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Proceedings of the Symposium on
"Role of Distress Agriculture in Containing Acute Rural – Some Statistical Issues"

Chairman : Dr. K.C. Seal
Convenor : Dr. H.V.L. Bathla

Six papers covering various aspects related with the theme of the symposium were presented by the following speakers :

1. Time to Look Beyond Agriculture for Rural Growth – Some Prospects
— J. Dash and Venkatramana R. Hegde
2. Role of Agriculture in Containing Acute Rural Distress — Saroja Rama Rao
3. Statistical Profile of Minor Irrigation in India — A.K. Srivastava
4. Agriculture from the Perspective of GDP Estimates — Ramesh Kolli
5. Quantitative Assessment of Agrarian Distress - Issues on Data Availability — Rajiv Mehta
6. Some Observations on Factors affecting Agrarian Distress in India and Combating Strategies — B.C. Barah

The following recommendation emerged out based on the discussions during the symposium:

- The indicators for rural distress need to be identified so as to develop an appropriate measure of distress as also to identify factors requiring intervention. It has been viewed that the non-agriculture sector is getting more importance in reducing rural poverty mainly because of the rising income disparity between agriculture and non-agriculture households. Further, investigations in this regard are desirable.

ABSTRACTS OF THE PAPERS PRESENTED

1. Time to Look Beyond Agriculture for Rural Growth – Some Prospects[1]

J. Dash[2] and Venkatramana R. Hegde[3]

The paper analyses state level data on growth, employment and poverty, to see what we can learn about economic growth and social welfare, with a view to improving rural life in general and agriculture sector in particular. Generally, studies on rural poverty and agriculture based on Gross State Domestic Product (GSDP) focus on entire economy in the absence of separate data for rural spectrum, which is an over simplification of the real problem. In this context, it is necessary to study separately the role of agriculture on rural progress and different sub sectors within the rural sector. This paper attempts to provide both growth and participation effect of agriculture in promoting rural development and containing rural distress. The propositions investigated are the following: What is the composition of the rural economy and its interlink among different sub–sectors? Does agriculture growth play significant role for overall growth and particularly for rural progress? Under what conditions does additional support for agriculture will be both overall growth enhancing as well as poverty reducing?.

We use multiple rounds of the employment-unemployment survey by National Sample Survey Organization (NSSO) covering 18 major states for 1993-94, 1999-2000 and 2004-05. We have restricted our focus on rural sector on employment, GSDP and poverty in the entire paper. The projected population details for the respective periods have been obtained from Census of India publications. The data on state-wise poverty on corresponding years have been taken from Planning Commission's press releases. The GSDP data at 1993-94 prices are obtained from the National Accounts Statistics of CSO. For cross section analysis, eighteen major States have been considered. Each of these States has a population of more than 10 million with at least 50 per cent in rural area. Thus, small States such as Arunachal Pradesh, Uttaranchal, Goa, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim Tripura, Delhi and all UTs are out of the purview of this study.

For the purpose of this study, we first obtain industry–wise employment data from NSS which gives the percentage distribution across industries of each of the four categories of workers. We apply this distribution to the absolute numbers of workers of each category. Then these figures have been adjusted for total population with the help of census data to get total working persons for each year and add up the four categories (male-female-rural-urban) in each industry to derive estimates of total workers in each industry. Then we estimate total workers in each of the sectors in rural parts. Using industry-wise workers in the rural area, we estimate rural GSDP for each sub-sector.

A regression model has been developed to explain across the states variation of different industries in terms of GSDP, employment and poverty. For this purpose, three regression equations have been estimated for 18 major states. The main variables used in the study are Agriculture (A), Mining (M), Manufacturing (MU), Electricity, Gas and Water Supply (EGW), Construction (C), Transport storage and communication (TSC), Trade, Hotel and Restaurant (THR), Financial services (FS) and Public Administration and Other services (PA). The variable rural poverty (RP) is added to study the effect of agriculture on both workers and growth on poverty. In the process, some of the independent variables are found insignificant and dropped from the model. Finally, the Multiple Regression is run on the rest of the variables and is expressed as

$$A_t = \beta_1 + \beta_2 M + \beta_3 MU + \beta_4 C + \beta_5 THR + U_t$$

$$t = 1 \ldots 18 \text{ and } U_i \sim N(0, \sigma^2) \qquad (2.3.1)$$

The independent variables M to PA are non-stochastic and β's are parameters estimated using ordinary least squares(OLS) method. Error term (U_t) is tested for heteroskedasticity using Cook-Weisberg Test and no such evidence is found. Similarly, regression of employment in agriculture with rest of the sectors is expressed as

$$A\_W_t = \beta_1 + \beta_2 MU\_W + \beta_3 C\_W + \beta_4 THR\_W + \beta_5 FS\_W + U_t$$

$$t = 1 \ldots 18 \text{ and } U_i \sim N(0, \sigma^2) \qquad (2.3.2)$$

The regression of poverty on rural employment in different sectors expressed as

$$RP_t = \beta_1 + \beta_2 A\_W + \beta_3 M\_+ \ldots \beta_{10} PA\_W + U_t$$

$$t = 1 \ldots 18 \text{ and } U_i \sim N(0, \sigma^2) \qquad (2.3.3)$$

The model has high explanatory power and all the variables are significant at 10% level.

Impact of Agriculture on Non-agriculture

The analysis revealed that, the sub sectors viz., construction, transport, financial services and public administration are found statistically insignificant vis-à-vis agriculture. Construction is treated as a proxy for capital formation in agriculture and the insignificant result shows that the investment level in agriculture is dismal. The insignificant influence of financial sector probably imply that the sector is having limited access to a wide range of financial services such as credit and insurance. The growth in public administration (including community and other services) on agriculture is also found to be statistically insignificant. This might be due to the fact that, government is pushing for public private partnership model even in rural services. As expected, manufacturing sector has grown faster during 2000-05 and also competed with the growth of agriculture sector. This probably implies that, farmers favour locally produced goods and machineries. Electricity and water supply sector have shown a strong linkage with agriculture growth, which might be due to easy access, availability of cheaper machineries and modernization of the sector.

Impact of Agriculture on Poverty

Role of agriculture on rural poverty is found to be insignificant for the year 2004-05. It is the case with mining, manufacturing, electricity and financial services. Surprisingly, more and more non-agricultural sectors participated in reducing rural poverty. For instance, during 1993-94, transport found to have strong negative effect on rural poverty reduction has been turned out to be strong positive during 2004-05. This shows that the sector helped in creating additional income to rural poor. The results may imply that, the recent growth in agriculture has not helped in reducing rural poverty. Therefore, the focus on fostering agricultural growth as the starting point in designing poverty reducing strategies, especially in rural sector does not hold. There are also differences to be expected in the size of the participation and indirect growth effects across states depending not only on the share of the sector but also on the structure of the economy.

Impact of Agriculture on Employment

On employment front, contrary to the belief, agriculture, construction and trade sectors displaced more workers and might also result in increase in rural poverty. But the indirect effects of manufacturing, transport and public administration are substantial and more effective in reducing rural poverty. The financial sector is found to be highly negatively related with agriculture. The observed inverse relation may be due to collapse of rural cooperative banks and its inability to absorb additional employment, as the sector is highly skill oriented. Therefore, the results may indicate that, **though the non-agriculture sector growth in employment is marginal, its impact on poverty reduction is substantial.**

Reviewing the evidence on the growth contributions of agriculture and the non-agricultural sector on rural progress, it emerges that non-agriculture sector is more important in reducing rural poverty. The rising income disparity between agriculture and non-agriculture households seems to be the main cause of rural distress. This probably implies that, the increased focus on agriculture although improve rural employment and reduces underemployment, such steps will also widen the gap of agriculture and non-agriculture divide. This calls for creating more and more non-agriculture jobs for rural growth.

The evidence from the cross-state regressions indicates that the effect of agriculture on fostering growth and participation may not be relevant. In addition, both the micro and the cross-state evidence indicate that growth linkage effects from agriculture to non-agriculture appear to be large. In sum, while the direct growth contribution of agriculture is on average likely to be smaller, this is often likely to be compensated by its contribution to non-agriculture growth through the linkage effects.

Pro-poor growth requires both agricultural development and growth in the non-agriculture sector because the poorest people are most likely to depend on rural non-farm income earned in restricted local markets. Demand within these markets and therefore income for the poor will only increase following an increase in agricultural incomes. There is a need to ensure that the poor have access to safe and affordable energy supplies, a wide range of financial services and savings, credit and insurance products.

To sustain poverty reduction, the government must return to reforms aimed at generating non-farm job opportunities for the rural poor. No high-income nation today employs even 10 per cent of its labour against more than 50 per cent in India in agriculture. An essential element in modernization is the creation of conditions that lead the vast majority of the rural population to migrate out of agriculture into industry and services including food processing. It is only through a large reduction in the labour to land ratio that farmers will be able to achieve the standard of living comparable to those available in industry and services. **However, this paper does not undermine the importance of agriculture in any way, as agriculture continues to be an important driver of macroeconomic behavior of our country. Adequate food production and broader base of income generation are necessary to support non-agriculture from the demand side.**

[1] *The findings, interpretations, and conclusions expressed in this paper are entirely that of the authors. They do not necessarily represent the view of Government of India or the organization they represent.*

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2. Infrastructural Statistics

Saroja Rama Rao

Introduction

India has a large agrarian economy with most of its rural population subsisting on farming. Over the decades since independence, Government made concerted efforts to improve the situation of the farmers. Nearly 95% of the farm land has been used for cultivation, only about 4% has been used for Orchards & Plantation. It contributes nearly 25 – 30% of Andhra Pradesh's Gross Domestic Product (GDP). It provides employment to around 80% of the total work force in the rural Andhra Pradesh. The annual decadal growth rate of work force for the consecutive periods from Agriculture including allied sectors declined from agriculture including allied sectors declined from 3.18% to 0.61% during the Population Census period 1981 to 2001. This reflects the impact of severe drought during the periods.

