PROCEEDINGS OF THE SYMPOSIUM ON "THE ROLE OF STATISTICS IN LAND USE PLANNING"

Chairman: Shri T.N. Dhar

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This symposium was organised during 49th Annual Conference of the Indian Society of Agricultural Statistics on 22nd and 23rd Feb., 1996 at Lucknow under the Aeigis of the Directorate of Agriculture, Uttar Pradesh. The Chairman thanked the Society for inviting him to preside over the session and introduced topic of the symposium. He pointed out that this aspect has been important in every phase of development, However, it has gained much more importance in these days when the pressure on land has increased tremendously. He also emphasised the importance of statistics in the planning process where the land resources are limited and its utilisation has to be viewed not only in terms of monetary gains but also in terms of the sustainability of agricultural development. For land resource utilisation, environment compatibility is another dimension which has gained importance in its multidimensional situation, the present day emphasis on information technology, remote sensing applications and the application of geographical information system (GIS) have provided enormous statistical capabilities. After the introductory remarks the chairman invited the speakers to present their papers. In all six papers were submitted for presentation of which five papers were presented covering various aspects of role of statistics for land use planning.

Based on the presentation of the papers, subsequent discussions and observation of the Chairman following recommendations were made:

- The scope of manifold classification needs to be improved and made more broad based.
- In view of paucity on data on land use suitability, capability and potentiality and also on soil erosion, salinity, degraded land etc., official statistics system should be geared up to collect all such statistics.
- For effective land use planning, there is need to develop land use information system. (LUIS)

- Land use planning needs to be carried out simultaneously at the national, regional and local level with an integrated and sustainable approach keeping in mind the social demand and limited supply of lands.

- There is need for applications of GIS and Remote sensing techniques in land use planning.

The abstracts of papers presented are as follows:

Official Statistics and Land Use Planning

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Land is one of the most important but limited natural resource which determines overall progress of the people of the country or a region. Unfortunately, the efficiency and productivity of this basic resource has deteriorated because of inadequate planning and management practices adopted in the past. In the recent past five year plan, it has been endeavour the Government to improve the overall efficiency and productivity of landuse through application of modern technology. The efforts of the government for land use planning have been hampered due to inadequate availability of statistics, organisational and cost constrain in data collection. The present paper is basically oriented to:

(i) To identify the nature and type of landuse planning being adopted.

(ii) To indicate the availability of statistics as collected under the official system for landuse planning.

(iii) To identify the gap in the availability and requirement of statistics for landuse planning.

Nature and Type of Landuse Planning

The landuse planning is of different type varying from region to region and with the objective. Some of the major landuse planning aspects are detailed hereunder :

(i) Land use planning according to capability and suitability of the land is one of the important aspects. The classification of land according to capacity and suitability requires large scale detailed

surveys which unfortunately have neither been conducted nor feasible under official system.

(ii) Land use planning is done basically to meet certain requirements and fulfilling the objective. This requires planning and land use in such a way that land is allocated amongst different enterprises more optimally. This requires the statistics of present land use pattern as well as idea of changes required.

(iii) Planning for agricultural land which is about 58% of the total area of 328.8 million hac, needs proper planning apart from planning for land under non-agricultural uses to improve its efficiency and productivity. A good deal of statistics is being collected under the official system in this field.

(iv) Planning for reclamation and improvement of waste and degraded land is one of the very important aspect of land use planning either through reclamation and improvement or through changes in its use of degraded and waste land. However, due to conflicting and controversial definitions of waste land, it has been difficult to collect reliable and accurate statistics of degraded waste lands.

Statistics of land use:

The official statistics on land use in India is being continuously collected since 1884, although the geographical coverage and its scope has been gradually expanding.

The reported area for which statistics on land use classification based on land records are available; is classified into nine broad categories. This ninefold land use classification includes (i) forest land (ii) Area under non-agricultural uses (iii) Barren and unculturable land (iv) Permanent pastures and other grazing land (v) Miscellaneous tree crops and groves not included in the net area sown (vi) culturable wastes (vii) fallow land other than current fallows (viii) current fallows and (ix) net sown area. The available statistics under these heads of classification provides the basic information about changing and existing pattern of landuse and scope for bringing out changes in future pattern of use through planning and development.

