REPORT OF THE EXPERT COMMITTEE ON AGRICULTURAL STATISTICS

Directorate of Economics & Statistics

DEPARTMENT OF AGRICULTURE AND CO-OPERATION

FEBRUARY, 2011

A. VAIDYANATHAN
CHAIRMAN

GOVERNMENT OF INDIA
COMMITTEE ON IMPROVEMENT
OF AGRICULTURE STATISTICS
DEPARTMENT OF AGRICULTURE &
CO-OPERATION
KRISHI BHAWAN
NEW DELHI – 11 0001

Dear Dr Basu

Our Committee was set up to address the following tasks: (1) review the performance of the current schemes for improvement of crop statistics, their deficiencies and measures to improve them; (2) assess the potential of remote sensing techniques to collect land use and crop statistics and indicate how to utilize this potential; and (3) suggest an institutional framework for improvement of agricultural statistics.

Our Interim Report, presented in July, 2010, dealt with the first task. It emphasised the need for a radical reform of the existing ICS schemes and outlined a concrete programme for restructuring organization and procedures. We are glad that the Ministry has accepted that report. It is our pleasure to present you this final report setting out our findings and recommendations on the existing system and measures to improve its performance as well as our assessment of the role of future role of RS and the measures needed to exploit its potential.

Detailed review of FASAL - the present programme to estimate area under major crops based on remote sensing - has highlighted its capability to generate area estimates down to the district level as well as problems involved in use of imagery for estimation, attainable level of crop and spatial detail and validation of estimates. Sensors capable of higher resolution and overcoming the cloud cover problem will increase its capability in terms of spatial and crop detail. But considerable amount of work is necessary to get a clearer idea of the feasible and affordable levels of coverage and accuracy. Moreover the capability of RS for yield estimation remains to be established. Therefore RS must be viewed, for the present, as complementary to and not as a substitute for, the current system of compiling agricultural statistics.

The restructuring of the conventional and time honoured system of collecting agricultural statistics, along the lines suggested in our interim report is imperative. The programme for RS should be incorporated into the work of the National Crop Statistics Centre. Besides providing independent estimates of land use and cropping in the sample villages covered by NCSC, it should conduct studies to develop and test methodology for using current and prospective high resolution sensors for area estimation, and help in deciding its scope and choosing an appropriate and cost effective hardware designs. Based on the knowledge and experience gained in the process, the use of RS as an independent alternative source of estimates, and also as a means of reducing the human effort required to collect primary data can be expanded in a phased and gradual manner. Much further work is needed to establish the capability of RS for yield estimation.

Our work has benefitted from participation of and contributions to our deliberations from several non members and their organizations: Special thanks are due to:

- Shri A.K. Srivatsava, Deputy Director General of NSSO for his personal contributions to discussions and his colleagues in Field Operations Division in analyzing data from supervision reports and organising field surveys in selected villages;
- officials of the Department of Space for helping us understand the technical and operational aspects of FASAL and operational capabilities of remote sensing for generating agricultural statistics;
- officials of the Directorate of Economics & Statistics in the Ministry, and
- Directors of four State Remote Sensing Centres as well as the statistical agencies of Andhra Pradesh, Gujarat, Karnataka and Uttar Pradesh for pilot studies in selected villages to assess the capability of RS to identify different land uses and crops and estimate area under them.

We would like to place on record our high appreciation of Ms. Shobha Marwah, Adviser in the Ministry and our Member Secretary, Shri Sanjay, till recently Additional Statistical Adviser in the Ministry for their substantive contributions to collating and analyzing a large mass of data and to the preparation of this report. Thanks are due to Shri S.S. Gill, Economic Officer, Smt Jharana, for providing organizational and administrative support for the conduct of meetings.

Serving on this committee has been both a privilege and rewarding experience. We hope that our report will help restructure our agricultural system to make it leaner, tighter and function under a strong professional leadership.

(A. VAIDYANATHAN)

New Delhi
February, 2011

U. R. Rao	S.P. Mukherjee	Prem Narain	S.M. Jharwal
A.S. Nikhade	Utpal Ghosh	V.K. Arora	P.C. Mohanan
A. Prakhasam	B.R. Shah	V.K. Singh	S.K. Ghosh

Shobha Marwah

अर्थ एवं सांख्यिकी निदेशालय, कृषि मंत्रालय इस समिति को सचिवालयी सहायता प्रदान करेगा जो अपने गठन की तारीख से 6 माह के भीतर अपनी रिपोर्ट राष्ट्रीय सांख्यिकी आयोग को प्रस्तुत करेगी ।

डी. के. राय, अवर सचिव

MINISTRY OF AGRICULTURE

(Department of Agriculture and Cooperation)

(DIRECTORATE OF ECONOMICS AND STATISTICS)

NOTIFICATION

New Delhi, the 11th August, 2009

F. No. G. 30011/4/2009-E.A.—A committee has been constituted on 26th February, 2009 under the Chairmanship of Prof. A. Vaidyanathan, Eminent Agriculture Economist, by the Ministry of Agriculture, Government of India for improving agricultural statistics and to examine use of remote sensing applications in agricultural statistics. The Committee would also review present schemes of Timely Reporting Scheme (TRS), Establishment of an Agency for Reporting of Agricultural Statistics (EARAS) and Improvement of Crop Statistics (ICS). The Committee has the following members :

1. Prof. U. R. Rao, Former Chairman, Space Commission.
2. Professor S. P. Mukherjee, Chairman, Calcutta Statistical Association.
3. Dr. S.M.Jharwal, Principal Adviser, D/o Agriculture & Cooperation, M/o Agriculture.
4. Economic & Statistical Adviser, Directorate of Economics and Statistics, M/o Agriculture.
5. Additional Director General,NSSO, FOD, M/o Statistics and Programme Implementation.
6. Dr S.D.Sharma, Additional Director General, ICAR, New Delhi.
7. Dr. Prem Narain, Agriculture Scientist.
8. Deputy Director General, National Statistical Commission.

9-12. Director, State Agricultural Statistics Authority (SASA) - Uttar Pradesh, West Bengal, Andhra Pradesh and Gujarat.

13. Adviser (ASI), Directorate of Economics and Statistics, M/o Agriculture.

Terms of Reference (TORs) of the Committee are as under :

1. Review the current methodology used in Timely Reporting Scheme (TRS), Establishment of an Agency for Reporting of Agricultural Statistics (EARAS), Improvement of Crop Statistics (ICS) and General Crop Estimation Survey (GCES) for estimating land use, crop-wise area, irrigated area, yield and production.
2. Assess the problems being faced in observing prescribed methodology, organisation and procedures for collection and validation of the data.
3. Suggest ways and means to ensure availability of estimates, which are reliable and collected timely.
4. Suggest institutional framework for Improvement of Agricultural Statistics.
5. Review experience of Remote Sensing technology for estimating area and yield of various crops.
6. Suggest measures, techniques and organisational arrangements needed to make satellite data more reliable by ground truthing the same.
7. Other relevant issue relevant for improving reliability, accuracy, standards, timely collection, etc. of Agricultural Statistics.

Directorate of Economics & Statistics, M/o Agriculture would provide secretarial assistance to the Committee, which would submit its report in six months from the date of its constitution to the National Statistical Commission.

D. K. ROY, Under Secy.

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ABBREVIATIONS

AIG	Agricultural Information Group
AWiFS	Advanced Wide Field Sensor
CAPE	Crop Acreage and Production Estimation
CCEs	Crop Cutting Experiments
CES-F&V	Crop Estimation Survey of Fruits & Vegetables
DES	Directorate of Economics & Statistics
EARAS	Establishment of an Agency for Reporting Agricultural Statistics
FASAL	Forecasting Agricultural Output using Space Agro meteorology and Land-based observations
FOD	Field Operations Division
FS	Field Study
GCESs	General Crop Estimation Surveys
GIS	Geographical Information System
GPS	Global Positioning System
IASRI	Indian Agriculture Statistical Research Institute
ICAR	Indian Council of Agricultural Research
ICS	Improvement of Crop Statistics
IEG	Institute of Economic Growth
IMD	Indian Meteorological Department
INCOIS	Indian National Centre for Ocean Information Services
ISI	Indian Statistical Institute
ISRO	Indian Space Research Organisation
LAI	Leaf Area Index
MoES	Ministry of Earth Sciences
MoU	Memorandum of Understanding

NAIS	National Agricultural Insurance Scheme
NCFC	National Crop Forecasting Centre
NCSC	National Crop Statistics Centre
NHB	National Horticulture Board
NRSACs	National Remote Sensing Application Centres
NRSC	National Remote Sensing Center
NSC	National Statistical Commission
NSSO	National Sample Survey Organisation
PFZ	Potential Fishing Zones
RS	Remote Sensing
SAC	Space Applications Centre
SAG	Statistical Analysis Group
SAR	Synthetic Aperture Radar
SASA	State Agricultural Statistics Authority
SRSACs	State Remote Sensing Application Centres
TRS	Timely Reporting Scheme
VAO	Village Assessment Officer/ Patwari

CONTENTS

LIST OF ANNEXURES

1. Background

Evolution of the Agricultural Statistics System

1.1 Collection of agricultural statistics in India has long been done by village level officials over most of the country except in the states under the permanent settlement system. In the pre Independence era, when land taxes were the principal source of governments' tax revenue, these officials were mostly permanent, and prominent residents of the village with firsthand knowledge of farmers and farming in their localities. The revenue departments of the provincial governments had put in place a system of standardized format for recording land use and cropping information and periodic inspections by higher level officials to make sure that the records were complete and accurate. The primary purpose of the system was to ensure proper assessment of land taxes – then the dominant source of government revenue. The government also depended heavily on these village records and the village officials' 'eye assessment' of the state of harvest for assessing production changes from year to year around estimates of 'normal yield' made at the time of revenue settlements. These estimates, based on impressionistic judgment rather than systematic measurement of actual yields, were necessarily very rough but adequate to keep track of the impact of droughts and other natural calamities that called for alleviation measures by the state.

1.2 The situation changed dramatically in the post independence era when government policy sought to achieve rapid agricultural growth as part of its overall strategy to promote economic development. As the government's role in formulating and monitoring development programmes and formulating policies regarding pricing, distribution and foreign trade of farm products that constitute the bulk of consumption for most of the population became critical, the need for a system that would provide reliable and timely data on agricultural trends increased. In the early 40s, statisticians in the Indian Statistical Institute and in government had begun to explore ways to build such a system. A systematic survey in a sample of villages to verify the accuracy of the traditional system of gathering land use and cropping through independent field verification found the patwari system to be reasonably reliable. However, since then the system has deteriorated progressively as the interest of State Revenue Departments for proper compilation of village level data and in following the prescribed supervision and inspection procedures declined with the expansion in the nature, scope and range of their functions. This led to the adoption of sample survey techniques for estimating land use and cropping data at the state and national levels.

1.3 It was also clear that the 'annawari' estimate of yield could not meet the needs of planning and development. Professor Mahalanobis' path breaking work in the forties had shown that yields of individual crops could be estimated accurately and economically using statistical sampling techniques. This was followed by extensive work in the Indian Statistical Institute on technical aspects of design and conduct of large scale sample surveys to generate reliable data on various aspects of agriculture. The National Sample Survey (NSS), set up as part of Indian Statistical Institute (ISI), was entrusted with the task of conducting integrated sample surveys of land use, cropping and yields.

1.4 Around the same time, Statistical Wing of the Indian Council of Agriculture Research (ICAR) which subsequently became Indian Agriculture Statistics Research Institute (IASRI), led by Dr PV Sukhatme and Dr V G Panse experimented with crop cutting on randomly sampled plots for estimation of crop yield rates. But they recommended complete enumeration of land use and cultivation for estimation of crop acreages by the revenue agency. The ICAR adopted their approach and over the next few years area estimation based on complete enumeration was extended to cover the major portion of area under food grains in almost the whole of India; and sample crop cutting was used for yield estimation of wheat and rice. This came to be the basis for official estimates.

1.5 While National Sample Survey demonstrated the feasibility of using sample surveys as a technique, the differences between its estimates and those generated by the conventional methods used by state governments were a matter of wide debate. States were opposed to leaving the responsibility entirely to a central agency like the NSS. There were also controversies over differences in estimates based on different designs and methods of conducting crop cutting experiments. Careful scrutiny of the data by experts showed that, provided the sampling design is statistically sound and experiments and procedures are observed meticulously, different designs and the shape and size of plots chosen for experiments will have little impact on yield estimates.

1.6 Eventually the integrated land use and cropping surveys by NSS were given up. NSS itself was taken over and made an autonomous organisation (NSSO) of the Central Government. The entire responsibility for collecting the agricultural data was given to the state governments, which continued to use the traditional patwari system. The scope of crop cutting surveys for estimating yields was however progressively expanded. Earlier experience of NSS and extensive research of experts (in ISI and NSSO) specialising in agricultural sample surveys were used to evolve a common design and methodology for use by all state governments for crop yield estimation. The responsibility for implementing sample surveys for yield estimation through General Crop Estimation Surveys (GCES) was also vested with the states.

1.7 However, failure to address the weaknesses of mechanisms for collecting and verifying data at the village level, compounded by inadequate attention given by state governments to take corrective measures, eroded the ability of the system to provide reasonably complete, reliable and timely data on crop area and yields. This led to the introduction of the present system consisting of the Timely Reporting Scheme (TRS)/ Establishment of an Agency for Reporting Area Statistics (EARAS) for area estimation and a revamping of the crop cutting surveys in a 20% rotating sample of villages. It also provided for a centrally funded Improvement of Crop Statistics (ICS) scheme through which the primary data collection and conduct of GCES would be supervised and verified by special staff in an independent sample of some 10,000 villages and 30000 experiments.

2. The Current System

2.1 Area Estimation

2.1.1 The Timely Reporting Scheme (TRS) first introduced in Maharashtra and Uttar Pradesh in 1968-69 was gradually expanded to all temporarily settled areas with central government grants-in-aid as part of a centrally sponsored scheme. Its principal objective was to reduce the time lag in getting reliable and timely estimates of area sown under major crops and to provide the sampling frame for conduct of crop cutting experiments under General Crop Estimation Surveys (GCESs). The scheme envisaged that complete enumeration of crop areas by village patwaris would be done on a priority basis in 20% of the villages and that village crop area statements will be submitted to higher authorities in each state by stipulated dates for preparation of advance estimates of area under major crops. The villages were randomly selected in such a way that all villages will be covered once in five years.

2.1.2 While TRS was used for preparation of advance crop estimates during each season, records of land use, irrigated and un-irrigated crop areas continue to be compiled by village officials in non-TRS villages. These data, which are finalized after some delay, are included in the district wise statistics of land use and cropping published by the Directorate of Economics and Statistics.

2.1.3 For the permanently settled areas of Kerala, Orissa and West Bengal, a separate scheme called EARAS (Establishment of an Agency for Reporting Agricultural Statistics) was started in the early 1970s and subsequently extended to the Northeastern states. Under this scheme data on land use and cropping were to be collected through sample surveys done by a dedicated group of field staff under the state statistical authority responsible for agricultural statistics with the costs being fully met by the central government (except in west Bengal), The main features of different area statistics related schemes are set out in **Annexure 1**.

2.1.4 By common agreement between the central and state statisticians, states under both schemes were expected to adopt common design for selection of sample villages, recording formats, supervision mechanisms and reporting procedures. In both segments, the task of collecting and maintaining records of plot by plot data on land use and crop area was entrusted to village level functionaries. The observance of prescribed procedures in collecting, recording, verifying their completeness and meeting time schedules for reporting was to be monitored by higher level officials of the state governments.

2.1.5 The scheme for Improvement of Crop Statistics (ICS) is designed to verify, through first hand inspection by an independent set of officials, the observance of prescribed procedures in collecting and recording, completeness and accuracy of information, and prescribed adoption of time schedules for reporting as well as the conduct of crop cutting experiments. It covers approximately a sub sample of 10,000 villages chosen from among the TRS villages. With appropriate stratification using auxiliary information, the sample size of 10,000 villages is thought adequate to generate national and state level estimates of both area and yields of major crops within a reasonable margin of (sampling) error.

2.1.6 The responsibility for inspection of selected clusters of sample plots in these villages is divided between Field Operations Division (FOD), NSSO (4949 villages) and state government agencies (5359 villages). The central government undertook to meet the costs of special supervisory staff in each state (at the rate of one for every ten villages) to make sure of proper recording and timely reporting by village patwaris. Each inspector is required to record the nature and extent to which primary agencies in the sample villages had deviated from prescribed procedures and protocols. These are being compiled and published in annual reports of the FOD of the NSSO since 1974. These reports provide a useful basis for assessing the efficacy of TRS in providing reliable and timely data on land use and crop areas.

2.2 Yield estimation

2.2.1 During the 1950s the traditional annawari system coexisted with sample crop cutting surveys. Techniques of sample surveys for yield estimation developed by statisticians in the ISI formed the basis for comprehensive national level surveys done by the NSSO, as an independent professional organisation. However there were divergence between the estimates of NSS and official estimates. The scope and scale of crop cutting surveys were also extended during the period. Given that agriculture is entirely a state subject and that production estimates have a bearing on several sensitive policy issues (pricing, trade, public distribution. assessment and management of production shortfalls) involving centre-state relations, state governments were against leaving the entire responsibility for surveys to the central government or a central agency.

2.2.2 This led to the introduction of the General Crop Estimation Surveys (GCES). Under this scheme, crop cutting experiments are done in a sample of TRS/EARAS villages by one or more state agencies. By common agreement all states follow identical design and procedures for selection of sample villages and plots as well as field procedures for conduct and supervision of CCEs decided by sampling experts. The intention was to generate estimates of per hectare yields of various crops within a reasonable, specified margin of sampling error, at the state and district levels for 14 major crops and at the block level for wheat and rice. In 2004-05 more than 888,000 experiments were conducted to estimate yields for some 14 major crops and a host of minor crops in four main crop seasons (Early Kharif, Late Kharif, Rabi and Summer). In order to verify that the CCEs are conducted properly, the scheme provides for inspection of the experiments in a sub sample of 30000 plots in the ICS villages. Half the experiments are inspected by officials of FOD and the other half independently by state officials.

