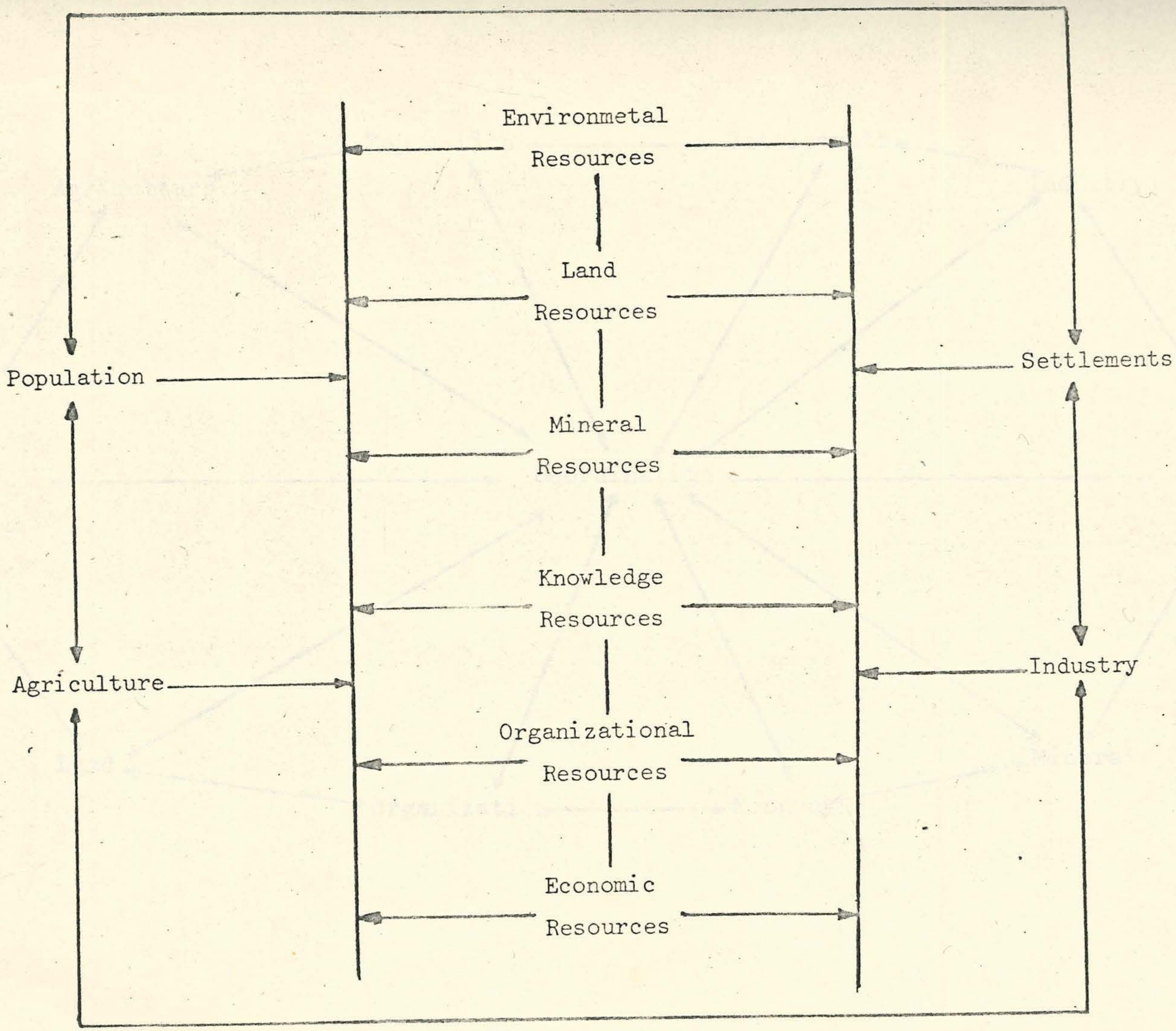



Fig. 1. Integrated development elements

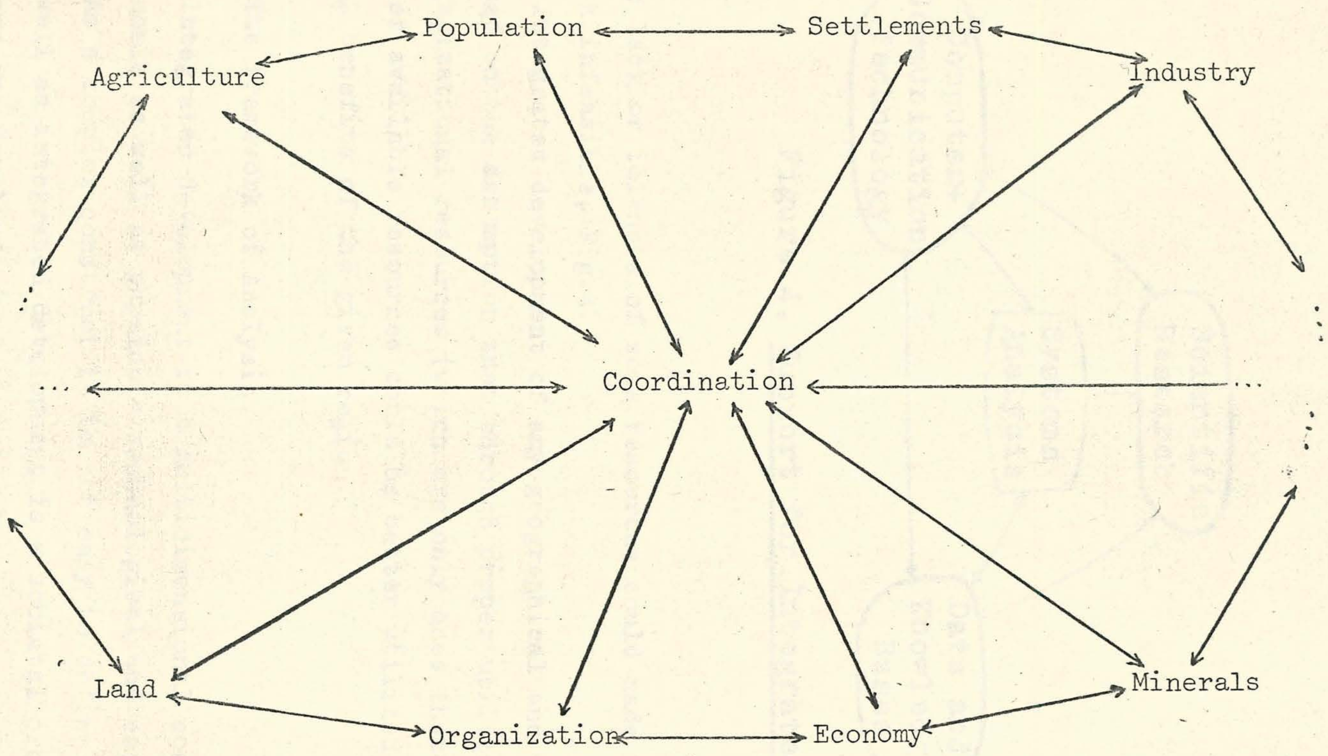



Fig. 2. Coordination

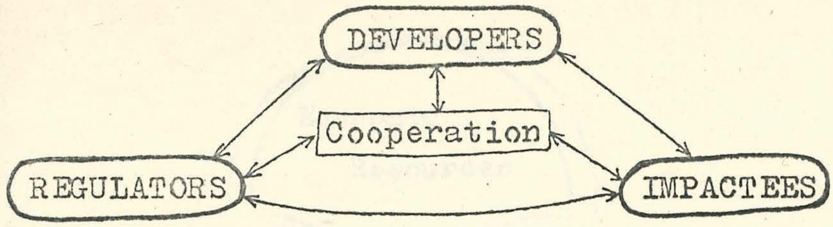



Figure 3. Cooperation.