Agricultural planning and development calls for detailed attention towards use of agricultural land in the country. The agricultural land usually comprises of net sown area, fallow lands — both current and other than current fallows, culturable waste, land under miscellaneous tree crops, groves etc. and permanent pasture and grazing lands. The statistics of agricultural land would show the scope for increasing the net sown area either through reducing the fallow lands

or reclaiming the culturable waste land. It may provide guidance for adjusting the area under pastures and grazing lands to maintain the health of live stock. Availability of irrigation is one of the most important factors which influences the pattern and intensity of land use. Infact whole planning of agricultural land for its use is guided by facility of irrigation. The area statistics reveals that area sown more than once has increased considerably from about 13.1 million hectare in 1980-81 to about 42.98 million hectare in 1992-93, mainly due to increase in net irrigated area from 20.85 million hectare to 50.10 million hectare during the same period. However, statistics also reveals that there is considerable scope for improving the intensity of land use through proper planning and developmental strategies.

Planning of land use requires optimal allocation of area under various crops which meet the required production of various commodities. The official statistics provide detailed information about allocation of area under various crops under both irrigated and unirrigated lands. This will help to identify the required changes in the allocation of area amongst competing crops to meet the requirement of various commodities.

The most important yardstick of the success of the planning and development efforts is the statistics of yield (productivity) improvements in various states/regions under different pattern of landuse. Under official system of collection of statistics, most of the statistics are collected with separate yield estimates of irrigated and unirrigated lands.

Classification of land according to rainfall and irrigation

Planning for appropriate landuse require not only the statistics on status of irrigated and unirrigated land but further classification of unirrigated land with different levels of rainfall. This statistics is usually maintain in the official system but is not readily available to the planners of different levels.

Apart from this hydrological statistics relating to availability of ground water, drainage network reservoirs, ponds etc. is being collected and maintained under official system. As the concept and definition of wasteland and degraded lands is controversial, the statistics of estimates of such land in the country is also not very reliable. The official system of collection of landuse do not collect any statistics on degraded lands for which different estimates have been put forth ranging from 130 to 175 million hectares in the country.

Major part of the statistics for taking decisions about land use planning are collected and available under official statistics. However, certain statistics such as that on land use suitability, capability and potentiality as also data on

soil erosion, salinity, degraded land etc. are not available under official system of collection of agricultural statistics. Official statistical system has to be geared up or build to collect such statistics which is essential for proper land use planning in the country.

Agro-Climate Based Planning for Sustainable Agriculture

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Agriculture in India is still dependent on the vagaries of monsoon and would continue to remain so in near future. The climate of India may broadly described as tropical monsoon type. There are four seasons (i) Winter—January-February, (ii) hot weather summer—March-May (iii) rainy South-West monsoon period—June-September and (iv) post-monsoon period (North East Monsoon) Southern peninsula—October-December.

Soil and land form a natural resource base which sustains most of the life forms on the earth. There is degradation of land resource due to mining, water logging, salinity, shifting cultivation and soil erosion. There is an imperative need for conservation of soil and land resources. Precise scientific information on characteristics, potential, limitations and management needs of different soils is, therefore indispensable for planned development of these resources.

The issues related to sustainability in development particularly in Agriculture sector always existed in one form or the other, however, in recent days it has got focussed attention. Jodha (1991) treats sustainability as a characteristic of agricultural system. It is the ability of the system to maintain a certain well defined level of performance over time, and if required to enhance the same through linkages with other systems without damaging the ecological integrity of the system.

Agro-Climatic Regional Planning (ACRP)

Planning implies optimum use of scare resources for the upliftment of the standard of living of the masses. In long run, each agro-climatic region would have to plan for maximisation of agricultural output on a sustainable

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basis. To tackle this issue, a new approach to agricultural planning, Agro-climatic Regional Planning (ACRP) was initiated in 1988. Based on agro-climatic factors, the country was delineated into 15 agro-climatic zones. This approach marks a departure from the sectoral approach in agriculture planning, so far practised in the country, to a more holistic approach. For detailed operational planning on more homogeneous area basis, the 15 zones were sub-divided into over 73 sub-zones, having a higher degree of commonality. The overall objective of ACRP is to bring together in a coordinated manner, resources, technology, people and management institutions for maximising the output and income through optimisation of resource use.