2.3 Use of Remote Sensing

2.3.1 Another major initiative is the programme to use remote sensing techniques for estimating area under major crops and forecasting their production by using it in combination with weather data. Initiated in 1988, its scope was gradually expanded to provide multiple in-season forecasts at the national level for major crops. This programme (called FASAL-Forecasting Agricultural Output using Space Agro meteorology and Land-based observations) is being implemented by Space Applications Centre, Ahmedabad and funded entirely by the Ministry of Agriculture. Currently, it provides pre harvest forecasts of (a) acreage and production for rice, wheat and potato at the state level, which are then aggregated into national forecasts; and (b) district level production for wheat, cotton, mustard, sugar cane, rabi sorghum and rabi rice which are then aggregated at the state level. Area forecasts are based on multi-date satellite imagery, which are constantly improving in terms of resolution and detail. Yield forecasts are based on empirical models of their trend relation to technology and of the relation between deviations in yield around the trend and fortnightly variations in mean temperatures. It is understood that the Ministry uses this information, along with information from TRS and other empirical models of yield, in making their advance estimates and forecasts of area and yield.

2.4 Recent Assessments of the System

2.4.1 That TRS/ICS/EARAS have belied expectations of contributing significantly to improvement in the quality of agricultural statistics (in terms of reliability, accuracy and timely availability) is well known. The deficiencies in their implementation and suggestions for remedial measures have been widely discussed in academic forums, scholarly articles, numerous seminars and, most recently, in the report of National Statistical Commission.

2.4.2 The Commission was of the view that data from a 20 per cent sample of villages covered by TRS villages in the temporarily settled States and EARAS is large enough to estimate crop area with a sufficient degree of precision at the all-India, State and district levels. It recommended that crop area forecasts and final area estimates issued by the Ministry of Agriculture should be based on the data generated by these schemes. However, they recognized the deficiencies in the working of the system and made a number of suggestions to correct them.

- The *patwari* and the supervisors above him should be mandated to accord the highest priority to the work of the *girdawari* and the *patwari* be spared, if necessary, from other duties during the period of *girdawari*.
- The *patwari* and the primary staff employed in Establishment of an Agency for Reporting Agricultural Statistics (EARAS) should be imparted systematic and periodic training and the fieldwork should be subjected to intensive supervision by the higher-level revenue officials as well as by the technical staff.
- For proper and timely conduct of the *girdawari*, the concerned supervisory staff should be made accountable.
- Timely Reporting Scheme (TRS) and Establishment of an Agency for Reporting Agricultural Statistics (EARAS) scheme should be regarded as programmes of national importance and the Government of India at the highest level should prevail upon the State Governments to give due priority to them, deploy adequate resources for the purpose and ensure proper conduct of field operations in time.
- In view of the importance of reliable estimates of crop production, the States should take all necessary measures to ensure that the crop cutting surveys under the General Crop Estimation Survey (GCES) are carried out strictly according to the prescribed programme.
- Efforts should be made to reduce the diversity of agencies involved in the fieldwork of crop cutting experiments and use as far as possible agricultural and statistical personnel for better control of field operations.
- A statistical study should be carried out to explore the feasibility of using the ICS data for working out a correction or adjustment factor to be applied to official statistics of crop area to generate alternative estimates of the same. Given the past experience of the Land Utilisation Surveys of the NSS and the controversies they created, the Commission is of the view that the objective of redesigning of the ICS, at present, should be restricted to working out a correction factor.

- The two series of experiments conducted under the National Agricultural Insurance Scheme (NAIS) and the General Crop Estimation Survey (GCES) should not be combined for deriving estimates of production as the objectives of the two series are different and their merger will affect the quality of general crop estimate.
- Crop estimates below the level of district are required to meet several needs including those of the National Agricultural Insurance Scheme (NAIS). Special studies should be taken up by the National Statistical Office to develop appropriate 'small area estimation' techniques for this purpose.

2.4.3 Working Group on Crop Husbandry, Agricultural Inputs, Demand and Supply Projections and Agricultural Statistics for the Eleventh Five Year Plan (2007-12) under the Chairmanship of Prof. V.S. Vyas made the following observations:

- Agricultural Statistics system of the country is evolved over a period of time to reflect the complexities in the agrarian economy. However, the system has recently come under criticism on counts of reliability, timely availability, coverage, and failure to meet the emerging demand for statistics. The National Statistical Commission had reviewed the system in detail and the 10^{th} Plan envisaged the implementation of its recommendations. However, a large number of these recommendations still remain unattended.
- Besides ensuring the implementation of these recommendations, a review of schemes such as Timely Reporting Scheme (TRS) and Improvement of Crop Statistics (ICS) that have been continuing for a long time, is necessary to reorient them for contemporary needs. The TRS can be affectively oriented to provide estimates of area under horticulture crop.

3. Committee's Mandate, Approach and Method

3.1 Terms of Reference

3.1.1 Issues concerning the deficiencies in the organization and functioning of exiting institutional arrangements and measures needed to remedy them were not addressed by these reviews. The NSC report merely suggested that the possibilities of using remote sensing as source for agricultural statistics be explored**.** At the instance of the newly constituted National Statistics Commission, the Ministry of Agriculture constituted the present Committee to address these issues. Its specific terms of reference are as follow:

- Review current methodology used in TRS, EARAS and ICS & General Crop Estimation Surveys (GCES) for estimating land use, crop-wise area, irrigated area, yield and production.
- Assess problems being faced in observing prescribed methodology, organisation and procedures for collection and validation of data.
- Suggest ways and means to ensure availability of estimates, which are reliable and collected timely.
- Suggest institutional framework for Improvement of Agricultural Statistics.
- Review experience of Remote Sensing Technology for estimating area and yield of various crops.
- Suggest measures, techniques and organisational arrangements needed to make satellite data more reliable by ground truthing the same.
- Other relevant issue for improving reliability, accuracy, standards, timely collection, etc. of agricultural statistics.

3.2 Approach and method

3.2.1 Initial tenure of the Committee (composition given in **Annexure 2**) which was constituted on 26th February 2009, was for six months. But it soon became evident that this was unrealistic. Concurrent study of the functioning of TRS, EARAS and ICS on the one hand and assess the role of remote sensing as an independent source of key agricultural statistics was not feasible within this time frame. It was therefore decided to focus first on improving the existing system and take up the assessment of remote sensing subsequently.

3.2.2 In reviewing the strengths and weaknesses of the existing system , the Committee has studied available material in (a) detailed documentation of the methodology, organizational procedures used for collection of agricultural statistics generally and of the specific schemes for estimation of area, yields and production of crops; and (b) numerous critical reviews of the functioning of the system in scholarly publications, seminar proceedings, and reports of various official committees; (c) the discussion and recommendations on Agricultural Statistics in the National Statistics Commission's report as well as other recent publications on the subject; and (d) the annual reports on the working of TRS/ICS/EARAS and their ability to provide complete, reliable and timely data based on inspection of a subsample of TRS villages; (e) the organization and functioning of FASAL, the scope of estimates generated by it and their use by the Ministry for estimating area and yields.

3.2.3 All this material was circulated among members; most of whom have played or continue to play key roles in designing and operating various schemes both at the central and state levels and therefore have firsthand knowledge of the organisational and managerial problems at various levels. In addition, the Committee held a series of meetings for detailed discussions with (a) members who are heads of State statistical departments on the organisation for data collection under various TRS schemes as well as the problems they face in ensuring that prescribed procedures for collecting, collating and verifying data and observance of time schedules for these operations at the ground level; (b) officials of the Ministry of Agriculture about the adequacy of data furnished by the states, the need for and basis of adjustments to take account of lacunae in terms of completeness and timeliness, and (c) officials of the NSSO, Field Operations Division.

3.2.4 Besides studying the FOD reports on the working of these schemes, the Committee decided to conduct a special survey in 102 villages 51 from the ICS sample and an equal number from non-ICS sample, to assess the accuracy of crop wise area recorded/reported by the patwari in sample plots in these villages by comparing it with information on crops and area actually cultivated obtained from farmers who cultivated them. The organization and conduct of this survey took considerable time. Because of this the committee sought and obtained approval for extension of the deadline to June 2010. An interim report on our assessment of the deficiencies in the organization and functioning of existing institutional arrangements to implement the existing schemes and recommendations for restructuring them was submitted to the Ministry in July 2010. This report has since been accepted by the Ministry.

3.2.5 Work on RS applications was proceeding in parallel. SAC provided us background materials on the current state of remote sensing technology and the methodology and procedures used for estimating crop areas and yields from satellite imagery. The Committee had a series of meetings with experts from NRSC and SAC to learn about their experience in actual application under FASAL, the scope, quality and level of detail achieved in estimates, and their reliability. The basis for and methodology of verifying the validity of RS based estimates was discussed at length.

3.2.6 A sub-committee of the committee met twice with officials of the Space Research Organization to better understand the methodology of using information from satellite imagery to discriminate between different types of land use and crops, establishing the area under specific crops, problems of getting clear imagery especially during the monsoon, techniques for validating the estimates with independent observations of ground truth, and the extent to which use of high resolution satellites and improved sensors might help overcome limitations in respect of scope and detail of estimates.

3.2.7 In addition, a special pilot study was commissioned in 12 selected villages to assess the potential of using high resolution satellites for getting a comprehensive picture of land use and cropping at the village level. This study also provided for verifying the accuracy of RS estimates for these villages by comparing them with data on the actual situation collected by independent inspectors. The task was carried out according to a programme decided jointly by expert members of the Committee and SAC experts and implemented by State and regional remote sensing centres. Because of delays in getting required financial approvals from the Ministry, this exercise in selected villages could be taken up only during crop year 2009-10.

3.2.8 Expert technical advice from SAC and NRSC of technological aspects together with a careful assessment of technical possibilities and organizational aspects have shaped the consensus of the Committee on the need to view the role RS as complementary to the conventional, but radically restructured, and to suggesting an operational strategy for expanding the scope and coverage of RS for generating land use and crop data . The report on the role remote sensing was completed in January 2011,

3.2.9 In all meetings, besides members, several officials of the Directorate of Economics and statistics and of Field Operations Division of the NSSO and State Remote Sensing Applications Centres (SRSACs) contributed to the discussions. **Annexure 3** gives the dates and venues of these meetings and the topics on which presentations were made and discussed. A list of non members and invitees who participated in the deliberations is also presented in this Annexure.

3.2.10 In this final report we present our findings, conclusions and recommendations on (a) the functioning of the current system based on TRS/EARAS/CCE, improving the current system and suggestions for restructuring it to provide more objective, reliable and timely crop data in Chapter 4; and (b) performance of FASAL, the nature and extent of role that RS can play in the future and the strategy for making effective use of its potential (Chapter 5).

4. Assessment of the Current System and Measures for its Restructuring

4.1 Area Estimation

4.1.1 Discussions on the working of various ongoing schemes for improvement of land use, cropping and yield data were focused, professional and remarkably open and candid. They highlighted various technical, organizational and managerial problems faced in implementing them. These were supplemented by a detailed analysis of the results of inspection of a subsample of ICS villages collated and published in annual reports of FOD. These reports give an idea of the extent to which prescribed procedures and time schedules for area and yield estimation have been observed by State primary workers as well as the magnitude of their impact on the estimates, state wise and crop wise. **Annexure 4.1 to 4.4** give detailed tabulations of the data given in these reports. The following are main points that emerge from the FOD annual reports:

4.1.2 Inspectors are expected to (a) verify that the basic village records on land use and crop area (called completion of girdawari) are complete at the time of their visit at specified times during each crop season; (b) determine whether village officials in the sample villages had sent TRS returns to higher levels on the prescribed dates; (c) record errors of omission and commission in entries of area under selected crops based on first hand observations on the crops grown on the plots falling within the sample clusters of each village; and (d) compare the area under selected crops obtained from first hand inspection with the entries for the sample clusters in the girdawari.

4.1.3 Timely completion of girdawari (**Annexure 4.1**): In 2007-08, FOD supervisors of the central subsample report that less than half the villages (41 to 48% in different seasons) had not completed girdawari at the time of inspection. In some states none of the sample villages had completed the task while in others all had. In half the states covered, the proportion of villages that had completed girdawari by the prescribed date was less than half in all seasons.

4.1.4 Compared to the central sample, state level inspectors consistently report a higher rate of on-time completion (and a much lower rate of non completion) of girdawari both overall and in a large majority of states. Both show an increase in non-completion rates since 2000-01. The extent of timely completion difference varies across states and seasons. The differences are quite marked in several states (notably Andhra Pradesh, Gujarat, Jharkhand, Uttar Pradesh and West Bengal). Of these state officials of Andhra Pradesh and Gujarat, attribute low rates reported by central inspectors to their insistence to base their observations on actual entries in the girdawari while state inspectors accept data maintained by village officials in kachcha records. In some states (Assam, Bihar) where both report very low rates of completion, the girdawari system is either weak or non-functional. In a few others (Haryana, Kerala, Orissa) both report near 100% on-time completion of girdawri. Of these, Kerala and Orissa have staff specifically designated for compiling data in sample villages under the control and supervision of their SASAs.

4.1.5 Timely submission of returns (**Annexure 4.2**): In the central sample, overall the proportion of villages submitting TRS returns on time is smaller compared to the proportion which have completed girdawri on time. This is also the case in a majority of states, the difference being more marked in some (notably Punjab, Rajasthan, Tamilnadu, Uttar Pradesh and Uttarkhand. There are a few cases where observance of timely submission of TRS returns is higher than girdawari completion on time. Data for the state sample show a higher proportion of villages submitting TRS returns on time in a majority of states. But in both samples, overall, the proportion of villages submitting returns on time is less than 50% in the main Kharif and Rabi seasons. The following table gives a summary view of the overall picture in 2007-08:

Table 1: Status of Completion of girdawari and Submission of TRS returns - all states 2007-08 (% of all villages)

Season	Central/ State Sample	GWNC	TRS after completing GW	TRS by due date	TRS after due date	TRS not submitted
Early Kharif	C	48	47	31	21	47
	S	33	68	35	36	27
Late Kharif	C	41	50	43	16	39
	S	14	74	54	29	11
Rabi	C	41	51	39	14	46
	S	16	71	48	27	18
Summer	C	42	40	27	15	53
	S	23	60	36	28	21

C: central sample; **S**: state sample. **GWNC**: girdawri not complete at time of inspection; **TRS**: Timely Reporting Scheme Returns

4.1.6 Errors in entries (**Annexure 4.3**): Inspectors were also expected to check for errors of omission and commission in the figures of crops and areas recorded in the girdawari. These errors are of three types: not reporting crop grown on the survey number; recording of crop when there is no crop in the number; and under assessment of area. In 2007-08, 25 % of survey numbers inspected in the central sample had errors in the Early Kharif season; 39% in Late Kharif; 34% in Rabi and 22% in Summer. The incidence of errors according to state sample inspectors is much less: 22% in Early Kharif, 13% in Late Kharif, 16% in Rabi and 15% in Summer.

4.1.7 Here again, compared to the central sample, the percentages of survey numbers without any errors as reported by state inspectors is not only consistently higher in all years but also show larger and more sustained improvement over the years.

4.1.8 Estimates of area under major crops: FOD reports also compare estimates of area under selected crops made by the inspector based on first hand inspection of sample plots and the figures recorded in the patwari's records, In central sample villages taken as a whole, the patwari estimates of area under all the selected crops are consistently lower than that of the inspector. In 2007-08 the difference ranged between 4.1% (Wheat) and 12.8% (cotton). Over the years its magnitude shows considerable variations being the least in Rice (5.6%) and Wheat (4.1%) and largest in Cotton (12.8%) without any sustained trend. The magnitude and even the direction of difference however vary between states and crops.

4.1.9 Detailed state wise and crop wise tables comparing the Patwari entries and that of Supervisor for area during 2007-08 are given in **Annexure 4.4.** The following table gives an idea of the overall average ratio between the two for selected crops and the number of states in which ratio is higher or lower as reported by central and state level inspectors.

Table 2: Comparison of Area estimates of Patwaris and Supervisors in ICS villages 2007-08

Crop	Central Sample			State Sample		
	Average all villages	States where the ratio is >1.0	<0.95	Average all villages	States where the ratio is >1.0	<0.95
Paddy Late Kharif	1.004	7/16	1/16	.991	6/16	1/16
Maize	0.972	3/11	2/11	.994	3/11	0/11
Cotton	0.975	1/9	3/9	.987	0/9	0/9
Sugarcane	0.944	2/9	3/9	.968	2/9	2/9
Wheat	0.946	3/12	6/12	.983	5/12	2/12
Gram	0.939	2/8	3/8	.976	2/7	2/7

4.1.10 To sum up, the inspection reports show that a large proportion of the sub sample of central sample villages supposed to be supervised and inspected closely (a) have not completed girdawari at the time of inspection; (b) do not submit TRS returns on time; (c) a sizeable proportion submit returns after a delay and/or without completing girdawari; (d) there are sizeable errors in recording of crop area by patwaris whose estimates are on the average below those of inspectors; and (e) there are large differences in all these respects across states and crops with state sample inspections presenting a more favourable picture than those emerging from the central sample.

