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Proceedings of the Symposium on Applications of GIS for Agriculture and Rural Development

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Convenor: Dr. A.K. Srivastava and
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This symposium was organised during 53rd Annual Conference of the Indian Society of Agricultural Statistics on 2nd Dec, 1999 at Tiruchirappalli under the Aegis of the Department of Statistics, St. Joseph's College (Autonomous), Tiruchirappalli. The chairman thanked the Society as well as the organisers for inviting him to participate and preside over the session. He not only introduced the topic but presented a paper **Application of remote sensing and GIS for agriculture and rural development in the context of integrated mission for sustainable development.** He explained in detail various aspects of the programme-integrated mission for sustainable development which has been in operation through National Remote Sensing Agency, Hyderabad. He emphasised the need as well as the role of remote sensing as an effective tool to integrate multiple facets of agriculture particularly in the context of sustainable development. Including the paper of the chairman in all, five papers were presented in the symposium.

Based on the presentations of the paper and subsequent discussions, following recommendations were made:

- GIS should be used alongwith satellite data for sustainable development programmes. Areas of applications, where Remote Sensing (RS) and Geographic Information System (GIS) may be effectively used, should be identified. Some such areas are land use statistics, soil survey mappings, natural resource management, command area and watershed management, disaster management, forestry and crop forecasting etc.

- Geographic Information System should be used for micro level planning, particularly for implementing and monitoring of rural development programmes. Data needs and their availability at smaller area levels should be identified and ensured, particularly in relation to micro level planning for agricultural and rural development.

- There is need to develop efficient spatial sampling procedures particularly in the context of RS and GIS applications.

- Duplication of efforts should be avoided in the development of any GIS system. For this purpose, information sharing mechanism should be developed.

- The district wise database integrated with GIS should be developed in the country for balanced regional rural development. Creation, maintenance and sharing of the data archives for agricultural and rural development is an essential requirement for proper utilisation of GIS as a powerful tool.

- There is a need for taking up a study integrating the aspects of small area statistics, remote sensing and GIS applications for agricultural and rural development. This study should be taken at a pilot level in few selected districts.

Summaries of the papers presented are as follows:

Spatial Sampling Procedures with Varying Size Using GIS

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1. Introduction

The Geographic Information System (GIS) is a powerful tool for storing, retrieving, analysis and integrating spatial and non-spatial geographical data apart from drawing any kinds of maps. In last few decades there has been substantial developments in the field of GIS and spatial statistical techniques (Ripley 1981, Griffth 1988, Haining 1990). Unfortunately, the level of integration between these two rapidly growing fields are at very low profile. However, recent advances of computer hardware and GIS softwares has a great potential to change substantially in statistical approach to the study of geographical reality. The ability shown by GIS to handle various kinds of informations through their geographical coordinates has a vast potential, particularly, for survey design and processing. The two major fields of spatial statistical survey methods namely spatial sampling design and control of error propagation can be well handled through GIS. The main objective of this article is to suggest some spatial sampling procedures with varying size employing GIS technologies for increasing precision of area sampling.

2. Estimation of Spatial Correlation Coefficient and Testing its Stationarity

Let there are N polygons in a map, then the first order Moran's coefficient of correlation of i-th location and r-th order can be obtained as:

$$\beta_{ir} = \frac{m}{s} \frac{\sum_{i=1}^{m} \sum_{j=1}^{m} W_{ij} (X_i - \bar{X}_r)(X_j - \bar{X}_r)}{\sum_{i=1}^{m} (X_i - \bar{X}_r)^2}$$

where W_{ij} = 1, if j-th polygon is first neighbour of i-th polygon
0, otherwise

$$S = \sum_{i}^{m} \sum_{j}^{m} W_{ij}, \qquad \bar{X}_r = \sum_{i}^{m} \sum_{j}^{m} W_{ij} X_i$$

where, m is number of polygons of r-th order to be considered. In this way spatial correlation is obtained for each polygon. Now, for testing stationarity of r-th order spatial correlation, the hypothesis to be tested is

$$H_o : \beta_{ir} = \beta_r, \forall i$$

against $H_1 : \beta_{ir}$ not all the same $\forall i$

The one important statistics to measure the variability of β_{ir} is

$$v_r = \frac{1}{N} \sum_{i}^{N} (\beta_{ir} - \bar{\beta}_r)^2, \qquad \bar{\beta}_r = \frac{1}{N} \sum_{i=1}^{N} \beta_{ir}$$