The ultimate goal of the approach is, achieving the best trade off between maximizing the productive efficiency of given resource endowments, using appropriate technology and maintaining long term sustainability of such use of resources. The project was initiated by regionalising the country into major agro climatic zones/regions and later into sub zones/regions, having higher degree of commonality. The ACRP approach to regionalisation takes a holistic view of the systems of crop and other non-farm activities not only in terms of output and productivity, but also, employment including skill information. In order to assess the status of resource endowment in a region the basic information on socio-economic indicators, land and water resources, crops and cropping systems, agricultural support system and allied sectors like horticulture, fisheries, agro processing was collected and analysed. The diagnostic phase brought out developmental issues of a region leading to appropriate regional development strategies. The ACRP approach has been further taken down to the district level; wherein priorities of a local areas are considered after detailed investigations.

The agro-climatic exercise, which have been completed for 35 districts have clearly brought out of the regional variations within sub-zones of a broad agro-climatic zone, availability of resources, present status of agricultural productivity, development issues, strategies, research needs etc. It provides crop output projections and suggested development programmes for each sub-zone.

To ensure sustainable developments in all economic sectors the adoption of a disaggregated approach is essential, particularly one that gives attention to the inherent differences of environment. ACRP is emerging as the only sustainable option available for agricultural planning as it takes into consideration the ground realities without loosing sight of the current calls of the day, most importantly, participatory and space specific approaches to development.

Land Use Planning for Sustainable Development in Rural India

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The basic characteristics of an underdeveloped economy is that a very high proportion of working population is engaged in agriculture, which contributes a very large share in the national income. Despite varying degrees of industrial development, Indian rural economics shows some distinct feature. First, there is no significant change in the labour force employed in agriculture. Second, more than one third of the net state domestic product is contributed by agriculture and the third, which is most important is that land accounts for more than 50% of the total assets of rural households. Therefore, in a poor agrarian economies like India, land is the most important asset. Therefore, rural landuse planning should be an important component of sustainable agriculture development and in the formulation of environment friendly approach.

Landuse planning is systematic way of making the best use of limited resources through assessment of present and future needs, resolving conflicts between competing uses, seeking and choosing sustainable options, for bringing out desired changes. Rural landuse planning is formed fundamentally by landuse planning of life, production and natural environment. The quantity of land demand is estimated by each planning level, however, the total land demand is generally more than the existing rural land area. Thus, this step can be realised through transfer of land ownership and rights to utilize land.

Problems of Rural Land Use Planning

Landuse planning problems are results of some mistakes in developmental methods or policies which have taken a detour in the development process of the country. The reason for this may be lack of awareness on the importance of proper landuse, or the lack of information needed to predict the landuse disorder in the future.

It was the consensus that in most of developing countries, there is so much inadequacy in rural land use database as well as the lack of uniformity in methodologies and data quality. In face of growing population, there has been increasing pressure on land particularly for agriculture and settlement use. The rate of conversion of most of the prouctive agricultural lands to settlement use has been thwarted to some extent due to speculative price in the urban fringe and rural homesteed land and low purchasing power of the people.

Population changes also provides rough information of how rural agricultural land was affected by conversion or over exploitation. In India the per capita availabilty of arable land was 0.30 hectares in 1970-71 and had gone down to 0.22 hac in 1985-86. It has been decreasing every year due to the population pressure. In addition to this there are other numerous reasons like, Government policy, forestry development, cropping pattern, poverty and unemployment for failure of land use planning.

Goals of Rural Land use Planning

The goals of land use planning should be specific as it defines what is meant by the "best" use of land. Goals may be grouped into efficiency, equity and sustainability. Land use planning must be economically viable, so one goal of development planning is to make efficient and productive use of land. Efficiency is achieved by matching different land uses with areas that will yield the higher benefits for the lower cost. Land use must also be socially acceptable, besides being economically viable. Among the various definitions of sustainable development FAO (1990) defines it as 'sustainable development is the management and conversion of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water, plant and animal genetic resources is environmentally, non degraded technologically appropriate, economically viable and social acceptable'. Sustainable land use meet the needs of the present without compromising the future generations.

The Strategy for Land Use Planning in India

There is a need to establish concrete and complete methodology of rural land use planning keeeping in view the purpose, methodology, technology of implementation by making mutual agreement among the persons concerned. Apart from this there are following points which should be taken into account while formulating stategies for proper land use planning.

