REMOTE SENSING & DIGITAL CARTOGRAPHY for DEVELOPMENT PROCESSES

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INTRODUCTION:

International Cartographic Association has adopted the following limited definition: "Cartography is the totality of scientific, technical and artistic activities aimed at production of maps related representation on the basis of data (field measurement, aerial photographs, satellite imagery, statistical materials etc.) collected by other disciplines".

The United Nations, however, uses a much wider concept of Cartography, dating from 1948 according to which 'It is the science of surveying and mapping and embraces all phases of mapping from data collection to data processing and data presentation, thus including surveying, aerial photography, topography, toponymy, photogrammetry, drawing and map reproduction'.

In professional usage cartography embraces production of various topographical, engineering, geographical and thematic, earth sciences/resources maps.

The Science and art of mapping i.e. Cartography is in a state of rapid evolution. The induction of computers and satellites have brought a revolution in this field.

The techniques of remote sensing (RS) are having multiple applications in various major disciplines viz. Geological Studies - Mineral Resources, Soil Surveys, Forest Resources, Agricultural uses, Water Resources, Land Use, Environmental Studies and have added a new dimension to the surveying capabilities for accelerated pace of map making and map revision. The techniques have found wide applications in finding thematic information of diverse types, on a regional scale expeditiously, economically and efficiently.

We should keep ourselves abreast with these rapid scientific and technological developments - particularly application of satellite imageries for cartographic uses and should use them in an optimal manner so that low cost, up-to-date maps can be produced efficiently. The Cartographic applications of remotely sensed data and products will enable us to discharge our obligations in an efficient and economic manner.

Spectacular progress in science and technology, and frightening growth of the world population, have not only made a great impact but also a great demand on the surveying, mapping and allied disciplines. The rapid population growth

(Indian population is forecasted to reach a billion by 2000 A.D.) which in some regions follows an exponential curve, requires rapid production of supplementary food, development of new energy generating plants, transportation and communication systems, schools, hospitals, etc. At the same time the technological progress, which permits rapid execution of huge engineering projects, changes irreversibly the face of the earth, disturbing in the process the natural ecological balance. The complexity of modern life is such, it is difficult to rule out shortcomings. However, countries on the road to development can put themselves in a somewhat advantageous position in this regard, if they would only profit from the earlier mistakes made by industrialised nations.

The first step in such an effort is planning for rational development (in harmony with nature), tailored to the overall conditions of the country concerned, its traditions and culture, and in keeping with its physical characteristics such as extent, topography, climate, resources and population.

The techniques of remote sensing have added a new dimension to the surveying capabilities for such purposes.

In the present day context and needs when countries are passing through critical phases of known resources proving to be inadequate to meet the multi-farious growing needs of an ever increasing population, Cartographers have a useful role. We need to multiply our available resources manifold and towards this goal we all have to pool our managerial, scientific and technological resources and expertise. We need numerous types of maps and other geo data, on which to base our developmental planning, we need more of them, better and faster and more frequently. Administrators and planners, scientists and technologists have to appreciate that there is no substitute for a good map for a common base. All planning design, analysis and execution must be based on a scientifically established data base so that plans and schemes dovetail into each other after having been conceived in identical multidimensional space, suitably and adequately referenced.

Man's material, happiness and well being depends upon his understanding of the environment in which he lives and his skill in making use of the resources available to him. Historical processes have created an imbalance and given rise to marked differences in the material development of not only nations but of regions within the same nation.

A new awareness of need for development with social justice and for a far more equitable distribution of the fruits of technological revolution is a special feature of the last few decades.

That a number of resources which are essential for the present stage of technological Civilisation are non-renewable and limited in their availability is a disturbing fact but alas all too true. In this context it is well worth noting that the World is heading for an acute shortage of resources currently in use. Knowledgeable experts have projected that if the present resources consumption and environmental pollution continues even at the present rate, the world reach a critical stage within a century. It may not exactly be so but all the same the fact of ever increasing pressure on land and other resources due to continued expected growth of population increased consumption due to expected improvements in earning capacity and consequential urbanization and changes in the pattern of land use can not be ignored.