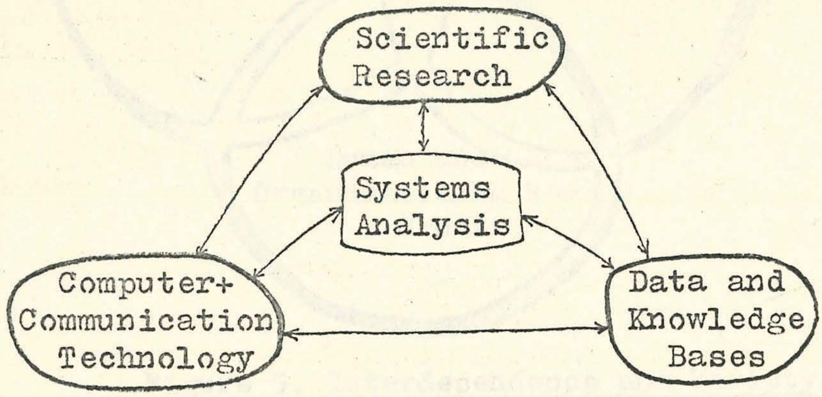



Figure 4. Support for Integrated Development.

The lack or idleness of some resources could made integrated development task infeasible, Fig.5.

Integrated development of any geographical and socio-economic area is based on the assumption that through proper utilization of knowledge and organizational resources (which are only ones that grow through usage) all other available resources could be better utilized for the economic and social benefits of the given region.

3. The Framework of Analysis.

Integrated development is a multidimensional construct within the socio-economic as well as physico - technological and environmental spaces.

As a complex construct it is not easy to define and measure. Development as well as integrated development is a societal process, and different autors are involved within the development process could have different concepts of integrated development, some of them being contradictory. The methodology of systems analysis does not define the integrated development concept for the given case but rather this methodology is used by all important actors involved in the given case and through the debate resulting some more rational integrated development concept may be chosen.

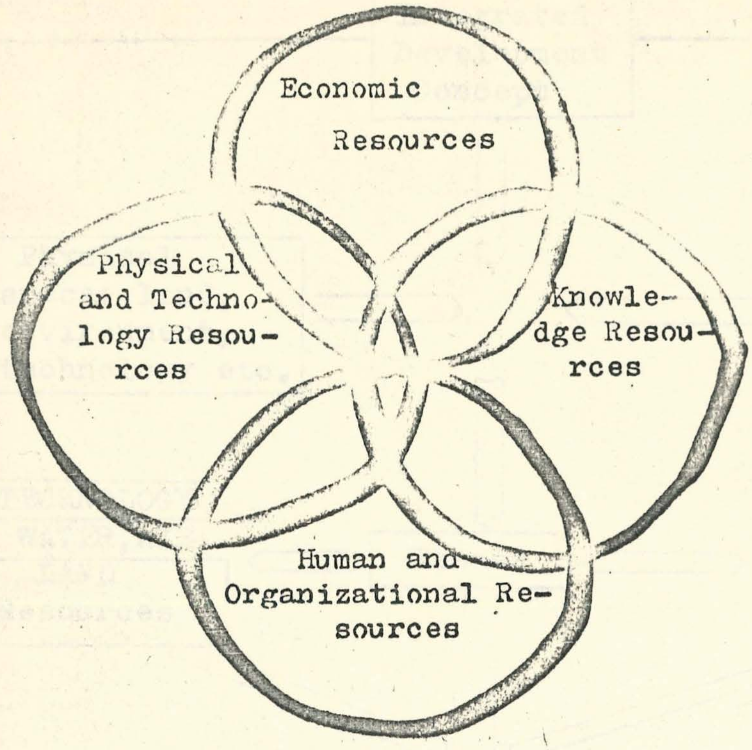



Figure 5. Interdependence and Variety.

However, it is our duty to stress the importance of the conceptualisation process within the framework of analysis. It is not necessary to consider just the quantitative form of the development concept, however it requires that at least development areas could be defined within the socio - economic and physical subspaces. Moreover since any development process is time dependent , time as a dimension of analysis should be considered

On the one hand if more time and precision could be devoted to conceptualisation phase, then one could expect also more precision of the systems analysis, however on the other hand the systems analysis could clarify the complex behavior within the socio - economic and other spaces and help in better conceptualisation of the integrated development.

Iterative nature of conceptualisation of the integrated development should be kept to very carefully.

The analytic framework as proposed for the first stage of analysis is shown in Fig.6. Any integrated development concept is imbedded in the socio-economic and geographical spaces, therefore the first issue which should be considered is regionalisation. This issue is strongly related to other issues i.e. specialization, coordination, cooperation, interdependence and variety and so on. The second issue which should be considered is - rural versus urban development |22|, strongly related to other issues such as, household aspiration and income, land and water resources, employment opportunities and so on. Analysis of inter - relations between issues, actors, institu-

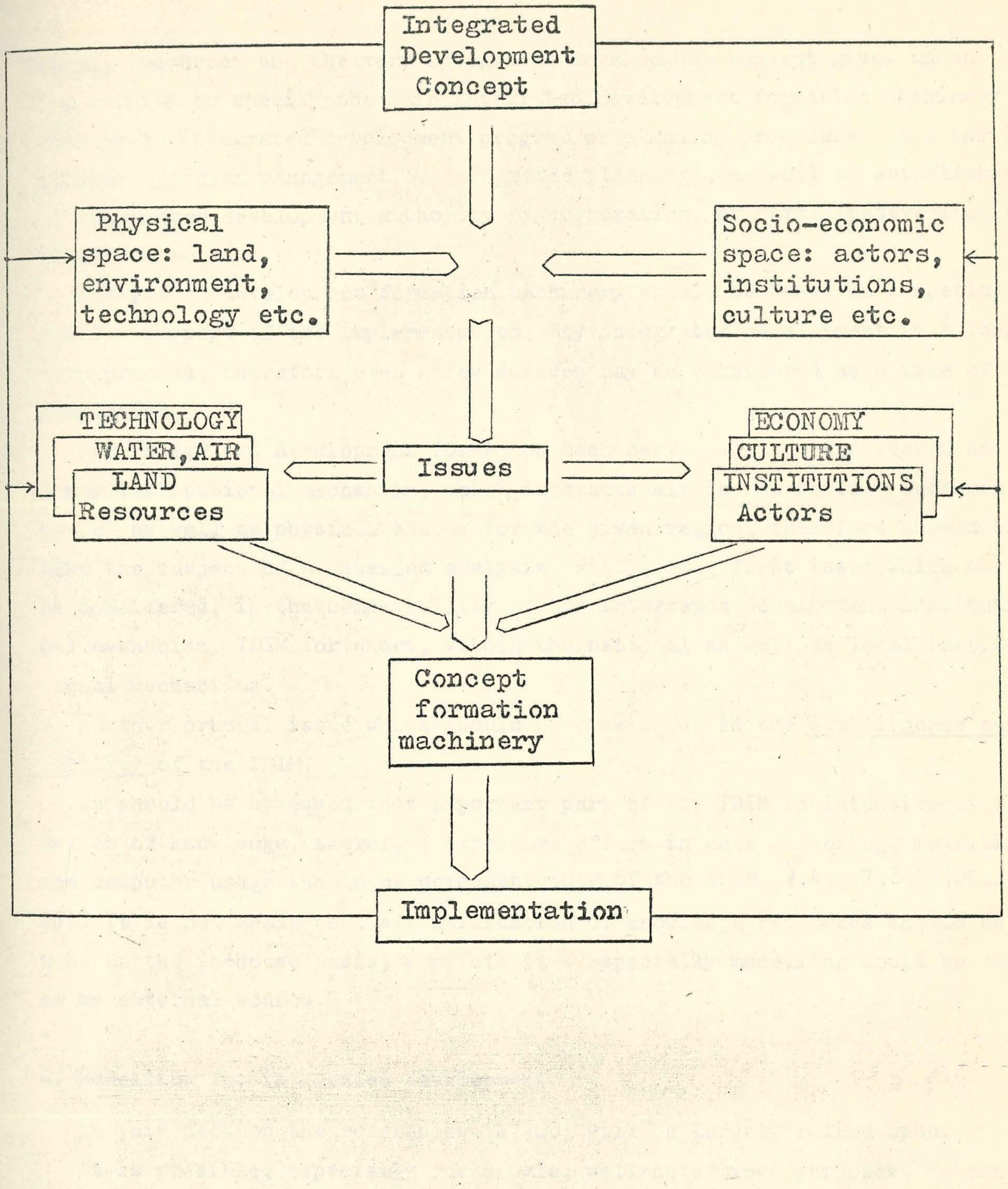



Fig.6. Framework of Analysis

tions, resources and the very integrated development concept gives us an opportunity to specify the main integrated development formation machinery such as an integrated development program or planning procedures and institutions (program management or integrated planning), as well as establishment of integrated development authority or corporation, or participative institutions and so on.