4.2 An Alternate Exercise to Check Accuracy of TRS Area Estimates

4.2.1 Since data from the inspectors of the ICS sample is inadequate to judge the accuracy of crop area (by season and crop) compiled by the village patwaris, the committee conducted a special survey during October-November 2009 with the help of retired officials of FOD in 102 villages (not a statistical sample) from 19 states: 51 from the ICS sample and an equal number from non-ICS sample. This inquiry sought to assess the accuracy of recorded/ reported crop wise area in different seasons based on a comparison of the extent of area under different crops in the sample survey number in 2008-09 as reported by the FOD supervisor at the time of actual inspection last year in the case of ICS villages (and as recorded in the last year's khasra as it was at the time of the survey in non-ICS villages) with information on the same items obtained from farmers who cultivated the fields for the sample plots/patches in each village. Variation has been calculated by subtracting ratio of ICS/Khasra entry to that of farmer's observation from 1. Thus, if farmer's figure is more than the entry in ICS schedule or Khasra register, the variation is positive. The Gross cropped area of a village was calculated by adding crop-wise area under different crops of all seasons. The results on Gross cropped area of the villages compiled from this exercise are presented in Table 3.

4.2.2 Among ICS villages where the supervision by FOD officials is more closely monitored, the khasra was complete in all selected villages. Gross crop area reported by farmers of sample plots was less than the supervisors' figure at the time inspection in about half the villages and greater than khasra figures in about a third of the villages and more or less equal in about a fifth. The range of variation is very wide – ranging between -50% or more to +50% or more. While the distribution of villages within this range is quite diffused, there is a marked concentration of villages (12/51) in which the farmers' figure is lower than that of the ICS supervisor by more than 40%. In 12 out of 16 villages where farmers' figure is higher than the ICS supervisor figure the difference is less than 20%.

4.2.3 In sharp contrast, the survey results for non-ICS villages which are supervised by state agencies, the Khasra was not complete in about a fifth of the selected villages at the time of our field survey conducted nearly 6 months after the end of crop year 2008-09. These villages are 2 in Assam, Himachal Pradesh & Jharkhand, 3 in Bihar and 1 in Gujarat. Of the remaining 41non-ICS villages, the khasra figures are the same as reported by farmers in13. But in as many as 27 villages farmers figures were higher than those obtained from the khasra. In 14 of them, the difference was more than 40%. This picture is quite contrary to that obtained for ICS sample, the high incidence of under -statement of total crop area in the khasra and its large magnitude would seem to reflect the laxity in maintenance of khasra and in the supervisory process to ensure that they are complete.

Table 3: Variations in Gross cropped area

Range of variation	Number of villages	
	ICS	Non-ICS
< -.50	8	0
-.50-.41	4	0
-.40-.31	1	0
-.30-.21	3	0
-.20-.11	2	0
-.10-.01	8	1
.00	9	13
.01-.10	9	8
.11-.20	3	4
.21-.30	2	0
.31-.40	0	1
.41-.50	1	8
> .50	1	6
Total	**51**	**41**

Variation = [1-ICS or Khasra/F]

4.2.4 Table 4 presents the variations between the information provided by the farmers of patches/plots in the selected villages and those recorded by the supervisor in ICS villages at the time of inspection and the Khasra register at the time of the survey.

4.2.5 Taking all patches in sampled plots together; there was no difference between information provided by the farmers on the crops grown and area under each crop in 41% of patches in ICS villages and 52% in non-ICS villages.

4.2.6 Differences in recording of crop - farmers reporting crop but not recorded by supervisor/khasra and vice versa – is noticed in nearly two fifths of the plots in both ICS and non-ICS villages.

4.2.7 Differences in recording of area are found in about a fourth of the plots in ICS villages but in less than 10% of non-ICS village plots.

4.2.8 The correspondence between supervisor/khasra and farmers response is much closer in both categories of villages in the case of paddy, wheat and sugar cane: There is no difference in the area reported by farmers and recorded in ICS schedule/Khasra register in 60-80% of patches under these crops in ICS villages and 75-100% of patches in non-ICS villages. Differences in crop recording are only under Farmer (F) and not markedly different between the two sets of villages. Differences in area recording are however considerably larger among ICS villages.

Table 4: Incidence and nature of differences between farmers' information and figures recorded by supervisor/khasra in selected villages

State/Crop	Number of patches in ICS Villages					
	Total	No difference	F	ICS/Khasra	F is less	F is more
ICS villages						
All patches	4601	1901	624	1040	537	499
Paddy	283	173	40	0	36	34
Wheat	216	136	19	0	20	41
Sugarcane	32	26	4	0	1	1
Non ICS villages						
All patches	2820	1468	796	311	126	119
Paddy	210	158	32	0	9	11
Wheat	174	129	25	0	10	10
Sugarcane	6	6	0	0	0	0

'F' indicates that farmer reported that some crop was grown on a particular plot, but there was no entry in ICS schedule or Khasra.

The column 'ICS' (or 'Khasra') indicates that although there was entry in ICS schedule (or Khasra), farmer informed that no crop is grown in the patch.

'No difference'indicates those patches, where area under the crop obtained through farmers enquiry and as recorded in ICS schedule or Khasra is same.

The column'F is less' indicates that area reported by farmer is less, and the column 'F is more' indicates that farmer's figure is more, than that recorded in ICS schedule (or Khasra).

4.2.9 The incidence of 'no difference' plots varies across states: among ICS village plots, it is less than 30% in 4 out of 19 states and more than 70% in three.

The proportion of patches reporting differences in recording of crops is higher than all state average in 8 out of 19 states among ICS villages and 8 out of 16 states in non-ICS villages. Differences in recording of crop area are quite small in most non-ICS villages but quite pronounced in 5 out of 18 states among ICS villages. (For details see **Annexure 5)**.

4.2.10 The survey gives a better idea of the deficiencies in the data that is generated by the TRS/EARAS schemes. Strictly speaking, assessing these schemes in providing reliable data would require comparison between the khasra records at the time of inspection and information provided by farmers. But this has not been possible. In the case of non-ICS villages we could only compare the farmers information with entries in the khasra at the time of survey. Since the survey was conducted several months after the end of the crop season, patwaris would have had more time to complete the khasra. Even so the khasras were not available in a large proportion of villages. In the case of ICS villages the comparison is between farmers response and the crops and areas recorded by the FOD supervisor at the time of inspection. That the latter differ substantially from the actual ground situation at that time is evident from the survey. We could not get the actual entries in the khasra at that time of inspection. Since girdawri at that time had not been completed in a large proportion of villages, the situation is unlikely to be better than the survey results indicate.

4.3 FASAL

4.3.1 Area estimates: The programme, started nearly two decades back, shows a commendable foresight in recognizing the potential use of remote sensing for improvement of land use, crop area and crop yields. It is providing the Ministry with inputs for its national and state level advance forecasts of area and production. Its great attraction is the possibility of drastically reducing dependence on collecting the data through thousands of functionaries, involving high risk of human error, and very difficult problems of organization and supervision.

4.3.2 While its scope has expanded, the state and national level area forecasts are still limited to a 6-7 major crops. Not all the planned components have been implemented, especially those relating to yield estimation and crop-weather modeling. Our discussions have brought out the potential of this technique for getting more reliable and timely data on land use and crop area at a fairly high level of spatial disaggregation, much needs to be done to clearly establish the levels of crop and spatial disaggregation that is technically feasible and at reasonable cost.

4.3.3 There are several technical issues relating to the methodology of interpretation of imagery to identify crops and estimate their area and validation. The mere fact that the RS and conventional estimates appear reasonably close at an aggregate level is not reliable basis for validation; Besides exploring the reasons for wide divergences between the two at the state and district levels, methods for independent assessment of ground truth need to be evolved and tested.

4.3.4 The methodology for using remote sensing information to assess crop yields is as yet in early stages of exploration and presents a major area of challenge. The Committee could not go into the specification and estimation of models reported to be used for forecasting yields.

4.3.5 In an attempt to validate RS estimates for major crops with first hand observations of ground reality, understand the operational requirements for use of RS to generate the needed data, and the extent of crop and spatial disaggregation that can be realized, the Committee has undertaken a special study focused on 12 villages under different agro climatic conditions in 4 states during the current year. The study is underway and expected to be completed by end of June.

4.4 Crop Yield Estimates

4.4.1 For major crops in a state, yield is estimated through Crop Cutting Experiments (CCE) conducted on a sample of plots growing each crop as part of a scheme called General Crop estimation surveys (GCES). But for minor crops in a state, yield is generally estimated through oral enquiry, there is no prescribed methodology for estimating yield through oral enquiry. But, these vary from state to state. For a particular crop, CCE may be conducted in one state, but in another state, yield may be estimated through oral enquiry. The state-wise list of crops for which yield is estimated through CCE is given in **Annexure 6**.

4.4.2 Initially 1,70,000 CCE were planned at all India level to generate district-wise estimates of yield for major crops with less than 5% of margin of errors. For a few crops like Paddy, Wheat etc, the size of the sample was sufficient enough to generate estimate at block/tehsil level. Gradually, the number of CCEs increased to accommodate more number of crops under GCES and recently for the purpose of crop insurance to generate yield estimate at Gram Panchayat level. At present at all India level approximately 8,88,000 CCEs are conducted.

4.4.3 The major sources of area and yield statistics of horticulture crops are (i) Crop Estimation Survey of Fruits & Vegetables (CES-F&V) -a component of central sector Plan Scheme called Improvement of Agricultural Statistics implemented by the DES, (ii) Directorate of Economics and Statistics (DES), which compile data collected from State Agricultural Statistics Authorities (SASAs) and (iii) National Horticulture Board (NHB), which collect and compile data mainly through State Directorates of Horticulture. CES-F&V is supervised directly by DES, whereas the data collection undertaken by SASAs is supervised by NSSO under the ICS. But there is no provision of supervision by an independent agency of the data collected by State Directorates of Horticulture. The coverage is given at **Annexure 7**. There are several crops for which more than one source generates estimates and there is wide variation in estimates.

4.4.4 The selection of sample plots for CCE of the selected crops is done using a three stage stratified design, with taluka as the stratum and village as the first stage unit. In each sample village generally two fields growing the particular crop is chosen. These form the second stage unit from which 2 plots of specified uniform dimensions are selected as the ultimate unit. The design is meant to provide estimates of average yield at the state level within a specified, reasonable margin of sampling error (2-3% for major crops and 5% for others) at the state level. Increasingly however, state governments ask for district and even village level estimates. As a result the number of planned experiments has grown manifold: from 173 thousands in 1973-74 to 888 thousands as of 2004-05.

4.4.5 The selection of the samples and overall responsibility for ensuring proper implementation of the surveys is with the SASAs, The actual experiments are supposed to be done by trained personnel of state government from revenue, agriculture and statistics departments. There are clearly laid down procedures for (a) identifying the location of the sample villages and survey numbers; (b) keeping in contact with the cultivators of the sample survey numbers to be informed of the time of harvest; (c) personally conduct the actual harvest and weigh the produce; and (d) to determine the weight of harvested produce after it dries. The details of the sampling and operating procedures, which vary to some extent across states, may be seen in **Annexure 8**.

4.4.6 As with area estimation surveys, there is a central government scheme for checking the implementation of GCES based on independent inspection of the observance of procedures adopted in conduct of the experiments on a sample (subsample of the GCES sample) of about 30000 experiments split into 2 non overlapping samples, one being supervised by NSSO (FOD) officials and the other by state level supervisors. In both cases, the supervisors are reported to be personally present at the time the experiment is conducted and to record whether all prescribed procedures are followed. The process of storing and driage experiments on harvested produce is limited to a sample of the plots without any supervision. The supervisors also collect some key ancillary data on irrigation, fertilizer use and seed varieties used in the sample plots. FOD reports the comparison for 12 major crops.

4.4.7 While the sampling design is statistically sound, the criteria used for selecting sample villages and plots for CCEs for particular crops merit may affect the estimates and therefore merit a closer review. Errors can and do occur in conduct of experiments. For several reasons (1) the use of untrained personnel and unauthorized personnel to conduct them; (2) harvesting of produce in sample fields before the crop is fully mature; (3) wrong selection of sample survey/sub survey numbers and fields within them; (4) errors in selection of random numbers, location and marking of plots; (5) errors in measurement of fields due to use of nonstandard pegs, chains and tapes; (6) the fact that driage measurements are done only on a sub sample of the sample plots and that they are not supervised; and (7) errors in weighing of produce due to use of non standard balances and weights. Errors are also noticed in collecting ancillary information.

4.4.8 Errors of the type 1 to 5 have a direct impact on the accuracy of yield estimates. FOD reports suggest that in 2007-08, between 4% and 5% of the experiments in the centrally supervised sample taken as a whole are conducted by untrained or delegated workers and that the incidence of this deficiency is on a rising trend. In Uttar Pradesh the current incidence is as high as 19% to 47% and shows a steeply rising trend upto 2006-07. In 2007-08 it has reduced drastically without any apparent reason. No information on the incidence of premature harvest is available. Available evidence suggests that non-availability of standard measuring and weighing devices is a problem in a significant proportion of villages. **Annexure 9** shows season-wise delegation of work and conduct of crop cutting experiments by untrained workers over the years in the states covered and for Uttar Pradesh, where the delegation is very high. In other states these varies between 0 and 1.

4.4.9 The FOD report based on the Supervisor's observations show that in 2007-08 errors of all types add up to about 29% and 32% of the number of experiments in the central and state samples respectively. The composition is however different between the two: thus the state inspectors report 1% errors in selection of survey/sub survey numbers and plots within them while they are noticed in about 2% of experiments in the central sample: errors in measurement of field, in selection of random numbers, location and marking plots, (which have a direct bearing on the accuracy of yield estimates) weighment, are found to be more numerous in the central sample (10%) compared to a mere 4% in the state sample; 11% of the central sample had errors in ancillary information compared to 8% in the state segment; the percentage with inadequate arrangements for storage etc are higher in state sample at 4% against 2% in the central sample. The incidence of unspecified errors in the state sample at 22% is double that in the central sample (12%).

4.4.10 Over time, differences in the incidence of error reported by FOD and states follow a similar pattern except that while the central sample shows a progressive reduction in overall incidence, the reverse (i.e an increasing) incidence of errors is noticed in the state sample. The incidence of errors that affect yield estimates is consistently much higher but declining in the central sample and much lower with no trend in the state sample. Time series on incidence of errors in crop cutting experiments for both Central and State Sample are given at **Annexure 10**.

4.4.11 The use of these results must be analysed by recognizing deeper problems in ensuring that the prescribed procedures are followed rigorously. A major issue relates to the extent to which functionaries responsible for conducting the experiments are able to keep track of the progress of cultivation and readiness to harvest on the selected sample plots in a situation where sowing and harvesting dates even for the same crop variety, in a given region and more so when different varieties, are being cultivated. It is far from clear whether and how well the present procedures for preparation of crop calendars takes care of this aspect and how they are updated in the light of ongoing changes in cropping patterns and varieties. FOD officials aver that the prescribed procedure whereby the person designated to conduct CCE in a sample plot of a particular crop in a particular village is informed at the time of sample selection which is well ahead of harvesting time and that he is expected to keep in frequent contact with the cultivator to get information on the readiness of crop for harvest and the designated date and time of harvest. The logistics of doing this and ensuring concurrent presence of the functionaries responsible for conducting the experiments, the inspector and the farmer cultivating the plot at the time of actual harvest seems very daunting. FOD officials however claim that this problem is not serious though not absent. The incidence of failure to meet the condition of concurrent presence of supervisor/ inspector (missing the conduct of CCE) and extent of harvests being done without presence of the primary worker (loss of CCE) are collected for ICS samples. The list of Loss and Miss of CCEs for 2007-08 for Central and State Samples is placed at **Annexure 11**.

4.4.12 The other, and in some ways far more serious, problem arises from the fact that the conduct and CCEs tends to be distributed between different line departments, that supervision is also fragmented by departments and that the SASAs who are supposed to be responsible for this function have neither the authority nor the personnel to handle it. Supervision especially in GCES is notoriously lax. The problem has been greatly aggravated by states' insistence to increase the sample size of CCEs several fold to get yield estimates at the block level. This has had a serious adverse effect on the quality of experiments under the GCES, besides increasing the workload on the available staff (which has not increased), and making effective supervision nearly impossible, the use of these estimates for insurance and drought/flood relief gives room for local and political pressures to influence the results and thereby eroded the objectivity of estimates. The overall estimates are therefore subject to non-sampling errors whose magnitude is likely to be much larger than sampling errors.

4.4.13 As with area estimation, yield estimates from CCEs in the central sample (CS) of ICS and those obtained from the state samples (SS) also differ widely (see **Annexure 12** for details). Table 5 compares the estimates from these two sources for selected crops. Overall the two estimates are more or less equal in about 40% of the 48 crop yield estimates covered. CS is more than SS estimate in about 35% cases and CS is lower in a little over a fifth. This distribution however varies widely across crops: the incidence of CS=SS is highest in the case of wheat (5 out 6) and the lowest in maize (1/6). The relative incidence of CS>SS is highest in maize and least in summer rice; while that of CS<SS is highest in gram and summer rice.

Table 5: Comparison of yield estimates from ICS and state samples of crop cutting experiments for select crops 2007-08

Crops	CS= SS *	CS > SS	CS < SS	Total
RICE (KHARIF)	6	5	2	13
RICE (SUMMER)	3	1	3	7
MAIZE	1	4	1	6
GROUNDNUT	1	2	1	4
SUGARCANE	3	2	1	6
WHEAT	5	1	0	6
GRAM	1	2	3	6
All Crops	**20**	**17**	**11**	**48**

** difference within the range of +_5%*

4.4.14 Table 6 presents a similar comparison between the two estimates yields for crops covered in each state. In Haryana and Punjab central and state sample estimates are close to each other for 4 out 5 crops for which yields in ICS villages have been estimated. In 4 states the two estimates differ in all crops covered; in the rest the ratio varies 2/7 to 3/4. FOD reports highlight these differences but the reasons for them have not been analysed.