It all highlights the urgent need for

a) renewed efforts to locate and evaluate resources systematically,

b) developing technology so that needs are mostly met by use of renewable resources and by alternate resources of which there is as yet abundance,

c) conservation of available resources as much as possible to ensure that long term interests of the nation are protected.

Now, before resources can be made use of they must be located and evaluated. In this field considerable progress has been made and there is ample scope for introducing scientific investigation techniques and planning. A systematic inventory of natural resources should be undertaken as a very first step towards planned development. In the sphere of location and evaluation of natural resources, the critical and scientific role of Geodetic and Topographical surveys is often lost sight of till a fairly late stage resulting in plans being delayed or else plans being prepared on inadequate data. In both the cases the loss to the community is considerable. Developments in the field of surveying and mapping have made it possible to speed up the process of making reliable inventory of the regions topographical and infra-structural resources so very essential for sound and scientific development planning.

We are at the cross roads, we might as well look at where we started from and where we are going. We are all aware how thousand of years ago man started thinking about the environment, about the surroundings - and started making rudimentary maps. Things have changed much since. We have reached a stage where mapping has developed into a very well identified discipline - a scientific discipline in its own rights. Of course, as things kept on changing, the subject has become wider & wider. It is in this total context that I would like to discuss the future of cartography.

Large tracts of earth have not yet been mapped. The process of mapping is a very, very slow process. Hardly half to one percent of the world is getting mapped progressively, and so, in that sense we have a long way to go for a global coverage (See Annexure 'A'). Of course, there are regions which are very well mapped. Fortunately, in India, we are very well placed because the 1:50,000 cover is available for us, which is not the case for very many countries.

The history of cartography dates back to the ancient times when the basic concepts about shape and size of our planet earth and its relation with the universe were at their infancy. Gradually, as man's knowledge about our planet grew, there were increasing demands made on the cartographer or the map maker, to provide more realistic or accurate representation of the earth's surface in order that man could move from one point to another, shape and develop the land as he wished, demarcate his land holdings and so forth. The data for such cartography was derived entirely through ground surveys.

Initially, for field surveying and mapping 'Planetable' procedures were used. The 'Planetable' was subsequently replaced in stages by graphical and then by instrumental photogrammetry.

When we consider cartography in totality, one major consideration has to be to prepare maps for all defence forces, administration, development and of course, management of the region. What role does a cartographer have in the economic development of a region? I think that is the sort of question we should pose to ourselves. As we all know, it is a passive role but it should be an active role. By this what I have in mind is the mental image of a cartographer of the past. He used to draft the map once the measurements had been made. If that is the role we have in the mind, then there is not very much future. But I don't think that is the role which a cartographer has to assign to himself. He has to graduate to a positive role.

Today, there are two fundamental disciplines or techniques of image analysis, namely, manual or visual and automated or digital. Digital techniques are becoming increasingly popular in keeping with the developments of digital computers, microprocessors and interactive computer systems. Although digital techniques are likely to simplify the repetitive tasks of image analysis, it is appreciated that 'human image-interpretation has been and will become more important and will require a higher degree of comprehension of the natural environment'. This view also appears to be supported by the ESCAP mission of the United Nations and other authorities.

REMOTE SENSING:

It can be said that our immediate knowledge of external world is limited to the range and scope of what human sensors can receive and comprehend. The eye can see only a very small part of electromagnetic spectrum known as visible spectrum - the ear can hear only within a small range of frequency. If somehow we could gather information in a wider range of electromagnetic spectrum, then we would have the possibility of being able to see a hitherto unseen world. This is what modern remote sensors have made available to us.

The term 'Remote Sensing' (RS) implies 'acquiring information without physical contact or data acquisition from a distance'. With the advent of RS techniques, the methodology took a different shape. Aerial Photography serves many important applications diverse field of agriculture, forestry, geology, topography, terrain mapping and land use etc. With the advent of satellite data/imagery, another dimension has been added to the surveying capabilities.

These applications are possible as remotely sensed data have four basic properties. Firstly, they provide a synoptic view of the terrain, which facilitates the study of objects and relationships. Secondly, certain types of imagery can provide a three-dimensional view of the objects sensed. Thirdly, characteristics of objects not visible to the human eye can be transformed into image form. Lastly, they provide a permanent record of objects, phenomena and relationships, as they exist at a given time.