Integrated development formation machinery should be based on a special law for support of the implementation. Any integrated development is a long term process, therefore even a few decedes may be considered as a time of completion.

Any integrated development formation machinery should be considered as a new institutional mechanism, which interacts within the socio - economic space as well as physical spaces for the given region, therefore should be also the subject of a detailed analysis (Fig.7). The first issue which should be considered, is the compatibility of the integrated development institutional mechanism, IDIM for short, within the national as well as local institutional mechanisms.

Another crucial issue which should be considered is the <u>intelligence capability</u> of the IDIM.

It should be stressed that important part of the IDIM is intensive utilization of knowledge, therefore extensive effort in data gathering, modelling and computer usage should be permanent duty of the IDIM |3,4,5,7,8,11,20,23,28, 29|. It is not meant that all utilization of knowledge resources should be done on the in-house basis, some of it , especially modelling could be done by external bodies.

4. Modelling for integrated development.

In this section the references |27,28| will be largely relied upon.

It is possible, especially for single, well-determined purposes, to construct models of much lower dimensionality, or variety, than their real-life objects. When this is not feasible,because the action to be undertaken would affect the whole system, the complexity has to be reproduced. For a system of a region's complexity (sectors, national system) a problem arises: if and how to reconcile and integrate various approaches to and aspects of the system during the modelling, analysis, and implementation phases. This applies both to different scientific opinions and to different interests, whether they are driven by objectives of individual entities or do not have any value judgement background.

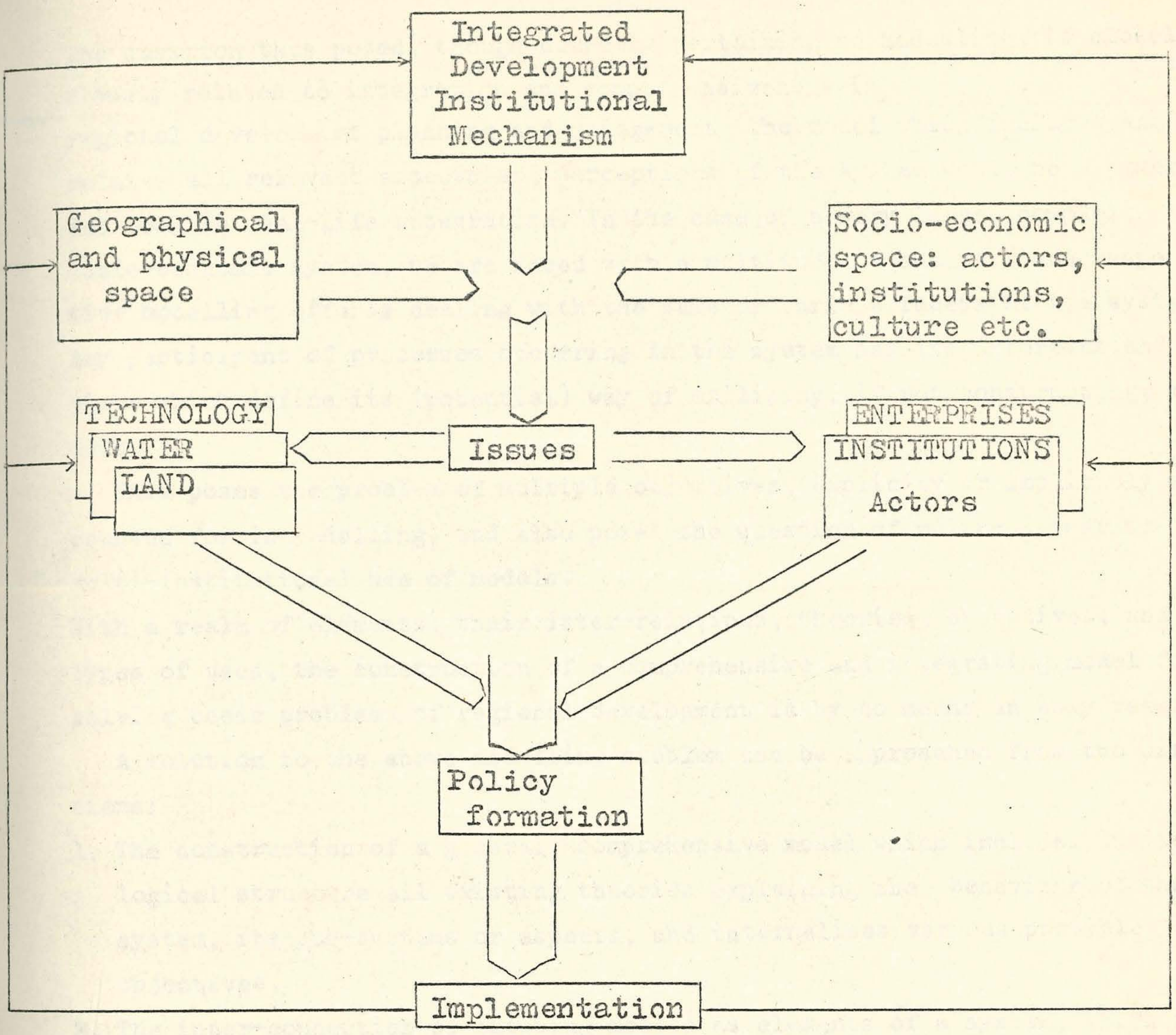



Fig.7. Framework of IDIM analysis

The question thus posed, though directly pertaining to modelling, is closely closely related to integration and comprehensiveness in regional development planning and management. The model which includes and relates all relevant aspects and perceptions of the system would be a powerful tool in real-life integration. In the case of a very large, complex, socio-economic system, we are faced with a multitude of analysis and respective modelling efforts dealing with the same or various facets of the system. Any participant of processes occurring in the system has its interests and views which define its (potential) way of utilising, if not constructing, models.

This poses the problem of multiple objectives, explicity or implicitly accounted for in modelling, and also poses the question of multi-partner or multi-institutional use of models.
With a realm of elements, their inter-relations, theories, objectives, and types of uses, the construction of a comprehensive and integrating model for solving basic problems of regional development is by no means an easy task.

A solution to the above modelling problem can be approached from two directions:

1. The construction of a general, comprehensive model which includes in its logical structure all existing theories explaining the behaviour of the system, its sub-systems or aspects, and internalises various possible objectives.
2. The inter-connection of existing models as elements of a system, which in itself is the model of a large and complex system.

The system {X,I} could therefore be represented by models corresponding to individual entities, X's and by their inter-relations reflected by I. In the case of an attempt to construct an all encompassing model, these entities could become elements of the model, based mainly on hierarchies numbered n:1,...,N. There is a whole spectrum of possible approaches between the two extremes. First, the comprehensive model may be subject to certain structurisation following the definition of element rationale. We have already spoken of entities national, sectorial, regional, and at the lowest level physically located units such as enterprises, flow channels (routes or telephone cables), farms and households. Additional structurisation is brougth in by existing cultural, power and institutional systems and by implementation capacities (performance limitations). Existence of thus conditioned multi-hierarchy finds its reflection in modeling.