This clearly indicates that lower the value of v_r the stronger the evidence that spatial correlation coefficient corresponding to v_r is fixed. In absence of any distribution form of v_r, Monto Carlo techniques (Hope 1968, Brunsdon C., *et al* 1998) can be used as an alternative. The procedure for given order r is as follows:

(a) Make note of v_r for correctly located observations.

(b) Randomly scramble the locations among the observations.

(c) Repeat previous step P-1 times, noting v_r each time.

(d) Compute rank of v_r for correctly located case R after arranging in ascending order.

(e) The p-value for randomization hypothesis is R/P.

3. *Sampling Procedures Based Spatial Data*

Sampling design for spatial data have a long traditional starting from Mahalanobis (1940). Hedayat *et al* (1988) proposed a sampling plan in which contiguous units are excluded, thereby resulting in second order inclusion probabilities being zero corresponding to pairs of contiguous units. Arbia (1993) extended this technique and proposed "Dependent Areal Unit Sequential Technique (DUST). This sampling design considered three important steps for selecting a areal sample of size n out of N. (i) Estimation of spatial correlation coefficient β with the help of auxiliary character X at various distance lags (ii) Testing the stationarity at various order spatial correlation's for identifying zones and (iii) Selecting the first unit by assigning weight one and $\prod_{i=1}^{k} (1 - \beta^{d_{ik}})$ for selecting k-th unit, where k = 2, 3, ..., n and d_{ik} is the distance between i-th and k-th unit measured in terms of physical distance between centroid or in terms of neighbourhood. It has been demonstrated that some of the important traditional techniques are sub-cases of DUST. The estimation procedure based on simple random sampling (SRS) estimation procedure has been used to analyse the data of a simulation study. It has been observed that there is substantial gain in efficiency using DUST as compared to SRS.

4.1 The Proposed Sampling Procedure

Let there are N area polygons out of which a sample of size n is to be selected. Further let X is a size measure, value of which is known for each polygon. Let h denotes the h-th zone h = 1, 2, ... H. The weights for s-th selecion based on spatial correlation and distance from already selected units in the sample for the h-th zone is denoted by $W_{hi}^{(s)}$ which is given by

$$W_{hi}^{(s)} = \prod_{i=1}^{s} (1 - \beta_h^{d_{is}})$$

where d_{is} is the distance/lag between i-th and s-th remaining units of the population where s = 2, 3, ..., n_h, n_h is the number of polygons in the h-th zone. The i-th polygon of the population is selected at s-th draw by assigning $W_{hi}^{(s)} X_{hi}$ weight, where $W_{hi}^{(1)} = 1$.

4.2 Estimation Procedure

Let the character under study be Y and $y_{hi}; i = 1, 2, \ldots, n_h$ is the observation associated with i-th sampled unit from h-th zone.