Table 6: Comparison of yield estimates from ICS central and state sample CCEs by state 2007-08

State	CS =SS *	CS > SS	CS < SS	No of crops
Andhra Pradesh	2	1	2	4
Chhattisgarh	0	1	1	2
Gujarat	0	2	0	2
Haryana	4	0	1	5
Karnataka	2	3	2	7
Kerala	1	1	0	2
Madhya Pradesh	0	4	0	4
Orissa	2	0	0	2
Punjab	4	1	0	5
Tamil Nadu	0	2	2	4
Uttar Pradesh	3	1	0	4
West Bengal	2	1	1	4
All States	**20**	**17**	**11**	**48**

** difference within the range of +_5%*

4.4.15 Also of interest is to compare estimates of yield across crops and states based on GCES (which as we have seen, are conducted by state agencies from a sample of all TRS villages) and the final yield forecasts of the Directorate of Economics & Statistics (DES), Central Government. Out of 91 observations, the DES estimates are close to the GCES estimates in 64 cases. This proportion ranges between 55% (summer rice) and 90% (gram) and exceed 66% in all but 2 crops (see **Annexure 13** for details).

Table 7: Comparison of estimates of yield under CES & DES during 2006-07

Crops	DES=CES (<>5.0)	DES>CES	DES<CES	Total
RICE (KHARIF)	12	3	3	18
RICE (SUMMER)	5	1	3	9
MAIZE	9	1	2	12
COTTON	6	3	0	9
GROUNDNUT	5	1	2	8
SUGARCANE	8	0	2	10
WHEAT	10	1	4	15
GRAM	9	0	1	10
All Crops	**64**	**10**	**17**	**91**

4.4.16 From Table 8, it appears that this is mainly because in nearly half the states (including several of the large ones) DES adopts GCES estimates for all these crops. In others the proportion of crops for which DES figures differ from GCES varies from 1 out of 5 (Rajasthan) to 5 out of 6 in Gujarat. In these cases DES is reported to adjust GCES estimate based on supplementary information from state agricultural departments, inputs from Crop Weather Watch group and also remote sensing. These adjustments seem to be made for a large majority of crops in Gujarat. Karnataka, Maharashtra and Tamil Nadu.

4.4.17 In interpreting these comparisons, it is important to note that DES estimates relate to final forecasts, and not the finally revised estimates incorporating corrections of omissions and corrections in GCES data, which are reported subsequently. The DES practice of publishing finally revised estimates, which used to the base for estimating national income, has been discontinued since 2004-05. For national income estimation CSO now uses state government estimates of production.

Table 8: Comparison of estimates of yield under CES & DES during 2006-07 in different states

State	DES=CES (<>5.0)	DES>CES	DES<CES	All
Andhra Pradesh	6	0	0	6
Assam	4	0	0	4
Bihar	4	0	2	6
Chhattisgarh	3	0	0	3
Gujarat	1	3	2	6
Haryana	6	0	0	6
Himachal Pradesh	2	0	1	3
Jammu & Kashmir	1	0	0	1
Karnataka	3	2	3	8
Kerala	1	0	1	2
Madhya Pradesh	6	0	0	6
Maharashtra	4	1	1	6
Orissa	2	0	1	3
Punjab	6	0	0	6
Rajasthan	4	0	1	5
Tamil Nadu	1	2	2	5
Uttar Pradesh	6	0	0	6
West Bengal	3	0	1	4

4.5 Assessment

4.5.1 In sum, the inspection reports of the ICS and state samples for area estimation show that:

a. The proportion of villages that do not complete girdawari on time and those that do not submit TRS returns on time or not, are very high. The TRS reports sent by states to the DES and used to prepare advance estimates are based on information which is incomplete and not adequately validated.

b. There are significant differences between the figures for villages that have completed girdawari at the time of inspection in the area under major crops. There are also wide variations in this respect across states and between ICS central and state samples and they do not show any systematic pattern. Moreover, records were not available for inspection in all sample villages, the data generated by the inspection reports are inadequate to estimate the margins of error. Because of these limitations, and given that the samples are small, it is not possible to hazard any estimate of the magnitude of error from the data generated by inspection reports.

c. The low priority given by state governments to ensuring proper maintenance of records of land use and cropping by village officials, the weak arrangements for their supervision, and the fact that non-ICS villages which constitute nearly 90% of the TRS sample villages, give cause for apprehensions about the reliability of the data generated under the present system.
d. This conclusion is reinforced by our exercise at post facto verification of khasra figures for 2007-08 with information provided by cultivators of the sample clusters in selected 102 villages, which covers 20 plots in the sample clusters of these villages, also show large but varying differences between the two sets of figures across crops and across villages.
e. For similar reasons there are apprehensions about the accuracy of yield estimates based on crop cutting experiments. Inspection reports of ICS villages show high incidence of errors in the conduct of experiments, errors due to lack of proper measuring and weighing equipment and difficulties of ensuring that procedures for storage and driage estimates of harvested produce are followed. These problems are likely to be far greater in the state sample because of the fragmentation of responsibility for conduct as well as supervision of CCEs in the states and because the number of experiments undertaken is unmanageably large.
f. The data generated by the central and the state samples under ICS scheme cannot be used to estimate sampling errors of area and yield estimates because the sample size is too small and the inspectors of the two sub-samples do not follow prescribed procedures with equal rigour and also because non sampling errors are large.

4.5.2 All these have been regularly highlighted in annual reports of FOD inspection. These Reports are supposed to be discussed in the annual conferences of central and state statisticians, but neither the Centre nor the States have shown interest in addressing these deficiencies and taking any corrective action. The administrative agency(ies) responsible for the primary work has paid very little attention to the findings of the NSSO. Desired convergence of various schemes like TRS, EARAS and ICS has not happened, nor the recommendations of various expert groups including the NSC made any visible impact on the present system.

4.5.3 The problem arises in case of estimation of area and yield of various horticulture crops including fruits and vegetables, where there are multiple agencies involved in collection and compilation of data and it is not clear which one is used as official estimates.

4.5.4 The Directorate of Economics and Statistics in the Ministry of Agriculture has the daunting task of providing advance forecasts of area four times capturing four seasons and end of season estimates of yield for major crops based mostly on reports sent by state governments from time to time. The first advance forecast is based on assessments of state governments built up by field offices of their agricultural departments supplemented by information on crop weather conditions, status of irrigation reservoirs and availability of inputs. It provides four advance estimates at different stages of each crop season. These assessments are revised in the subsequent three rounds based on 'more precise information' on these aspects provided by state governments built on the basis of village records and finalized through a process of vetting at different levels of the state government. Given the delays, incompleteness and errors in the primary data, a great deal of judgment necessarily goes into this vetting process. The basis and extent of such adjustments remain opaque. The data received by the DES is not authenticated or timely and is subject to unknown margins of error.

4.5.5 Conscious of these limitations, the Directorate spends much time and effort in scrutinizing the data for gaps in coverage and inconsistencies, seeking clarifications from SASAs and getting independent advance forecasts of area from FASAL, the Crop Weather Watch Group in the Ministry, and information and first hand impressions from state officials and field visits, and auxiliary information on trends in input use (for yields). This exercise, and adjustments to estimates of area and yield reported by states based on them, is focused mainly on rice, wheat and a few other major crops. The Directorate needs to be commended for the care and seriousness with which they try to do as best as they can in presenting estimates. But inevitably informed, but necessarily subjective, judgment plays an important role in this process. Most assessments of trends in agricultural production and policy discussions use the estimates as the best available and broadly consistent with other macro economic trends. But the margins of error remain uncertain. The need for improvements in the quality of the basic data and for more transparent and objective ways of making adjustments to imperfect data using cross checks with independent sources and consistency with the behavior of consumption, prices and wages is indisputable.

4.5.6 The deficiencies in the current system of both area and yield estimation under TRS/EARAS are not due to deficiencies in its design. The selection of sample villages for collecting data on land use and crop area, as well as the selection of sample villages and plots for crop cutting experiments are based on rigorous and statistically sound principles. The format and procedures for collection, recording and reporting of the data have been worked out with considerable care. It also provides for mechanisms for independent inspection of the observance of the prescribed procedures and verification of the accuracy of the data generated. Properly implemented, the system will generate estimates at the state and central levels within an acceptable margin of statistical (sampling) error. That it has failed to do so is mostly due to lacunae in institutional arrangements to implement the programme due in part to its huge scale, the diversity of crops, the exclusive reliance on human agency for direct observation and recording of data; weaknesses in the arrangements for supervision and inspection; and the fact that, in making estimates, the primary data are adjusted in ways that involve subjective judgement.

4.5.7 The central problem is the deterioration of the system of maintaining village land use and crop records – the basic source of primary data. Village level revenue staff are increasingly overburdened with multiple functions; maintenance of accurate and complete agricultural data is given a low priority. Supervision of land agriculture related records is increasingly rare and far too perfunctory to ensure their completeness and accuracy. The trend to shift from the traditional system of appointing village officials into one where they are drawn from a transferable cadre adds greatly to the difficulties of collecting data based on first hand inspection of all plots. Over the years the priority attached by state revenue departments in ensuring maintenance of complete and reliable land use and crop data has declined to the point of indifference. Periodic inspection of these records by higher level officials has become increasingly rare and lax.

4.5.8 SASAs have neither the authority nor the staff in sufficient numbers and with appropriate training to undertake independent and rigorous inspections on sufficiently large samples to minimize sampling errors and provide estimates of sampling errors. There are widespread complaints of unfilled vacancies even as the demands for disaggregated estimates at the district and sub district levels of area and yields have mounted. In an attempt to cope with staff shortages, SASAs have tended to divert the centrally funded staff meant to ensure maintenance of complete and reliable records in the ICS central sample to attend to other functions. These problems are more serious when, as is widely the case, responsibilities for data compilation, supervision and validation are fragmented among different organizations working more or less independently. The experience of Orissa suggests that, at least in the case of crop area estimates, these problems can be minimized by having dedicated staff for compiling primary data working under the control of SASA. Data are generated on time, and they are more complete and subject to more effective supervision. The problem is more complex in the case of yields.

4.5.9 Non-sampling errors, inherent in collecting and supervising data relating to thousands of plots and sub plots in numerous villages using a large number of functionaries is a more serious problem. The present system that relies entirely on a large number of poorly trained functionaries at the ground level, belonging to different executive agencies and charged with multiple functions, leaves a huge scope for non-sampling errors. Checking them is difficult without a unified, strong and professional agency to ensure that field workers follow prescribed procedures strictly. Devising effective institutional arrangements that would ensure reliable data and their timely availability is the major serious challenge.

4.5.10 On a rough estimate an average Indian village has a gross crop area of 300 hectares; and there are about 3.2 parcels per hectare. Collection of data on land use and cropping involves inspection of some 1000 plots spread over different seasons per village and some 35-40 billion plots over 120,000 villages under TRS. Plots are not of uniform size; and often plots are divided into sub-plots and used to grow different crops. The number of crops is also large – the official list is more than 100. Even if on the average the number of crops grown per village is only 30, the exercise, properly done, involves compiling and recording nearly 10 billion entries in a year by 100,000 village level functionaries. Even if they are all well trained and highly motivated, the scope for human errors of omission and commission, both unconscious and deliberate is large. It is essential to explore ways in which the scale of primary data collection needed for getting reliable area and yield estimates can be made more manageable and which reduces the scope for human error.

4.5.11 For this purpose we recommend a two pronged strategy to:

- One develop the capacity for expanding the use of remote sensing as an independent source of land use, crop area and, to the extent possible, yield estimates; and
- Two radically restructure the scope, organization and management of existing system of collecting primary data.

4.5.12 Remote sensing has the potential to collect primary data on land use and crop area data at a high level of spatial disaggregation. It could significantly reduce (a) reliance on direct plot by plot inspection for area estimation and/or using it to check the accuracy of primary agency records and (b) help ensure that supervisors of the sub sample are present at the time actual harvest. (At present, given the wide variation in timing of harvests of particular crops in a given season, getting correct information on the date of harvest of different crops in selected sub-sample plots and ensuring that the supervisors are actually present to check that CCEs are properly carried out presents a daunting and difficult task).

4.5.13 FASAL is a good beginning but as yet its use is limited to a few crops. Much more work is essential to understand its potentials and limitations before RS can be put to effective use. Rapid advances in remote sensing technology are constantly expanding the accuracy, level of detail and spatial disaggregation at which these tasks can be handled. The basic methodology for using remote sensing information to assess crop yields is very promising even though it is going to be a major challenge to operationalise this method. We need to better understand the problems involved in optimizing the use of Remote Sensing imageries of different resolutions for meeting agricultural data needs, their capacity to discriminate between different crops and estimating area of crops (especially of minor and mixed crops) grown on small and fragmented plots, techniques for verifying the accuracy of RS estimates with ground truth, and the appropriate organizational arrangements to use them.

4.5.14 The existing arrangements in the Ministry are wholly inadequate both in scale and expertise needed for this purpose. This would require a proactive effort to establish a larger, stronger and adequately funded RS unit in the Ministry manned by personnel with the necessary technical expertise and experience to pursue systematic work on problems of using RS for improving agricultural statistics. Besides significant strengthening of the central unit, the Ministry needs to work out ways in which similar units can be set up in state and the modalities of collaboration with SAC/ NRSCs and state remote sensing units.

4.5.15 The scale and pace of adoption of RS for generating agricultural statistics will necessarily be gradual. It cannot however replace the existing system for collecting primary data for land use, cropping, irrigation and yields through ground level agencies. Identification of numerous minor and mixed crops and estimation of their area through RS may not be possible under our conditions. However, in the case of major crops, RS can and should be used mainly as an independent check of estimates obtained from the existing system. The use of RS for yield estimation, even for major crops, is a far more difficult and complex undertaking. The methodology and techniques are still in the early stages of experimentation. Pending the satisfactory resolution of these problems, the present system of collecting detailed land use and cropping data and of crop cutting experiments for yield estimation by state level agencies must continue but with radical changes to address the numerous deficiencies detailed earlier.

4.6 Revamping the Existing System

4.6.1 Restructuring institutional arrangements must address the following problems: 1. Devising measures to improve the quality of data generated by the system needed for different purposes at different levels of government, 2. Ensuring adequate and properly trained staff for collection of the primary data at the ground level and 3. Vesting the responsibility for supervision and validation of data with an organization equipped and enabled to function autonomously and maintain high standards of professional integrity.

4.6.2 The present system, which depends on data collected from some 120,000 villages mostly by untrained, over stretched and poorly supervised functionaries of the revenue department, has proved inadequate to meet the demands of the central, state, districts, sub-districts and even village levels. The system is too large to manage and obviously unable to meet the claims made on it. Various schemes to improve the situation have not been effective. States have shown little interest in taking much needed corrective measures. The situation calls for drastic reforms in the system.

4.7 Establish National Crop Statistics Centre (NCSC)

4.7.1 We recognize that radical reorganization of the entire system covering such a large number of villages is not a realistic possibility. A more practical course would be to focus on changes that would ensure meeting the data requirements for advance forecasts, for getting reliable estimates of output of major crops individually and for broad categories of other minor crops including fruits and vegetables and for government policy making at the national and state levels. The requirements can be met from a much smaller number of villages than those covered by the TRS/EARAS. A smaller sample will be far more manageable in terms of organisation, requirements of trained personnel and proper supervision at reasonable, affordable cost.

4.7.2 We recommend the establishment of National Crop Statistics Centre in the Ministry of Agriculture at Delhi for producing reliable and timely data on land use, crop area and crop yields at state and national levels. It should be an autonomous and professional organization with a governing body chaired by a person of high professional standing with first hand experience in design, organsiation and conduct of sample surveys of agriculture and comprising of:

a. 3 or 4 external members with expertise and experience in application of statistical techniques for collection of agricultural data using sample surveys and image analysis;
b. Senior professional of the Directorate of Economics and Statistics, Ministry of Agriculture responsible for collation of basic data and crop forecasts, and From the Agricultural Statistics Wing of the NSSO;
c. 3-4 representatives of State DES in rotation.

4.7.3 The Governing Body shall decide on all matters relating to methodology, design and field procedures as well as supervision of the field work at the ground level and take appropriate action to correct deficiencies in field work. Executive head of the Centre should be a qualified Statistician with experience in conduct of sample surveys.

4.7.4 Beside the necessary administrative staff, the Centre should have adequate technically qualified staff for reviewing and collating primary data from the states and from independent supervisors for conducting analytical work using the data, and conducting limited scale type studies, as well as experts who are well versed with remote sensing techniques and use of space data, who can actively interact with scientists from SAC / NRSC and State Remote Sensing Centres.

4.7.5 The proposed Center should be fully funded by the Central Government and the primary data collection, supervision and processing will be done by units located in the state DES with independent supervision being done by its staff in Delhi. The methodology and procedures used, the data generated, findings of inspection reports and remedial action taken will be placed in the public domain. Special attention will be given to rationalizing sampling and improving the conduct and supervision of CCEs to minimize the problems that have been experienced under ICS. In course of time, The Centre should also review methodology for estimation of area and yields of minor crops and fruits and vegetables for getting better estimates at the state and national levels. Remote Sensing Applications to be used for crop Statistics can also be brought under the purview of the proposed Centre.

4.7.6 While the funding will be from the Central Government, their staff should be appointed under the scheme but located within the Directorate of Economics and Statistics in the state governments (or where it exists, a separate agency headed by a professional statistician responsible for collection of basic agricultural statistics) responsible for and wholly dedicated to collecting land use and crop data and conduct crop cutting experiments in the sample villages. In the states of Kerala and Orissa where under the EARAS scheme, the DES (SASAs in these states) are responsible for the crop statistics and have been provided with dedicated statistical staff under the EARAS scheme, the existing arrangements can be modified to suit the needs of the proposed scheme.

4.7.7 Once this centre is established, the present system of supervision by both NSSO and State under the central sector scheme of Improvement of Crop Statistics will be modified. NSSO currently provide technical guidance in sample selection and does sample supervision of the agricultural statistics under the ICS scheme.

For the new scheme a sub-sample of the selected villages will be inspected by FOD personnel to verify the area and crop cutting experiment. The sub-sample would be large enough to statistically validate the data by field staff and to work out correction factors for final estimates. Alternatively we may also consider the merging of the agricultural statistical unit of NSSO with the proposed centre. Besides achieving economy and synergy of expertise, it will also facilitate use of the findings of supervision for corrective action.