The actual theoretical capacities of integrating various theories pertaining to regional problems and at the same time the necessity of providing an instrument for rational decision-making in complex regional situations point out the second, the system of models approach as appropriate for the present situation.

The philosophy underlying this approach is essentially the same as for any other analysis of a system. If the equations describing an individual element's behaviour in itself and in interaction with other elements forming together some mathematical model vary substantially, reflecting not only various behaviour patterns of the elements but also various types of analyses and mathematical formalisms which led to the establishment of given equations, then the same may happen on a higher aggregate level with no detrimental effects to the model's validity. Diverse models forming the model system, based on different kinds of analyses, can be regarded as elements of this system, inasmuch as they reflect real elemental entities. If these entities (elements, aspects, inter-relations) are adequate representations of reality, then the whole model (model system) is as well.

Individual entities X would then correspond to elements of reality as modelled with various theories and techniques, but they should also incorporate types of purposes of uses. Inter-relations I, even if not technically realised, should be explicated so as to enable formation of the whole {X,I}.

The model system would include models of various levels of hierarchy and various entities on each level. For any object represented by models there should be a possibility of aggregation (simplification). Wherever possible, real objects should be represented by more than one model. This requirement of model redundancy, resulting from obvious cuts in complexity which every model introduces is especially important in view of multi-purpose, multi-partner usage of the model system. (See |18,25| for interpretations of models as projections into subspaces and methodologies for the initial space reconstruction.) Redundancy of models concerns both formal theories which may explain and predict certain phenomena and stages of solution process as depicted before. Such an aprroach does not exclude formally comprehensive models comprising many levels of hierarchy or recoursive schemes of their deployment and pertaining to various types of entities. If activated in conjunction with others, partial models will have to be very carefully coordinated. In general, the question of ensuring appropriate common work of various models is the crucial one here. Apart from the question of structure as related to external functions that the model system should perform, there is the question of internal organisation of the very function.

This is primarily the question of inter-model communication, standardisation, model definition, and language. Now we shall turn to the requirements as to the structure and functioning which relate to external communication.

Structurisation of any model, and hence of the model system, has various sources and purposes. It is a reflection of existing real-world structurisation and of potential structurisation propensities. In a solution it may be rearranged so as form an optimal (for a global objective) structure. This simple picture is somehow complicated because the entities which constitute the structure, if they were to be systemic (how otherwise could they appear as coherent entities?), represent certain objectives. It is within the structure composed of these (more or less consciously) goal seeking entities that the new solution has to be implemented. A fully formalised normative global approach would assume complete knowledge of individual entities' objectives (actual and solution-generated) and of global objectives and tend to optimally coordinate these so as to satisfy all participants. Recent experiences (see |1,3,4,11| on Soviet work in economic modelling) show that we are far from obtaining workable results in this domain. Assumptions have to be loosened and iterative procedures or even gaming are being proposed. Models (model systems) from the upper level normative tools become multi-purpose, multi-access prediction and planning devices. The development oriented model system would be a vehicle for experience gathering, comparison and summation, and for conflict containment or resolution. It is only in this way that the model system could satisfy the requirements of comprehensiveness and integration. Thus, whatever the formal characteristics of models may be, in order to play their roles adequately, they must fit into the user structure - institutional or informal with regard to the scope of influence and interest, implementation, instruments available and objectives. Studies of the imbedding of model systems in institutional frameworks meant for regional development are reported in |18,28|.

The model system is therefore meant to represent, and to be interfacted with, the whole sociental policy making process, as its instrument. The methodology involves distiction of various phases and modelling formalisations in policy making processes (optimal control, simulative, decision analysis models), so that abstract considerations can be related to real problems. Communication with the users must be ensured both with regard to situation evolution represented by descriptive or normative models and to goal formation models.

Collaboration of the policy making process participants in model system construction (from the outset and then in updative expansion) will facilitate interfacing through better emulation of the process itself. Abstract ideas of hierarchic relations and organisational recursiveness, which fail to follow reality in formally rigid representations, could then be heuristically tested in a loose framework. (Note that the emulation of the policy making process may be regarded as a sufficient way of representing the whole system for normative purposes, $\{\{X,I\}_Y\}$.).

It is assumed for a given model and relation complex of the system that the specific subsystems - aggregate or individual models - can be activated. That is, subsets of $\{X,I\}$ (a maximum potential configuration), $\{X,I\}_Y$, would be generated on the basis of external specification Y. Subsequently, the data set would have to be specified. Individual models X may themselves span more than a single entry, defined by full specification of $n=1,\ldots,N$. As the problem area would have to be specified in the language of indices n, the possibility of misspecification appears. The final configuration of $\{X,I\}_Y$ would then result both from the problem area perception of the user and from the set of available potential configurations $\{\{X,I\}_Y\}$. Within Y, and therefore to some extent also within n, such additional attributes to the problem could be given as objectives and type of purpose. Models can be used simply for projections and then Y would specify merely the "physical" portion of the system to be "presented", e.g.

$$\{\{X,I\}_{T_1}^{T_2}\} \text{ i.e. over a time period } (T_1,T_2).$$

When, however, an objective Q is specified within Y, it firstly influences the choice of model configuration $\{X,I\}_Y$, and secondly transforms that state of the $\{X,I\}_Y$ into an optimal one:

$$\{\{X,I\}_Y\}_T \xrightarrow{Q} \{\{X,I\}_Y\}_T^{opt}$$

The final specification of the task which the model system has to perform for its user would involve functions or purposes of use P. This would make the scope of models considered still narrower. Even within the class defined by task $Y(n,Q,P)$ the variety of approaches and theories must exist, as stipulated by the redundancy requirement. Individual users can therefore see their own "side of the box", but also get some idea about what others see. Participants of the policy making and management processes will feed appropriate Y's into the system which will make virtual structures $\{X,I\}_Y$ appear for the time of activation.

They will, however, also be able to look at Y's (potentially) utilized by other model system users/policy process participants. It is important to take note of this feature of a multi-partner model creation and use, i.e. communication of models or perceptions. This is a necessary condition for the system's effectiveness, otherwise it could be a collection of models not corresponding to user's interests or mutually non-available, and therefore not capable of testing and expanding. Once the model system is used by various partners of regional development as a language, the question arises as to its specific role in solving the coordination and regionalisation problems mentioned, and then in the determination of development directions. Model communication conditions mentioned above, referring to mutual knowledge of general situation perceptions (if not specific policy parameters), including such fundamental issues as data and notions definitions, possibility of data verification, etc. and of values kept to (if not specific objectives), is also a necessary condition for reaching any explicit or implicit consensus (see|11,25|). A condition for explicit consensus would be sharing of certain values and correspondence of preference scales which may be asked for from the model system by an upper-level authority. If only the above weak conditions hold for getting an answer, an appropriate comprehensive global objective function must be formulated. An answer (whether direct or coordinative) would be an optimal solution for both higher level authority and for lower level entities. If this is not feasible, then there might be a temporary consensus over specified solutions on the basis of individual preferences. Otherwise, there might be an implicit horizontal consensus on the lower lewel as a result of partial temporary agreements whether on values or on solutions. Whatever formal operations could be performed with the model to obtain a global solution or its characteristics, it is essential that the <u>necessary condition</u> for model system effectiveness is at the same time the necessary <u>condition for reaching a consensus among development process partners</u>.The model system structure consists of a series of classisications which may be seen as axes in a "model space". Such an illustrative classification is not intended to span the model space in any sense, as it may always be possible to have two different models at one point of the classification grid and the axes are often correlated. Rather, it is meant to provide the variety needed for decision making and the appropriate problem solution.

This structure, as exemplified below, is overspecified in the sense that it contains more elements and relations than would in reality exist for individual case studies so that for each case a mapping into the structure is feasible.

