Achievements in Applied Research in Sample Survey at IASRI

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1. Introduction

The Indian Agricultural Statistics Research Institute is a pioneering Institute in the field of research in Agricultural Statistics in India which made a modest beginning in 1930 as Statistical Section of the Indian (then Imperial) Council of Agricultural Research. As per the mandates of the Institute to promote and conduct research in Agricultural Statistics, the Institute has contributed significantly over the years in research in the field of sample surveys, design of experiments, statistical genetics, bio-statistics, forecasting techniques, statistical economics and computer applications. The development of suitable sample survey methodologies for estimation of various parameters pertaining to crops, livestock, fisheries production and allied fields have always been one of the most important activities of the Institute from the very beginning. The Institute was instrumental in the development of sample survey methodology for estimation of crop production through crop cutting approach which formed a sound objective method of estimating crop production in the country. The sample survey methodologies for estimation of livestock numbers, products and attendant practices, for estimation of extent of cultivation and production of fruits and vegetables, for estimation of fish catch both from marine and inland resources, for estimation of cost of production of crops as well as livestock products and for evaluation studies such as assessment of development programmes like IADP, HYVP, dairy improvement programmes etc. are other important contributions of the Institute. Most of the methodologies evolved are being adopted by the concerned departments in various states of the country and this work is being coordinated by the Directorate of Economics and Statistics and other concerned wings of the Ministry of Agriculture, Government of India. Some of these methodologies are being internationally used.

In this article, the research highlights in sample survey at the Institute in different areas of applied research have been presented.

2. Sampling Methodologies Developed - At a Glance

One of the most striking features of recent development in statistics is the rapid growth of interest in development of sampling methodologies and their applications as well. The sampling approach being a most cost prohibited way of obtaining an estimate of a character of a population has compelled the survey statisticians to probe into problems of basic research. Survey sampling has considerably helped the concerned organizations in providing estimation of important population parameters for scientific planning in various developmental programmes. The Division of Sample Survey of the Institute undertook research in sample survey techniques and their application in agriculture, animal husbandry, fisheries, forestry and allied fields. By now, several methodological investigations have been carried out by the Division for evolving suitable sampling methodologies. Some of the methodologies have been adopted by State Departments and other related agencies and some are in the process of implementation. The broad categories under which these methodologies can be classified are:

(i) Crops

(ii) Horticulture and Plantation crops

(iii) Livestock

(iv) Fisheries

(v) Evaluation studies, Demographic studies, Socio-economic studies and all such studies which do not fall under above stated four categories.

2.1 Surveys on crops

One of the essential features for viability of any survey methodology is that it must be in conformity with the available infrastructure. For estimation of production of crops, one could concentrate on obtaining information on production of crops from the ultimate units. However, in the context of our country, estimation of area and yield is important which ultimately gives the production of crops.

Before 1919, method of determining crop yield was being done by traditional method. This method however, was subjective and unreliable. In 1919, objective method of crop cutting experiments by random selection of villages, fields and plots was recommended by Board of Agriculture. Initial attempt in practice goes to Hubback (1923-25) for carrying out surveys for estimation of yield of paddy in Bihar and Orissa. Hubback's idea of random sampling was pursued further for estimation of area and yield of jute crops. It may be mentioned that before independence, cash crops were considered more important as a source of revenue.

Before 1943-44, the official procedure of annawari estimation was defective and unreliable. This resulted in grave lacuna in the official estimates of yield of food grains. A serious food crisis occurred in the country in which Bengal famine was worst. This crisis could have been averted if reliable estimates of yield of food crops could be available.

Estimation of production of food crops was taken up seriously by Government of India. The Indian Council of Agricultural Research (ICAR) initiated pilot studies for developing methodologies for estimation of area and production of important food crops under the leadership of Sukhatme (1943-44).

The significant research in crop surveys in Sample Survey at the Institute are as under:

The method of crop cutting experiments developed in mid-forties for estimation of yield of a crop was standardized for different field crops which is widely adopted for estimation of production of principal crops in India and other developing countries. The standardized method of crop cutting experiments is a sound objective method of estimation of crop production.