4.7.8 The Centre should take the initiative in taking advantage of new technology such as use of hand held devices for field data collection, online data transmission besides computerised processing for preparation of the state/ national estimates based on the sampling methodology. This will help reduce the scope for human errors and can substantially bring down time lag in the preparation of crop estimates. It should also take the initiative to get land records and cadastral maps of the sample villages computerized, besides facilitate the use of computers for selection of sample plots for inspection and CCEs and speeding up the estimation procedures. The composition of supervisory staff for the new scheme should therefore include certain amount of IT professional besides statisticians to advise and monitor the working of the scheme.

4.7.9 The details of the sampling strategy will have to be decided by NCSC after review by sampling experts to achieve both economy of operations and reliability of estimates. The present sample size for the ICS (10,000 villages and GCES) is considered adequate to provide reliable estimates at the national and state level for principal crops. Tentatively, for purposes of getting a rough estimate of likely costs, we assume that state wise crop area will be estimated through enumeration of sample plots in a sample of 15000 villages. These villages will be selected from different agro-climatic zones in proportion to the gross cropped area of the zone. Deep stratification criteria (e.g irrigated and unirrigated areas) can be used to improve the sampling efficiency

4.7.10 In each selected village 100 survey numbers are proposed to be selected in clusters for plot to plot crop enumeration. It is expected that 3 to 4 days may be required to cover a village in a season and to ensure coverage of all short duration crops also in the enumeration, usually a village will require to be visited 4 times in a year.

4.7.11 Along with area estimates, the yield per hectare for major crops in the states is proposed to be obtained under the scheme. Usually there are 10 major crops in a state and in a village generally 3 major crops may be available. With 2 experiments planned to be carried on a crop in a village, 6 crop cutting experiments may be conducted in a village. Thus around 15000 X 6 = 90000 experiments will be conducted under the scheme by the primary workers. Out of these, 60000 experiments on 6 major crops in Kharif and 30000 experiments on 4 major crops in Rabi will be conducted.

4.7.12 Given the geographical and topographical nature of land in the country, not more than 10 villages may be covered by a person in all 4 seasons during the year. Thus manpower required in the scheme for primary field work is 15000/10 = 1500. At the rate of one supervisor for 4 primary workers, total 375 supervisory officers may be required under the scheme taking into account all levels of hierarchy.

4.7.13 On a rough estimate, the resources required to employ 1500 primary workers is around 45 crore rupees in a year. For the supervisory levels the cost is estimated as Rs. 15 crore. Besides the cost on account of personnel, the cost of cost of instruments, stationary etc will be around Rs. 20 crore. Taking into account another 10 crore towards the travel and other administrative costs, the proposed Centre will require about Rs 90 Crore. The net additional expenditure will however be smaller as the present ICS could be merged with this programme and supervisory personnel could be sourced by redeploying personnel in Ministry of Agriculture, NSSO, etc. already engaged in this work. The Committee is of the view that this amount will be fully justified in view of the vast improvement in the quality of information available for policy making on critical issues relating to food and agriculture.

4.8 Improving TRS/EARAS in villages not covered by NCSC

4.8.1 The rest of the TRS villages should continue to generate the district level data but with improved arrangements for collection and supervision, and such changes in formats and procedures as may be found desirable. The present dispensation whereby collection of primary data and maintenance of their records is vested with village level functionaries with multiple functions and answerable only to the Revenue department therefore needs a drastic overhaul. Some of the solutions include: allowing patwaris/VAOs to hire part time local assistants for the purpose; hiring trained people specifically for collecting and maintaining records of land use and cropping answerable to the statistics authority. There are serious doubts whether the necessary reorganization of village administration is feasible and affordable.

4.8.2 If remote sensing proves to be capable of providing reliable and timely estimates of land use and crop-wise area at a high level of spatial disaggregation, dependence on plot-wise recording by village officials could be greatly reduced. It would also greatly help to improve the sampling design for CCEs using more sophisticated stratification, and entrust crop cutting experiments to a professional cadre under the state statistical authority. These issues need further deliberation. In the meanwhile it is important to review the scale and design of crop cutting experiments necessary to generate district level yield estimates with acceptable margins of error. In no case should the scale of CCEs be expanded to provide block and village level estimates. This tendency, currently widespread, not only makes proper conduct of experiments and their supervision very difficult but also is a source of serious distortion in estimates due to moral hazard biases and local pressures.

4.8.3 Use of Remote Sensing for estimating land use and crop-wise area will surely reduce the dependence on plot-wise recording by village officials and also facilitate shift towards for more sophisticated techniques of stratified sampling for crop cutting experiments. But this requires state governments to develop in-house technical capability and expertise to use remote sensing, set up appropriate infrastructure and establish linkages with SAC / NRSC and State Remote Sensing Centres. In the meanwhile, the present arrangement for getting land utilization statistics by complete enumeration by village officer under revenue department as well as arrangements for CCE must continue. However at a minimum, the authority and responsibility for supervision and validation of data must be vested with an autonomous organization with an adequate trained staff under its control. This is essential to redress the problems arising out of the current dependence on functionaries of revenue department at the village level and the involvement of multiple agencies in supervision. Such an organization must be equipped and enabled to function autonomously and maintain high standards of professional integrity.

4.8.4 State DES is obviously the appropriate organization to be entrusted with the task. But if they are to meet the above criteria, a major change in their status and authority along the lines recommended by the National Statistical Commission is imperative. They should be given the responsibility, authority and resources to conduct independent inspections of the primary records at the village level in a sub-sample of villages. All this calls for an expansion in the number and quality of professional staff of SASAs with adequate staff dedicated to the collection of agricultural statistics and earmarked financial allocations for the purpose.

4.8.5 The central government may consider funding a part of the cost of staff dedicated to inspecting on a sample basis the completeness and accuracy of village khasras at the end of each crop season, supplemented by enquiries from farmers cultivating selected plots. Based on the assumption norms assumed for the NCSC, about 1 supervisor per 4 villages, and supervision of a sub-sample of 5,000 villages outside the NCSC would require about 1200 persons and their cost would be around Rs. 50 crore a year. Any such assistance should be on the strict condition about qualifications and ensuring the personnel will be dedicated to agreed norms of supervision and not diverted to any other tasks.

5. Role of Remote Sensing for Improving Agricultural Statistics

5.1 Background

5.1.1 The potential of remote sensing to provide independent, timely and reliable data on land use and cropping at a high level of spatial disaggregation has been recognized for over two decades. Space Applications Centre (SAC), Ahmedabad and National Remote Sensing Center (NRSC), Hyderabad have been active in developing methodologies and using them for commissioned studies on a variety of aspects relevant to agriculture (including demarcation and resource mapping of watersheds, forest cover, patterns of land use and cultivation, and irrigation in the select command areas.) Some like water shed and forest cover mapping are large scale studies at the regional and national levels; others focus on particular aspects in specific locations of interest to sponsors mostly various government departments and agencies. It is also reported that many studies related to the use of remote sensing for crop production forecasting and for mapping and monitoring of natural resources were done through State Remote Sensing Applications Centres, State Agricultural Universities and many other institutions. Based on these, use of remote sensing and weather data for crop acreage estimation and yield forecast on a larger scale was considered feasible and envisaged under Crop Acreage and Production Estimation (CAPE) and subsequently Forecasting Agricultural output using Space, Agro-meteorology and Land based Observations (FASAL) programmes.

5.1.2 The Indian Society of Agricultural Economics and ISRO organized a joint seminar in 1989 to discuss the potential of using remote sensing for providing independent and timely estimates of crop area and production of major crops in India. While recognizing this potential, the seminar emphasised the need for (a) making the results of studies of these aspects done by the space agencies available for wider discussion by agricultural statisticians and economists; (b) sustained collaborative effort by remote sensing experts and agricultural statisticians in developing, testing and refining the methodologies; and (c) the need for rigorous and independent data on the actual ground level situation in study areas for validating RS estimates. But unfortunately this has not happened.

5.1.3 SAC has done numerous studies to develop, test and improve methodology for using remote sensing for several purposes including forecasts of crop area and production. These studies have been published in specialized technical journals and several are accessible on the Web. They have also been presented and discussed in conferences and seminars of specialists and with sponsoring agencies. NRSA has also done several region and location specific studies of land use, cropping and irrigation sponsored by various government agencies. Detailed reports of these studies are given to sponsors. But these are not published; nor are they made available to interested researchers and knowledgeable professionals outside these agencies. This has precluded free and open discussion of the methodology, data and substantive findings of these so essential for learning from experience and advancing knowledge. .

5.1.4 The methodology for use of satellite remote sensing for forest cover mapping was developed and demonstrated at national scale by NRSC. The survey of the extent and quality of forest cover based on remote sensing commissioned by the Ministry of Forests & Environment marks major step towards institutionalizing its use by government. The results were at substantial variance from statistics compiled by Forest departments. This generated a serious discussion between the two on the reliability of remote sensing based estimates. In the event, both the Ministries took a proactive stance in making the data available in the public domain and mounting a sustained effort to encourage free and open discussion among professionals in Forest and Space Departments to analyse and identify the factors that account for the divergence. This process has not only succeeded in reconciling the differences but, more importantly, led to greater clarity about concepts, definitions as well as refinements in measurement. Remote sensing is now widely accepted as an independent, reliable and objective basis for monitoring the country's forest cover at the national and regional level. This has been institutionalized under the Forest Survey of India and it uses the technology in bringing out biennial forest cover maps of the country.

5.1.5 Similarly, in the Ocean and marine fisheries sector, we have seen a major positive surge by the Ministry of Earth Sciences (MoES). Here too, an institutional mechanism is in place by the setting up of INCOIS which deals with wide varieties of ocean related observations using remote sensing and in-situ observations. These are being effectively used in predicting potential fishing zones (PFZ), benefiting the fishermen in a big way and sustainable development of the fishermen community in the coastal regions of the country.

5.2 FASAL

5.2.1 Background: In the sphere of agriculture, the Department of Agriculture and Cooperation, sponsored a project titled 'Crop Acreage and Production Estimation' (CAPE) in 1987, with the specific objective of using remote sensing techniques for crop area estimation and production forecasting. Under the project, basic procedures, models and software packages for using remote sensing and weather data were to be developed. Aimed at providing in-season estimates of crop acreage and production for certain specified crops, methodology development and its validation was carried out by Space Applications Centre. Based on the evaluation of results and recommendation of Committee set by Department of Agriculture and Cooperation, area coverage under the project was expanded to account for 80 percent or more of national production of a crop.

5.2.2 The project implementation was led by SAC. NRSC and its Regional Centres, State Remote Sensing Application Centres, State Departments of Agriculture and State Agricultural Universities/ Institutions have participated in the implementation of the project. The concept of FASAL which grew out of this project, was proposed to, and approved by, the Planning Commission in 1994.

5.2.3 The Department of Space formulated a concrete project proposal for FASAL in 1997. A special task force examined the proposal and recommended a phased implementation of the project and setting up of National Crop Forecasting Centre (NCFC) for coordinating the various activities envisaged. After several rounds of review and discussion by the Committee of Secretaries and Planning commission, the project, with some modifications, was eventually cleared by the Expenditure Finance Committee for implementation as a centrally sponsored project for a six year period from 2006 to 2012.

5.2.4 The launch of FASAL by the Ministry of Agriculture of the Government of India marks an important step towards use of remote sensing for generating advance forecasts of area and production of major crops in different seasons. It envisaged an integrated approach involving satellite data, agro-meteorological data as well as field based observations for pre harvest forecasts of acreage and production of major crops. This was expected to strengthen the current capabilities of early and in-season crop estimation attempted through advanced estimates from econometric and weather based techniques with Remote Sensing applications. Use of econometric and weather-based models was envisaged for forecasting the total cropped area, early in the season, before it becomes amenable to remote sensing data. Mid-season assessments were to be supplemented with multi-temporal, coarse resolution remote sensing data. In the latter half of crop growth, direct use of remote sensing data was envisaged to estimate the acreage and forecast the yield by integrating remote sensing and meteorological data. In addition, the use of field information and weather inputs at various stages was expected to go as input in analysis of remote sensing data, serve as major source of information in case of episodic events, thus increasing the accuracy of forecasts. It was expected to result in development of a comprehensive system for tracking and monitoring of crop prospects.

5.2.5 In order to implement the scheme and coordinate its various components, a National Crop Forecasting Centre was set up in the Directorate of Economics and Statistics in the Department of Agriculture & Cooperation, Ministry of Agriculture as the nodal organization to coordinate the following activities, undertaken under the programme.

a. Designing the data base structure covering crop statistics, crop calendar, administrative and geographic statistics, input and management practices, weather parameters, episodic events, available remote sensing sensors (data format, price, path/row coverage etc.) and collate real time data to assist all forecasting activities, as well as archival of FASAL data/ information. Agricultural Information group (AIG) in the NCFC was to implement these tasks.
b. Statistical analysis for design of survey programme, evaluating it for continuous upgrading and development and use of statistical and econometric approaches for making crop forecasts. A Statistical Analysis Group (SAG) to be set up for the purpose was expected to work closely with AIG (NCFC).
c. National Sample Survey Organisation and State Agricultural Statistics Authorities were to design ground data collection and provide support for analysis of remotely sensed data for meeting the statistical needs of early assessment, and also evaluate the accuracy of remote sensing analysis for generating inventory/forecasts. These organizations were expected to work in coordination with field survey teams.
d. SAC was entrusted with the task of developing procedures and models for analysis of remote sensing data, software packages and its technology transfer to the team involved in operational implementation of project.
e. Development and estimation of econometric and agro meteorological crop forecasting models for regional monitoring of crop status and quantitative yield predictions, integrating remotely sensed information into the models to improve spatial representativeness and the robustness of the models and summarizing and organising forecast results was expected to be the responsibility of the Institute of Economic Growth, New Delhi and Indian Meteorological Department, New Delhi.

5.2.6 Evidently, the intention was to build an interactive and integrated network of agencies working closely with both field level agencies that collect the primary data under the existing system and those like ISRO and other specialised agencies

(IMD, ICAR, IEG, NSSO) as well as academic researchers participating in the programme. It required strengthening infrastructure for using the latest methodologies for data collection, analysis and interpretation (especially in RS) and professional staff with the necessary knowledge, skills and experience in different fields. The scheme provided for ensuring that the programme as a whole including the FASAL unit in DES will be adequately funded and building a team of professionally qualified staff and physical infrastructure to achieve these goals.

5.2.7 While the Committee could not examine in depth the functioning of all these components and their activities individually, discussions with the DES officials involved in and familiar with FASAL clearly indicate that these objectives have not been met. NCFC has not played its expected role in ensuring that specific activities are undertaken by various agencies as part of an integrated programme and coordinating its various components. Agro climate modeling, supposed to be done by IMD, made little progress and neither NSSO nor the statistical agencies of state governments, have been involved in designing field data collection or providing analytical support for analysis of remote sensing data. Several ICAR institutions have participated in implementing the crop area estimation and yield forecasting under FASAL. Institute of Economic growth has been working, more or less independently, on area and yield projections using econometric models. The vision that various components and institutions will work in an interactive and coordinated way to evolve into an integrated system has not been realized.

5.2.8 The Ministry has not built a strong and cohesive unit, with adequate number of staff and professional expertise needed, to provide the strong and pro-active leadership to implement the original mandate of FASAL. Moreover, the activities envisaged under the programme are fragmented in different sections with little effective supervision. In the event, the scope of FASAL has been limited to getting Remote Sensing and Agro-meteorological inputs based estimates of area under and yields of major crops. Practically all technical work of interpreting satellite imagery and preparation of advance forecasts of area, and use of RS for yield estimation is coordinated by SAC. The unit in DES does little more than collating the estimates provided by SAC with the help of SRSACs. It is ill equipped to make any significant substantive contribution to interpretation of imageries or estimation and validation procedures.

5.2.9 In this report the Committee has attempted to provide an assessment of (a) the extent to which the current FASAL programme provides an independent, reliable and timely advance estimates of area under major crops and their yields; (b) the potentials and limitations of existing and prospective improvements in imaging technology and methodologies of interpretation to provide detailed and disaggregated estimates of land use, crop areas and yields at different levels of aggregation; (c) indicate the future role of RS as source for estimating on land use, crop-wise areas and crop yields and assess the extent to which it can be used for improving the quality and timeliness of key agricultural statistics as a complement to existing systems as well as a means to improve its efficiency; and (d) outline a long term strategy to make effective use of the potential of RS.

5.3 An Assessment of the Current FASAL Programme

5.3.1 Crop Area Estimates

5.3.1.1 Scope and Coverage: FASAL's work so far has been focused almost exclusively on providing advance forecasts of area under selected major crops to the Ministry of Agriculture on a regular basis. Originally, it was envisaged that the programme would generate area estimates for 4 Rabi crops (Rice, Jowar, Rapeseed & Mustard and Wheat) and 9 Kharif crops (Rice, Cotton, Sugarcane, Jowar, Ragi, Bajra, Jute, Maize, Groundnut). Subsequently, the Winter-potato was added as part of the project. But currently, estimates cover all the above Rabi crops and 5 kharif crops. The number and spatial detail of the estimates also vary depending on the crop coverage. The programme provides three advance estimates of area at the state and national level, namely, (1) one soon after planting, (2) the second during mid season and (3) third when the crop is fully established. Multiple in-season forecast are provided using Advanced Wide Field

Sensor (AWiFS) and Radarsat Data. In the case of jute, a single estimate of the area sown is provided about a month before crop harvest using LISS-III data. In some cases at the national level and at the state and district levels, major crop growing regions in selected states are covered and district level forecasts are provided. Extrapolated forecast for state are also provided.

5.3.1.2 The choice of crops covered under CAPE and FASAL is based on list suggested by Department of Agriculture and Cooperation and data on their spatial distribution provided by Directorate of Economics and Statistics, taking into consideration the capability of satellites that provide the basic imagery and the extent to which they permit the identification, and classification of different crops and estimating the area under each within acceptable margins of statistical error.