(i) It needs to be carried out simultaneously at all levels in integrated manner (ii) It is necessary to formulate comprehensive rural land use planning (iii) To formulate landuse conversion policy and land use order on legal grounds (iv) There is a need for land use information system for scientific and effective landuse planning (v) There is a need of establishing international standards and nomenclatures for rural land use planning (vi) Promote integrated community

based rural land use planning and lastly (vii) There is need to conduct micro-studies on sustainability of land use.

Land use planning is not an easy task. It is continuous process and require the commitment of the government, people and cooperation of international organisation. Land use planning in the country is rival for its overall development both social and economic. The country reached at a stage where urgency of rural land use planning is needed. The demand for land comes from the pressing need for production of food, shelter and infrastructure. Hence, the land use planning is equally important for maintaining the ecological balance of the physical importance.

Some Statistical Approach for Estimating Area Under Different Land Use Categories

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The land use planning is a means of optimum utilization of the natural resource especially, the land, which is one of the resource based on its related factors like socio-economic conditions, soil type, climate, water availability etc. for the production as a whole. Naturally, the effective land use planning of a particular region need informations related to various input factors of production. The landuse statistics not only helps in this planning process but also used to generate information about other related factors. The recent advances in the field of computer technology especially in the field of geographical techniques like Geographic Information System (GIS) and remote sensing increased the potential to charge substantially the statistical approach to study the geographical reality. The GIS has shown its ability to handle various kinds of informations through its geographical coordinates particularly for survey design and its processing.

Although, there are various applications of statistical techniques in the area of remote sensing and GIS as applied to landuse planning, the problem of estimation of proportions under different land use categories is of special interest. This procedure is based on exploiting the information of spatial correlation, which plays prominent role while sampling from space. Also, model based estimated procedure, incorporating spatial correlation in the model itself is discussed. Further, model of error propogation is discribed which can be used to integrate three important sources of data i.e. census, survey and remote

sensing, along with some other problems related to data analysis for land use statistics.

Sampling From Space:

The adjacent units in space are often more alike than those which are far apart because of existing spatial correction. The traditional sampling designs do not exploit this information in the selection process of the sample. 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) further improved this technique and described a sampling technique "Dependent Areal Units Sequential Technique" i.e. DUST which avoids the inclusion of neighboring area in the area sample. This sampling design consists of three important steps:

(i) Estimation of spatial correlations β with the help of auxiliary information X at various distance lag (ii) Testing the stationarity of various order correlations for identifying the zones and (iii) Select the first unit by assigning weight 1, and $\prod_{i=1}^{k-1} (1 - \beta_1 d_{ik})$ is the weight assigned for selecting k-th unit in the sample of size n where k = 2, 3, ..., n and d_{ik} is the distance between i-th and k-th area unit measured in terms of physical distance. Most of the traditional sampling designs are found to be particular case of this design. It is not out of place to point out that this sampling design can be employed using GIS package like ARC/INFO, which is capable of integrating spatial and non-spatial data.

Model Based Approach:

In the earlier development of survey sampling, super population were used by Cochran (1946) to compare different sampling strategies, by incorporating spatial correlation coefficient in the error structure of the model. Recently, super-population model have been extensively used for estimation of population parameters. Metheron (1971) has developed the theory of regionalised variables extensively. Let $\mathbf{z}$ be a vector which represent a point in space and $y(\mathbf{z})$ is the value of character under study at this point. Let $y(\mathbf{z})$ is a random variable than expected value be $E[Y(\mathbf{z})] = p$ and its variance-covariance matrix is $K(\mathbf{z}, \mathbf{z}+\mathbf{h}) = K(\mathbf{h})$ where $\mathbf{h}$ is a vector in R^n. Now in case of land use

$$Y(\mathbf{z}) = \begin{cases} 1, & \text{if } \mathbf{z} \text{ belongs to class considered} \\ 0, & \text{otherwise} \end{cases}$$

The average of $Y(z)$ in an area A is $P = (1/A) \int_A y(z)\, dz$

Again, the estimator for land use classes can be written as $\hat{p} = (1/n) \sum_{j=1}^{n} y(z_j)$ and

$$V(\hat{P} - P) = \frac{1}{n^2} \sum_i \sum_j K(z_i - z_j) + (1/A^2) \int_A dl \int_A K(l - z)\, dz$$

$$- (z/(nA)) \sum_i \int_A K(z_i - z)\, dz$$

The estimation of this variance is not possible until some model is to be specified, which estimates the covariance between two grid points i.e., $K(z_i - z_j)$. Hans (1983) considered several models for the correlation coefficient for estimating landuse categories in Norway.