Cropping Pattern

There has been substantial change in cropping pattern, the farmers have moved from traditional cereals to cash crops and hence the risk of crop loss increased due to higher proportion of purchased inputs and developed technology. During 1954-55 the percentage of area under total cereals to Gross cropped area was 64.12% and to has come down to 35.65% during the year 2006-07. One of the striking features of changes in cropping pattern is that over a period of time Ananthapur district has almost become a mono crop district hence it transformed the socio-economic life of the people. Further, there is a decline in the farm harvest prices and increase in cost of cultivation causing indebtedness of the farmers.

Cost of Cultivation

The Groundnut crop is predominantly sown in Anantapur, Chittoor and Kadapah districts and the yield shows it is very less and there by huge loss incurred by the farmers. On an average the farmers were spending Rs.34995/- on Chillies and Rs.16616 on Cotton per hectare for cultivation, on other hand the yield per hectare is not increasing and prices were stagnated. In A.P. 80% of the farmer households were procuring seed through farm saved and 47% through purchase. The contribution of Agriculture sector in the State Income is given below.

The per capita income shows steady increase because of constant growth in the population, but when we examine the contribution part it is highly fluctuating around 25-30%. There was a continuous drought during the period 1999-00 to 2007-08 in the State except 2000-01 and standing crops were affected due to prolonged dry spells during the months of July and August. The relative decline is not necessarily due to collapse in Agricultural Production but due to downward trend in farm harvest prices also. Nearly ¼ of the State Income is accrued from Agricultural Sector.

Cropping intensity is one of the indices for assessing the efficiency of agriculture sector. He cropping intensity i.e., the ratio of gross area sown to net area sown is 1.26 in 2007-08 against 1.24 during 2005-06. The level of cropping intensity moves in consonance with the behaviour of monsoon and availability of water. The total food-grains in Andhra Pradesh has reached an all time high of 198 lakh tonnes. This was made possible due to effective management of Agriculture Sector.

Levels of Indebtedness

Until recently, there was no concrete study that would provide some estimates of the actual extent of rural indebtedness. In order to study the state of the Indian farmers, the Union Ministry of Agriculture intended to conduct a comprehensive Socio-Economic study of Indian farmers covering educational level, levels of living, farming practices, possession of productive assets, resources availability, indebtedness etc. Subsequently, the National Sample Survey Organisation (NSSO) conducted the Situation Assessment Survey of Farmers during the year 2003 in the rural areas as part of NSS 59th round.

- The indebtedness is one of the major factors for agrarian distress in the state and it is worth noting that the States where the agrarian distress was reported to be severe, there the incidence of indebtedness was also high.
- In Andhra Pradesh the indebtedness among the farmers households was recorded as high as 82.02% which is highest among 15 Major States.
- The indebtedness was recorded lowest in Assam (18%) State.
- Barring 4 States (Assam, Bihar, Orissa and Uttar Pradesh) among 15 Major States, all other 11 States recorded indebtedness more than the Nation average (48.60%)
- The prevalence rate of indebtedness among different social groups in Andhra Pradesh was highest compare to All India.

Source of Income

In Andhra Pradesh major source of income was from cultivation and average monthly per capita income was Rs.743 as per 'Situation Assessment Survey of Farmers conducted during the year 2003 by NSSO. The other sources of income were from Wages, Farming of Animals and Non-farm business.

Consumption Behavior

- Average House hold size in Rural Andhra Pradesh was 4.7 at All India it was 5.5
- In Andhra Pradesh average monthly per capita consumption expenditure in rural sector was Rs.603.82 as per NSS 61st round.

- Out of Rs.603.82, Rs.323.15 (53.50%) was spent on Food items and remaining Rs.280.67 (46.5%) was spent on Non-food items and nearly Rs.23.13 (3.83%) was spent on Education and Rs.47.07 (7.80%) on Medical.
- Further, about 25% of the rural population was spending Monthly Per Capita Expenditure less than Rs.365 and 8% spending MPCE less than Rs.270.
- The State specific poverty line of Andhra Pradesh in 2004-05 was Rs.292.95 per capita per month.
- As per this norm nearly 11.20% of rural population was below poverty line as per 61st round of NSS Consumption Expenditure.

The number of households reporting cash loans outstanding in Andhra Pradesh is highest (423 households per 1000 households) among 15 major states. At all India the number of households reporting cash loans outstanding in 265 per 1000 hrs. The average amount outstanding per hhs. Is highest in Kerala (Rs.19663). In Andhra Pradesh the average amount outstanding per hhs. Is Rs.10590.

Conclusion

The State Government has taken up new initiatives for the welfare of the Farming community notably the introduction of the programmes like POLAMBADI, RYTU CHAITANYA YATRAS to mention a few. Recently the Central Government have announced the loan waiver of small and marginal farmers in the Country. As per this scheme a total number of 63.41 lakh farmers have been benefited in the State, the loan waiver being Rs.11354 Crores. The State Government also set up Agricultural Technology Mission under the Chairmanship of Hon'ble Chief Minister of Andhra Pradesh. This mission undertakes research activities for the development of Farm sectors so also to alleviate the distress of agriculturalists.

Directorate of Economics & Statistics, A.P., Hyderabad

3. Statistical Profile of Minor Irrigation in India

A.K. Srivastava

India has a history of progressive irrigated agriculture. It is among the foremost countries in the world practicing large scale irrigation through development of its water resources for irrigation, generation of hydropower and providing domestic water supply. Irrigated agriculture is fundamental to Indian economy, particularly, from poverty alleviation point of view. Irrigation is a primary input to agriculture production and Minor Irrigation schemes are more popular in the country specially due to small fragmented holdings.

Minor Irrigation sector comprises of Surface and Ground water schemes viz. tanks, ponds, diversion wiers, lift irrigation schemes, wells and tube wells etc., spread over the entire country and its rural environment Minor irrigation sector as a whole is formulated, planned, investigated and implemented by the State Governments and Union Territories. However, the Government of India is assigned the task of policy planning design and development of the sector.

The status of the Minor Irrigation in India as revealed through Quinqunnial Minor Irrigation Census conducted by Ministry of Water Resources is highlighted in this paper. Number of schemes and irrigation potential created and utilized by them, utilization status of the scheme, water distribution system adopted and season wise irrigation by them are most important features analysed in the paper.

As per the third Minor Irrigation Census the number of Minor Irrigation Schemes in the Country in 2000-01 was 19.7 Million, of which 18.5 Million were Ground Water Schemes (GW) and 1.2 Million were Surface Water Schemes (SW). Further 62.4 million hectare (mha) of Irrigation Potential is created through Ground Water Schemes & 11.9 mha through Surface water schemes. 72% of the Potential created in GW is utilised while the percentage utilisation in respect of SW is 58%.

A good number of MI Schemes after construction go out of use due to one or other reason causing loss of irrigation potential that these schemes would have provided. The census reveals that around 11% schemes were not in use during reference year, of which 4% were permanently out of use and 7% were temporarily out of use. As a result around 8% of created Irrigation Potential was lost. Under utilization of schemes due to constraints also has been a cause of concern. Out of 17.5 Million "in Use" schemes, 7% are under utilised due to inadequate power, 29% due to Less water discharge and 64% scheme are under utilised due to other reasons such as mechanical breakdown, channel breakdown and siltation.

Study has been undertaken to analyse the utlisation of irrigation potential of MI Schemes during different crop season. The Census data reveals that although the Irrigation potential created for Rabi is more, the utilisation of irrigation potential has been more in Kharif (65%) as compared to Rabi (62%).

Data has been collected through the Census regarding the device being used in MI Projects for distribution of water in the field. Four specific devices are sprinkler, Drip irrigation, open channel and underground channel. It has been noted that micro irrigation system like drip and sprinkler systems have not yet gained popularity in most of the States.

Tanks and ponds are important source of irrigation through surface water. Out of 5.56 lakh Tank enumerated in the census, 4.71 lakh were in use. Remaining 0.85 lakh Tanks were not in use due to one reason or the other. Due to non-use of the tanks, nearly 1 million ha. of Irrigation potential is lost. Another around 2 million ha. of potential is lost due to under utilisation of tanks.

For optimum development and efficient utilization of water resources in irrigation, it is necessary to address few important issues as under

a) Bridge the gap between irrigation potential created and utilized,

b) Restoration of existing tank irrigation system,

c) Integrated development of surface and ground water resources,

d) Participatory irrigation management through Water User Association,

e) Improve irrigation efficiency by use of sprinkler and drip irrigation,

f) Pricing of water to cover cost of operation and maintenance of storage and distribution system.