The need for operational RS from air-craft and earth orbital platforms for topographical maps and resource surveys has been established beyond any controversy. AP provides a high resolution imagery which can be utilised for large scale topographical mapping, thematic and resources survey. Satellite Imagery provides a very large coverage in the same frame. The main advantage of the imagery is in its capability of giving a dynamic information through a repetitive coverage. As at present, seeing the present technology and the future trend in orbital data acquisition and utilisation techniques, RS would have answers for meeting the challenges of the planners to provide them a dynamic information system well in time.

Space imagery of improved resolution and with stereo possibilities as well as hyper-small scale AP taken from air-crafts will find increasing use in mapping. While satellite imagery would give sufficient data for macro planning, AP would provide information for specific purposes and of specific areas. Used as complimentary data sources, the system will prove very useful.

The information content of imagery, however, is affected not only by the capabilities of the sensor but also by effects of the atmosphere. The primary carrier of operational RS data, namely, the Electro-magnetic Radiation (EMR) in travelling from the source to the sensor undergoes absorption, radiation, reflection, scattering, polarisation and spectrum redistribution. Thus, the nature is capricious, variable not very homogeneous and highly complex and a single phenomenon, such as colour change in a crop may be the result of one of many variables'. The above explains, why in the case of analysis of Landsat MSS imagery, where a single pixel is of the order of 79 m square, the smallest identifiable details has sometimes been of the order of 20 hectares.

The concept of 'map' and 'mapping' requires some more clarification as a certain amount of misconception appears to persist in the usage of terms in the context of RS technology utilisation. Thus we come across statements like; 'ERTS-1 can map the entire Earth every 18 days' and 'Brazil was mapped with side-looking radar in a single flying season'. These statements require to be modified. It could of course be said that 'presentation of any type of information organised on the basis of geographical location gives us a map'. However, cartographic presentation of RS data is one in which each element of information is unambiguously related to its point of origin on the earth with a known standard accuracy. A map has much more than photo imagery. Apart from homogeneity of scale, it contains selected information in its true spatial relationship, a very large percentage of this information which is just not available on photo imagery has to be laboriously collected and pieced together by field research and it also normally contains elevational information about terrain in the shape of contours. Thus a distinction would be required to be made between cartographic presentation of the analysed RS data and the graphic displays of the same in the pre-analysis phase. On the basis of this classification, topographical maps derived from stereo photos fall in the first category, while a mosaic of bulk processed Landsat imageries falls in the second and there is a vast difference in their information content.

A major improvement in its consequences perhaps even exceeding the impact of the replacement of optical-mechanical scanners by electronical scanning of linear arrays constituted by large number of CCD-sensors would be a replacement of the present multispectral sensing systems by imaging correlation spectrometers. Instead of simultaneous acquisition of a limited number of separate images-each using a discrete spectral band, followed by processing to use a comparison of spectral signatures as an input for classification - such an imaging correlation spectrometer would be based on selective feature extraction from the full spectral band-width in the visible and near infrared, available for remote sensing from space. Theoretical studies indicate the feasibility of such instruments which would fit into concepts for third generation earth observation satellites.

Some Second Generation Earth Observation Satellites (SGEOS) have been equipped with pointable sensors (SPOT) with expected resolution of 10 & 20 metres.

Quality improvements can also be expected for RBV or television systems, including a higher ground resolution (Landsat and Meteor series). The same is the case with camera systems. Basically, camera technology is mature. Improvements must be expected for better adaptation to the space environment, especially in view of possible future free-flying systems as a complement to cameras operated on board manned spacecraft.

The Digital Cartographic Systems coupled with satellite imagery and aerial photography provide an extremely important tool for the development processes through quick responses to the needs of decision makers and planners.

In 1949, a group of experts invited by the Economic and Social Council at the U N Headquarters deliberated how cartography, in its wide sense, could be made subservient to the aims of the United Nations and in particular to "the promotion of the economic and social advancement of all people".