Define,

$$t_{hi}^{(s)} = y_{h1} + y_{h2} + \ldots + y_{hs-1} + \frac{y_{hi}}{W_{hi}^{(s)} X_{hi}} \sum_{j \in \rho} W_{hj}^{(s)} X_{hj}$$

where ρ is the set of all population units not selected in the sample. An unbiased estimator of population mean and its estimate of variance are

$$\hat{\bar{Y}} = \sum_{h=1}^{H} Z_h \bar{y}_h$$

$$\hat{V}(\hat{\bar{Y}}) = \sum_{h=1}^{H} Z_h^2 \hat{V}(\bar{y}_h)$$

where

$$Z_h = \frac{N_h}{N}, \bar{y}_h = \frac{1}{n_h} \sum_{i=1}^{n_h} t_{hi}^{(s)}$$

and

$$\hat{V}(\bar{y}_h) = \frac{1}{n_h (n_h - 1)} \sum_{i=1}^{n_h} (t_{hi}^{(s)} - \bar{y}_h)^2$$

5. Simulation Study

In the simulation study village wise data from District Hand Book Census 1991 for Rohtak district of 492 villages of Haryana has been utilized. The village wise map was digitized using PC-ARC/INFO software and irrigated area of the village has been treated as character under study (Y), whereas, total cultivated area of the village as auxiliary character (X). The whole district has been identified as one zone after testing the spatial correlation coefficients of different order. The over all spatial correlation coefficient for the district was approximately 0.22. The problem is to compare different sampling strategies for estimating population mean $\bar{Y}$ = 609.0022 ha. with respect to its accuracy, biasness and stability. In this simulation study 1000 samples of different sizes has been selected following various sampling procedures and the parameters related to accuracy, biasness and stability has been obtained. The results are presented in the following table.

Sample Size/ Strategy	30			50			100		
	R.B.	R.E.	C.V.	R.B.	R.E.	C.V.	R.B.	R.E.	C.V.
STG–I	0.28	–	13.38	0.19	–	10.66	0.12	–	7.72
STG–II	0.74	0.87	14.73	0.73	0.99	10.39	0.15	1.29	6.77
STG–III	0.19	6.26	5.32	0.01	7.00	3.94	0.04	8.16	2.70
STG–IV	3.09	8.38	4.76	1.98	8.60	3.63	0.93	8.79	2.63

STG-I – Simple random sampling without replacement strategy
STG-II – Usual DUST Technique proposed by Arbia with the estimator of SRSWOR
STG-III – Proposed Sampling Strategy with $W_{hi}^{(1)} X_{hi} = 1$
STG-IV – Proposed Sampling Strategy R.B. – % Relative Bias
R.E. – Relative Efficiency C.V. – Coefficient of Variation

From the above table it can be seen that the performance of the proposed strategy is far better in all respects except R.B. It can also be observed that performance is improving with increasing sample size.

Role of GIS in the Rural Development : Vision for New Millennium

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1. Introduction

Interest in and the use of Geographic Information System (GIS) have accelerated in recent years. The management and manipulation of spatially related data using computer-aided techniques began in the 1960s and has grown rapidly in the 1990s.

The growing world population is seriously increasing demands as the earth's resources of land, air, water & raw materials. As the pressure on natural resources and land increases the greater is the need for popularly organized agreements about how they should be shared not only for the benefits of human but for all forms of life. For efficient decision making several questions are raised by, professional of various field, concerned with day to day problems. All of these questions and many more like them are concerned with geographical patterns and processes on the surface of the earth.

Advancement of technology and information management systems in the GIS environment have opened up newer avenues for infrastructure planning and management deviating from the traditional approach. It is an already established fact that a computer-aided Data Base Management System (DBMS) in the GIS environment is a very efficient tool for quick management decision making and can also be used in rural development. GIS technology can be used to facilitate faster understanding of single as well as multiple aspects of the pace of rural development. A significant benefit of GIS technology is its ability to visualise spatial data, to interpret information visually and to improve intuitive understanding of the distribution of land interrelationship among phenomena. This significant characteristic of GIS helps its use in the planning and management of infrastructure in rural areas. GIS applications in rural development allow systematic collection, updation, processing and distribution of related information. It can be used to visualise the market structure through socio-economic status of the people of rural areas; which can be helpful for economic decision making as well as planning activities, cost control and project management. The GIS environment is able to provide a powerful means to develop and compare alternative plans.