5.3.1.3 So far SAC has been primarily using optical imagery from IRS Advanced Wide Field Sensor (AWiFS), LISS III sensor; and microwave data from Synthetic Aperture Radar (SAR) of the Canadian satellite RADARSAT. AWiFS has spatial resolution of 56m and data can be acquired every 5 days. This enables multiple acquisitions during the crop season and monitoring the crop as it grows. This data is being used for in-season forecasting of Wheat, Winter- Potato and Mustard crops.

5.3.1.4 LISS III sensor provides imagery in the optical region of electromagnetic spectrum for crops grown in the relatively cloud- free Rabi and summer seasons. At each pass it covers a swath of 141 km at an interval of 24 days (repetivity). The basic unit in which the spectral information on ground features is available covers an area of 23 square meters. Features with smaller dimensions, compared to resolvable spatial resolution of LISS III, cannot be identified with precision. In practice, identification and interpretation (digital analysis) of different features is usually done for every pixel .

5.3.1.5 Obtaining imagery in the optical part of the electromagnetic spectrum during the Kharif season (and also the Rabi season for rice in a couple of states) is difficult because of heavy cloud cover. This problem is sought to be overcome by using satellites with microwave sensors. Here again the currently feasible methods of interpreting data acquired from such satellites limit the range of crops that could be covered and the level of spatial aggregation that can be achieved. This explains why the coverage of estimates for other Kharif crops is limited to one or two states. It should also be noted that state level estimates are based on estimates for constituent districts that meet the criterion of having significant areas under the particular crop growing in sufficiently large contiguous patches that can be identified from satellite imagery. Adjustments are made for others to get the state totals.

Table 9: Space Application Centre Crop Forecast Schedule and Crop Coverage - Year 2009-10

State and National Level multiple forecasts

Sl. No	Crop	Forecast	Period
1.	Wheat	Rabi Cropped Area	Last week of January
		First forecast (F1)	Last week of February
		Final Forecast (F2)	Last week of March
2.	Rice Kharif (For Orissa - Rice and Ragi)	First forecast (F1)	Second week of September (First week of August in Orissa)
		Second Forecast (F2)	Second week of October (First week of October in Orissa)
		Third forecast (Only in Orissa)	Second week of October
		Final forecast (F3)	Last week of January
3	Winter Potato	F1	Last week of January
		F2	Last week of February
4	Rapeseed & Mustard	F1	Last week of January
		F2	second week of March
5	Rabi Rice	F1	second week of March
		F2	second week of April
6	Jute	F1	first week of August

State and district level coverage of crops and forecast schedule

Sl. No.	Crop	State	Forecast schedule
1.	Wheat	Bihar, Haryana Himachal Pradesh, Punjab Rajasthan, Uttar Pradesh	March mid
		Madhya Pradesh	February end
2.	Mustard	Assam, Gujarat Haryana, Madhya Pradesh Rajasthan, Uttar Pradesh West Bengal	January mid
3.	Cotton	Rajasthan	October end
		Haryana, Punjab	November 1st Week
		Andhra Pradesh, Gujarat Karnataka, Madhya Pradesh Maharashtra	December mid
4.	Kharif Rice	Andhra Pradesh, Assam Bihar, Chhattisgarh Haryana, Jharkhand Karnataka, Madhya Pradesh Orissa, Punjab Tamil Nadu , Uttar Pradesh West Bengal	January last
5.	Rabi Rice	Andhra Pradesh, Orissa	April mid
6.	Rabi Sorghum	Karnataka Maharashtra	January mid
7.	Sugarcane	Maharashtra, Uttar Pradesh	November mid
8.	Groundnut	Orissa	First week of August
9.	Ragi	Orissa	January last
10.	Potato	Bihar Punjab Uttar Pradesh West Bengal	January mid December mid December mid January last
11.	Onion	Gujarat	February 1st week
12.	Jute	Orissa	First week of August

District level forecasts are made only at the time of final forecasts, which are generally made one month before harvest of the crop.

5.3.2 Estimation Procedures

5.3.2.1 SAC is currently the nodal agency for implementation of remote sensing component of FASAL and training for using them based on sustained research and development for improving techniques. Practically all technical work of interpreting satellite imagery and preparation of advance forecasts of area is done by Space Application Centre (SAC). SAC develops the technology protocols, software packages and training for using them based on sustained research and development for improving techniques and operational procedures on a continuing basis. NRSC and its Regional Centres, State Remote Sensing Application Centres (SRSACs) have professionals trained and experienced in the use of these techniques and software packages for processing and interpretation of satellite imagery. They participate in collection of ground information and analysis of satellite data for state / national level acreage estimations for selected crops according to protocols devised by SAC and under its supervision., Agriculture Universities, State Agriculture Departments and DES have also been contributing in the process of data analysis and support to the program in the respective region/ states. The estimates are sent to SAC, which passes them, after review, to DES.

5.3.2.2 The SAC exercise involves a series of complex operations: the geographical boundaries of study areas of the units to be covered on the ground have to be synchronised with those obtained from satellite imagery; 'ground truth mapping' to establish and validate statistical correlations between different physical features, categories of land use and specific crops with the spectral information relating to these features embodied in the basic units (pixels) that compose RS imagery; establishing signatures for classifying individual pixels according to different land uses and crops; using these signatures to identify the locations of crop coverage, and estimate the area under different uses and crops in the study area. The attainable level of detail and precision depends on the accuracy of the signatures and the minimum dimensions of objects that can be identified with the satellite used.

5.3.2.3 SAC has done, and continues to do, sustained work to develop, test, and improve the methodology and implementation protocols in all these respects. It has built a huge library of validated, region specific signatures for different land uses and crops. The district is the basic territorial unit for actual estimation. Districts to be covered for a particular crop are selected on the basis of available district level data on the extent and intensity of its cultivation. As active participants in implementing FASAL they have firsthand experience in actual application of these protocols under diverse field conditions. Estimating the area under selected crops and adjustments for districts, which have not covered, are centralized in SAC. The results are then transmitted to the FASAL unit in the Ministry's Directorate of Economics and Statistics.

5.3.2.4 SAC uses rigorous statistical methods for establishing signatures, interpretation of imagery and identifying and classifying pixels according to characteristics of land use and crops. The sampling errors in the estimates are reported to be low and within acceptable limits. While at the aggregate level there is certain amount of correspondence between the two estimates, i.e. RS and official estimates, the degree of correspondence varies between crops and regions and differences are found to be large at lower levels of aggregation.

5.3.2.5 For instance, collection of ground truth in training sites for developing signatures is supposed to be done at the same time or close to the dates satellite pass used for collecting imagery for the entire area under study. Another issue relates to the choice of the timing of pass for estimation purposes. The aim is to collect the imagery for the first advance forecast some 45 days after sowing; the second coinciding, approximately, with the time when the crop is fully established over the sown area; and the third when the crop has matured but not yet harvested. The determination of these dates is often difficult.

5.3.2.6 Dates of sowing and harvesting vary across crops and different varieties of a given crop; all these vary across regions. The dates of sowing and harvesting for any given crop and variety are not fixed but tend to be staggered depending on rainfall, availability of irrigation and other factors. All these are changing over time. The current knowledge on these aspects of crop calendars is known to be outdated; there is no mechanism to update them periodically. The basis on which SAC has handled this aspect – in terms of the strategy used for deciding optimum number and timing of pass by region and crop under conditions of varying sowing /harvesting dates for crops and extent to which it captures the current situation - needs to be checked.

5.3.2.7 The Committee recognizes the importance of using rigorous statistical techniques for effective use of RS, and also the impressive amount of systematic and continuing effort put in by SAC to develop and test models and procedures for generating reliable estimates. However questions have been raised about whether the statistical models used for interpretation /classification of pixels from RS imagery and assessing the probability distribution of misclassification are the best among alternatives. Extensive discussions between expert members of the Committee highlighted the complexity of the undertaking and the importance of assumptions and judgment in various phases of its application. They brought out the need for further work to test the probability of misidentification and misclassification of area under different crops especially at the district level and to explore ways to improve the models and procedures.

5.3.2.8 Furthermore, since crops are cultivated in an immense number of small plots, all of which cannot be clearly demarcated by RS with current sensors, it is difficult to ensure 100% accuracy in identification of crops and the area sown in them. Limiting the focus to providing advance seasonal forecasts for selected major crops that are grown on extensive areas takes care of the problem to some extent but not fully. For instance patches within the area covered by 3 x 3 pixels of LISS III sensor (the basic unit of estimation with LISS III), which grow crops different from the crop identified by the ground truth signature, could get counted as the main crop. On the other hand, a given crop, which is grown in scattered patches outside the area covered by the basic unit of estimation, may get left out. We have no way of knowing the extent to which the above factors affected the accuracy of RS estimates. However, errors due to the presence of mixed crops is not going to be significant at larger levels of aggregation like National/State.

5.3.3 Difficulty of Validation

5.3.3.1 We compared (a) the final forecast of crop wise area as produced by SAC with advance estimates of DES and with the final revised estimates at the state level; and (b) district level estimates of area from SAC with estimates of state statistical organization of area actually sown based on complete girdawari. In the process it was discovered that the data on (a) are available for all 5 years. But there are large gaps in the compilation of district level estimates of SAC. In some cases estimates are available only for last year or two. All districts have not been covered in all years.

5.3.3.2 Estimates of area under wheat and Kharif Rice at the national level, for selected states and districts for some recent years are presented in the **Annexure 14**. In the case of wheat, the two estimates are quite close in for Haryana, Punjab, Rajasthan, UP and HP, the difference being less than 2% +- in most years. Differences are larger in Bihar (+3.5 to +9.3%); MP (-.02% to + 5.9%) and variable across years. Somewhat surprisingly, the all India estimates of DES are consistently higher than those of RS based estimates in the range of between 3% to 15%. Differences across districts are much larger both in a given year and inter-year variations in individual districts are much wider.

5.3.3.3 In the case of Kharif Rice, the differences between the two estimates are much wider. Both at the national and state levels SAC estimates are lower in most years. The differences range from 6.5% to 18% at the national level. In a majority of states the difference is more than 5% being as high as 20 -40% in some. At the district level, the differences are much wider in magnitude and range both in particular years and over years. The percentage difference between RS and official estimate of area under other crops is given in Table 10 below:

Table 10 : Percentage difference between RS and Official estimate of area under other crops#

Crop	State	Year	State total *	Total for districts**	Range of inter district variation**
Rabi rice	Andhra Pradesh	2007-08	-1.4	-1.5	-17 to +19.7
	Orissa	2008-09	-10.9	-12.8	all minus 6 - 54
Sugarcane	Uttar Pradesh	2007-08	+4.9	+4.2	-24 to +96
	Karnataka	2008-09	NA	-30.7	-62.5 to -27.6
Mustard	Haryana	2008-09	+13	+11.4	+18.4 to +300
	Madhya Pradesh	2008-09	-15.7	-24.1	-49 to -5.2
	Rajasthan	2008-09	-5.1	-1	-33 to +51.3
	West Bengal	2008-09	+1.7	+5.2	-12.5 to +23.9
Cotton	Andhra Pradesh	2008-09	-6.8	-17.9	-37.5 to +28.9
	Haryana	2008-09	+3.2	+0.7	-5.5 to +23.5
	Karnataka	2008-09	NA	-42.6	-89 to +4
	Madhya Pradesh	2008-09	NA	-33.1	-63.9 to +0.6
	Punjab	2008-09	+1.1	+1.9	-12.8 to +49.9

= (RS/SASA - 1)*100

* RS relative to final forecast by DES

** Relates to districts covered by both RS and SASA

5.3.3.4 District level comparisons of SAC forecasts with the figures from completed girdawari could not be made for all years except for wheat. The general picture that emerges is as follows; (1) the difference between the two for the total of districts that have been covered by SAC and for which data corresponding state bureau estimates are available are variable across crops, states and years. (2) in all states and crops, the differences at the aggregate level are much smaller than differences across districts; (3) differences between the two estimates at the district level are much larger and have a much wider range.

5.3.3.5 It is difficult to assess the reliability of either SAC or the official estimates as both the methods do have inherent errors of commission and omission of varying nature and magnitude. Differences in timing, coverage and methodology make meaningful comparisons difficult. . The methodology and procedures of interpretation of imagery and validation of estimations used by SAC are of course more clearly defined than those used by DES. But, for reasons already cited, there are other sources of error in remote sensing whose incidence and magnitude are difficult to estimate. Our interim report has highlighted the deficiencies in the functioning of the official system and they are prone to numerous sources of errors. Since both the methods have inherent errors of their own and there is no common reference for either of them, it is required to evolve a standard reference for proper validation. These comparisons cannot, therefore, be the basis for assessing the reliability of different estimates from either source. The only basis for validation of RS estimates is through an independent, direct verification of the actual situation in the study areas. It is strongly recommended that this must be an integral part of the programme.

5.3.4 Role of Ministry in FASAL

5.3.4.1 The FASAL unit (NCFC) in the Ministry is not involved in any of these technical operations. It is small and does not have the needed skill and expertise for informed engagement with SAC on technical aspects or to devise ways of validating the estimates. Estimates provided by SAC are reported to be used along with information from other sources (including TRS returns, field assessment by state officials) for the official advance forecasts of area under major crops. The importance attached to these different sources of information and the extent and manner in which they shape the official forecast are not spelt out clearly.

5.3.4.2 Though the scheme itself has been approved for six years and is scheduled to end in 2012, no serious thought has been given to the status of the programme beyond that time. DES avers that SAC's advance estimates are useful inputs along with several others (including TRS) in framing its own forecasts. The question of validation has not been even considered seriously. Surprisingly, there is no attempt to collate the estimates provided by SAC and review them in relation to estimates of state governments reported as part of the TRS, or the final estimates prepared after completion of girdawari in all villages. Nor has any attempt been made either by the Ministry or SAC to undertake a systematic scrutiny of the differences, identify the factors that account for them and assess the extent to which they can be reconciled. The methodology of crop area estimation using satellite remote sensing data under FASAL is given in **Annexure 15**.

5.3.4.3 Given the widespread concern about the quality of agricultural data, and the well known deficiencies in the official system for compiling the data, such a scrutiny is critical for an objective assessment of RS as an independent source of generating reliable data; ways in which its scope and reliability can be improved; and also the long term role it can play as a complement to the existing system and for addressing the problems of the traditional system of compiling the data through tens of thousands of village level officials.

5.3.4.4 The Committee is in favour of continuing the present programme using RS to provide advance estimates of major crops as well those based on higher resolution imagery and newer sensors. In doing so, a necessary first step is to validate the accuracy of the RS estimates for different crops by comparing them with assessment of the actual area under them in selected sample locations determined first hand by an independent set of field staff. These locations could be selected through a statistical sampling representative of agro climatic regions, and regions classified according to the importance of a crop in relation to total cropped area. The comparisons would give an objective basis for determining the degree of accuracy of estimates at different levels of spatial disaggregation and use of different satellites. At the same time, it is desirable to assess the extent to which these estimates are sensitive to differences in sowing and harvesting dates and explore ways to handle the problem. We strongly recommend standardization in the use of RS method to obtain agricultural estimates with improved accuracy.

5.3.4.5 We have highlighted the deficiencies of present system of getting these data by tens of thousands of village functionaries, the huge scope of errors of omission and commission inherent in it and the fact that remedying them is unmanageably difficult. It is also important to explore the extent to which the scope, level of detail and spatial disaggregation at which RS can discriminate between, and provide estimates of, area under different categories of land use, different crops discriminating and between irrigated and rain fed crops. The next chapter presents the results of a study in a few selected villages to understand the extent to which RS can be used for this purpose at the micro level, the problems involved and the scope for addressing them with developing technology.

5.3.5 Yield Estimation

5.3.5.1 Approach to the problem: FASAL's original mandate envisaged a multi pronged approach to yield estimation including: (a) econometric modeling (trend analysis, input-output models) for yield forecasting, (b) models to estimate the effect of agro-meteorological factors on crop yields; and (c) use of remote sensing data for this purpose. Econometric modeling for yield projection is also being done in the Institute of Economic growth. The results, and the use made of them by the Ministry, were not made available to the Committee Work on agro met models, expected to be developed and tested by IMD, does not seem to have made any progress.

5.3.5.2 Two approaches to estimating crop yields based on RS have been proposed: (1) RS data or derived parameters which along with weather data are directly statistically related to yield; and (2) estimate crop bio mass from RS based on some of the biometric parameters like Leaf Area Index (LAI), and use it along with other input parameters to obtain a yield prediction model. The logic of these approaches and their relative merits are briefly outlined in the **Annexure 16**.

5.3.5.3 The first approach envisages yield simulation models using parameters relating to physiological growth of crops (using RS based estimates on processes related to photosynthesis of crop canopies) along with numerous other inputs and weather variables. The structure of such models and their information requirements are daunting.

5.3.5.4 The second approach uses crop biomass estimated from the Leaf Area Index using RS. There are questions about the accuracy with which LAI can be estimated by RS. The estimates of biomass from remote sensing does exhibit correlation with crop yield but needs to be properly calibrated to make it fully convertible to crop yields, which are of interest for estimating production. Moreover, the relation between the two is a complex function of several factors - climate, irrigation and bio chemical inputs – all of which are variable across crops and for the same crop across regions. It is also to be noted that estimation of biomass at a specified time interval and subsequent changes in field realities, sometimes, may produce deviations in yield figures. Possibilities need to be explored to carry out near real-time refinements in yield estimations and this will help in enabling better decision making. Without such procedures, it is difficult to operationally use the yield figures, as the reliability of these estimates could be in question.