In order to estimate the cost of cultivation of important food and cash crops, sampling techniques were developed. The developed methodology was adopted by the Ministry of Agriculture in the comprehensive survey on cost of cultivation of principal crops which forms the basis of fixing remunerative prices of agricultural commodities.

A suitable sampling and measurement techniques were evolved for estimation of incidence of pests and diseases and assessment of consequent loss in yield of paddy, wheat and maize crops.

In view of the importance given to the production of fodder in the Intensive Cattle Development Programme, pilot surveys were undertaken for evolving sampling methodology for estimation of area, yield and production of principal cultivated fodder crops.

Based on two surveys carried out, a suitable sampling methodology for estimation of area of grazing land and average yield per unit of grazing area in different seasons was evolved and chemical composition and botanical classification of grasses in each season were studied.

With the emphasis on white revolution, studies on cost of production of fodder crops assumed special importance, as cultivated fodders are the major inputs in dairy farming. The methodology available for estimating the cost of cultivation of cereal and cash crops did not seem to fit into studies on cost of production of fodder crops. With this in view, a pilot study for developing a suitable methodology for estimation of cost of cultivation of fodder crops was undertaken in Jalandhar tehsil of Punjab State.

A study was conducted to estimate the cost of cultivation as well as cost of production of potato, to estimate the area and yield rates of different varieties of potato and to study the extent of adoption of improved agronomic practices under cultivator's conditions.

In view of the difficulties to capture all the pickings of cotton during its long period of harvesting, a study was undertaken to develop methodology for estimation of yield of cotton on the basis of data of past few pickings. The results showed that it was possible to estimate the yield of cotton with good precision by adopting double sampling approach. In order to forecast the yield of cotton based on data of first one or two pickings, number of bolls, number of plants and plant height, multiple linear regression approach was tried successfully.

In view of unavailability of standard methodology for estimation of foodgrain losses, a survey was conducted in order to develop a suitable statistical methodology for estimation of post-harvest foodgrain losses specially, wheat.

A sampling methodology was developed to estimate area and production of cultivated fodder crops other than Jowar and Berseem and to review regular production on the lines of food-grains.

With the advent of remote sensing technology during 1970s, it's great potential in the field of agriculture opened new vistas of improving the agricultural statistics system all over the world. An attempt was made to develop a suitable methodology for estimation of crop acreage, crop yield and crop yield forecasting using remote sensing techniques.

The methodology developed under the previous study for crop yield estimation using remote sensing techniques was tested and an improved estimator of crop yield was obtained using post stratification based on satellite data in the form of vegetation indices.

A study was conducted to explore various possibilities of obtaining reliable land utilization statistics with minimum time lag at any smaller geographical level i.e. panchayats/blocks/tehsils based on sample survey using spatial sampling and remote sensing techniques. Under this study, suitable models were developed for integration of land use statistics obtained through different sources i.e. the complete enumeration, spatial survey and remote sensing.

A methodology was developed to estimate the various post-harvest food grain losses due to operational and casual factors and also due to periodic/seasonal fluctuations.

In view of the importance of fertilizers for increasing productivity in agriculture, a sampling procedure for selection of representative samples of fertilizer from ship was developed.

A methodology based on Crop Cutting Experiments (CCE) data as well as farmer appraisal data of crop produce was developed to estimate precise yield rates of different crops at Community Development Block (CDB) level.

A methodology was developed to estimate the cost of production of coconut. The cost of production of coconut was obtained by taking into account the establishment cost of orchard as well as the annual maintenance cost.

The Small Area Crop Estimation Approach (SACEA) developed by the IASRI for assessment of yield rates of different crops at the Gram Panchayat level was tested for large scale adoption in one district each of the State of Uttar Pradesh, Punjab, Rajasthan, Andhra Pradesh and Karnataka. The standard errors of the estimates were in the acceptable range. The report of the study was submitted to the Department of Agriculture & Co-operation, Ministry of Agriculture.

A study to estimate the crop yield at small area level for principal crops namely, wheat and paddy using small area estimation techniques was carried out to examine its applicability for getting reliable estimates of yield at lower levels such as block/tehsil which are very much needed for the purpose of micro level planning.