2. Historical Prospective of Rural Development

History shows that most advancement has led people away from rural areas and development has been restricted to non-rural centres. Even during the Industrial Revolution, industries developed in various pockets, either changing the profile of the settlement on acquiring a distinctly non-rural character.

The basic concept of rural development had its origin in the mid-seventeenth century in England. A group of people called 'Quakers' or 'friends', organised themselves on the principles of selfless sacrifice. They believed in the dignity of all human beings. This philosophy was later propagated throughout the world.

Over a period of time the differences between rural and urban /industrially developed areas started widening. In the race for achieving development, policies and programmes were oriented more towards urban/industrial areas. The tragedy of most developing countries is that very scant attention has been paid so far to the development of rural areas in their unplanned growth. Due to the lower emphasis placed on rural development, large-scale population redistribution, with millions of people migrating to urban areas, has had disastourous consequences.

In India, over the last 50 years several programmes/schemes have been launched for rural development but their output or results have left much to be desired or have not been commensurate with the effort and resources expended. While the past can not be erased, proper planning for future development becomes undoubtedly the most important function of rural management.

3. Issues of Rural Development

The process of planning is being decentralized to smaller-area units (village level) to facilitate drawing up of development strategies that are sustainable, area specific and take into account the local needs. While in the past, the management system suffered due to a lack of appropriate data and adequate infrastructure facilities, the availability of authentic and relevant data in several forms and improved infrastructure facilities today have facilitated orderly development planning of rural areas to ensure a reasonable quality of life in the villages. Optimal development of rural areas involves some important issues, like systematic maintenance of land records, facilities planning, provision of infrastructure, employment generation, food security etc., which should be carefully taken into account and discussed make it successful and ensure its efficiency and reliability in the development of society.

In view of globalisation/liberalization and economic reforms (since 1990s), development of rural areas has become one of most important factors not only for the government but also for the corporate sector. Globalisation and integration into the world economy presents opportunities and challenges for both the government and the corporate sector. At a time when competition is hotting up and there are pressures to control costs, it is imperative to achieve planned all round development in order not to be left behind. For the government faced with a resource crunch on the one hand, and development demands on the other, proper allocation of resources to development projects coupled with appropriate policies for their implementation assumes paramount importance. Improper or unbalanced development puts a heavy strain on nation's resources.

4. Vision for New Millennium

A vision is a dream, which we want to achieve. It is important because it can provide a direction and overcome the inertia of the present state.

In view of multiple objectives to be achieved, it is therefore necessary to upgrade the database for smaller area units and devise methodologies for preparing integrated development stategies. It is imperative that interrelation and interdependencies between various sectors of planning are understood to

facilitate integration of sectorial stategies. To answer apparently simple geographical questions requires that data from several sources be integrated into consistent form. Some important areas of rural development for which GIS can be used to assist in proper policy and plan formulation and implementation, once the database (spatial and non-spatial) has been prepared, included the following:

- Agriculture
- Infrastructure
- Energy: solar, wind, geo-thermal, biogas etc.
- Industrial development: Small scale industries, Traditional crafts industries
- Land record
- Project assessment
- Market planning for corporate sector: Distribution, Market expansion

For the application of GIS to be efficient and successful in planning and implementation for rural development, there are a few issues that should be taken into account are:

- Non-duplication of efforts
- Data warehousing
- Proper documentation
- Compatibility with other data sources
- Wider dissemination of the utility of GIS

Conclusion

As 70 percent of our population resides in rural areas and their contribution to the national economy is substantial, emphasis on the development of rural areas, for uplifting the socio-economic status of the people, is a prime area of concern in the overall development strategy of the country. GIS has emerged as a revolutionary tool in an era of economic reforms, when efficiency of planning and decision making are of utmost importance. GIS will provide a "holistic" approach for decision making in the direction of efficient planning and management for the development of rural areas.