Ministry of Water Resources, Government of India, New Delhi

4. Agriculture from the Perspective of GDP Estimates

Ramesh Kolli

The importance of agriculture to Indian economy has been quantified extensively by researchers and users of data over the years. Agriculture (including livestock, forestry and fishing) sector has a dominating presence in the Indian Economy, despite its direct contribution reducing over the years (at current prices), from 52.3 per cent in 1950-51 to 17.5 per cent in 2006-07. This sector contributed as much as Rs. 5,95,058 crore to the gross domestic product (GDP) of the country, at current prices in 2005-06, while its value of output in the same year was Rs. 7,68,075 crore. The total exports of agricultural and allied products during 2006-07 was Rs. 56,628 crore, accounting for 7.4 per cent of total value of output. The contribution of agricultural and allied products to exports during 2006-07 accounted for over 9.9 per cent of total exports of the country. As per the NSSO's Labour Force Survey, 2004-05, about 72.7 per cent of the rural workforce and 62 per cent of rural households are dependant on agricultural activities. Among the workers (rural and urban combined), according to both principal and subsidiary status, as many as 23.9 crores or 58.5 per cent are working in the agriculture sector. According to the Economic Census, 2005 about 6.44 million enterprises (15.3 per cent) were engaged in agricultural activities. Besides this direct contribution, the sector has a multiplier effect on the performance of secondary and services activities like manufacturing, trade, hotels & restaurants, transport and other services. A good agriculture year boosts up the economy from the demand side with increasing rural incomes resulting in higher demand for industrial goods and services.

There are interesting features within the agriculture sector that emerge while analysing the data available from the national accounts statistics. The contribution of traditional subsistence crops like rice, wheat, coarse cereals and pulses has been declining in the overall value of output of the sector. On the other hand, important commercial crops like oilseeds, fibres and fruits and vegetables and animal husbandry are steadily increasing their share in the agriculture sector. The share of livestock products has increased from 25.3 per cent in 1999-2000 to 27.2 per cent in 2005-06, indicating the growing importance of livestock sector to supplement rural incomes. Complementing this, the share of crop-husbandry is steadily declining. However, within the crop-husbandry, the emerging crops in terms of increasing contribution to the value of output of agriculture sector have been the oilseeds, fibres, and fruits and vegetables, with the share of oilseeds increasing from 7.5 per cent in 1999-2000 to 9.5 per cent in 2005-06, fibres from 3.5 per cent to 4.0 per cent and fruits and vegetables from 22.5 per cent to 25.6 per cent during this period. As against this, the traditional foodgrain crops' contribution has declined from 35.0 per cent in 1999-2000 to 30.2 per cent in 2005-06 in the case of cereals; and from 4.7 per cent in 1999-2000 to 4.4 per cent in 2005-06, in the case of pulses.

In terms of exports within the agriculture and allied products, the share of items cotton, fruits and vegetables and processed fruits, etc., sugar, meat and other allied products has increased steadily during the last few years. Between 1997-98 and 2006-07, share of cotton has risen from 3.3 per cent to 10.8 per cent, fruits and vegetables and processed fruits from 5.0 per cent to 8.5 per cent, sugar from 1.0 per cent to 5.6 per cent, meat products from 3.3 per cent to 5.7 per cent and other products from 11.2 per cent to 13.4 per cent. At the same time, it should be noted that share of agriculture and allied items in the total exports has steadily declined from 18.9 per cent in 1997-98 to 9.9 per cent in 2006-07. This, however, is in line with the declining share of agriculture in the overall GDP of the country, due to the much higher growth of other sectors of the economy.

For increasing the rural incomes, prices of agricultural commodities play an important role, besides the availability of marketing facilities. It has been generally noted from the data on wholesale price index (WPI) from 1999-2000, that prices of agricultural commodities (in terms of primary commodities) have risen relatively lower than that of the general index of WPI, with the exception of 2005-06 and 2006-07. The recent spurt in WPI of primary commodities, vis-à-vis, that of the general index of WPI should be noted in the context of studying the trends in rural incomes.

Another important contributing factor to increasing rural incomes is the public investment in agriculture. The data on public investment in agriculture shows a significant spurt in the recent years, particularly after 2002-03. Public investment in agriculture has risen from Rs. 7,716 crore in 1999-2000 to Rs. 10,591 crore in 2003-04 and Rs. 17,125 crore in 2005-06. This increases in public investment in agriculture sector in the recent years has enabled the rate of public investment in agriculture to go up from 0.4 per cent of GDP in 1999-2000 to 0.5 per cent of GDP in 2005-06.

The national accounts statistics produced by the Central Statistical Organisation (CSO) provide a mass of disaggregated data on agriculture sector, both at crop-level and at state-level. This includes value of output at current and at a pre-determined constant year prices, value of inputs, implicit price indices, investment (separately by public sector, private corporate sector and household sector), and consumption expenditure. A thorough analysis of these data would enable identifying the areas of concern, emerging important cash crops, trends in prices across the crops and states, in the context of increasing rural incomes. Besides these, extensive data is available on credit extended to agriculture sector from the Reserve Bank of India, which is of considerable relevance while studying rural distress.

Central Statistical Organisation, New Delhi

5. Quantitative assessment of agrarian distress – Issues on data availability *

Rajiv Mehta

Background

Ever since the onset of Green Revolution in early seventies, the agricultural sector has not only gained the strength to provide self-sufficiency in foodgrains but also imbibed entrepreneurial dynamism in farming. Besides anchoring the food and nutrition security, the sector continued to be the prime source of livelihood for about two third of country's population and established stronger linkages with other sectors as supplier of inputs and consumption of output. Its development assumed significance for the overall growth of economy. In this process, Indian agriculture has gradually transformed from conventional to modernised methods of cultivation. The cropping pattern also shelved its rigidities and gradually turned to the market forces. The changes in economic environment started percolating in the farming sector. However, the performance of agricultural sector in the recent decade has been less inspiring as compared to the era of successful green revolution and since the late nineties; the agricultural growth has decelerated sharply. The economic resurgence experienced, after the reforms initiated in early nineties, is perceived to be bypassing a large segments of population in the rural areas and the hinterland of the economy. The distress in agriculture is now seen to be not confined only to the small and marginal farmers but is affecting across the size classes in agrarian economy. The quantitative assessment of such agrarian phenomenon in time and space therefore becomes necessary for planning, policy formulation and their implementation.

Issues on Agrarian Distress

The statistics and indicators relating to agriculture sector have been of immense and vital utility to assess the performance. Based on these derivatives, the sluggishness of the growth in agriculture is quantitatively inferred. However, it is equally important to synthesise the issue of distress in agriculture, which is beyond the decelerated growth of agricultural production. It also relates to disparities in the economic conditions of the people engaged with agriculture, sustainability of agriculture, response of the sector to inputs, resource use efficiency and eventually the profitability and competitiveness of farming. These issues have assumed particular significance in the context of reports of farmers' suicides in certain parts of the country.

In the preparation of 11^{th} Plan strategies for development of agriculture and allied sector, addressing the social and economic dimension of farming has been one of the core agenda. The central theme of the 11^{th} Plan approach paper is to restructure policies for achieving accelerated, broad based and inclusive growth. The objective is at faster reduction in poverty and to bridge the divide in the economic conditions of different segments of population. In the context of the 11^{th} Plan vision of achieving 9 per cent overall annual economic growth, it has been envisaged that agriculture and allied sector should grow at 4.1% per annum during the plan period.

In this process it was recognized that the lower growth rates of agriculture is a fallout of more frequent aberrations in agro-climatic conditions, stagnation in irrigated area, inadequate response of cropping intensity in irrigated agriculture, weakening production response to inputs and inadequate availability of inputs and to a large extent inefficient systems of post-harvesting and marketing arrangements. Briefly, the factors responsible for lower agricultural growth in the recent decade relate to stressed natural endowments such as land and water, capital stock depletion and inadequate investment supplementation, decline in the production response to the application of various inputs, declining resource use efficiency, persisting technology gap and knowledge deficit in agriculture and inadequacies in the institutional support for research, extension, credit, marketing and risk mitigation. The higher growth would be possible either through expansion in area under cultivation or improvement in yield or the combination of both. In this regard, soil health, irrigation, seeds, fertilizers and mechanization are the key factors to improve the yield levels. To actualize such end to end objective, the important Growth drivers are identified as area expansion, yield improvement (soil health and nutrient management, water management, seed management and farm mechanization), animal husbandry, fisheries, institutional support (extension, credit, marketing and post- harvest management and risk management and programmatic interventions. Besides, improvement in farmers' income would in-turn play a catalyst in further enhancing production efficiency and response. Therefore, it would be imperative to create non farm employment opportunities for the farm households for improving the income and on-farm investment capabilities. Further, the agro processing sector has the tremendous potential for non - farm employment generation in a highly dispersed manner, which needs to be tapped.

Quantitative Measures of Agrarian Distress

The planning and development of agriculture sector are being placed in harmony to such envisaged dynamics of agriculture sector. This endeavour has been necessitating reliable and timely availability of statistics on various facets of agriculture and the Indian agricultural statistics system to modulate and reorient to the emerging needs of planning and decision making. It is imperative to take stock of availability of statistics and the gaps therein to meet the emerging needs of planning and decision making, addressing the issue of agrarian distress.