The developing nations are not well equipped for the extraction of information from data even though the raw data are liberally and abundantly available.

"Knowledge is power". There is hierarchy in the extraction of "information" from "data" and in further processing of information to "knowledge". The "intelligence function" is a fundamental attribute in these couplings, but "intelligence" itself also has a basis in "knowledge".

Aerial photography, satellite imagery now coupled with the advancement of micro-electronics in the field surveys and in computer cartography has created a revolution in data handling and management techniques to further the developments of the developing world and to reduce the miseries of mankind, through multiple applications in various major disciplines viz. Geological Studies - Mineral Resources, Soil Surveys, Forest Resources, Agricultural uses, Water Resources, Land Use, Environmental Studies and have added a new dimension to the surveying capabilities for accelerated pace of map making and map revision. The techniques have found wide application in finding thematic information of diverse types, on a regional scale expeditiously, economically and efficiently.

DIGITAL CARTOGRAPHIC SYSTEM:

A modern Digital Cartographic system generlly consists of -

(a) A Host Computer System with a main-frame/mini/micro computer, graphic-plotters, A/N terminals with graphics capability, optical disc and necessary software besides necessary storage and line printers.

(b) Interactive cartographic work station(s) comprising of a micro/mini computer, digitizing table, interactive edit stations, plotters besides necessary storage and software.

(c) Raster/Vector Cartographic Scan work station(s) comprising of a scanner, a monitor terminal with necessary software.

(d) Photogrammetric work station(s) comprising of a control computer, a photogrammetric analytical plotter, a cartographic plotter-server with necessary storage and the software.

(e) Digital image processing work station(s) comprising of a micro Computer-cum-A/N terminals with graphic capability, digital image plotter/printer with necessary storage and software.

(f) Cartographic plotter server work station(s) consisting of a precision plotter connected to a micro computer with necessary software and storage.

All the work stations are connected through a Local Area Network (LAN) through DEC/ETHERNET facilities. While all the various workstations are 'Stand Alone', they can utilise the computing facilities and software of other work stations through the LAN. Digital Data from the various work stations is stored in the Host Computer and necessary Geographical Information System (GIS) can be set up through necessary software. The systems are fully integrated and superimposition facilities of data exist through the necessary software and LAN.

Modern Digital Cartographic Systems are sophisticated, complex and capital intensive. Management is also complex and sensitive. Management implies getting adequate returns on investment which for government organisations would mean ensuring quality output and minimum down-time. This is dependent upon sound technical management, good logistic support, a comprehensive personnel policy and an adequate research and development support. Managers have to be alive to developments in the field and be able to adopt the last happenings/developments to their use.

SURVEY INTEGRATION:

Inventory of resources alone could never to be the end point, if the development was the ultimate aim. The growth process in development surveys thus because one of incorporating social and economic factors in the integrated and after regional studies.

The first step in such an effort is planning for rational development(in harmony with nature), tailored to the overall conditions of the Country concerned, its traditions and culture, and in keeping with its physical characterics such as extent, topography, climate, resources and population.

The decision makers and planners, then, are the users of the data and information processed to "Knowledge" provided explicitly for the use by the Integrated Surveys-facilitated for a quick retrieval through Digital Cartographic Systems. These techniques have added a new dimension to the surveying capabilities for such purposes.

Interaction with other users/organisations is extremely essential. Utility/needs of the users engaged on development, planning, administration, defence etc. are essential to be catered for Public relations specially for the system, should be an important activity. Standards for coding, classification for acquisition, exchange of Digital data etc. will avoid confusion. These Digital Centres should laster, promote and maintain high professional and ethical standards - to strive for the conditions conducive to achieve excellence, to ensure service to the people and to promote active cooperation among all the personnel engaged in it to undertake and promote research and the development and functioning of the digital system to serve the common people by reaching the desired information to those who need. Continuous inter-action with the planners and administrators must be maintained.