Identification of Potential Zones for Agroforestry using GIS

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Introduction

Technological advances in computation have fulfilled the need for computers in integrating data from a variety of sources, in manipulation and analyzing data in providing output which could be used as part of a decision-making process. The need of classified information has given birth to the specialised branch of information system like GIS which is the demand of today's society. GIS can be defined as "an organised collection of computer hardware, software and geographic data designed to efficiently capture, store, update, manipulate, analyse and display all forms of geographically referenced information."

The world's first computer based GIS and the origin of the term Geographic Information System came from Canada in 1962 when the Government Agency In-charge of Energy, Mines and Resources established a Computer System for the whole of Canada. The 1990s promises to be one of the most interesting decades for rapid growth of GIS. GIS has applications in diverse fields like resource exploration, infrastructure management, land use information system, watershed management, wasteland development, urban planning, rural development etc.

Need for Agroforestry

Producing food in adequate quantities and of quality for the fast growing population is one of the most important problems faced by the developing countries. The problem becomes more difficult, because it is necessary not only to devise means of producing this basic need, but also to ensure that the quality of land resources that are directly or indirectly utilised in producing food is maintained and improved. Therefore, it is essential to increase productivity and at the same time we must conserve and enhance the quality of eco-system.

Forests are one of the most important renewable natural resources which contribute substantially to the social and economic development. They also play a major role to enhance the quality of our environment. Therefore, a management and a farming system is required that is not only capable of producing food from marginal agricultural land but also capable of maintaining

and improving the quality of producing environment. One such system is agroforestry which helps in providing all necessities of life and at the same time maintaining the quality of land resources. Agroforestry plays a vital role in achieving integrated rural and urban development which is of great importance for planners. The agroforestry is comparatively recent system adopted by the Forest Department. But due to its relevance in the present context, it has generated great interest among planners and research workers. Agroforestry has been defined as: "a sustainable land management system which increases the yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land and applies management practices that are compatible with the cultural practices of the local population."

According to King (1963), success of the agroforestry system depends on: (1) Provision of incentives, (2) Social amenities and services and (3) Marketing facilities. Without these, agroforestry system like any other system of rural development are doomed to fail. It is therefore necessary to consider the factors responsible for growth of agroforestry while examining the relevance of agroforestry systems to social, economic and environmental development. The most important requirement for recommending/adopting agroforestry system is identification of potential zones for growth of agroforestry.

Sampling Design

Keeping in view the above facts, the primary data can be collected with the help of field survey. The sampling design of the survey will be stratified multi-stage sampling. To start with, a district of a particular state can be taken as study area. The tehsils/blocks of the district can be treated as strata. The total villages of each stratum can be divided into three groups. In the first group villages which are either in the forest area or having common boundries can be kept. In the second group those villages can fall which are adopted by the State Forest Department for the promotion of agroforestry/social forestry programs. The rest of the villages can be listed to the third group. Some villages can be selected from each group of different strata by SRSWOR. All the selected villages can be completely enumerated for collecting the basic information related to agroforestry. On the basis of collected information during complete enumeration, a sampling frame can be prepared for further selection. The households of each selected village can be divided into four categories based on holding size. Some households from each selected village proportionally from each category (at least two households from each category) can be selected by SRSWOR for detailed enquiry. The questions related to economic, social,

cultural aspects of agroforestry can be asked. The data related to infrastructural facilities like availability of plants, location of nursery, distance from the related market can be collected. Apart from this the questions related to problems in adopting agroforestry and its available alternatives can be studied. The secondary data from population census, livestock census, land use statistics and available socio-economic data of the region can be collected.

Methodology

The collected data from primary as well as secondary sources can be suitably analysed to identify the major factors affecting the growth of agroforestry. Once, the important factors responsible for growth of Agroforestry are identified, decision hierarchy for ranking agroforestry areas can be made using Analytic Hierachy Process (AHP). AHP is a decision-making technique which can be used to analyze and support decisions in which multiple and even competing objectives are involved and multiple alternatives are available. In order to do this, a complex problem is divided into a number of simpler problems in the form of a decision hierarchy. AHP is often used to compare the relative suitability of a small number of alternatives concerning an overall goal.