I. Place in the "Physical Hierarchy" Scale:

1.1 global
1.2 international
1.3 regional
1.4 sub-regional
1.X individually physically located

A specific number of levels depends upon the object of modelling (scale of the country of economy). Parallel to the physical scale hierarchy is the sectorial breakdown as shown below:

II. Sectorial Breakdown Hierarchy:

2.1 global (main factors)
2.1 main factors
2.2 complexes of sectors
2.3 sectors
2.4 industries
2.X individual needs, goods, services or types of flows (information, money, goods, etc.).

In order to finally point out the real world subject of the model one would have to specify the temporal dimensions shown below:

III. Temporal Dimensions: | 7 |

3.1 long-range
3.2 medium-term
3.3 short-term

For each of the above classifications two parameters have to be specified for entering and activating a model: the level of aggregation of scope and the appropriate entities or breakdowns on that level. Once it is known what the model (s) should represent one is obliged to establish the function it will play in the decision process and (therefore) the way it should be built.

The structure, generated by the above three dimensions, may, to large extent, reflect the perception of reality shared by those who develop models and agree to use them. It is, therefore, in a sense a normative view: this is how one should look at reality, as opposed to the perception suggested by the existing policy making process. In parallel to the above there is an actual institutional policy structure within which development is really defined. If, for a better representation, individual policy process participants $n_{pk}$ install their own models in the system and make them all accessible, such a game becomes more realistic, constituting an interpartner interface. The structure of $\{n_{pk}\}$, and a structure $\{X,I\}_n$ corresponding to it will therefore constitute a full model of a policy process, including objectives there appearing.

IV. Functions:

4.1 description of process (alternative developments)
4.2 description of objectives and purposes
4.3 solution search

V. Types of Models:

5.1 data base
5.2 econometric
5.3 I/O
5.4 simulation SD
5.5 simulation - others
5.6 programming - linear
5.7 programming - non-linear
5.8 programming - dynamic
5.9 optimal control
5.10 game theory
5.11 gaming
5.12 expertise-interaction
5.13 decision analytic
5.X1 deterministic
5.X2 stochastic

This quasi-classification does not account for the whole wealth of theories which may drive various formal representations. In order to achieve a required redundancy of models for identical configurations of the previous classifications various types of models based on differing theoretical assumptions must be included. Redundancy would therefore mean inclusion of a variety of models into each "functional" block of a structure exemplified by Figure 8.

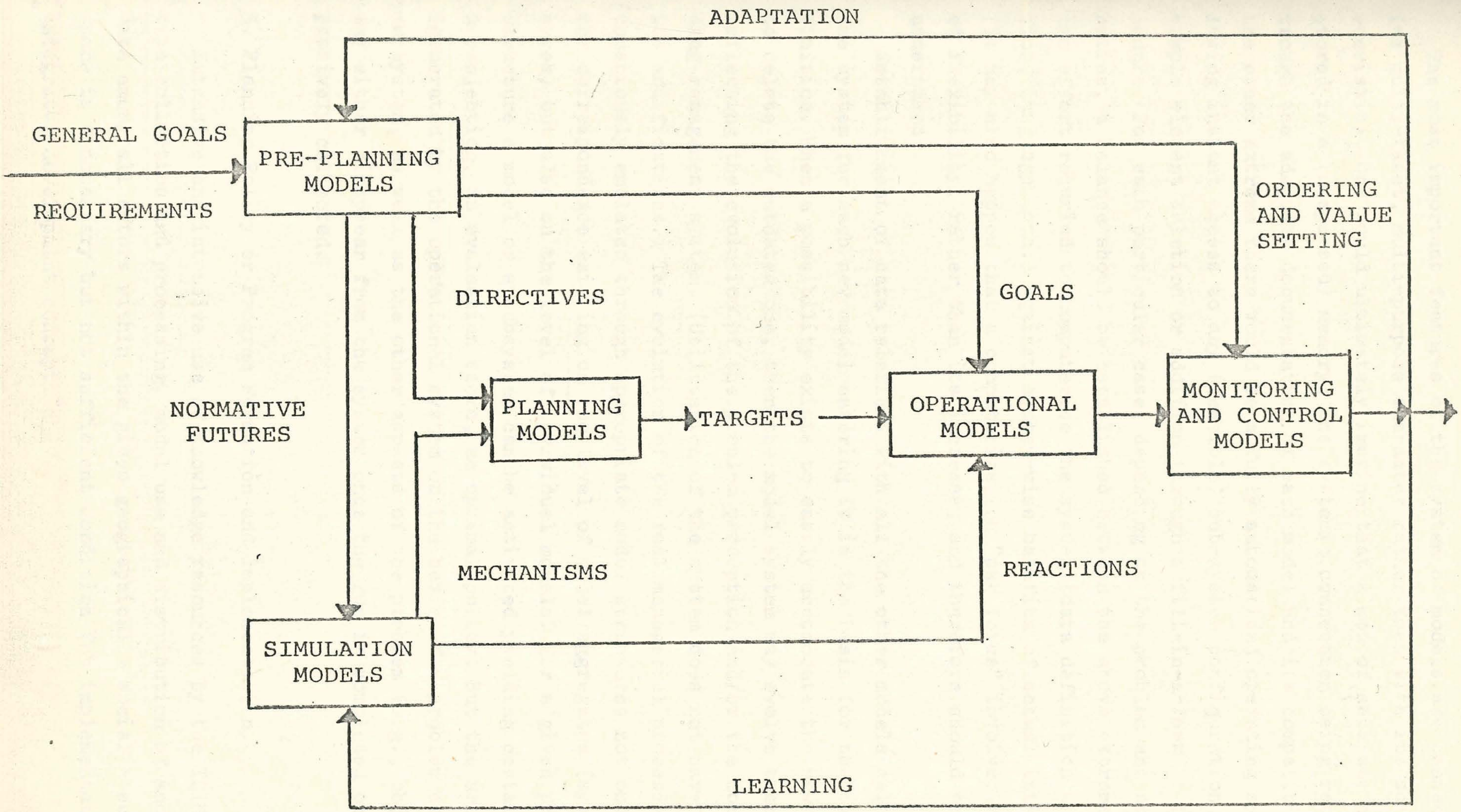



Figure 8. Use of Models for Solving Problems of a Functional Nature

The most important features of the system of models are connected with its multi-facet, multi-purpose character rather than with its software characteristics. One could ultimately imagine that a set of separate models is stored in a (dispersed) memory, the systemic connection being realised trough the adequate documentation of each model and its compatibility. At the other extreme there would be a fully automatised operating system, allowing instant access to any (feasible) sub-system configuration, and a simple element deletion or addition through a fill-in-a-form type procedure. For each particular case, depending on the problem and actual capacities, a balance should be established between the above extremes, weighing the effort requried to computerise the system (data definition and transmission, language, etc.) against system-wise benefits of actual interlinkage. (It may also happen that a computerisation "par force" involves the loss of flexibility, rather than its increase, and therefore should not be undertaken).

Establishment of data relations with all the other models belonging to the system for each new model entering it is the basis for the system definition. When a possibility exists to easily accomodate the new model and to delete the outdated one, then the model system may evolve over time, reflecting the evolution of the problem perception and/or the corresponding management system. (Utilisation of the system does not have to involve its modifications.) The evolution of the real managerial process has to be consciously emulated through appropriate model structures not only through the correspondence existing on the level of model aggregates (system structures) but also on the level of individual models. For a given problem structure a model or a subsystem can be activated yielding certain results, a projection, an evaluation score, an optimal policy. But the activated (generated by the operational system on the basis of a problem description) subsystem, as well as the other aspects of the problem (e.g., objectives) may either disappear from the system once the run is completed or just be passively collected.

## 5. Planning Policy or Program Formation and Implementation.

Extensive and intensive use of knowledge resources by the IDIM, through data collection and processing, model use and distribution of knowledge and data among all actors within the given geographical - social - economic space is a necessary but not sufficient condition for implementation of the integrated development concept.

IDIM have to have authority or power given by law for establishing the planning, program or policy and for execution of it.