The existing profile of agricultural statistics is primarily capturing three dimensions of agrarian domain. Firstly, the domain of natural endowments such as land, water and agro-climatic conditions that has been harbouring the production space for a large range of agricultural commodities in the farm, animal husbandry and fisheries sub-sector. The second dimension relates to the output of these segments. This inter-alia relates to the statistics on allocated production resources such as land, livestocks, water-bodies etc., inputs and infrastructure and quantum of produce. While Land Use Statistics (LUS) is a comprehensive and systematic account of natural endowment of land, spanning over 328 million hectare of geographic space of the country, crop statistics assimilates the diverse agro climatically influenced crop acreage and production details of numerous crops, grown over 141 million net sown area with about 135 percent cropping intensity. The strength to this elaborate statistical system, is its being well integrated on geographical and administrative hierarchy. Over the years, the statistics on livestocks, poultry and fisheries are being strengthened as these sub sectors have emerged as the faster growing segments of agrarian economy. These statistics in turn facilitate derivation of various indicators of productivity and growth which are crucial for measuring the performance of agriculture over time and space.

Third dimension relates to socio-economic and institutional aspects such as distribution of production assets among the population e.g. land holding, farm returns, income prices, access to institutional support. The Agriculture Census and the Livestock Census are two important sources of statistics on distribution and ownership of assets in agriculture. The socio economic surveys conducted by National Sample Survey Organisation are providing several important statistical indicators on consumption, nutrition, labour force participation assets, debt and investment etc. Quantitative assessment of agrarian distress also requires regionally and sectorally disaggregated data layers on demographic and income parameters. One of the major causes of accentuating agrarian distress is the coexistence of demographic rigidity of rural population with shrinking share of agriculture in the economy. The economic condition of farmers is also influenced by the costing of production, market access and price realisation, the quantitative parameters, for which data need to be sourced from various sources and often specific data required for this purpose is not available and proxy indicators have to be worked out.

No doubt, the complexities involved in any system are on account of the diversities prevailing in the domain and the dimensions of its coverage and both these attributes abundantly exist in the agrarian economy of India. This complexity in-turn reflects on the data system as well, which is coming under severe pressure of data demand, accuracy, timeliness and desegregation. With the diversification of agriculture, several commodities and their value added products have become important, particularly the horticulture crops, and existing system of agriculture statistics does not capture these details comprehensively. Synthesis of issues such as livelihood security associated with agrarian distress, liberalization, dynamics of competitiveness, market linked development, equity, resource allocations, sustainability etc are occupying focused concerns of all those associated with the sector of agriculture. Hence there is a need to re-invigorate the agricultural statistics system in to rural statistical system, encompassing statistics on inputs, production, factors of production, value addition, rural infrastructure, market and trade and addressing the gray areas of measuring competitiveness, statistics on niche products, capital formation in and for agriculture, monitoring domestic supply and demand vis a vis global situation and linkages of farm and non farm activities in rural areas, so that the system can play a more effective role in planning and decision making.

Ministry of Agriculture, Govt. of India, New Delhi

[*] *Views Expressed are of the author.*

6. Some Observations on Factors Affecting Agrarian Distress in India and Combating Strategies

B.C. Barah

Agriculture is under distress and there seems silent but widespread unrest among the farmers. The gap between growing expectation or aspiration of the farmers and shrinking achievement causes frustration and distress. Hence, managing expectation and achievement is a challenge. Among the prominent supply side factors affecting the agricultural sector include the declining factor productivity and degradation of soil and water resources due to intensive agriculture. The externality of falling farm income as well as non farm income, as the system fail to absorb the rapidly growing pool of manpower, have resulted to shrinking overall household incomes. At the macro scale, notwithstanding high growth potential, vast bypassed rainfed areas are deprived of technology penetration and adequate policy attention. The poor performance in agriculture in the rainfed areas increased the incidence of poverty in high, land and low and uncertain factor productivity, besides exacerbating regional disparity. Ironically, rural distress is allegedly manifested in farmer suicides, which is attributed to debt trap and crop failure in the common parlor. Increase in the incidence of farmers' suicides in recent years is a reality, which cannot be brushed aside as an event associated with drought or other natural disasters. Consequently agrarian crisis and rural distress has emerged a nation wide phenomenon and a leading policy issue. A high proportion of agricultural indebtedness is observed i.e. nearly 58 per cent of the farmer respondents in Karnataka felt lack of social support (feeling of "left alone to face the problem"), is a major cause of distress where 61.6 percent of total farmers are indebted. The reason may partly be due to technology and often due to risk of unforeseen climate change and natural calamities.

Poor growth performance could be attributed to technology stagnancy, unfavourable terms of trade and the declining profitability of agriculture. These factors have increased farmers' indebtedness, which is allegedly the *raison d*e'etre of the farmer's suicides. The net farm returns have declined drastically, while the cost of production has grown faster than the value of output. Under the circumstances, whether the crisis is endogenous (technology/natural) or exogenous (policy, socio-cultural, etc.) to the sector, is a subject of intense investigation. While cost reduction is the main plank in addressing the viability of agriculture, but the major cost component is the labour costs, which distorts overall cost management. The overall key question is whether the crisis is driven by failure of agricultural technology to generate additional income and employment or lack of alternative opportunities and strategy for appropriate interventions.

Agrarian Distress: Causes and Intensity

- The cycle of intermittent agricultural growth has weakened welfare of vulnerable sections and making them increasingly sensitive to the slightest economic shocks. Advent of WTO, GM varieties, collapse of output price, spurious seeds, farmers' indebtedness and rapidly increasing cost of production have further worsened the situation. In the factor market, the farmers silently pay the prices dictated by the suppliers, while, in the product market, they are mute receiver of prices determined by market operators. While, in the production side, multiplicity of the factors of market, weather and systemic flawed credit delivery system are predominant. The solution thus lies on precautionary steps to prevent further eruption.

- Among the factors attributed to the deceleration in agriculture growth and poor access to irrigation infrastructure, are the prominent amongst others. Small farmers who are left with very negligible surpluses of their own to invest in their farms lead to under investment and deep debt trap. Growing indebtedness is a critical malaise, which is wide spread among the farming community and increased the probability of suicides. Rice is a major crop, but its performance has been dismal in majority of the growing areas. Having climbed the peak during the 1980s, the growth of rice productivity has decelerated rapidly since the early 1990s, which is a worrisome factor. Cost of cultivation has increased faster than the value of output. Rapid increase in cost in one hand, the un-remunerative output prices in other hand, resulted to erosion of farmer's profit margins. Moreover, changing tariffs policy on commodities like cotton, spices and edible oil under trade liberalization has destabilized production of several crops, caused serious crisis to the farming community. The farmers who are at disadvantage due to unequal access to production inputs, face extreme variation in productivity of major crops of rice, sugarcane, groundnut and cotton and others. The most striking features of the variation of profitability are large inter-regional differences in cost of cultivation, yield and gross income. The profitability varies from very low in some states and even negative in Orissa, West Bengal and Madhya Pradesh, while it is positive in Punjab and Haryana and few southern states. Analysis shows that the most areas lacking favorable infrastructure facility has emerged as distress hotspot. Extreme vulnerability to vagaries of natural calamities such as drought, floods, submergence cyclone, earth quick, and other biotic and abiotic stresses have been the distress inducing factors. The perpetuation of stresses have made agriculture riskier and output uncertain. Risk is particularly important to small farmers in unfavourable production conditions, whose primary production activity mostly revolve around meeting the household food need. Interestingly the nature and significance of risk has also changed even in resource-endowed areas both in intensity as well as spread. It is evident from the analysis that number of districts having larger yield risk was 70 in 1980s, which increased to 127 in the 1990s, price risk is also systematically spreading to more districts. The distressing trend among the ever-growing small and marginal farmers, which currently stood at 80%, is a disturbing signal at the policy circle. The group also suffers from discriminatory access to production inputs such as land, irrigation, agricultural credit and poor technology penetration. Therefore, in order to reduce inter-regional and inter-household differences in farm profitability significantly, policy focus should be tilted towards development of irrigation infrastructure, access to institutional credit, supply of inputs, adoption of technologies particularly use of high yielding variety seeds, development of market infrastructure and adequate price supports should be provided particularly in the backward regions. More careful interventions are required to create space for opportunities in rural areas for the small and marginal farmers. The reforms in agricultural sectors such as amendments in APMC act, emergence of retail chains, aggressive policy on agro-processing, innovation in credit delivery systems, crop diversification, which are underway, also required to be understood in proper perspective. The strategies to harness opportunities have to be backed by adequate agricultural R&D solutions in agriculture. With the changing environment and supply side constraints, agriculture has become more knowledge and capital intensive. The role of ICT seems more meaningful to provide generic information and empower farmers with scientific know-how and information on markets and prices. Otherwise, the goal of achieving 4% agricultural growth in the next five yeas will remain unfulfilled.