An appropriate sampling methodology for estimation of area under paddy in Meghalaya state was developed using remote sensing, GIS and ground survey. The developed methodology has been implemented in Meghalaya and an attempt is being made to adopt the methodology for estimation of area under paddy in other states of North-East region. The report of the study was submitted to Space Application Centre, Ahmedabad.

A study is being conducted in two States namely, Maharashtra and Andhra Pradesh in order to investigate the causes of variation between official and trade estimates of cotton production and to suggest ways and means for improving the reliability of estimates of Cotton production from the two sources. The study so far has revealed that official estimate is based on scientific methodology. The methodology is objective, scientific and verifiable and sampling design is proper but various problems have been observed in actual implementation of the Crop Cutting Experiment (CCE) scheme for Cotton. There is no scientific methodology for obtaining trade estimates. The interim report of the study was submitted to the DES, Department of Agriculture & Co-operation, Ministry of Agriculture.

In view of the successful adoption of methodology for estimation of area under paddy in Meghalaya state, a study is being conducted in North-East hilly region in order to develop an integrated methodology for area estimation of major crops i.e. paddy, maize, potato, ginger, pineapple, cashewnut and vegetable as a group using remote sensing, GIS and ground survey.

2.2 Surveys on horticulture and plantation crops

Horticulture and plantation crops contribute in various ways towards the prosperity of a nation. Cultivation of fruits and vegetables, if taken as organized industry, has scope for employment and upliftment of rural population. Some of the plantation crops like coconut, arecanut, cashewnut etc. and spices like pepper etc. are important from internal consumption angle and export point of view. Lac is another

commodity of similar value. Lac and cashew are grown in economically backward rural areas such as hilly and tribal areas. The status of statistics regarding these crops is not very satisfactory. The sampling technique developed for estimation of area and yield of various field crops can not be directly applied to horticultural and plantation crops due to inherent differences in various aspects like sowing, growth period, cultivation practices, harvesting etc. Accordingly, IASRI bore the brunt of developing methodology for area and yield statistics of these crops. The significant surveys by the Division of Sample Survey of the Institute are as under:

A suitable methodology for estimation of area and production of important plantation crops like arecanut, coconut and cashewnut was developed and is being used in major growing areas.

A survey was conducted for estimation of yield of lime and to study the cultivation practices of lime in Nellore district of Andhra Pradesh.

A methodology was developed for simultaneous estimation of area and production of fruits and vegetables and to study their marketing practices.

For estimation of cost of production of major fruits and perennial crops, sampling techniques were developed.

In order to develop a methodology for estimation of production of lac and extent of adoption of improved practices for its cultivation and remuneration received by the tribals, a survey was conducted in Bihar. The yield as well as production of lac were found to be greatly influenced by the price received by the tribals and, therefore, for maintaining production at reasonable level, adequate marketing facilities and support price would have to be ensured.

A pilot sample survey was conducted in Valsad district of Gujarat state for determining the cost of production of Chikoo and for studying its marketing practices.

An appropriate methodology for estimation of area and production of major fruits was standardized based on a series of pilot sample surveys conducted for the purpose in important fruit growing regions in the country.

A series of pilot sample surveys were conducted for developing sampling methodology for estimation of area and production of different vegetables in important areas like Delhi, Bangalore, Pune and Nasik. A suitable methodology for the purpose was standardized. Surveys on marketing of vegetables and their price spread were conducted in Delhi to investigate the share of growers vis-à-vis various intermediaries like wholesalers, retailers etc. on the price paid by the consumers. It was found that the share of the intermediaries formed a substantial component of the final price of vegetable.

Surveys were undertaken on cost of cultivation of crops like orange in Maharashtra, banana and mango in Gujarat, vegetables in Delhi and Gujarat and oilseeds and pulses in important growing regions of the country. These surveys provided valuable information on the various cost components of these commodities as well as return to the cultivators with known degree of reliability.

A survey was conducted in Bihar, Uttar Pradesh and Maharashtra states in order to evolve an appropriate methodology for estimation of Lac production.