Planning, programs or policies for localized integrated development differ from the national or business ones, |4,8,20|.

Unfortunately, the accumulation of knowledge in the field of management and controllability of development is still limited and relatively much smaller than in other fields of modern management. Simultaneously, the management and control of development is one of the key management problems of today. The diversity of development areas is broader and broader and each development undertaking has its own "rules of the game". Nevertheless, some universal aspects of the development processes as well as universal needs for the improvement of different development processes exist, especially with regard to integration and comprehensiveness.

Analytical as well as systems engineering approaches to the socio-economic plans, programs or policies could play an important role in the improvement of the efficiency and effectiveness of the modern tools for development management.

The aim of this section is to present systems analytic frameworks applicable to socio-economic plans, programs, or polices. Insofar, however, as notions of systems analysis and also of development plans, programs, and policies have very broad meanings, some specification as well as illustrative examples are necessary.

Due to the limited resources any real socio-economic system has a limited development potentiality. By the actuality of development of a given socio-economic system we understand processes caused by a permanent system dynamic characteristics and institutional machanisms of the subsystems. If it is desired in some sector, region or locality i to meet at a given time $t_1$ the output value $x_i^*(t_1)$ and the situation is such that

$$x_i^c(t_1) > x_i^*(t_1) > x_i^a(t_1)$$

where

$x_i^a$ - value of output $x_i$ which would be reached according to actuality of development

$x_i^c$ - value of output $x_i$ which could be reached according to capability of development

then a new, at least temporary, institutional mechanism for time period $(t_o, t_1)$ should be introduced.

An ad hoc, temporary, goal-oriented institutional mechanism aiming at the fulfilment of condition:

$$x_i^c(t_1) > x_i(t_1) > x_i^*(t_1) > x_i^a(t_1)$$

we will call the development plan program or policy.

The desirability of achieving progress may be considered as a product of the probability of success $p^*_{x_i}$ and social, political, economic or technology values $W(x_i^*)$ divided by cost $C(x_i^*)$:

$$d(x_i^*) = \frac{W(x_i^*) \cdot p^*_{x_i}}{C(x_i^*)}$$

The development plan, program or policy should be considered as a temporary mechanism for increasing the probability of success, $p^*_{x_i}$, as well as increasing social, political, economic and technological value $W(x_i^*)$ and decreasing the $C(x_i^*)$. Sometimes only increasing the probability of success is enough for launching of the development plan, program, or policy since the social or political value of success is so high that even high costs could not significantly decrease the desirability index.

Of course, if

$$x_i^*(t_1) > x_i^p(t_1) \quad \text{then} \quad p^*_{x_i} \equiv 0$$

$$x_i^p(t_1) > x_i^*(t_1) >> x_i^c(t_1) \quad \text{then} \quad p^*_{x_i} \quad 0$$

where

$x_i^p(t_1)$ - value of output $x_1$ could be potentially reached.

A new development plan, program or policy introduces now interlinkages between sectors and regions or subsectors and subregions, however, the main institutional mechanism of sectors or regions remains the same.

Development plans, programs or policies are by definition normatively oriented and therefore ge-ared by the norms stratum: needs, values or goals. Variables in the norms stratum are interrelated. Needs are on the top of the norms stratum hierarchy and usually express basic needs like physical necessities, security, quality of life, self-actualization.

Values are more precise expressions derived from these basic needs, for example, environmental protection, health, energy, economic wealth, freedom and so on. Goals are the most precise expression derived from values |5|. Development plans, programs or policies may be oriented to various types of needs, values or goals and therefore different machinery should be used to undertake different norm-oriented plans, programs or policies. Nevertheless some general, universal features of the formation of a development plan, program or policy exist. For example, the goal-setting procedure is a very important stage in the preparation of any development outline and even if this development outline is more wekly defined in the case of a need-or value-oriented plan program or policy, the transformation of needs to values and then to goals and subgoals is necessary, since goals will be a guide for the actions, as well as the basis for the control of results. Furthermore, goal setting is a communication tool for the development participants to clarify the scope, the level of ambition and directions of the plan, program or policy.

Uncertainty and misunderstanding during the formation and implementation can be avoided to a large extent by thoroughly formulating the plan, program or policy goals. The goal-setting procedure consists of iterative analytic processes as illustrated in Figure 9. Goal-setting should start with situation forecasting followed by its analysis and evalution. After that goal-presetting procedures could begin, followed by an iterative procedure of goal setting. The goal setting procedure is usually a group activity, since it requires a broad scope of konwledge and experince. Graphical and matrix techniques are usually used by the group during their activities, with frequent assistance from computers.

Many development outlines are societal, i.e., involve participation of, or impact on, a variety of distinct socio-institutional groups and therefore it is necessary to consider the socio-psychological perception of goals. Let $A_i$ be value weight, $B_{ij}$ goal weight with respect to value i; $C_j$ the aspiration level with respect to goal j; and $D_j$ the real magnitude of indicator j, then the discrepancy between the aspiration level and indicator magnitude could be computed and weighted to the importance of the goal for the connected values |5|:

$$E_j = (C_j - D_j)\sum_i A_i B_{ij}$$

(Dis) - satisfaction of the system is the sum of the goal discrepancies:

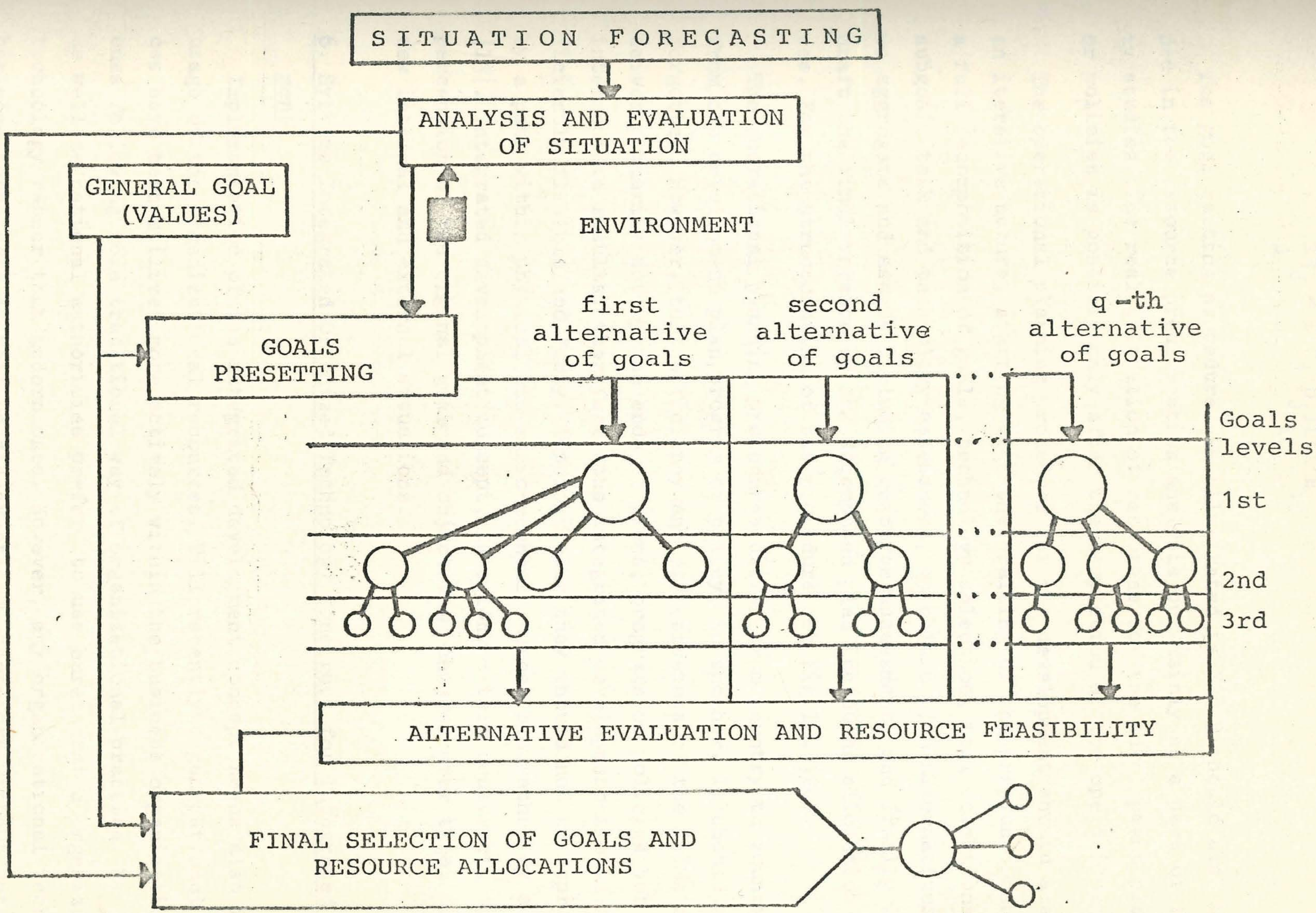



Figure 9. Procedures for Goal Setting

$$\sum_j E_j = \sum_j (C_j - D_j) \sum_i A_i B_{ij}$$

The goal setting procedure, as illustrated in Fig.9 should also be included in the resource preallocation analysis but mainly as a part of feasibility studies. The real allocation of resources for the development plan, program or policies is possible only after the completion of the operational plan.

The operational planning procedure for the development should also have an iterative nature, starting with the drafting of the preplan. Then through a full decomposition of goals, technology selection, task formation for each subgoal, task and technology assessment, we obtain plan alternatives which we aggregate and assess including resource assessment, and finally we can draft the final version of the decomposed plan including allocation of resources. For the structuration of the procedure see Fig.10, |20|.

The operational planning procedures differ from country to country and from one development plan, program or policy to another. It should not be forgotten, however, that efficiency and effectiveness of the IDIMs are preceived primarily not by the ends of plans, programs or policies but by the intermediate results, therefore the integrated development should be sufficiently flexible and fuzzy. Topologically they should not be represented by a path within physical and socio-economic spaces but rather by a tube |13|. Integrated development concept, is a long - term construct, therefore perception of the orginal goals and objectives changes over time, due to new internal and external situations.

## 6. Systems Integrated Organized Technology Construct for Integrated Development.

Implemantation of the integrated development concept needs also intensive usage of the organizational resources. Till recently organizational resources have been utilized more actively within the business organizations, other ones following more traditional way of organizational practice. Many local as well as national authorities prefer to use bureaucratic organizational technology rather than modern ones. However, any organizational technology has some advantages as well as disadvantages, therefore without detailed analitycal procedures, it is difficult to choose the proper organizational solution for the given purpose. Organizational technology for IDIM as well as for implementation of the integrated development outline should be adequate to the complexities of the goals and tasks as well as to the availability of resources.

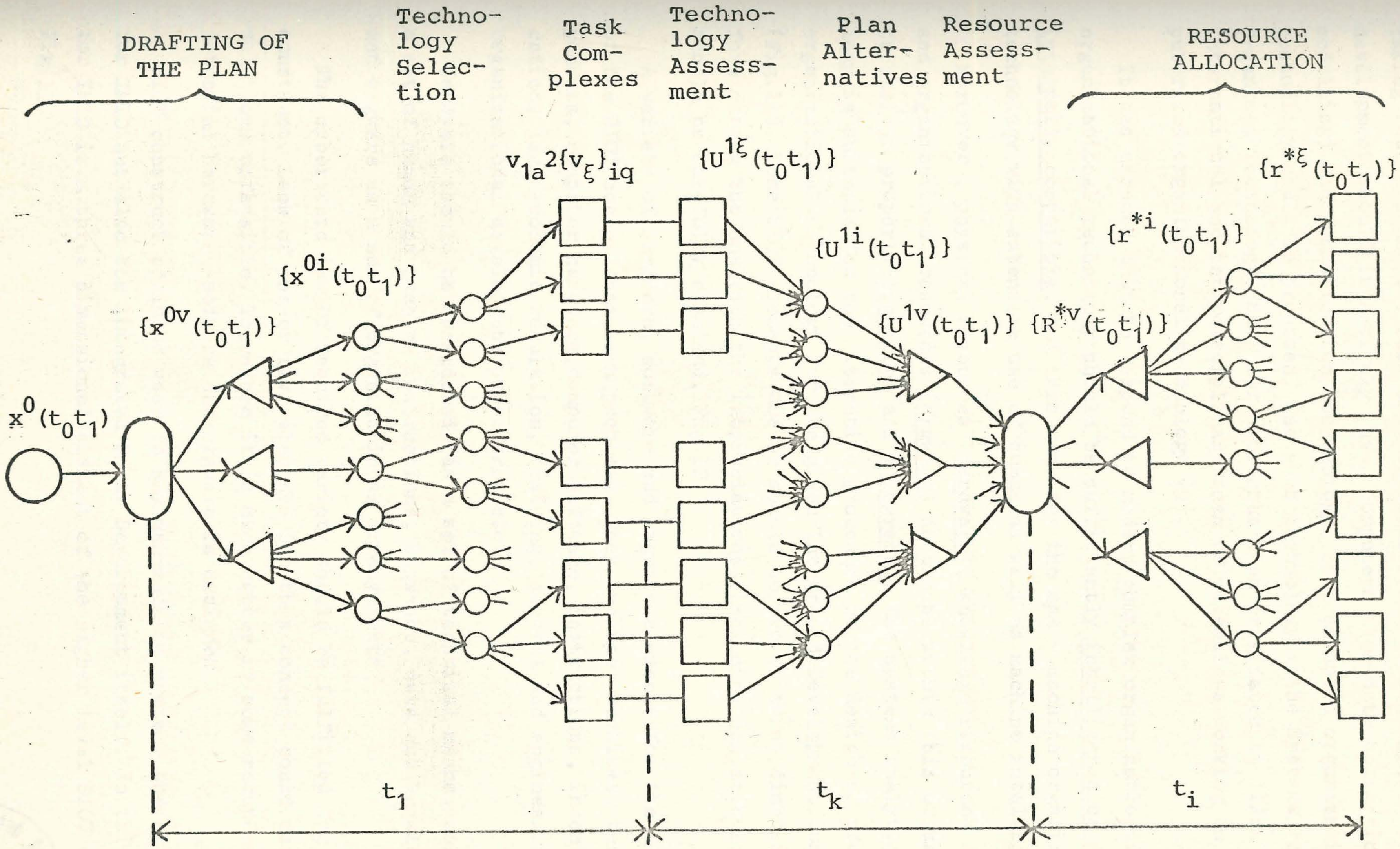



Figure 10. Procedure for the Operational Planning Process.

Taking into account the fact that organizational technology for integrated development should intensively use computers (for data collection and modelling) and communicetion technology, only advanced organizational technology could be proposed. One such technology - the Systems Integrated Organized Technology, SIOT for short, has been originated at IIASA by the international and interdisciplinary team of scientists working on the computerized organizational technology |9|.

It was assumed that to respond to modern complex organizational tasks the organizational technology should be sufficiently <u>intelligence capable</u> and <u>internally compatible</u>, and this requires the man - machine organizational technology with extensive use of human as well as machine intelligence.

Moreover , physical resources (<u>hardware</u>), knowledge resources (<u>software</u>) and organizational resources (<u>orgware</u>) should be within this organizational technology properly <u>organized</u> and <u>integrated</u>. The systems analytic methodology is suitable for the iterative procedure of the design of proper SIOT organizational technology for the given Integrated Development Concept (Fig.11). Some SIOT elements are or should be two or three dimensional, therefore during the analysis the interrelations (including compatibility issues) should be carefully examined, Fig.12.