For identifying potential agroforestry zones, an analytic environment provided by GIS and a decision making method provided by AHP can be used. The study area (district) can be divided into raster map cells (villages) and AHP can be used to rank each raster cell. Pairwise comparisons of all related attribute values can be done to find out the Relative Importance Weights (RIW). The relative importance of hierarchy elements can be established based on RIW. A suitability index for each raster cell can be determined by aggregating the RIWs at each level of hierarchy.

After determining suitability index for each raster cell, the attribute data collected from secondary sources can be linked using GIS and suitability rank can be obtained. Maps of attribute data can also be made with the help of GIS software. The maps of different soil properties based on soil survey on 10 sq. km. grid is available with NBSSLUP, Nagpur. The GIS software can be used for digitisation of all the villages of the district. Digitisation of different layers of maps like road networks, water channels, soil maps, maps of natural resources, location of market, location of nursery, availability of land etc. can be done. The spatial data and different maps can be superimposed on each other and as a result of this method, the Spatial-AHP, the appropriate zones of agroforestry can be identified.

Apart from this, the satellite data of different seasons of a year can be acquired from National Remote Sensing Agency, Hyderabad to study the spatial distribution of the available natural resources in the district. Suitable maps can be generated with the help of available computer software after digital processing and ground truth verification with the help of ground survey. The toposheets of Survey of India (SOI) can be used for this purpose. Appropriate land use pattern can also be studied to encourage agroforestry.

It is expected that the GIS based technology developed in this way will help in identifying the potential zones for adoption of different types of agroforestry not only in the study area but also in other parts of the State. This will provide a guideline for identifying the appropriate zones in other parts of the country. In short the GIS, one of the prime components of the new information technology revolution will play a vital role in the development of strong, reliable and speedy technique/tool for planning, management and development of agroforestry.

Data Needs and Requirements for Application of GIS in Rural Development

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Advances in computer and communication technology have presented a unique opportunity for planners and decision makers to apply specific systems and techniques to address the issues of rural development in an integrated manner (APO 1997). A developing country like India whose 70 per cent population lives in rural areas, rural development plays a vital role in the socio-economic condition of the country. Geographic Information System (GIS), remote sensing and global positioning systems (the 3-S technology) are evolving as efficient tools that integrate biophysical and socio-economic data which can be used to develop alternative strategies to address complex and multi-dimensional problems like rural development. Advances in satellite image processing and computer analysis have made it possible to evolve a realistic, accurate and uniform database to facilitate the decision making process. Hence, the much felt need of hour is to develop a sound and responsive GIS based database for rural development especially in the contest of the Ninth Five Year Plan.

In this presentation an attempt has been made to indicate the emerging data needs for rural development in the light of major dimensions of the Ninth Plan. The capabilities of the existing system of data sources to cope with emerging requirements has been examined. Finally, certain measures have been suggested in the light of future needs for developing a reliable GIS for rural development.

The word geographic in a Geographic Information System implies the data with specific locations. In a geographic information system, the data should be referenced in a manner which will allow retrieval, analysis and display on spatial criteria. A geographic information system should at least consists of a data processing subsystem, a data analysis subsystem and information use subsystem. The data processing subsystem includes data acquisition input and storage. The data analysis subsystem includes retrieval, analysis and output of information in various forms. Information use subsystem includes relevant information applied to the problem. In the design of a geographic information system, specialized graphic input and output components often play a dominant role in shaping the architecture of the system. A concise definition of GIS was given by Jackson, James and Stevens (1998) "a computer system for efficient input, storage, manipulation analysis representation and retrieval of all forms of spatially index and related descriptive data."