A survey was conducted to develop a suitable sampling technique for estimation of price spread of vegetables at different stages of marketing and cost of cultivation of important vegetable crops

grown in the area. The different marketing and cultivation practices followed by the growers were also studied.

An attempt was made to study the variability of various components of cost of cultivation of vegetable crops at different stages of sampling and to determine the sample sizes for given levels of precision.

A sample survey was conducted to study the extent of production and cultivation of Cashew practices in Goa.

A suitable methodology was developed for estimation of yield of pepper in the states lacking in statistical procedure for estimation of yield of the crop.

In order to develop a suitable methodology for estimating the production of important vegetable crops and their yield rates on the basis of partial harvest, a suitable theoretical framework was developed for sampling from two dimensional populations spread over space and time with particular reference to vegetable crops and the theory was tested using secondary data collected under earlier vegetable surveys at IASRI. The total production of important vegetable crops and their yield rates were estimated using the developed methodology on the basis of primary data.

A pilot sample survey was conducted for developing a suitable sampling methodology for estimation of area and yield rates of ginger and potato in hilly areas.

A pilot study was undertaken to develop sampling methodology for estimation of area, production and productivity of important flowers on the basis of market arrivals.

Using secondary data, the effect of various inputs was studied on the yield of important vegetable crops. It was found that fertilizer, irrigation, human labour contributed significantly towards yield.

In view of National Statistical Commission (NSC) recommendation, a pilot study was conducted in two States namely, Maharashtra and Himachal Pradesh covering important fruits and vegetables. Under this study, an alternative methodology for estimating area and production of horticultural crops was developed which is cost effective and less time consuming and in which the survey procedures have been simplified. The study has revealed very encouraging results and demonstrated the feasibility of estimating the production of fruits and vegetables with much smaller sample size. As per recommendation made by the NSC, there is a need to test alternative methodology in few States before actually implementing it on a large scale. The report of the study was submitted to the CSO, Ministry of Statistics and Programme Implementation.

2.3 Surveys on livestock

The Institute has made a significant headway over the years in research in sampling methods in estimation of livestock and its products, rearing and maintenance cost of livestock etc. The estimates of livestock products such as milk, wool, eggs and meat etc. are needed for policy making and better planning for development of livestock. Division of Sample Survey of the Institute bore the brunt of developing sampling methodology for estimation of livestock and its products. The panorama of development of sampling methodologies is as under:

Appropriate sampling techniques were developed for estimation of production of principal livestock products like milk, wool and meat using the relevant information on livestock practices adopted.

Suitable sampling methodologies were developed for ascertaining the cost of production of important livestock products such as milk, wool, poultry and eggs based on a series of investigations carried out in different animal husbandry regions of the country. Suitable methodology was also evolved for studying the economics of grazing cattle and buffaloes.

The methodologies were standardized on the basis of a number of diversified investigations into alternative designs, procedure for recording and sampling techniques for measurement of (i) wool quality of fleeces of principal breeds of sheep in India in terms of qualitative values of fibre diameter, staple length, crimps per cm., and medulation percentage; (ii) chemical and bacteriological quality of milk supplied by the procedures; (iii) solids-not-fat in milk in terms of Richmond's modified formula and (iv) amount of milk sucked by calves under farm conditions.

Sampling methodologies were developed by the Institute for estimation of production and costing of principal livestock products, when the products were to be covered individually. The developed methodologies were quite suitable for adoption. The cost patterns of these products and changes in the annual output could not be estimated unless sample surveys are repeated every year on each of the product which would not be cost effective. Therefore, an integrated sampling methodology was developed for simultaneous estimation and costing of principal livestock products every year through one single survey.

A systematic sampling technique of milk recording for obtaining reliable estimate of milk production in key village areas was developed. The developed technique was operationally feasible.

A survey was carried out to develop a suitable methodology for estimating the specific rates of fertility & mortality in non-migratory flocks of sheep & goat with respect to breed, sex and age.