5.3.5.5 Status of actual application: We do not have much information on the status and results of work in implementing these approaches. While there are many publications on these methods, there is a need to have more information on such methods and status of further improvements with respect to results of work in implementing such approaches operationally. Their theoretical basis and actual application are reported to have been discussed with agricultural scientists. Reference was also made to some experiments in collaboration with research institutions to test them. We were told that SAC has made yield predictions for wheat using RS inputs and other collateral data. However, the Committee was not given specific information on these efforts or their outcomes to make focused judgements. It would seem that work on this aspect has not received as much attention and sustained effort as evidenced for area estimation.

5.3.5.6 Use of RS for better design of CCEs: The potential of RS to provide reliable yield estimates even for major crops cannot be judged without far more intensive methodological and empirical research in collaboration with agricultural scientists. We suggest that SAC should explore the possibilities of using auxiliary information on variety, fertilizer use and irrigation collected for sample CCE plots supervised by Field Operations Division (FOD) of NSSO as well as even more detailed information for experimental plots in research stations to establish better grounded relations between biophysical factors, weather and greenness index for independent prediction of yields. This should receive greater attention in future programme for using RS.

5.3.5.7 Apart from this, remote sensing can provide real time data on the spatial distribution of the area under different crops which can be used for increasing the efficiency of crop cutting experiments for yield estimation. It can be used for improving the sampling design of CCEs through stratification which will reduce the sample size required to get estimates at acceptable margins of error and facilitate tighter control over the quality of experiments. This capability will increase with improvements in the level of crop and spatial detail of major crops made possible by advances in remote sensing technology. Making using of this potential of RS must be an important component of RS applications to improving the quality of agricultural statistics. This should be one of the important areas to be taken up as a high priority activity in future programme for using RS

5.3.5.8 It is necessary to have a strong multi disciplinary team of experts to look into this matter in close coordination and evolve a viable methodology for operational crop yield estimation. This calls for participation from various Departments/ Ministries/ Academics on statistical modeling groups, IMD experts, experts in Agro-meteorology, experts from ISRO in vegetation studies, modeling, remote sensing, historical data modeling expertise and so on to realize such a system.

5.4 Village Studies

5.4.1 Objectives and Study Plan

5.4.1.1 Besides assessing the methodology and results of FASAL, it was also considered important to examine the potential of existing and prospective advances in RS technology to get reliable and detailed estimates of land use and crops up to the village level. In principle, high resolution satellite imagery that is expected to be available on a regular basis, used in conjunction with detailed cadastral maps, opens up the possibility of deciphering these features even in particular survey numbers. If this potential and the methodology for its large scale application is established, remote sensing could provide much of the data now being collected by the existing elaborate network for compiling estimates of land use and cropping at any desired level of disaggregation and also provide a ready frame for selecting samples for Crop Cutting Experiments. The Committee therefore considered it necessary to conduct a rigorous and intensive study in a few selected villages to assess the capability of using remote sensing to get estimates of land use and cropping at the village and plot level.

5.4.1.2 To this end the Committee planned an in depth study using both RS methodology and direct measurements at the field level in selected locations across the country. Initially it was proposed to commission special studies to provide estimates of land use, irrigation and crop wise area for (a) selected districts (b) selected TRS villages in these districts; and (c) field clusters chosen for supervisory check under ICS based on LISS III and LISS IV imagery for the current, and the previous crop year. It was expected that such a study would bring out both substantive and operational problems involved in use of remote sensing and help focus on ways to resolve them. Further comparisons of girdawari figures for selected villages and plot clusters with those obtained from remote sensing and interviews with farmers of select clusters would provide the basis for a meaningful assessment of the magnitude of errors of omission and commission in the girdawari, the capability of getting reliable estimates from satellite imagery and the measures needed to improve and refine it.

5.4.1.3 To begin with, a sub-group of the Committee visited SAC, Ahmedabad, and reviewed the current methodologies used by SAC based on detailed presentations on the methodology followed for the estimation of crop acreage. During the discussions it emerged that the focus of SAC was mainly on identifying and estimating area under major crops at the level of states and in some cases districts based on sample segment approach. They were not in a position to undertake a study at the village level of the scope and detail in randomly selected villages as initially envisaged by the Committee.

5.4.1.4 It was therefore decided to do a in-depth study in selected villages to (a) estimate land use and crop-wise area in as great a detail as possible with available RS data for the crop year 2009-10; (b) conduct an independent plot by plot physical enumeration of land use and crop wise area in all plots of the villages; and (c) compare the two to assess the extent of correspondence between the two and the reasons for differences.

5.4.1.5 Space Application Centre (SAC) was not in a position to undertake the RS based estimation at the village level, but agreed to technically support State RS centres in implementing the study. The study was entrusted to RS Application Centres at Lucknow, Bangalore, Hyderabad and Gandhinagar. Given time and budget constraints it was decided to confine the study to 12 villages (see list below) with diverse agro climatic and cropping systems in 4 states.

STATE	DISTRCT	TEHSIL/BLOCK	VILLAGE
Andhra Pradesh	Khammam	Nelakhondapalle	Surdepalle
	East Godavari	Pithapuram	Viravada
	Chittoor	Thamballapalle	Diguvapalem
Gujarat	Anand	Anand	Sundan
	Mahesana	Becharaji	Surpura
Karnataka	Mandya	Pandavapura	Thyvadahalle
	Gulbarga	Shahapur	Mudball
	Udupi	Udupi	Badanidiyur
	Chikmangalur	NR Pura	Belluru
Uttar Pradesh	Muzafarnagar	Muzafarnagar	Budina Kalan
	Barabanki	Ramsnehi Ghat	Aliabad
	Agra	Kol	Siyakhas

5.4.1.6 The reliability of RS estimates has to be judged by comparing the estimates of these aspects with the actual situation on the ground. Comparison with figures in the records maintained by village officials is not appropriate, given the high incidence of errors of omission and commission in these records. Hence, the need for a careful and independent exercise to determine the ground level realities by rigorous inspection of all plots to ascertain the actual use to which they are put and the crops that are grown on them in every season. This operation was carried out by staff specially recruited and trained under the supervision of State Agricultural Statistics Authority (SASA). They obtained information on actual land use and cropping during the three main crop seasons during 2009-10 by physical inspection of all plots in the selected villages. These were subsequently aggregated at the village level and compared with the RS based estimates. This part of the study was completed according to plan; the Remote Sensing exercise did not due to some technical problems.

5.4.2 Results of Study

5.4.2.1 Being amongst the first of its kind exercise in Indian conditions, the study faced several difficulties. To begin with, the intention was to use LISS III and LISS IV satellite imagery for each season. It was known that the resolution attainable with LISS III would not be able to provide village level estimates of land use and crops in as great detail and accuracy as LISS IV. Using both would also help assess the extent and nature of differences between the two at a broader level as well as the possibilities of using them in combination. In the event it turned out that LISS IV imagery for the villages selected for this study were available only for Rabi season in a few villages.

5.4.2.2 Non-availability of imagery presented a major problem and led to dropping 2 of the selected villages in Karnataka and replacing 3 villages originally selected in AP with 2 new villages. As a result, the study could be carried out only in 9 villages against the planned 12 villages. LISS III imageries were used in 7 villages during Kharif and 6 villages during Rabi. Further, for Rabi season, LISS IV images were used for 5 villages while 2 villages used LISS III data (in addition LISS IV). All 4 villages that reported summer crops used only LISS III data. Hence, a majority of the villages used LISS III images while LISS IV was used for 5 villages in Rabi. A summary of data used in the special study is brought out in Table 11.

Table 11: Villages covered by the study and details of satellites used and dates of pass

State	Village	Kharif		Rabi		Summer	
		Satellite	Date	Satellite	Date	Satellite	Date
Andhra Pradesh	Arakatavemula	NA	-	III IRSP6 IV	12/03/10 16/02/10	NA	
	Kamanur	NA	-	III IRSP6 IV	05/04/10 16/02/10	NA	
Guajart	Sundan	III	30/10/09	IV	31/01/10	III	15/04/10
	Surpur	III	28/09/09	III	26/01/10	III	02/05/10
Karnataka	Badanidiyur	III	23/10/09	IV	15/02/10		
	Tyavadahalli	III	29/10/09	IV	25/02/10		
Uttar Pradesh	Ailabad	III	14/10/09	III	07/03/10	NA	
	Budiana Kalan	III	19/10/09	III	11/03/10	III	15/06/10
	Siyakhas	III	23/10/09	III	27/03/10	III	20/06/10

5.4.2.3 The methodology for use of RS under FASAL, developed and tested over several years, was designed to generate estimates of area and production of selected major crops for states and districts. It uses a sample segment approach, which is not applicable for assessing land use and crop wise area estimation at the micro level based on a wall-to-wall mapping. The procedures and protocols for this purpose were not envisaged under FASAL. The procedures and protocols for using RS at the village level have not been developed under Indian conditions, nor was this possible in the given time and resource constraints. The SRSACs have had to use available knowledge and relevant software in conducting the study.

5.4.2.4 Moreover, protocols for collecting ground truth information to establish and validate signatures for classifying pixels according to use and crop categories could not be followed rigorously. The dates of pass for collecting ground truth were not always close to the dates of pass for getting imagery for estimation. The latter in all cases were obtained for only a single day, which often did not capture the phase when the crop cover overall, and more so for particular crops, is at its maximum. Note that in the case of AP, the dates of pass for Rabi estimates turned out to be well beyond the Rabi season. This, as we will see presently, does affect the reliability of estimates.

5.4.2.5 Under these conditions it was not possible to assess the extent to which higher resolution imagery from LISS IV could provide more detailed and accurate mapping of land use and cropping at the village level as compared to LISS III. (Such a comparison seemed possible in two villages but was not done). Nevertheless this exercise has been useful in highlighting the problems involved in use of RS to generate detailed village level data under different conditions and of validating them with first hand measurements of ground reality. This has helped us in outlining the future strategy for effective use of RS imagery using higher resolution imagery using both optical and non-optical (microwave, infra red) sensors that are becoming available.

5.4.2.6 The exercise requires digitisation of cadastral maps of each village and synchronising them with the maps prepared from satellite imagery. Boundaries of the selected villages were demarcated on the geo-referenced satellite picture on the basis of the precise latitude and longitude of their locations. These were then superimposed and synchronised with the cadastral maps. On this basis the plot and sub-plot boundaries are also identifiable from the satellite based maps. Whereas in Gujarat, cadastral maps have already been digitised, this process could be managed within a shorter time and less effort than in villages (which form the majority) whose cadastral maps had to be obtained and digitised. After synchronisation of geographical boundaries, the two estimates of total geographical area were found to be in close agreement in all villages and seasons (Table 12).

Table 12: Comparison on Geographical area

Area in hectare

State	Village	Remote sensing	Field study	% variation
Andhra Pradesh	Arakatavemula	1848.59	1848.43	0.01
	Kamanur	2011.29	2013.63	-0.12
Gujarat	Sundan	532.40	530.48	0.36
	Surpura	812.10	801.32	1.35
Karnataka	Badanidiyur	301.89	294.06	2.66
	Tyavadahalli	68.36	69.84	-2.12
Uttar Pradesh	Aliabad	157.75	157.05	0.45
	Budina Kalan	844.62	845.10	-0.06
	Siyakhas	175.20	175.65	-0.26

% variation = (Remote sensing - Field study)/ Field study *100

5.4.2.7 Area under Invariant Features: Comparison of area under invariant features could not be done in all states. In AP both built up area and area covered by roads, canals, tanks and streams, were found to be substantially smaller than those recorded by the field survey. In the UP villages too, built up area according to RS is substantially less than that of the survey figures. The differences could be to some extent due to the fact that cadastral maps are outdated and do not reflect considerable changes that have taken place in land use due to new buildings, road alignments and dereliction / encroachments, water bodies and streams. It is reported that while RS estimates of built up area cover only the area covered by buildings the estimate from village record includes the area of the plot on which they are situated. For instance, in AP, unlike the official land classification, which counts the entire area covered by these features as area under tanks and streams, the RS estimate does not cover shrubs and bushes, which have grown in them. While these seem plausible, the possibility of misidentification/ misclassification by RS cannot be ruled out. This aspect requires more detailed investigation than was possible in this exercise. These observations are summarized in Table 13 below.

Table 13: Comparison on area under invariant features such as Settlements, roads, tanks, river, canal etc.

Area in hectare

State	Village	Remote sensing	Field study	% variation
Andhra Pradesh	Arakatavemula	90.60	105.76	-14.33
	Kamanur	255.23	414.55	-38.43
Gujarat	Sundan	47.99	46.21	3.85
	Surpura	133.22	131.05	1.66
Karnataka	Badanidiyur	71.82	108.44	-33.77
	Tyavadahalli	16.09	20.70	-22.27
Uttar Pradesh	Aliabad	30.06	34.37	-12.54
	Budina Kalan	56.44	100.30	-43.73
	Siyakhas	12.71	14.65	-13.24

% variation = (Remote sensing - Field study)/ Field study *100

5.4.2.8 Estimates of agricultural land and crop area: The two estimates of the extent of agricultural land (comprising cultivated area, fallows, pastures and miscellaneous tree crops) are also in close agreement in most states. However, estimates of total cropped area and area under different crops in different seasons differ from those obtained from the field survey in varying degrees. RS estimate of Kharif area is very close to the survey estimate in 2 of the 5 villages, whereas is substantially higher than survey estimates in the remaining 3 villages. In the Rabi season, the estimates are again quite close in 2 villages; RS estimates are substantially higher than FS in 2 other villages and substantially lower in other 2 villages. In the Zaid season, RS estimates are much higher than the survey figures (Table 14)

Table 1 4: Comparison of Total Cropped Area

Area in hectare

State	Village	Kharif			Rabi			Zaid		
		Remote sensing	Field study	% variation	Remote sensing	Field study	% variation	Remote sensing	Field study	% variation
Andhra Pradesh	Arakatavemula				531.8	997.1	-46.7			
	Kamanur				758.2	966.0	-21.5			
Gujarat	Sundan	476.3	440.7	8.1	469.9	471.9	-0.4	425.7	252.4	68.6
	Surpura	676.9	594.3	13.9	357.1	392.3	-9.0	108.7	67.6	60.7
Karnataka	Badanidiyur				185.6	135.6	36.8			
	Tyavadahalli				41.2	35.4	16.4			
Uttar Pradesh	Aliabad	85.5	70.3	21.6	87.2	70.0	24.5			
	Budina Kalan	739.3	759.2	-2.6	755.8	439.6	71.9	405.1	250.7	61.6
	Siyakhas	128.0	132.1	-3.1	156.0	155.1	0.5	19.2	8.0	138.6

% variation = (Remote sensing - Field study)/ Field study *100

Note: Care should be taken while interpretation of above figures, particularly the large deviations, as date of pass with respect to satellite data acquisition does not synchronise with that of the ground situation when FS data is collected.

5.4.2.9 Identification of crops: The differences are much wider when we compare in accuracy with which RS has identified specific crops grown on different plots and estimated area under each. A detailed plot wise comparison of RS and FS reporting of crops grown in 5 villages (3 in UP and 2 in Gujarat) shows that the proportion of plots for which RS has correctly identified crops, grown on them, varies from 18% to 54% at an overall level. The number of crops grown as recorded by the field survey is invariably much larger than the number identified by RS. Amongst those which are identified by both, the number of plots where crops have been correctly been identified by RS is much smaller, by and large, but in varying margins as compared to the findings of the field survey. (**Annexure 17**). These findings are summarized in Table 15 below.

Table 15: Percentage of plots where land use is correctly classified in Field Study and Remote sensing

State	Village	Kharif	Rabi	Zaid
Andhra Pradesh	Arakatavemula		45	
	Kamanur		38	
Gujarat	Sundan	39	25	
	Surpura	26	38	
Karnataka	Badanidiyur		54	
	Tyavadahalli		46	
Uttar Pradesh	Aliabad	20	14	
	Budina Kalan	33	35	40
	Siyakhas	18	32	40

Note: Care should be taken while interpretation of above figures, particularly the large deviations, as date of pass with respect to satellite data acquisition does not synchronise with that of the ground situation when FS data is collected.

5.4.2.10 Crop coverage**:** It is noteworthy that the number of crops reported by Field Study (FS) is invariably higher than those identified by RS. The number of plots under identified crops according to RS estimates is invariably lower than those recorded by FS but by varying margins. Field survey data collected by visiting every plot in the village, are obviously far more detailed and accurate than estimates based on RS. Broadly speaking the incidence of correct identification by RS relative to FS appears to be better in crops that are cultivated extensively (Table 16).

Table 16: Incidence of correct identification

State	Village	Kharif			Rabi			Zaid		
		1	2	3	1	2	3	1	2	3
Andhra Pradesh	Arakatavemula				1	67	8			
	Kamanur				3	35-89	6			
Gujarat	Sundan	4	12-68	10	5	8-34	13			
	Surpura	3	14-71	7	3	10-57	8			
Karnataka	Badanidiyur				1	0-49	1			
	Tyavadahalli				2	96-100	10			
Uttar Pradesh	Aliabad	3	60-86	4	8	6-33	8			
	Budina Kalan	5	29-100	7	7	0-100	8	3	6-100	13
	Siyakhas	4	8-45	3	4	22-50	3	3	0-50	4

1: number of crops identified by both RS and FS; 2: Range of ratio between number of plots identified by RS and those reported by FS; 3: Number of crops identified by FS but not by RS

5.4.2.11 Crop wise area estimates*:* There are also large differences in the area estimates for major crops from RS and FS. However, differences are not as striking as in accuracy of plot-wise identification. In fact, according to data for 6 villages (for details see **Annexure 18**) covering both seasons, RS estimate for the majority of crops covered are 75% or more than the FS estimate and actually exceeds it (by a large margin in some cases), in 14 out of 46 observations. This may be partly due to misidentification and misclassification of crops and areas by RS which could be due to several factors, like, spatial resolution, time/season of imaging, and corresponding ground truth availability (Table 17).