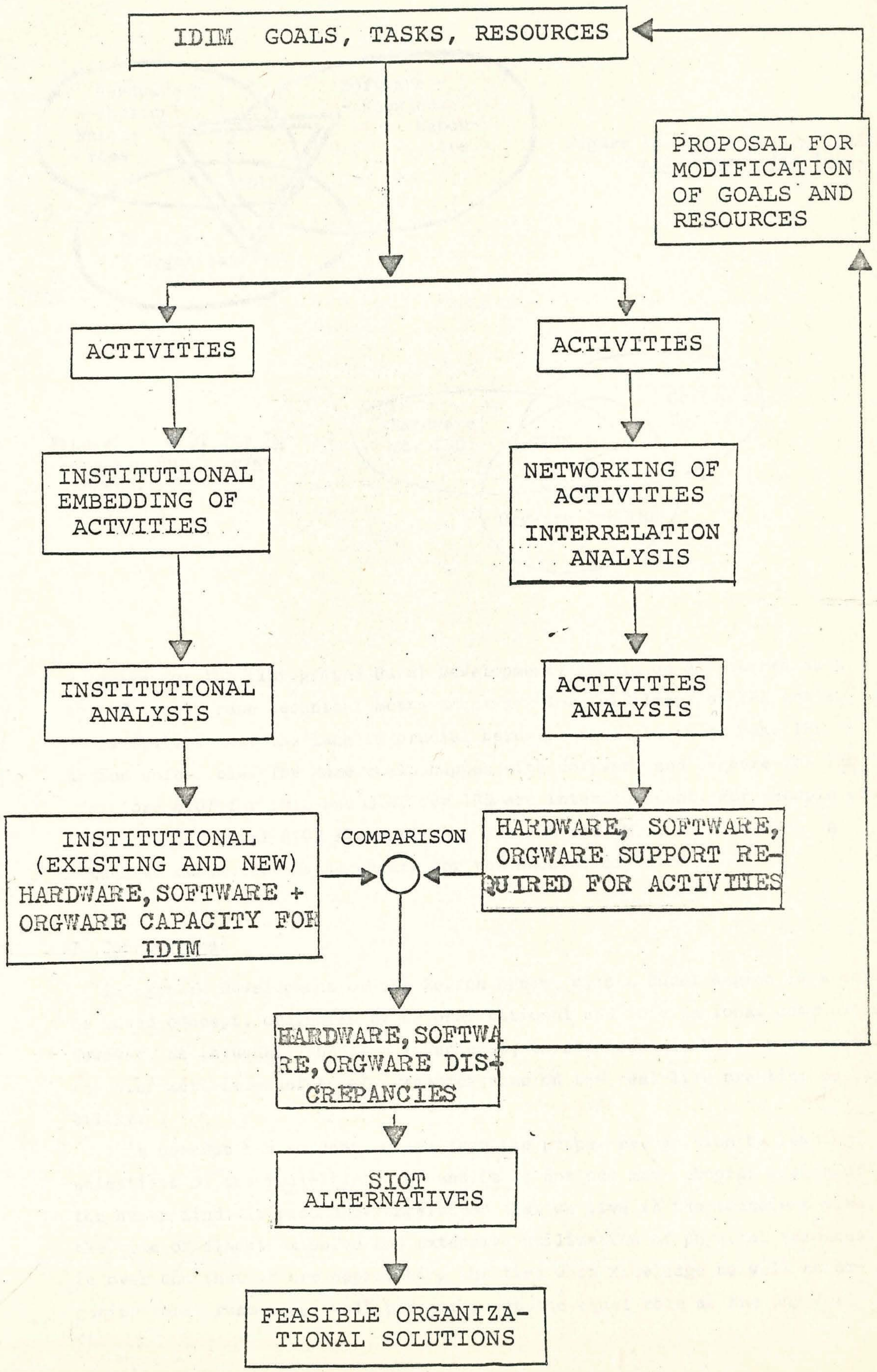
A variety of hardware, software and orgware elements for the realization of the SIOT concept has been proposed. They include: machines, technical components, computer hardware, computer software, instructions, incentives, education, law, economic regulation, training, general and engineering services, organizational development procedures etc.

Hardware should be considered as a set of technical means, software as a set of human and machine instructions, know-how, data and knowledge bases, and orgware as a set of organizational arrangements.

The cybernetic law of required variety should be fulfilled for any SIOT construct. Lack of one or few elements for this concept could made all SIOT solutions unfeasible. Therefore it is much better if some redundancy of the potential hardware, sofware and orgware is designed.

SIOT construct could be used to any man-machine system, therefore not only for IMID but also for Integrated Rural Development itself. In this case SIOT for IMID is a three dimensional element of the higher level SIOT construct, Fig.13.

Figure 11. ANALYTIC FRAMEWORK FOR ORGANIZATIONAL DESIGN



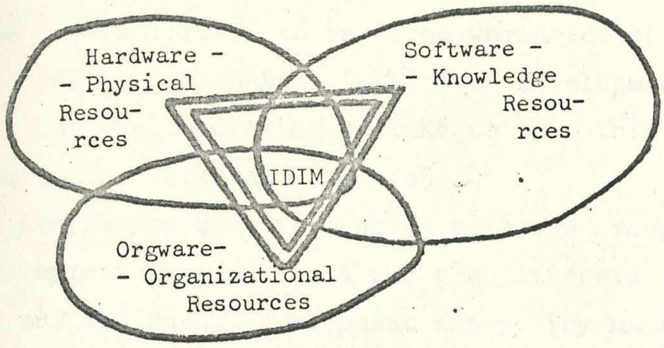



Figure 12. Hardware, Software and Orgware for IDIM.

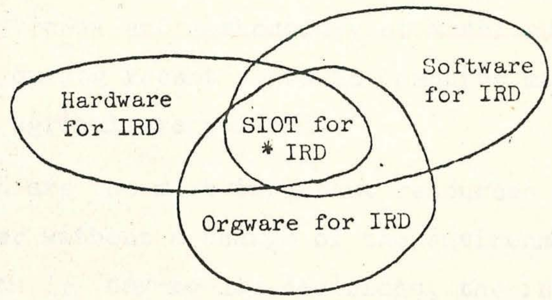



Figure 13. SIOT for Integrated Rural Development.

Hardware for IRD (Integrated Rural Development) should be considered as a set of appriopràte technical means necessary for fulfilment of IRD goals. It is obvious that the lack of crucial hardware elements could make IRD action unfeasible. The same could happen with software and orgware for IRD, therefore SIOT for IMID and SIOT for IRD are interdependent. For example education as a crucial SIOT element, both for IRD and IMID, is different in these two cases, but is necessary for the success of both.

## 7. Conclusions.

Integrated Development of the Region hence, also a Rural Region is a science based concept, orginated by several national and international communities. However, as it usually happens in science, this concept is based more on the forntier activities of today research than on the real-life practice or capability.

This concept has no dobt arisen from the proper recognition by leading scientists of the real-life needs and it is not one more utopian vision of the human mind. It should be understood that we live in the transient time, the time of almost exlusive and extensive utilization of physical resouces, is over and that we are approaching the time when knowledge as well as organizational resources will play at least the equal role as the physical ones.

From the point of view of technology (hardware) all or almost all elements for realization of this concept are available, however the software and orgware components are far from the required level. This seminar tries to make a step forward to increase worldwide knowledge within the area of this two lacking components. Integrated Development of the Region is still concept for the future, if we like to make this concept more practical, then more theoretical work should be done.

The seminar brought together a selected group of systems, regional and rural development theoreticians and practitioners concerned with modelling regional or/ and rural development and policy making with purpose of examining current knowledge on the subject. An attempt was made to combine theoretical concepts for explaining the process and methodology of model building with first-hand experience gained during recent years in computer model constructions for different level of agriculture policies.

The people and arable land are the most important resources for accelerated rural development, however without a change of the environment within which the rural people make their day-to-day decisions, the integrated rural development is impossible.The key elements for appropriate environment are access to the means of production, technology, knowledge, organizated, planning and markets and the incentive system that motivates action.

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