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Proceedings of the Symposium on "Statistical Aspects of Research in Agricultural and Environmental Sciences Status and Scope"

Chairman : Dr. V.K. Gupta
Convenors : Dr. Prajneshu
Prof. N.C. Das

Six papers covering various aspects related with the theme of the symposium were presented by the following speakers :

1. Statistical Aspects of Design and Analysis in Agricultural Engineering Research — Dilip Kumar Swain and Bimal Chandra Mal
2. Statistical Aspects of Research in Animal Sciences : Status and Scope — B. Singh
3. Small Area Estimation in Agriculture – Some Applications — U.C. Sud
4. Nonlinear Statistical Model for Characterizing-cum Growth of Bamboos — Gitasree Das, Arun Jyoti Nath, Subrata Nandy and Ashesh Kumar Das
5. Structural Time Series Modelling: Status and Scope — S. Ravichandran
6. Statistical Aspects related to the Registration of Plant Varieties in India — R.C. Agrawal
7. Model-based Inference in Finite Population Sampling Theory — B.V.S. Sisodia
8. Econometric Approach of Estimation of Technical Efficiency of Fish Culture Farms — A.K. Roy

The following recommendation emerged out based on the discussions during the symposium:

- The main emphasis was on discussing current status and scope of various areas of Agricultural Statistics, like Sample Surveys, Design of Experiments and Statistical Methodology to solving important research problems in various branches of Agricultural and Environmental Sciences.

ABSTRACTS OF THE PAPERS PRESENTED

1. Statistical Aspects of Design and Analysis in Agricultural Engineering Research

Dillip Kumar Swain and Bimal Chandra Mal

Statistics, as an essential tool for engineering and sciences research, has been greatly affected by the fields with which it interacts. Statistical intervention has improved the management of the natural resources such as agriculture, fishery, forestry, wild life, etc. The common features of statistical approach that takes agricultural engineering research beyond the traditional are: problem focused, management, system based and integrative. The research aims to solve the problems that are well defined with clear geographical boundary. Specific objectives are retained in the research to enable effective design of the study and analysis of the resulting data. The research usually aims to understand the impacts of changing resource management, and also to bring about improvements through statistical analysis. In Agricultural system, the key questions to be answered are generally expressed as a statement of hypothesis, which are usually suggested by past experience, observations, and at times by theoretical considerations. The hypothesis has to be verified or disproved through experimentation. The statistical design and analysis of some experiments of agricultural engineering research are discussed in this paper.

Selection of rice variety and evaluation of the crop management practices were the objectives to increase the rice production in non-water stressed rice-growing areas in Asia during the wet season (Swain *et al.* 2007).

Statistical analysis and crop simulation model were used for selection of rice variety and appropriate nutrient management strategy. A field experiment was conducted with 12 popular rice verities and varying N levels in a split-plot design, where varieties were in the main plot and N levels in sub-plots of the design. Grain yields and time series growth parameter data collected from the experiment were analyzed as per the design. Grain yield of these varieties was simulated at varying N levels using ORYZA 1N model. A paired 't' test confirmed that simulated grain yield of the varieties were in close approximation with the observed values under changing N levels. The rank order of each variety was determined from simulated and observed grain yield at optimum N application level (80 kg N/ha). Duncan's Multiple Range Test (DMRT) was used to find the values, which were significantly different. Through the DMRT, the rice variety Ranjit was selected. Optimum N level of 80 kg/ha was recommended through the statistical analysis of grain yield. The variety Ranjit with 80 kg N/ha application was recommended as the developed technology for rainfed non- water stressed regions. The performance of the technology (variety: Ranjit, and N level: 80 kg/ ha) was evaluated against farmers' practice (variety: Swarna, and N level: 40 kg/ha) in a Technology Verification Trial conducted in 2^3 factorial experiment design. The Technology verification trials of this practice produced 5.51 Mg ha^{-1} of rice, compared with 4.36 Mg ha^{-1} grown with the conventional practices of farmers.

Several researchers used statistical methods to evaluate the performance of crop simulation models. Jones and Kiniry (1986) used means and standard deviations for observed and simulated data, and linear regression parameters such as intercept (α), slope (β), and coefficient of determination (R^2). However, Thornton and Hansen (1996) concluded that use of the F-test (to test the null hypothesis that the regression line has unit slope and an intercept of zero) could be severely misleading. Willmott (1982) and Willmott *et al*. (1985) recommended the use of root mean square error (RMSE), and D-index (index of agreement), but suggested that RMSE is the best measure as it summarizes the mean difference in the units of observed and predicted values. The D-index is a descriptive measure, and can be applied to make cross-comparisons between models. Kobayashi and Salam (2000) used mean squared deviation (MSD), but concluded that root mean square deviation (RMSD) is probably more intuitive than MSD because the deviation is expressed on a relative basis against observations.

Timsina and Humphreys (2006) evaluated the performance of crop simulation model CERES-Rice and CERES-Wheat in rice-wheat system using statistical analysis. CERES-Rice predicted anthesis and maturity dates of rice fairly well with a low RMSE of 4-5% and high D-index of 0.94-0.95, but grain and biomass yield were more variable (RMSE = 23% for both; D-index 0.90 and 0.76, for grain and biomass, respectively). Similarly CERES-Wheat predicted the anthesis and maturity dates quite well (RMSE = 4–5%; D-index = 0.94–0.99), and grain and biomass yield reasonably well (RMSE =13-16%, and D-index = 0.86-0.97).

Designing of an efficient irrigation system requires information on infiltration characteristics of a soil, which is vital for both irrigated and rainfed agriculture. Infiltration was modeled and spatial variability of infiltration was analysed in a wasteland of Kharagpur, West Bengal, India (Machiwal *et al*. 2006). A total of 24 infiltration tests were conducted on a systematic squared grid pattern over the study area using double-ring infiltrometers. The observed infiltration data from all the test sites were fitted to four selected infiltration models and a best-fit model for individual sites was identified through statistical analysis. Based on the results of this study, it was concluded that the study area has wide spatial variability. Hydraulic parameters optimization techniques for production wells were compared using RMSE (Jha *et al.* 2004). Conventionally graphical step-drawdown test data analysis was compared with non-conventional optimization technique called Genetic Algorithm (GA) for the hydraulic parameters such as well loss coefficient and aquifer loss coefficient. It was revealed that the GA technique yielded more reliable well parameters with significantly low values of RMSE.

Agricultural systems and simulation analysis can be used to integrate the knowledge of bio-physical processes governing the soil-plant-atmosphere system to evaluate the production uncertainties associated with various management options. Statistical analysis coupled with simulation models predicts precise use of inputs i.e. water, nutrient, etc and evaluates management options for sustainability of food production in various agro-ecosystem which leads to precision agriculture.

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2. Statistical Aspects of Research in Animal Sciences: Status and Scope

B. Singh

The main statistical aspects of research in animal sciences are development and applications of experimental designs, methods of data analysis, linear models, sampling methodology, discriminant analysis, and fitting and predictive models for estimation and analysis of data in addition to creation of databases related to livestock statistics. Many advanced statistical techniques have been developed but they have not been used to the desired extent. There is enough scope for application of advanced statistical methodologies in various disciplines of animal sciences. Statistical methodologies and their aspects of research in animal sciences are reviewed and their status and scope are examined.

Designs and Analysis of Experiments

Three aspects of animal research, reduction of animal numbers, refinement of statistical methods and replacement of animals by non-animal alternatives (statistical designs and methods of analysis), should be considered while designing the animal experiment. CRD and RBD, the commonly used designs in animal experiments, are quite simple and robust. LSD is used to control the variation in two variables. The small order Latin squares have few degrees of freedom for error which can be increased by using repeated Latin squares. Factorial designs are used to evaluate two or more factors, simultaneously. The main advantage of factorial designs is the detection of interactions. The incomplete block designs are not frequently used in animal experiments.

To reduce the number of animals and the error variation the same experimental unit may be used for different treatments in different periods. Such designs are known by different names such as cross-over, change-over or switch-over designs. The disadvantage of such designs is the residual effects. One way to get rid of residual effects is the use of sufficient washout period which is not always possible due to limited time period. So the provisions should be made to estimate direct and residual effects, separately. The changeover designs balanced for first residual effects and with number of periods less than number of treatments has been introduced. The direct and residual effects of treatments can not be independently estimated in such designs except when an extra period is added to the basic design.

In many animal experiments the response variable is measured on the same animal under same treatment across occasions. Such observations will usually be correlated. A commonly used method for analysis of repeated measures designs is to compare treatment groups at each time point, separately. The other approach is to use summary measures. These approaches do not provide tests for time-point and interaction effects. The repeated measures ANOVA (RANOVA) provides tests for time points and interaction in addition to treatment effects. This method is valid under compound symmetry (CS) of covariance matrix. An approximate test may be carried out by adjusting degrees of freedom of mean squares by epsilon based on covariance matrix when CS condition does not hold. An alternative is to use multivariate approach that can not be applied in case of missing data. RANOVA for incomplete measurements has been provided by Singh (1997). The mixed model methodology analyzes such data correctly and efficiently. The results of RANOVA and mixed model methodology are very similar under CS and they differ only because of the incomplete data.

Most commonly used method for analysis of categorical data is chi-square method. The other method is to assign consecutive integer values to categories and then use ANOVA method. Recent methods include weighted least squares (WLS), generalized linear models and CATANOVA. The WLS methodology may be inefficient for small frequencies and can not be used with continuous covariates.

LSD and DMRT tests are too liberal and Tukey's and Bonferroni tests are conservative for multiple comparisons. Dunnett test is used for comparison of each treatment with control.

Applications of Linear Models

In fixed effects models, the method of least squares provides unbiased estimates of parameters. In mixed models the generalized least squares (GLS) estimator is best linear unbiased estimator for fixed effects when covariance matrix is known and it is unbiased in case of unknown covariance matrix for a wide class of variance components estimators.