Rural development is a complex issue which involves a large number of developing activities - economic, social and demographic with an integrated approach to improving living conditions especially of the under privileged and vulnerable sections. Since the inception of planning era, rural development has been one of the major thrust area of every Five Year Plan. The Community Development Programme (CDP) launched during first plan play a great role in the establishment of a development infrastructure at the grass root level in all parts of the country. CDP was a unique experiment in area planning, mobilisation of local resources and encouraging self help and people's participation.

During second and third plan, more emphasis was laid in favour of growth oriented sectoral programmes in the anticipation that prosperity will trickle from upper to lower strata of the society. However, trickle down approach did not get favour and direct strategy for poverty alleviation were initiated by generating productive employment during later plans. The importance of rural development has gained momentum over the time. Since the major dimensions of Ninth Plan are the quality of life, regional balance, generation of productive employment and self-reliance, rural development has got special recognition as main development strategy of the plan.

To begin with, statistical data is needed for reviewing the performance of rural development programmes in the past. Data is also needed to assess the available and potential resources, both physical and biological, the infrastructural facilities and institutional arrangements. Data is very much essential for the formulation, implementation, monitoring and evaluation of the overall impact of rural development programmes.

With an increasing trend of decentralised planning, the requisite statistics should be available with as much disaggregation as possible. The 73rd and 74th Amendment Acts 1992 pertain to the Panchayats and Municipalities respectively. Essentially the 73rd amendment provides a vehicle of more authority and planning at village panchayat level. This amendment provides an instrument of planning and implementation of various developmental programmes at micro or village level. This naturally puts pressure on data needs for policy formulation at village panchayat level.

Data needs and requirements for rural development is diverse as it pertains to various sectors of rural economy. Major statistical series for formulation and evaluation of rural development programmes include inventory of resources, land reforms and agriculture, animal husbandry and fisheries, non-agricultural productive activities, employment, education and literacy status, health and nutrition, family welfare, housing, levels of living and several others. However, indicators for programme implementation and monitoring progress includes land reforms, land development, irrigation, agriculture, animal husbandry and fishery, village industries, rural energy, cooperatives, housing and construction, health and sanitation, family welfare, education, transport and people's institution/voluntary organisations. Among these sectors, agriculture is very vital as a large chunk of rural population depends on it. Hence, land reforms and agricultural development have predominant role in the whole programme. The essential ingredients of the agriculture development strategy should be based not only on diversification but also on bringing about substantial increase in public investment with focus on improving productivity and income for small farmers. Policy makers have targeted agriculture and allied sector for generating productive employment during Ninth Plan. Realising that agriculture would offer lesser scope with more and more advancement, sectors allied to agriculture *i.e.* animal husbandry, fisheries, dairy etc. has been focussed during Ninth Plan as some of these have high potential for employment generation. Rural non-farm sector has special significance for employment generation in Indian context. Amenities available to the rural areas like education, medical and health facilities, electrification, economic services etc. are vital for the overall betterment of the economic and social condition of the rural population.

There are three broad methods of compilation of data (i) administrative records and reports, (ii) censuses and (iii) sample surveys. The first two have a major role in developing the data base as they are capable of providing

disaggregated statistics for small areas or villages. However, there is a need to improve the quality and reliability of statistics obtained through these sources to meet the growing needs of micro-planning. At the same time, there is a need of collating this information properly at a common place to serve the purpose of policy makers. Our administrative records/reports and periodical censuses and sample surveys are most comprehensive in scope and coverage but fall short in the final output often due to deficiencies in organisation and management. Greater commitment and willingness of all concerned to strictly comply with prescribed procedures and time schedules will bring about remarkable improvement in the system. A large number of suggestions for improvement in data sources have been discussed at length by Rao (1993). The basic problems pertaining to data are:

- Gaps in coverage
- Lack of uniformity in definitions and classification
- Defects in tabulation, processing, supervision, inspections, checking, planning, coordination and primary reporting agencies
- Gaps in geographical coverage
- Non-availability of statistics at disaggregated level
- Time-lag in the availability of data

The first three problems are related to non-sampling errors which can be minimized by giving proper training to field investigators and appropriate computer assisted methods can be developed for proper scrutiny of the field data. The problem of measurement errors occur at all stages of the process. A great deal of work has been done in this direction, but still the researchers feel difficulty in practical situations.