Practical Problems

In this section statistical aspects of the major practical difficulties and there possible solutions while using remote sensing and GIS techniques for land use planning will be discussed.

The remote sensing and GIS technology made possible to integrate data from different sources like census, survey and satellite for determining area under a particular land use category. Since, maps of different sources contains error the resultant output may distort reality due to severe error propagation effects. Let us consider that the whole area under study is divided into n sub areas in each of the maps. Let $\mathbf{z}$ is $n \times 1$ vector of n observed value. $\mathbf{S}$ is a vector of n true values, $\mathbf{H}$ is $n \times n$ blurring matrix such that $\sum h_{ij} = 1$, $h_{ij} \geq 0$, $h_{ij} \in \mathbf{H}$. Also, let $\mathbf{U}$ is vector of disturbance. It is assumed that each observed map can be represented as linear transformation of the true map through the relationship. Thus

$$\underset{\text{(Total error)}}{(z_i - S_i)} = \underset{\text{(locational error)}}{(h_{ii} - 1) S_i + \sum_{i \neq j} h_{ij} S_j} + \underset{\text{(measurement error)}}{U_i}$$

Arbia (1989) suggested three approaches to estimate these errors. First is based on joint pdf of the two dimension stochastic process of inputs z_i. Second is based on the assumption of the multivariate normality of z_i's. Lastly, the

third approach is based on obtaining the lower moments of the distribution of errors in the output map in terms of the moments of the distribution of errors in the input map and then fit, where it is possible, one of the tabulated distribution.

It is often possible that at the boundry of two classes, part of the sampled area belongs to category, say A and remaining part belong to B. Switzer (1983) described some of the presmothing and postsmothing techniques by modelling such type errors. Chikkara and Mckeon (1984) proposed a set of models that can be used to describe the classification errors for the units that are post stratified based on their spectral response.

It has been realised that the land use statistics in the country collected under ninefold classification does not provide sufficient information for planning at micro level. This can be obtained with the help of recent computer technologies like GIS and remote sensing through conducting surveys. There is high potential of research in this field, especially with the help of optimization techniques like linear programming.

Data Base for Landuse Planning in India : Problems of Availability and Comparability

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Land is a most precious and scarce resource. Keeping this in view, the Government of India has came out with a land policy declaration in 1986 laying down the principles and objectives which should govern an optimum landuse. At the state level State Land Use Boards have been step up to deal with the issues related to landuse planning. Scientific landuse planning requires a reliable and comprehensive database. This information is required not only at the national or macro level but also at grass root or the micro level. Thus the data requirements for landuse planning are indeed quite enormous.

Present Data Base

Two types database, which are complementary to each other, are available with regard to existing landuse, namely, data based on detailed ground surveys and data based on arieal surveys, including remote sensing data. The official statistics based on land records give details of landuse over nine categories. This is the most comprehensive database which is available at the district level

annually for a fairly long time and forms the mainbase for land use planning and analysis.

However, This data does not give adequate information on many qualitative aspects of landuse which are relevant for landuse planning. Further, there are gaps in the data and also data is not available for few part of the country especially North-Eastern states.

Since 1972, remote sensing data on some aspects of landuse has become available for some points of time. Though not as comprehensive and detailed as the land revenue data, the remote sensing data is a useful supplement to official statistics on landuse.

Problems of Comparability

The availability of data from different sources has however, added to the problem of their comparability. Even at the aggregated level the differences in the estimates for different types of landuse are too large to be easily reconciled or ignored. For instance while according to official statistics area under forests is 75 million hac. NRSA data put area under forest at 46.3 million hac. and Forest Survey of India at 64 million hac.

A major deficiency of landuse statistics in India is the absence of information on the qualitative aspects of landuse. For effective landuse planning more and more data on these qualitative aspects is called for at the micro-level.

There is a need to collect the data on qualitative aspects of land along with non-agricultural uses of land. To improve the degraded land the data on the ownership as well as geographical spread of the land should be made available. Also, there is need to improve the system of data collection in use of official statistics.