Hofer (1998) gives a brief outline of the prediction of breeding values when variance components are known and discusses the consequences of using their estimates. The empirical BLUP, using estimates of variance components from a wide class of variance components estimators leads to unbiased predictors. The fixed and random effects parameters can also be estimated simultaneously by using the Henderson's mixed model equations.

For balanced data, ANOVA estimators of variance components are minimum variance quadratic unbiased and minimum variance unbiased under normality. For unbalanced data Henderson's methods are commonly used. The ML estimation has attractive large sample properties such as asymptotically unbiased, asymptotically normally distributed and asymptotically efficient. The complete least-squares analysis provides the most efficient estimates of variance components. The testing of variance components is simple in balanced random models and no exact testing for main class variance component in unbalanced two-way random model is available except under last stage uniformity. Approximate tests for main class variance component under general two-way unbalanced random model have been developed by several workers.

Discriminant Analysis

The Fisher's linear discriminant function (LDF) is commonly used in animal research. It yields optimal results if parameters are known and assumptions of multivariate normality and identical covariance matrices hold. Probability of misclassification (PMC) for Fisher's LDF is available in books and it is given by Singh (2001a) when parameters are unknown. The quadratic discriminant function (QDF) is optimal procedure in case of unequal dispersion matrices. PMC of QDF is given by Gilbert (1969) for special and by Singh (2001b) for general situations. LDF performs better in populations without reversals and otherwise the full multinomial procedure for binary data. In case of mixed-continuous and discrete variables location model approach has been suggested by Krzanowski (1980). A coupling procedure by combining an adequate number of discriminators for different types of data has been proposed by Wernecke *et al.* (1986).

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3. Small Area Estimation in Agriculture –Some Applications

U.C. Sud

Statistics relating to various parameters of interest such as average yield, total size, important demographic parameters like birth, death etc. economic activities, education, health and natural resources are often collected by local administrative organization. Such local area statistics cannot be entirely relied upon when the decision makers need reliable data for formulating policies for distribution of funds among the lower administrative units for planning infrastructure development for creating basic amenities and for initiation of welfare projects for the local areas. In this context there arises a need for a mechanism for collecting reliable statistics at the local level.

Censuses, administrative files and sample surveys are three different mechanisms for generating data on various parameters. The data collected out of census and administrative files suffer from certain drawbacks like quality, lack of completeness etc. Seen in this context, sample surveys, if properly planned, are an important mechanism for data generation on various items of interest. Sample surveys are planned in such a way that they provide reliable estimates for larger areas. Thus, in the context of estimation of yield rates of crops the surveys are planned to provide reliable estimates at the district level. If from a sample survey planned for a larger area one is aiming to generate estimates for the lower level say a block or a gram panchayat there may be a situation where the data points falling in the small area may be too little. This may result in estimates with very large standard errors as to be of any use. In the worst case a particular small area may not have any data points. In this case it will not be possible to provide any estimates for the particular small area.

Faced with this scenario one is left with two choices. Either plan sample surveys for each of the local/small areas or use some small area estimation technique for estimation of parameters at the local area level. For instance, in the context of agricultural surveys, the random sampling crop cutting surveys proposed by the ICAR are being used to provide reliable estimates of crop yield at the district level. These estimates are obtained out of the General Crop Estimation Surveys (GCES) scheme organized under the administrative control of Directorate of Economics and Statistics (DES). With the emphasis on micro level planning estimates such as these are being demanded at the lower level which may be a tehsil or even a gram panchayat. The National Agricultural Insurance Scheme launched by the Government of India for the benefit of the farmers is a case in point. The present crop cutting experiments approach for framing estimates at the village panchayat level or even tehsil level may not be practicable in this situation as this will require conducting many more crop cutting experiments over and above the experiments that are already being conducted. The financial implications and organizations of so many crop cutting experiments will be very demanding. Therefore a small area estimation technique is needed in this case. The basic rationale of the approach of small area estimation is that certain assumption/models are conceptualized which are assumed to hold good for small as well as large area.

Early developments in Small Area Estimation Techniques were in the field of demographic studies. These were categorized under the general heading of Symptomatic Accounting Techniques (SAT). These techniques essentially involve utilizing current data from administrative registers and the related data from latest census. The synthetic method of estimation was developed by National Centre for Health Statistics (NCHS) in the year 1968. The method essentially involves using estimates for the larger area to borrow strength from outside the domain of interest to frame estimates for the local areas. Composite estimators which are the weighted combination of the synthetic estimator and the direct estimator are widely used for generating estimates for the smaller areas.

Using the small area estimation techniques, reliable estimates of milk production at the district level have been developed at the IASRI. For this purpose the synthetic estimator was developed using the breed of the animal as the grouping variable for developing the estimates at the district level. Another small area related carried out at the IASRI involved using satellite data for the Rohtak district along with GCES data on crop yield to develop synthetic estimator which in turn is used to estimate crop production in the different tehsils of Rohtak district. In this case the synthetic estimator was developed by using Normalised Difference Vegetative Index (NDVI) as the grouping variable for framing precise tehsil level estimates.

Using the farmers' inquiry based data on crop production and the GCES data on crop yield an estimator has been developed for framing estimates at the Gram Panchayat level. The approach is akin to small area approach in the sense that Block/District level estimates are scaled down to GP level estimates under the assumption that over estimation and under estimation are behaving in similar way in the entire area. Using the data on wheat crop for Basti district for the year 2000, estimates of wheat yield at the Gram Panchayat level were developed by Sharma *et al.* (2004) along with Percentage Root Mean Square Error (RMSE) by following the Small Area Crop Estimation Methodology (SACEM) approach. The results of the study indicate that the RMSE varied between 1-10%.

The above mentioned approach assumes that the gram panchayat level crop area figures are available. This may be true for temporary settled states but such figures are not available for permanently settled states like Orissa, West Bengal and Kerala. For these states area figures are generated using sample survey approach. Thus, every year 20% of the total cropped area is enumerated. The entire crop area is covered in five years. Needless to say that unlike for temporary settled states where Gram Panchayat wise area figures are available, for such states the figures at best are available for only 20% area. In this case estimates for the non-sampled area can be framed using the area level model. The area level models are basically mixed models wherein the direct estimators for the small areas are related to area-specific auxiliary data (assumed fixed) and area specific random effects through a linear model. Such models have been extensively used in the context of small area estimation studies. Use of these models and other related aspects along with results of analysis of data will be dealt with in detail in the lecture.

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4. Nonlinear Statistical Model for Characterizing Culm Growth of Bamboos

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The study on growth pattern of bamboos, especially the commercially most important parameter viz. the culm height, is important in developing scientific management systems for optimum yield. In this article nonlinear statistical models were used to characterize the culm height growth of two important bamboo species. One of these is an important non-timber forest product (NTFP) of North-East India known as *Melocanna baccifera* or Muli bamboo. The other one, *Bambusa cacharensis*, locally known as betua, is an important village bamboo species in the Barak Valley region of Assam. Villagers prefer to grow this species in their home gardens because of its multiple uses and having straight culm, preference being as high as 70 % compared to other species growing in this region.

The adequacy of the models was judged by testing the validity of the assumptions of randomness and normality of residuals by using one-sample run test and Shapiro-Wilk test respectively. Durbin-Watson test was used to examine the presence or absence of autocorrelation. To assess the goodness of fit of the suggested models, statistics viz. R^2, root mean square error (RMSE), mean absolute error (MAE) etc. were computed for each model. Gompertz model with additive and AR (1) error structure is found to be the most suitable model for describing the culm growth of *M. baccifera*. The physical interpretation of the parameters is also being discussed. The estimated parameters can be treated as a summary of the growth pattern and can be used to characterize the growth of the bamboo species. These values may be used for comparison across species or varieties or same species growing under different environmental conditions.

Gompertz model with additive and AR(1) error structure appears to be the most suitable model for the height growth data of B. cacharensis corresponding to clumps of different age groups viz. 2, 5, 10, 15 and 40 years. Wilk's-Test was used to test the equality of mean vectors (k, q, r, a) corresponding to clumps of different age groups. Next, Hotelling T^2 statistic was computed to test equality of two mean vectors (k, q, r, a) corresponding to clumps of different age groups**.** The constant k is known as the 'carrying capacity' of the environment. The growth curve increases to an upper limit k when t is large. Thus k is the most important parameter showing the maximum height that a bamboo culm can attain. Therefore one-way analysis of variance of k-values for clumps of different age groups was performed.

The Gompertz model with additive and AR(1) structure is identified by four parameters: k, q, r and a. Das *et al*. (2006) have shown that for M. baccifera $k = 1698.855$, $q = 10.839$, $r = 0.182$ and $a = 0.833$. The parameter q gives the position of the point of inflection i.e. the time when the growth rate is maximum. For M. baccifera estimated maximum growth rate $rk / e = 113.75$ cm per week. The growth attained at this point is estimated as $f = k / e = 624.97$ cm. And a is the autoregressive model parameter. Hence the observed culm height growth curve of M. baccifera may be characterized by its parameter estimates as (1698.855, 10.839, 0.182, 0.833). The role of k, q, r and a is very important in developing scientific management systems for optimum yield of bamboo.