Generally we need two type of data (I) data needed constantly over the years and (II) additional data needed on special occasions. Experience suggests that a permanent database should be maintained for data of type I, which should be updated annually.

The National Informatics Centre (NIC) maintains a network of computers with nodes as Headquarters of all districts. The role of the NIC is to provide computerised facilities for storage and communication of statistics rather than collection, analysis and interpretation of statistics. The NIC has already devised a district database in collaboration with district authorities and claims to have successfully implemented it in a number of districts. It is, therefore, recommended that to the extent feasible the national statistical system should make use of the NIC network of computers to develop a database separately for each village as defined under the panchayati raj system. In this direction census data will also be helpful as the 1991 Census basic data as well as all the census tables are held on machine readable forms and can be assessed for more detailed tabulation as and when necessary.

The geographic information system can inherit the capability to work at smaller geographical area by incorporating the recent methods for developing small area statistics. These will help the system to provide statistics at much lower level even with small sample size of the domains without going for actual survey. These statistics will play an important role in the future in the light of 73rd amendment act of the Constitution.

The various statistics such as area, production, soil type, land utilization etc. can be improved with the help of remote sensing techniques which can be one of the wonderful tool for GIS. The problem of geographical coverage can be solved with the help of this technique to a greater extent.

There is a growing recognition among the survey statistician that existing sampling design of the socio-economic survey does not satisfy the demand of modern times. It is, therefore, desirable to use sophisticated or complex survey design for this purpose. It is also essential to undertake a study of the design effect and the gain in efficiency due to present procedures of stratification, sample allocation and selection in respect of major socio-economic variables. These needs can be fulfilled by using the GIS as it can be linked to statistical packages like PC CARP, SUDAN etc. in which the analysis of data is performed by taking care of survey design. These packages also have facilities to analyse complex survey data on the basis of recent and computer assisted techniques. The methods of variance estimation techniques like linearization, Jackknifing, boot strapping etc. can be successfully incorporated in GIS to solve the problem of estimation of variances using spatial data encountered in GIS for complex surveys.

Any GIS should have the provision to incorporate the methods of new information technologies which are taking place all over the world particularly in developed countries. In some of these countries the whole survey process are computer assisted from the data collection stage itself which makes surveys better, cheaper, faster and more powerful (Shanks [5]). The computer- assisted telephone inter-viewers (CATI) is one of the most significant technology but it is difficult to implement in India in the near future. Apart from the above technique, the following points are to be taken care while developing GIS. Some of these points are discussed in detail by Hamilton and Trant [2].

1. Interlocking of surveys or studies in which more than one question may be taken from the same respondent.
2. The management or allocation of data collection resources between multiple surveys and measurement of staff-performance across the survey projects.
3. The creation of large or complex data sets by combining information from multiple sources (survey, non-survey).

4. Creation and maintenance of data archives, or comprehensive collection of data sets and documentation for large number of surveys in general area.
5. Select a single system for each major phase and build linkages or translation programmes to move information from each specific system to the other.
6. Develop general purpose or system-neutral procedure for data description, so that users could move data from one system to any other system that uses the same external structure for data description.
7. Rapid movement of information between geographically separated systems for data collection and analysis.
8. Use of in-expensive work stations for data collection, so that computers in the same local network can be dedicated to data storage and retrieval.
9. Perfect coordination and integration of information and their presentation in required form.

Finally, it can be concluded that in developing countries like India, the recent computer intensive technologies of GIS and remote sensing can play a vital role in the planning, management, coordination and implementation of their developmental programmes in rural areas. Unfortunately, presently these technologies are under utilized as far as its potential in concerned. Hence, efforts should be made to use these techniques for rural development.

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