A suitable methodology was developed for estimation of vital statistics in a comprehensive way for bovines. The estimates of age-specific mortality rates among cattle and buffaloes obtained from the studies in different parts of the country were utilized for construction of life tables.

A suitable methodology was evolved for estimation of incidence of diseases and occurrence of deaths on account of these diseases, losses in production due to disability and deaths and extent of losses in production and reproduction which could be avoided through protection measures.

For studying the availability of broilers and culled birds for canning purposes, a sampling methodology was developed to estimate month-wise/season-wise age specific vital characteristics affecting the growth and structure of poultry population and to estimate the production of broilers in terms of number and weight and culling of layers by size of farm at regular intervals of time**.** Under this study, appropriate models characterizing the production and culling patterns in poultry farms utilizing the estimated vital characteristics were also developed.

Using the (1989-90) data on Integrated Sample Survey for estimation of major livestock products of Department of Animal Husbandry, Himachal Pradesh and the livestock census (1982) data the synthetic method of estimation for small area was used to estimate milk production for the different districts of Himachal Pradesh.

A sampling methodology was developed for estimation of wool production in India and for collecting information on sheep keeping practices based on a pilot survey in different sheep breeding tracts of the country.

A suitable sampling methodology was developed for estimation of cost of rearing and maintenance of goats, attendant practices of goat keeping, procedures for evaluation of cost components and costs and returns in goat farming.

Studies were conducted on cost of rearing and maintenance of rabbits and cost of production of Angora rabbit wool.

To assess the quantum of herbage intake by animals through grazing, a study was conducted to estimate simultaneously the intake by animals through stall feeding as well as grazing in Dharmapuri district of Tamil Nadu.

An attempt was made to identify the factors responsible for gap in milk yield of buffalo and also to estimate the contribution of each factor through statistical tools viz. path co-efficient analysis, multiple regression technique and principal component analysis.

2.4 Surveys on fisheries

Fish is a rich source of protein and its industry provides livelihood to millions of people. Apart from its contributions to national income, fish industry accounts for appreciably export trade. Indian fish industry depends mainly on marine fish. IASRI in collaboration with the fisheries departments of states initiated pilot sample survey for developing sampling technique for estimation of marine fish catch during 1950-51. The other source of fish is from inland water. Inland fisheries comprise of two types of water viz. fresh & brackish. Keeping in view the need for developing a sampling technique for estimation of inland fish catch, IASRI jointly with Central Inland Fisheries Research Institute (CIFRI), Barrackpore undertook a survey in 1979-80 in West Bengal. A brief account of development of sampling methodologies in the field of Fisheries is as under:

A methodology pertaining to marine fisheries involving sampling over space as well as time was developed to estimate the fish catch along the coastal area of the country. The developed methodology was suitably modified by Central Marine Fisheries Research Institute of the I.C.A.R. depending upon the situation and is since been adopted by all maritime states for estimating the fish catch from coastal resources.

Based on secondary data pertaining to Chilka lake in Orissa state, a suitable sampling methodology was developed for estimation of fish catch from a lake and the feasibility of estimating fish catch by using partial data was explored.

Suitable sampling methodologies for estimation of inland fishery resources and catch of inland fish in regions of West Bengal and Orissa were developed.

In view of unavailability of reliable statistics of fish catch from ponds, tanks and reservoirs, a suitable sampling methodology was evolved for estimation of inland fisheries resources and total catch of inland fish. Besides, the prevailing practices of pisciculture were studied.

A survey was conducted to evolve a suitable sampling methodology for estimation of inland brackish water resources and to study the prevailing practices of brackish water pisciculture.

A sampling methodology was developed for estimation of fish catch from rivers and streams of the hilly areas.

2.5 Other studies

The Division of Sample Survey of the Institute has been in the forefront in taking up Evaluation studies, Demographic studies and Socio-economic studies and all such studies which do not fall under above stated four categories. The significant highlights of these studies are as under:

In order to ensure timely availability of inputs and credit facilities and to study the institutional changes required, the Intensive Agricultural District Programme was launched by the government in selected districts of the country. The Institute conducted bench mark and assessment surveys to evaluate the success of the programme.