This has been debated for some time now that inter-disciplinary groups should be set up so that all data is available in an integrated form for proper linkages between the various survey organisations and the planning organisations to establish a Central Co-ordinating Agency to co-ordinate the requirements of the various mapping organisations and the various agencies for a continuous dialogue to ensure optimum use of scarce cartographic resources, should be established. In fact to develop better liaison and to create increased awareness and understanding amongst the various mapping and user agencies setting up of Central Co-ordinating agency and the interdisciplinary groups are a must. By collating and integrating demands on long range basis and by adopting a system approach accepting data as and when required, most of the demands can be met within a reasonable time schedule. Geographic Information System is one of the areas to which attention must be focussed.

The integrated surveys of resources include the coordinated preparation, execution and evaluation of topographical surveys, natural resources surveys and human resources surveys in such a manner that a comprehensive picture, in the form of a series of maps with reports, is obtained of the situation of man in his natural environment OR Integrated survey is "a survey of comprehensive character involving a number of scientific discipline which together form a greater scientific unit. Each of the participatory disciplines must accept a subordinate position within the coherent whole, but without losing their individuality and proper character". Integrated surveys include all activities related to collection, analysis and interpretation of information needed for the formulation of concrete action programmes.

These concepts of integrated surveys have evolved further over time because of changes in survey objectives, enlargement of development objectives and most significantly, broadening views on the development process itself. Aerial photographs and Landsat imagery proved to be powerful tools in the execution of such surveys.

Putting together the results of the various technical, social and economic surveys lead to internal integration. The provision of information for the preparation of specific programmes and projects, where the terms of reference and objectives are defined. The purpose, and therefore the nature of surveys, however is not always as clear.. "Since the beginning of the 1970s, an increasing interest has emerged in the basis of data requirement and in the persons who define the data need specifications. For research purposes it became important to consider who does what with data, and for what and how the data are to be used".

Design and outcome of these surveys have extended from the surveyors and researchers to include planners, policymakers, and potential beneficiaries in the development process. This has demanded external integration; consideration of the needs of all interested parties in the design of surveys and the presentation of the resultant data and information in the form suitable for general planning and decision-making.

The main task of the survey integration group is therefore to act as an intermediary between those involved in the development process and, most importantly, to look at the needs and the responses made in terms of development activities. The participants in this development process and the interactions are illustrated in Figure (Annexure B).

Integration is necessary to aid communication and cooperation among parties to the development process to link natural resource studies to social and economic development processes, to improve efficiency in the use of the resources available for development and to help ensure that all parties in the development process are working to the same ends on projects which have a high social and economic utility.

Rural development demands multi-disciplinary work, that is, the participation of specialists from divergent disciplines involved in investigating a defined problem. A solution to the problem is sought through a summation of the contributions made by each discipline.

Survey integration requires the emergence of an area of knowledge and activities at the interface among existing disciplines leading to interdisciplinary work. Those involved must understand the existing disciplines and emphasise with their respective philosophies, concerns and perspectives. Planners, decision-makers, surveyors and researchers all have a specific and unique contribution to make to rural development. Since theories can be dis-proved but never proved, this must always remain true. In the physical sciences, however, successful experiments clearly lead to support of the theory.

It is this uncertainty which influences the clarity in contribution to be made to the development process. There is a difference in the role and contribution to be made by each discipline.

Survey integration is necessary to aid communication and cooperation among the disciplines involved in the development process. Perhaps the primary purpose, however, is the need for a common perception of what has to be done in terms of development objectives, information requirements and means.

This problem is further compounded by the need to integrate natural resource information into the social and economic development process. In resource development, not only the spatial dimension plays a central role, but the time dimension must also be considered.

Survey integration demands interdisciplinary perceptions, an understanding of the actors in the rural development process from the felt needs of the population to the political perspectives of decision-makers, and from the aspirations of planners to the uncertainties of social scientists.

Development organizations normally function under highly politicized conditions where formal sanctions and authority are seldom sufficient to ensure successful programme implementation.

In the mapping unit of a survey department, what are the costs of producing 1:50,000 maps compared to using the existing 1:25,000 maps? How do we assess the additional benefits vis-a-vis their additional cost? Survey integration is necessary to aid communication and cooperation among the disciplines involved in the development process. Perhaps the primary purpose, however, is the need for a common perception of what has to be done in terms of development objectives, information requirements and means.