For B. cacharensis the estimated parameters can be used to characterize the growth pattern of bamboo culms for clumps of different age groups. Bamboo clumps of different age groups can then be compared on the basis of these parameters. Each growth curve may be summarized by its parameter estimates as a single low-dimensional multivariate observation. Gompertz model with additive and AR(1) error structure was fitted to individual culms from clumps of different age groups. Wilk's-Test was used to test the equality of mean vectors (k, q, r, a) corresponding to clumps of different age groups. Since $P(F(8, 82) > 6.9956) = 5.351E\text{-}07$, clumps of different age groups are significantly different with respect to their growth parameters.

Hotelling T^2 statistic was computed to test equality of two mean vectors (k, q, r, a) corresponding to clumps of different age groups. A perusals the p-values confirms that 10-year old clumps are significantly different from the rest in terms of the parameters k, q, r, a. Further, one-way analysis of variance of k-values for clumps of different age groups indicates ($p < 0.001$) best culm growth for 10-year old clumps. However, it is worth mentioning here that further investigation is needed to confirm this fact by considering clumps of some more age groups between 15 and 40 years. Thus while developing management strategies, both age of culm as well as clump needs to be considered. However detail discussion on the same is beyond the scope of this work.

Thus the parameters (k, q, r, a) can be used to characterize the culm height growth of B. cacharensis growing in clumps of different age group. A perusal of the (k, q, r, a) values for M. baccifera (Das *et al.* 2006) reveals that these are distinctly different from the growth parameters corresponding to clumps of different age groups for B. cacharensis. Thus, the parameters can also be used to characterize the growth of different species. The parameter q gives the position of the point of inflection i.e. the time when the growth rate is maximum. For B. cacharensis this period varies between 6 to 8 weeks, whereas for M. baccifera the same is attained at almost 11th week. For M. baccifera estimated maximum growth rate rk / e = 113.75 cm per week, whereas for B. cacharensis it varies from 132.82 cm to 141.83 cm per week. Finally the growth attained by M. baccifera at this point is estimated as f = k / e = 624.974 cm and the same for B. cacharensis varies between 334.16 cm and 411.11 cm. Lastly, maximum height that a culm of M. baccifera can attain is nearly 17 meters whereas that of B. cacharensis varies between 9 to 11 meters. Such comparisons are important in developing proper scientific management systems for optimum yield.

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5. Structural Time Series Modelling: Status and Scope

S. Ravichandran

Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA) time series technique is widely used for modelling time series data. However, this methodology can be applied only when the given data is stationary. Another limitation of ARIMA approach is that it is empirical in nature and so it does not provide any insight into the underlying mechanism. An alternative mechanistic and quite promising approach viz. “Structural time series modelling (STM)” approach can be effectively utilised for modelling time series data in the presence of various characteristics such as level, trend, seasonal, and cyclical fluctuations. In this approach, characteristics of the data dictate particular type of model to be adopted from the family and is much more wider than ARIMA technique.

STM models are formulated in such a way that their components are stochastic and are driven by random disturbances. The key to analysing of these models is the “State space” form, with state of the system representing Various unobserved components, such as trends, cycles and seasonals. Once in state space form (SSF), Kalman Filter provides means of updating the state, as new observations become available. Predictions are made by extrapolating these components into the future. Kalman filter, a smoothing algorithm is used for obtaining best estimate of the state at any point within the sample. Prediction and smoothing is carried out once parameters governing stochastic movements of state variables have been estimated. Estimation of these parameters, known as “hyperparameters”, is based on Kalman filter. Once a model is estimated, its suitability can be assessed using goodness fit statistics, like Akaike information Criterion (AIC) and Schwartz- Bayesian Information Criterion (SBC). Lower the values of these statistics, better is the fitted model. STM models can be fitted to the data using “Structural Time Series Analyser, Modeller and Predictor (STAMP) software package, SsfPack2.2 software package or by SAS (Statistical Analysis System) Proc UCM.

In the absence of seasonal and cyclical components, the STM reduces to a Local level model (LLM). The estimation of hyperparameters and likelihood function can be evaluated by Kalman filtering via prediction error decomposition. Once hyperparameters are estimated, one-step-ahead prediction of the estimator and Prediction error variance are evaluated recursively by Kalman filter. Reduced form of LLM is ARIMA (0, 1,1) model. Local linear trend model (LLTM) is also obtained from STM, when there is presence of trend and error and when both the level and slope are stochastic. Hyperparameters are estimated using maximum likelihood method for state space models. Reduced form of a LLTM is ARIMA (0, 2, 2) model. Forecast function of LLTM performs better than that of corresponding ARIMA model. Local linear trend model with intervention effect (LLTMI) incorporates the impact of intervention, which is concerned with making inference about effects of known events. These effects are measured by including intervention, or dummy variables. As for LLTM, estimation of state vector for LLTMI is carried out by putting the model in state space form and applying Kalman filter recursively by treating weight as an explanatory variable. These models were applied for modelling and forecasting of country's sunflower yield time series data. It was satisfying to conclude that Technological Mission on Oilseeds set up by Government of India in 1986 had a significant positive impact in enhancing sunflower yield.

When Cyclical Fluctuations are prominent, the three important sub-models of STM are:

(i) ***Cycle Plus Noise Model (CNM),*** wherein the trend is assumed to be constant. For estimation of parameters, model has to be put in state space form and then Kalman filter, prediction and smoothing are applied. After estimation of parameters, prediction and smoothing are performed. The reduced form from ARIMA family corresponding to CNM is "Constant + ARIMA (2,2)".

(ii) ***Trend Plus Cycle Model (TCM),*** which has three sets of equations. Estimation of state vector and hyperparameters is carried out by putting the model in state space form and subsequently Kalman filter is applied with proper initial values. Once the parameters are estimated using prediction error decomposition, Kalman filter, prediction and smoothing can be applied.

(iii) ***Cyclical Trend Model (CTM),*** in which the cycle is actually incorporated within trend. The essential difference between TCM and CTM is that, in the former, the observation depends on cyclical fluctuations explicitly whereas, in the latter, it does so on the previous observation implicitly through the trend. ARIMA (2, 2, 4) model is the corresponding analogue of both TCM and CTM.

Application of above models to all-India annual lac production data having prominent cyclical fluctuations would be thoroughly described in the talk.

For describing Seasonal Fluctuations, two important STM models are:

(i) ***BSM with dummy seasonal (BSMDS):*** Here, seasonality parameter is used in dummy variable form. For estimation of parameters equations have to be first put in state space form. Once BSMDS is in state space form, Kalman filter is performed to obtain updating, prediction and smoothing of state vector. Prediction and smoothing are carried out only when the hyperparameters are estimated using EM algorithm.

(ii) In ***BSM with trigonometric seasonality (BSMTS),*** the seasonality parameter is described in terms of "trigonometric seasonal". Further, if the trigonometric seasonal components are incorporated into a linear trend plus error model and the full set of trigonometric terms is included, the two models, viz. BSMDS and BSMTS will provide identical results.

Details of these models for modelling and forecasting of quarterly landings in Tamil Nadu in respect of two fish species, viz. silverbellies and croakers would be given in the talk.

Scope of Future Research Work

(i) In the above, we have considered only "Linear state space models". Nonlinear state space models may be investigated by employing advance techniques, such as Extended Kalman filter and Generalized Kalman filter. Subsequently, software for fitting such models also needs to be developed.

(ii) The above Univariate models may be extended to deal with bivariate situations, leading to "Bivariate structural time series models". These can then be applied for modelling and forecasting of say, rice production and rainfall time series data simultaneously.

(iii) In reality, there are multi – species present in any subsystem. For example, in fisheries and entomology, there are interacting species having prey-predator, competition, or symbiotic types of interactions. Appropriate estimation procedures along with relevant computer programs to handle such situations have to be developed in order to apply "Multivariate structural time series models" to real-life data.

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6. Statistical Aspects Related to the Registration of Plant Varieties in India

R.C. Agrawal

As per "Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act 2001", a new variety must conform to the criteria of Distinctiveness, Uniformity and Stability (DUS) in suitable tests before it is eligible for protection. According to Section 15(1) of the PPV & FR Act 2001, "A new variety shall be registered under this Act if it conforms to the criteria of novelty, distinctiveness, uniformity and stabilitys. Section 15(b) defines a variety to be distinct, if it is clearly distinguishable by at least one essential characteristic from any other variety whose existence is a matter of common knowledge in any country at the time of filing of the application. Section 15(c) defines a variety to be uniform, if subject to the variation that may be expected from the particular features of its propagation it is sufficiently uniform in its essential characteristics. A variety is called stable, if its essential characteristics remain unchanged after repeated propagation or, in the case of a particular cycle of propagation, at the end of each such cycle.

According to the Section 29 PPV & FR Rules, 2003, "the special tests shall be conducted only when DUS testing fails to establish the requirement of distinctiveness" and "The DUS testing shall be field and multi-location based for at least two crop seasons and special tests be laboratory based". Further, the "DUS test shall be necessary for all new varieties except essentially derived variety" and "the DUS test shall be conducted on a minimum of two locations".

The design of the growing trial or other tests, with regard to aspects such as the number of growing cycles, layout of the trial, number of plants to be examined and method of observation, is largely determined by the nature of the variety to be examined. Guidance on design is a key function of the Test Guidelines.

Three Types of Characteristics in DUS Trails

1. "Qualitative characteristics" are those that are expressed in discontinuous states (e.g. sex of plant: dioecious female (1), dioecious male (2), monoecious unisexual (3), monoecious hermaphrodite. These states are self-explanatory and independently meaningful. All states are necessary to describe the full range of the characteristic, and every form of expression can be described by a single state. The order of states is not important. As a rule, the characteristics are not influenced by environment.