A survey was conducted for studying the impact of new technology on crop production, its disposal and employment in agriculture in Delhi State.

A pilot sample survey was conducted in order to investigate a sampling procedure for assessing the losses in agricultural production as well as livestock caused by flood and to study the impact of floods on crops in the subsequent season.

A survey was undertaken with a view to determine the design and response parameters for studying the comparative performance in terms of production, investment return, etc. of different systems of farming singly or in combination and to compare different systems of farming in respect of labour intensification.

A study was conducted to estimate the energy requirement for different levels of adoption of modern technology in terms of labour and inputs like irrigation, fertilizers, etc.

Appropriate sample survey methodology for evaluation study such as assessment of high yielding varieties programme was developed. In order to develop the methodology, the assessment surveys were conducted on important cereals viz. rice, wheat, maize, jowar and bajra in 88 districts spread over 15 states of the country. The surveys under the study involved yield estimation surveys for determining the yield rates of high yielding varieties and comparative estimates of the traditional varieties and agronomic and agro-economic enquiry for spread of the high yielding varieties and extent of adoption of improved agricultural practices.

A suitable sampling methodology was developed in order to make continual quantitative appraisal of progress in milk collection areas of organized milk supply schemes and Intensive Cattle Development areas. This methodology would help in assessing the impact of milk supply schemes on rural economy in milk collection areas.

A sample survey was conducted to study constraints in transfer of new agricultural technology under field condition. Based on this survey, an attempt was made to develop a suitable sampling methodology for studying the effect of new agricultural technology including high yielding/improved varieties, fertilizers, plant protection chemicals and cultural and management practices for higher productivity of land. The extent to which the potential of high yielding/improved varieties were achieved under field conditions was determined and the constraints in the transfer of new agricultural technology to cultivators' fields were identified and investigated.

A methodology was developed for determining yield rates of crops in command and non-command area of irrigation project with reasonable precision and the impact of command area irrigation project on agronomic and management practices and other development measures was studied.

A study was conducted to develop a sampling procedure for estimating the extent of employment and income of small and marginal farmers and agricultural labourers.

A pilot study was conducted to assess the harvest/production and post harvest/post production losses of wool, meat, eggs and poultry meat, marine fishery, inland fishery, milk and oilseeds at different levels viz. producer, consumer and market**.** Suitable sampling methodologies for estimation of harvest and post-harvest losses of all the commodities and for all the levels under study were developed. The causes of losses at different levels were also identified for all the commodities.

A pilot study on agroforestry in Chhachhrauli block of Yamunanagar district of Haryana state was carried out to study the impact and constraints of agroforestry program in relation to socio-economic structure of the district, spatial distribution of natural resources as well as available infrastructure and to develop integrated approach for planning and development for optimizing the resources in the field of agroforestry.

A document on information support for management of agriculture was prepared. Focusing specifically on 'farmer-the man', the document attempts to establish a link between 'information system for agriculture' and 'the farmer'.

A new GIS based Objective Analytic Hierarchy Process (AHP) namely, Objective Spatial Analytic Hierarchy Process (OSAHP) was developed for identification of potential agroforestry areas. The study was conducted in Yamunanagar district of Haryana state and may be helpful for the social, economic and environmental development of the study area as well as in future research in the area of agroforestry.

To assess the survey capabilities in the private sector a questionnaire was designed and the private survey agencies in the country were asked to fill the questionnaire. On the basis of responses obtained, the different survey agencies were graded in terms of survey capabilities. A report containing survey capabilities of the private agencies was submitted to the CSO, Ministry of Statistics and Programme Implementation (MOS&PI).

A study was initiated with the specific purpose of formulating long-term mechanization strategy. On the basis of a survey carried out in 120 districts in the country, long term farm mechanization strategies were formed for each of the agro climatic zone/state.

Six manuals on (i) Area and crop production Statistics, (ii) Animal husbandry Statistics, (iii)'Agricultural prices and marketing, (iv) Cost of cultivation surveys, (v) Horticulture and spices Statistics and (vi) Fishery Statistics were prepared and submitted to the CSO, Ministry of Statistics and Programme Implementation.