CONCLUSION:

Knowledge is power (or Information is power). The R.S. technology helps us gather the scientific information faster and accurate. Any scientific or Industrial activity should, however, be undertaken keeping in view the objective desired to be achieved. The Survey objectives should be set out in the Inter-change between the levels of data collection and data utilisation. Decision makers and planners are the users of the data and Information is provided exclusively for their use by integrated surveys. They are also the people who should formulate information requirements. Continuous inter-action with the planners and administrators must be maintained. Realisation of the "POWER" of this tool for development at all levels - National, State, District & Sub-districts - is essential for realising the full impact of this technology for the uplift of the poor.

Map or Map Products are not an end product but as a means to an end. Information collected through RS techniques in the form of digital data or imagery helps in achieving such an end, for effective developmental activity in order to improve the quality of life of the people and also for maintaining proper ecological balance for a healthy environment. The final objective of our endeavour should be that the maps/data are utilised for the purpose intended. Greater interaction between data generators and users, and understanding between them will go a long way in ensuring faster development for a better progressive society.

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ANNEXURE 'A'

BASE MAP COVERAGE AND PERCENTAGE OF LAND AREA OF THE WORLD COVERED ON EACH SCALE CATEGORY, 1968

(Land area in thousands of square kilometres)

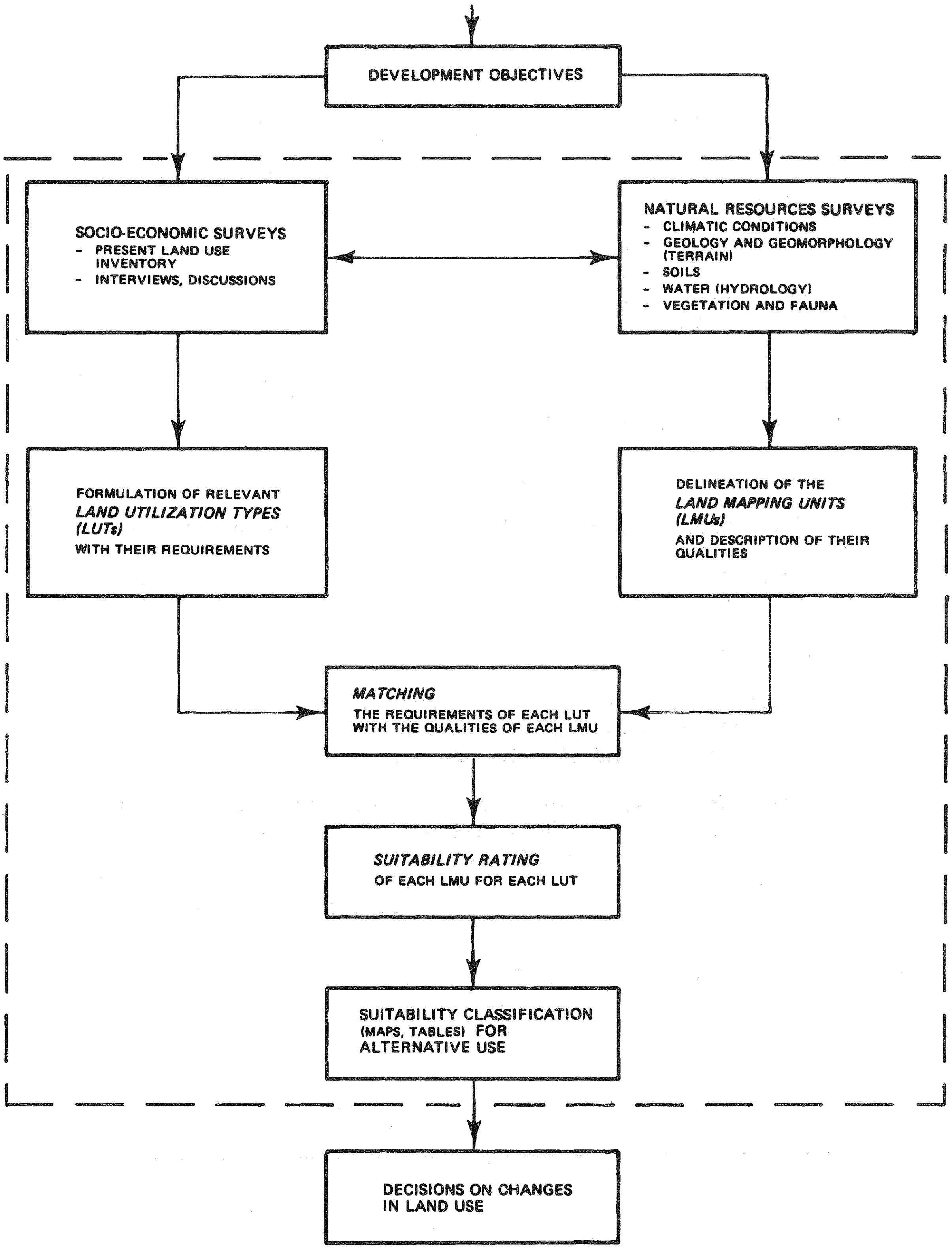
Region	1:250,000 Area covered (1)	1:250,000 Percentage (1)/B x 100	1:100,000 Area covered (2)	1:100,000 Percentage (2)/B x 100	1:50,000 Area covered (3)	1:50,000 Percentage (3)/B x 100	1:25,000 & larger Area covered (4)	1:25,000 & larger Percentage (4)/B x 100
Africa	6071	68.3	1484	16.7	1627	18.3	3	0.03
North America	19542	99.3	1712	8.7	8069	41.0	3287	16.7
South America	1185	9.7	989	8.1	403	3.3	403	3.3
Europe	2482	84.9	1777	60.8	1839	62.9	1841	63.0
Asia	2621	89.6	825	28.2	1144	39.1	342	11.7
USSR	22402	100.0	22402	100.0	4700	20.0	...	...
Oceania	7690	100.0	54	0.7	161	2.1	2	0.0
World	61993	81.0	29243	38.2	17943	23.4	5878	7.7