2. "Quantitative characteristics" are those where the expression covers the full range of variation from one extreme to the other. The expression can be recorded on a one-dimensional, continuous or discrete, linear scale. The range of expression is divided into a number of states for the purpose of description (e.g. length of stem: very short (1), short (3), medium (5), long (7), very long (9)). The division seeks to provide, as far as is practical, an even distribution across the scale.

   The Test Guidelines do not specify the difference needed for distinctiveness. The states of expression should, however, be meaningful for DUS assessment.

3. In "Pseudo-qualitative characteristics" the range of expression is at least partly continuous, but varies in more than one dimension (e.g. shape: ovate (1), elliptic (2), circular (3), obovate (4)) and cannot be adequately described by just defining two ends of a linear range. In a similar way to qualitative (discontinuous) characteristics – hence the term "pseudo-qualitative" – each individual state of expression needs to be identified to adequately describe the range of the characteristic.

Determining whether a difference between two varieties is clear depends on many factors, and should consider, in particular, the type of expression of the characteristic being examined, i.e. whether it is expressed in a qualitative, quantitative, or pseudo-qualitative manner.

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7. Model-Based Inference in Finite Population Sampling Theory

B.V.S. Sisodia

Conventional approach to sample survey theory is based on probability sampling for both sample selection and inference from the sample data, which is referred to as design-based approach. Plausible population models have been used at the design stage of a survey to help choose good sampling designs and estimators, but the inferences remained model-free (Cochran 1963, pp. 214, among others). In early seventies, Royall (1970-71) advanced a model-dependent approach in which population is assumed to obey a specified model, and model distribution provides valid inference about the finite population parameters like total or mean for a given particular sample, no matter in whatever manner it is selected.

A hybrid approach called model-assisted approach which uses supplementary information through population models but inferences are design-based. Sarndal *et al*. (1992) have given a detail account of this approach. It has been found that Generalized Regression Estimators play a prominent role in this approach.

The inferences in model-based and model-assisted approaches could be sensitive to model misspecification. Therefore, a lot of works have been advanced towards the robustness of the estimators under these approaches (Royall 1973a, 1973b; Scott *et al.* 1978; Write 1983; Tam 1987; Singh *et al.* 1987; Royall 1992; Dorfman and Valliant 2000; Kaushal and Sisodia 2007, among others). It has been shown that most of the estimators are robust under a concept of balanced sampling, overbalanced sampling and weighted balanced sampling. These balanced sampling procedures are based on moments of the auxiliary variables used in the models.

The works on robustness in stratified sampling are further advanced by Kaushal and Sisodia (2007) when the regression coefficients in population model are common across the strata. Very useful results are obtained by them.

Shrinkage estimators have also been developed under super population models following the concept of Thompson (1968). This work has been further extended to stratified sampling and the robustness of the shrinkage estimators has been worked out under the possibilities of varying and common regression coefficients in the model across the strata. Most prominent contributors in this area are Bolfarine (1986), Bouza (1990, 1994), Bouza and Alende (1991), Sisodia and Kaushal (2007) and Kaushal and Sisodia (2007).

An attempt has been made in the present article to review the most important works on model-dependent and model-assisted approach of inference in finite population sampling theory. Future scope in this area of research work is also highlighted.

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8. Econometric Approach of Estimation of Technical Efficiency of Fish Culture Farms

A.K. Roy

Aquaculture plays a vital role in ensuring fish availability for food security and nutrition in India. This sector has to develop and grow in an economically viable and environmentally sustainable fashion. That is possible through improved water management, better feeding strategies, genetic improvement of cultivable species and better health management leading to enhanced productive efficiency of aquaculture at farm level. Therefore measuring Technical Efficiency (TE) at farm level and identifying factors associated with efficient production and assessing potential for and sources of future improvements are need-of-the-hour for establishing sustainable aquaculture. Instead of increasing the use of inputs to increase production, efforts should be made towards output growth through improved TE, which means to produce more by utilizing inputs at hand more efficiently. Keeping these points in view, an attempt was made to estimate the technical efficiency of 221 aquaculture farms of Kolleru lake area, which is known as the Carp Pocket of India, located at Krishna-Godavari Delta in South India producing an estimated 70,000 tones of fish per year.

A stochastic frontier production function model was utilized to estimate the technical efficiency of carp farms using a software FRONTIER with the objective of identifying the role of various input on fish production as well as to assess the impact of farm specific and socio economic variables on technical efficiency of aquaculture farms. The estimated mean technical efficiency (TE) was observed to be 0.7260. The highest significant elasticity of coefficient was demonstrated for feed (0.2001) followed by organic manure (0.1411) justifying the importance of these two inputs in yield of carps. Assuming that socio-economic, demographic, farm specific, environmental and non-physical factors are likely to affect the efficiency of operation of any farm, in the present study altogether twenty-five nonphysical socio-economic, demographic and farm specific variables were included in the model to test the possible impact and association with the technical efficiency of aquaculture farms operating in the Kolleru lake area. Of the twenty-five variables considered for technical efficiency model, socio economic factors like religion, age, education, primary occupation, pond size, ownership type, source of water, depth of water, sources of advice taken, method of application of drugs, calamities faced, types of labour, types of feed and disease encountered have a positive impact on technical efficiency. On the other hand caste, number of children, experience, renovation, asset cost, source of seed, loan, harvesting technique, method of application of feed, periodical netting for biomass checking and types of organic manure showed a negative association with technical efficiency. Pond size and source of water were found significant at ($p < 0.05$) and types of labour, religion, method of application of drug, primary occupation and calamities are found significant at ($p < 0.10$). Likewise of the variables showing negative impact, periodical netting for biomass checking is found highly significant ($p < 0.05$), source of seed and harvesting technique and caste were found significant at lower level of significance ($p < 0.10$) demonstrating the influence of these factors in efficiency of carp culture operation**.** In-depth analysis of impact of pond size on TE indicates that a consistent increase in mean TE with the size of the farm showing highest TE value of 0.7552 for aquaculture farms of size greater that 10 ha.This may be due to the fact that larger farms are capable to capture the economics of size and operates at higher efficiency levels compared to those of marginal and small farms. Pond area is reported to have positive impact indicating large operations are technically more efficient than smaller ones. Pond size is reported to have positive relationship on productivity. Water is the primary component of all aquacultural activities and its importance has been reflected through significant positive impact on TE. Farmers those who have set up their farms by the side of irrigation canals facilitating regular intake and periodical discharge of water were found to operate with significantly higher mean technical efficiency of 0.7287 compared with those using water from other sources with a mean TE of 0.6648 ($F_{cal} = 5.57 > F_{crit} = 3.88$).

Types of labour employed also showed positive impact on TE. Farms employing permanent labour could utilize their services for timely operation of various farm activities reflecting significantly higher mean TE of 0.7354 compared with those who employed temporary labour which a mean TE of 0.6957 ($F_{cal} = 10.11 > F_{crit} = 3.88$). The majority of farms were operated by Hindu's who are influential and economically sound having an advantageous position for securing resources for investment resulting in significantly higher TE of 0.7275 compared to 0.6207 shown by other religions ($F_{ca\ l} = 5.33 > F_{crit} = 3.88$). The method of application of drug has also shown a positive impact over TE. To combat disease, drugs were used either diluting or spraying in water or mixed with feed shown an estimated TE of 0.7292, 0.7237 and 0.6284 respectively ($F_{cal} = 1.62 < F_{crit} = 3.04$). Primary occupation was also found to have a significant role indicating that farmers doing fish farming as the main activity showed a significantly higher mean of 0.7359 compared to those of others engaged in other activities, showing a mean TE of 0.6896 ($F_{cal} = 13.02 > F_{crit} = 3.88$). Impact of calamity on TE was found significant ($p < 0.10$). One possible explanation may be that Kolleru Lake is located in the flood and cyclone prone areas of Krishna and Godavari districts of Andhra Pradesh. As a result farms that were affected by flood water are automatically flushed out of organic load and metabolic wastes accumulated due to regular use of organic inputs. Farms reported to have been affected by calamity showed higher mean TE of 0.7276 compared to a mean TE of 0.7210 demonstrated by farms not affected by calamities during the last five years of operation, although the difference is not statistically significant ($F_{cal} = 5.57 < F_{crit} = 3.88$).

To sum up, the empirical results suggest that there are significant possibilities to increase efficiency levels by increasing pond size, provision for supply of fresh water, right method of application of drugs, employing labour on regular basis and leasing out the water bodies to fish farmers and educating the farmers to procure seed from reliable sources, proper harvesting technique and avoiding periodical netting. Analysis of potential TE improvement of aquaculture farms reveals that if the average farmer in the sample achieves the highest TE level that farmer would save 26.7 per cent in cost. The most technically inefficient farmer on the other hand would save 48.9 per cent. The study suggests that with the same level of input, there is potential to enhance the yield by 27.40% through efficient use of resources and improvement of technical efficiency at farm level from Kolleru Lake area. Differences in efficiency levels that are identified and explained with respect to various farm specific variables having impact on TE through estimating a model for technical inefficiency effects will help future researchers, planners and farmers in efficient management of their farms resulting in optimum utilization of resources.

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