BASE MAP COVERAGE AND PERCENTAGE OF LAND AREA OF THE WORLD COVERED ON EACH SCALE CATEGORY, 1974

(Land area in thousands of square kilometres)

Region	1:250,000 Area covered (1)	1:250,000 Percentage (1)/B x 100	1:100,000 Area covered (2)	1:100,000 Percentage (2)/B x 100	1:50,000 Area covered (3)	1:50,000 Percentage (3)/B x 100	1:25,000 & larger Area covered (4)	1:25,000 & larger Percentage (4)/B x 100
Africa	5849	65.8	2240	25.2	2284	25.7	107	1.2
North America	19640	99.8	1692	8.7	10076	51.2	5097	25.9
South America	2320	19.0	2491	20.4	598	4.9	1026	8.4
Europe	2771	94.8	2046	70.0	2224	76.1	1947	66.6
Asia	2630	89.9	948	32.4	1237	42.3	427	14.6
USSR	22402	100.0	22402	100.0	9400	40.0	...	...
Oceania	7690	100.0	1569	20.4	2276	29.6	1438	18.7
World	63302	82.5	33388	43.5	28075	36.6	10042	13.1

ANNEXURE 'B'


DEVELOPMENT OBJECTIVES
SOCIO-ECONOMIC SURVEYS
- PRESENT LAND USE INVENTORY
- INTERVIEWS, DISCUSSIONS
NATURAL RESOURCES SURVEYS
- CLIMATIC CONDITIONS
- GEOLOGY AND GEOMORPHOLOGY (TERRAIN)
- SOILS
- WATER (HYDROLOGY)
- VEGETATION AND FAUNA
FORMULATION OF RELEVANT *LAND UTILIZATION TYPES (LUTs)* WITH THEIR REQUIREMENTS
DELINEATION OF THE *LAND MAPPING UNITS (LMUs)* AND DESCRIPTION OF THEIR QUALITIES
MATCHING THE REQUIREMENTS OF EACH LUT WITH THE QUALITIES OF EACH LMU
SUITABILITY RATING OF EACH LMU FOR EACH LUT
SUITABILITY CLASSIFICATION (MAPS, TABLES) FOR ALTERNATIVE USE
DECISIONS ON CHANGES IN LAND USE