Table 17: Frequency distribution of number of crops according to ratio of RS estimates of area and FS estimates

State	Ratio of RS estimate to FS estimate of area				
	<50%	**50 - 75%**	**75 – 100%**	**>100**	**All**
Andhra Pradesh	1	1	3		**5**
Gujarat	4	2	2	7	**15**
Karnataka	2			3	**5**
Uttar Pradesh	6	3	10	7	**26**
All	**13**	**6**	**15**	**17**	**51**

5.4.2.12 The field survey, which was done within a small time window in the middle of the season, with supervised collection of data on crops actually grown on each plot, was meant to provide an authenticated picture of the actual ground level situation. But this process is not error free in so far as estimation of area under mixed crops and of multiple crops grown on the same survey/subdivision number are concerned. Comparisons with RS estimates must also take into account any difference between the timing of the imagery and that of the field survey. Satellite data on the other hand were obtained on a single instance but varying dates depending on availability of cloud-free data. While we are not in a position to assess the relative importance of these factors in accounting for these differences the following points are noteworthy.

5.4.2.13 Estimates based on imagery depend on the quality of cloud free imagery in particular locations, date of pass; whether the dates correspond to the time of maximum crop growth/ cover and of particular crops; the spatial resolution of the imagery; and the degree of accuracy in discriminating different land use categories, crops and estimation of the area under each. The quality of cloud free imagery is likely to be a serious problem in Kharif but less so in other seasons. However, multiple RS satellites, with reasonable time intervals in the date-of-pass, could improve the situation by increasing probability of obtaining cloud-free imaging, except during perpetually long and continuous cloud cover as during monsoon season.

5.4.2.14 Likewise, it may be noted that the use of remote sensing data from a single pass on dates ranging from 14 Oct to 30 Oct in Kharif; from 26 Jan to May 5 in Rabi; and between mid April and mid May for the Zaid is inadequate. Given the vast diversity of crops grown, and differences in crop calenders and regions, the RS data may not capture the phase of maximum cover for all crops and in all villages if image acquisition is not done according to the field conditions. Problems would be compounded if the dates of ground truth data for developing signatures are very different from the dates of imagery used for estimation. The results for the Andhra villages highlight this problem; but might also be a factor in other cases.

5.4.2.15 It is essential to note that date-of-pass and the concurrent ground truth data becomes an important factor for training set statistics and crop type classification. Also, it is to be noted that variability in the crop calendar with respect to local agro-meteorological conditions need to be kept in mind while data acquisition. These are the basic facts which is carefully handled under CAPE/ FASAL project through meticulous planning with respect to all State-specific data acquisitions and processing.

5.4.2.16 The other reason for the differences is that the resolution of LISS III (23 meters pixel size) is much too coarse to discriminate between crops which are grown on relatively small areas, scattered plots and when crops closely co-exist along with others in the same plot. Statistical analysis of the probability of correct classification of various land uses and crops suggest an overall accuracy of 70% with an accuracy rate for individual crops ranging widely around the average. Simultaneous imaging with LISS-III and LISS-IV, where LISS- IV imageries can be used to verify information from small areas, will greatly help in reducing uncertainties.

5.4.2.17 There is also the difficulty of discriminating between more than one crop being grown on a single survey/subdivision (this problem is highlighted in the UP villages) which are not amenable for mapping using LISS III data; and where (as in Gujarat villages) a large variety of crops are grown in small patches. The latter situation could also have a significant impact on crop wise area estimation by RS. In some areas (especially in the Udupi village), discrimination between different land use and crops are difficult because of the dominance of tree clad areas. Also, difficulty is observed in the discrimination between different trees and the fact that field crops and settlements are interspersed under trees, which makes it even more challenging for error-free classification.

5.4.2.18 The current study shows that while it is possible to use satellite imagery to map plot level land use and cropping at the village level, considerable amount of work to improve and test the methodology of interpretation and validation is necessary, before RS can be used on wider scale for estimating land use and cropping at higher levels of crop and spatial disaggregation. LISS IV is clearly appropriate for getting village level details and LISS III can be used to get estimates at district, State and National levels. It is also worth mentioning here that AWiFS (with 55 m spatial resolution) with high repetivity is a good candidate for regular national level crop estimation exercise. Hence, it is important to arrive at an optimal combination and judicious mix of these three sensors and field inputs for the future of crop acreage and production estimation in the country.

5.4.2.19 The experience from this pilot study suggests several specific directions of improvement in methodology of image interpretation, classification and validation. These include (1) updating and digitizing cadastral maps; (2) using satellite imagery from several passes during each season to identify the timing of maximum crop cover; (3) deciding the dates on the basis of more up-to-date information on cropping patterns and crop calendars for each season for different regions; (4) determining the scope in terms of crops to be covered based on the characteristics of cropping in different regions (care to be taken with respect to agro climatic conditions, coverage of rain-fed and irrigated areas and specially dealing with those figures for estimation); (5) exploring the possibilities of using satellite imageries to capture variations in sowing time, duration of the same crop across regions, crop varieties, and to differentiate between irrigated and rain-fed areas for more efficient design and management of crop cutting experiments.

5.4.2.20 At the same time it is necessary to find ways of solving the problems of obtaining high resolution imagery and interpreting them during periods of prolonged cloud cover and in difficult terrains. This calls for having better repetivity of satellite passes to enable more number of attempts to image cloud-prone areas and at the same time explore more possibilities with microwave sensors in the coming days. Moreover, it is apparent that RS cannot, in the present situation, distinguish between mixed crops and crops that are grown in relatively small areas and in scattered plots owing to limitations in spectral and spatial resolutions. Satellite imageries can be used to identify spatial concentrations of latter type of crops (especially vegetables and horticulture) and resort to specially designed sample surveys to get more details of their composition and output.

5.5 The Way Forward

5.5.1 Existing System: That the existing system for generating land use and crop area statistics does not provide reliable, complete and timely data is an indisputable fact. This is primarily due to its dependence on tens of thousands of overworked, poorly supervised village officials to compile the data, because of this it is prone to a high risk of errors of omission and commission, subjective judgements. The tasks of organization and supervision are obviously unmanageable. Attempts to address these problems through the Timely Reporting Scheme and EARAS by limiting the scale of data collection to one fifth of the villages have not been successful. Nor can it succeed because the effort needed to improve it is much too large and difficult.

5.5.1.2 In our interim report we had suggested a two pronged approach in improving the existing system. The first calls for a revamp of the existing system by setting up the National Crop Statistics Centre (NCSC) as an autonomous, professional organization in the Ministry of Agriculture for generating reliable and unbiased estimates of land use, crop area and yields at the state and national levels. For this purpose it is not necessary to collect data through the existing system on such a large scale as is now being attempted through TRS/EARAS over 120,000 villages. The required data both for area and yield estimates can be obtained from a much smaller number of villages (about 15000) selected through proper sampling design. The area data will be compiled for each sample village through complete plot wise inspection and yield estimated through crop cutting experiments in a sample plots, But with smaller size the task of organizing and supervising these operations will be far more manageable. In the process the incidence of non sampling errors, which is the main problem in the existing system, will be substantially reduced.

5.5.2 RS based system: The second prong emphasizes the need to take concerted steps to exploit the potential of RS for providing independent estimates and also help the existing system function more efficiently at all levels. This calls for a concerted and well planned effort to strengthen and institutionalize the capacity to utilize RS and progressively increase its scale and scope for generating these data. That it has the capability to generate estimates of land use area under major crops down to the district level has been demonstrated by FASAL. The pilot study of select villages suggests that even coarse resolution imagery can be used to get an idea, albeit rough, of the situation at the village level. However, the level of detail and accuracy with which crops can be identified and estimated with the current technology is limited. Advances in remote sensing technology are constantly improving the accuracy, level of detail and spatial disaggregation at which estimates can be made. One can even visualize the possibility of it providing a viable alternative to the present system of compiling village wise data on land use and cropping.

5.5.2.2 While RS has established its capability to produce reliable agricultural statistics, much more work and experience is needed to exploit its full potential. Hence, RS must be viewed as a complementary system, and not as a substitute, for conventional methods of collecting data for some time to come. It must also be recognized that even with better technology RS may not be able to provide area estimates for all crops and all regions. In any case the expansion in scope and coverage of RS must be a graduated process starting with measures to make more effective use of existing technology; learning about the potentials and limitations of evolving technology; developing and testing methodology for using them effectively and in a cost effective way; and on building strong institutions manned and managed by professionals to undertake these tasks. These issues are discussed in the pages that follow.

5.5.2.3 Hardware configurations**:** Currently, FASAL uses satellite imageries in the optical and near IR domain, generated by IRS LISS III sensor. LISS III provides imagery with a resolution of 23 meters for a given swath width of 141 km at an interval of 24 days. The basic unit in which the spectral information on ground features is available covers an area of 23 square meters. Features with smaller dimensions cannot be identified with precision. In practice, identification and visual interpretation of different features is usually done for an area of 70 square meters. This is considered suitable for mapping of land use/ land cover, including agricultural land and other vegetation up to a scale of 1:50,000. FASAL uses digital satellite remote sensing to estimate area under wheat at the national and state level and of some other major crops in selected states and districts, where they are grown on a sizeable scale, in contiguous stretches of land. Information from micro wave sensors of RADARSAT is also used to estimate state level area under rice during Kharif when cloud cover makes it impossible to get data from optical region.

5.5.2.4 Satellite and sensor designs/ technologies are changing rapidly with newer and improved capabilities of imaging. Plans are already underway to launch satellites with microwave imaging capabilities which work in a different spectral range and are capable of providing images even under heavy cloud cover conditions. The methodology and skill needed for interpreting these imageries are different, and considerably more complex, than that of visual spectrum. More such developments are expected in realization of newer sensors and satellites in the future. But our current knowledge of their implications for the range, level of detail and accuracy of land use and crop data that they can provide, as well as the kind of supporting facilities and personnel they will need, are insufficient for planning the RS programme for agriculture.

5.5.2.5 The efficacy of RS depends not only on the technological capability of satellites but importantly on the care and sophistication of methods used for deciding the timing of imagery and interpretation/classification of pixels and estimating area. Measures to improve the methodology used for the above purposes need to be examined: An important aspect relates to the basis for selection of training sites and dates of pass for collecting 'ground truth' observations for determining 'signatures' and the relative merits of the maximum likelihood method as compared to other approaches for classifying various features for ensuring minimum probability of misclassification.

5.5.2.6 Given wide variations in the dates for sowing and harvesting across regions, crops and varieties of the same crop, estimates are likely to be sensitive to the choice of location and date of pass of obtaining imagery to estimate crop wise area. At present these dates are decided on the basis of available information on crop calendars which are too gross and outdated. A systematic effort to get more detailed and up-to-date region wise crop calendars could help evolve a strategy for achieving a better fit between optimum number and timing of pass by region and crop.

5.5.2.7 While it is important to keep track of these developments, the immediate emphasis has to be on finding ways to make more effective use of the capabilities of AWiFS, LISS III and IV cameras which are part of RESOURSES AT 1 satellite and likely to continue in the near future. It is useful to explore the possibilities of using these imageries to provide estimates of land use and crop area these (again after independent ground truth verification on a sample basis) at the level of Country, State and districts and with respect to agro climatic regions and sub regions or by stratifying them on the basis of intensity of irrigation. The limitations of these satellites in terms of attainable level of crop detail and ability to deal with the cloud cover problem can be overcome in a phased manner with better repetivity through multiple satellites in addition to more sophisticated microwave sensors availability in the near future.

5.5.3 Suggested Future Programme

5.5.3.1 We are in favour of continuing FASAL but with significant changes in its scope and measures to improve its coverage and reliability. Its focus should be on

(a) providing reliable and timely advance estimates of area under major crops at the national, and state levels;

(b) expanding crop coverage in rabi and summer seasons, as well as crop coverage of kharif crops using microwave remote sensing and multiple satellites with frequent revisit capability for providing improved crop estimation;

(c) evolving a procedure for validation of RS estimates for different crops by independent, first hand assessment of the area actually grown in selected sample locations. The programme should be integrated with NCSC, once it is established, in a way that complements and supports it.

(d) devising ways in which satellites and sensors with different degrees of resolution can be used in optimal combinations to generate reliable data on conditions of, and trends in, land use, crop patterns and crop production at the sub district and village levels.

(e)The aim is not only to provide forecasts, but also estimates of actual area of different crops in different seasons and to help improve sampling design and conduct of crop cutting surveys. Demonstrating this capability, and operationalising it, could substantially reduce problems arising from the current dependence on village functionaries for collecting primary data.

5.5.3.2 Hardware requirements: The number of satellites, their design and the kind of sensors they need to carry needs to be examined in relation to the users' requirements in terms of level of spatial and crop detail, the periodicity of estimates on the one hand and taking into account technical feasibility and considering the implications in terms of manpower, organization and costs. This will have to take into account current state of technology and be reassessed periodically in the light of new developments. Pending this exercise, the immediate priority should be to develop operational capability to use combination of AWiFS, LISS III and LISS IV for detailed estimation of land use and crop statistics at national level to sub district and village levels. (see technical note from NRSA in the **Annexure 19**).

5.5.3.3 Based on the experience gained so far, we suggest for consideration the establishment of an operational remote sensing system for regular monitoring of agricultural parameters. It should consist of at least three identical remote sensing satellites, all orbiting at the same Sun Synchronous orbital Altitude, displaced 6-8 days apart in their equatorial crossing. This will ensure availability of enough imageries to obtain cloud cover free pictures around the time of interest. Each of these satellites may carry three identical payloads namely WiFS, LISS-3 and LISS-IV, along with a C-Band radar operating in two polarizations. While WiFS and LISS-III will be able to quickly cover larger areas at district, State and national level, LISS-IV will be able to closely monitor smaller areas, if necessary. In addition to the frequent surveys using three satellites, which will take pictures of each area once every 6-8 days to obtain adequate number of cloud free imageries, microwave sensor imaging will further guarantee availability of pictures even during cloudy days. Such an operational system will provide considerable amount of flexibility in tracking agricultural parameters.

5.5.3.4 New analytical techniques, particularly extensive use of difference techniques, will have to be developed to ensure timely processing of voluminous data obtained from such an operational system. Since such techniques have also been developed by SAC and NRSC for various other applications, it is now possible to operationalise a robust RS system for regular monitoring of agricultural parameters.

5.5.3.5 Several preparatory actions have to be taken to enable the system to be used effectively. These include:

- Getting a technical group to estimate the cost of setting up and operating the system and securing the necessary clearances, including budgetary allocations,
- developing and testing the methodology and protocols for using imagery to map land use patterns, identify and estimate area under different crops;
- working out organizational and personnel requirements for implementing these protocols;
- preparing a phased programme for training of personnel;
- evolving a methodology for independent ground truth verification of land use and crop area estimates on a manageable and efficient scale.

5.5.3.6 The RS unit being set up in the Ministry should collaborate with SAC to develop and test the methodology and protocols appropriate to getting comprehensive and detailed plot level data of land use and crops at the sub district level (blocks and villages). These should then be tested in a few selected villages chosen from different regions (preferably the same ones selected for our study) through the relevant regional and state RSACs with technical guidance and support from SAC. The estimates generated by these centers should then be validated, as was attempted in our study, by direct plot wise inspection in each of the villages by an independent set of investigators making use of the best available technology.

5.5.3.7 In addition, we suggest using hand held sensors (GPS) capable of automatically providing lat-long coordinates, based on which the nature of, and the area under, land use, irrigation status and crops grown on each plot as per the cadastral map.. Such sensors are already available and improved versions are in prospect. The information is in a digitized form which can be transmitted electronically to a centralized system for comparisons with the findings of direct field inspection and RS estimates. (The present state of this technique and its capability for collecting land use and cropping data are described in the **Annexure 20**).

5.5.3.8 Their use would drastically reduce the effort involved in recording plot level data by physical inspection and also ensure much higher levels of accuracy. If the pilot studies establish the feasibility of using such simple hand-held equipment for high data quality and validity, then, physical inspection of plots to ascertain ground reality can be dispensed with. This would greatly facilitate the potential for, and reducing the costs of, using high spatial resolution satellite data for generating, and validating RS estimates of key agricultural characteristics on a wider scale. This will also open up the possibilities of using a strong GIS / Geospatial database of all such ground validated points for cross referencing and over a period of time these vector data could be tagged with various other attribute data for building a strong time series information in the long run. Hence, this initiative would provide new possibilities of using RS, GIS and GPS as a combination of technologies for better future possibilities.

5.5.3.9 These preparatory studies will provide a better understanding of the issues and problems involved in using different satellites and methods of validation and find solutions to them, which in turn would provide a basis for using them in optimal combinations for wider geographical coverage. These studies should be started by the RS unit being set up in the Ministry. It should be shifted and made an integral part of the NCSC once it is established. This is necessary to encourage research and application of RS techniques focused on complementing and supporting the NCSC's field survey programme to generate reliable national and state level estimates of land use, crop areas and production.

5.5.3.10 Besides giving a clearly defined focus for its activities in terms of objectives and locations, RS unit will have a framework in which it works collaboratively with those responsible for sampling design and the collection of land use and area statistics and crop cutting experiments through field agencies. Over a period of time, this will help delineate the relative roles of different techniques for collection and validation of data and how they can be used in a complementary and mutually supportive manner.

5.5.4 Use of RS for Yield Estimation

5.5.4.1 We have already commented on the current approach to estimating yield using RS. No concrete results of their application are available to demonstrate the efficacy of estimating bio mass based on satellite imagery; the relation between bio mass and yields for different crops; and empirical validation of the estimates with actual verification in test sites. Validation of the findings would require testing the estimates for specific crops in selected locations (preferably research stations with controlled and well managed experiments) against the relations actually observed in these locations. We strongly urge that there should be a sustained, joint effort involving RS experts and agricultural scientists to address these issues. The process will also give an opportunity for focused interactions to better understand the relation between the biological, agro climatic and agronomic determinants of yield and their relation to bio mass and yield-biomass relations.

5.5.4.2 High resolution RS imagery at the village level is potentially useful to provide information relevant to design and conduct of crop cutting surveys for yield estimation under the NCSC. Since the sample villages are expected to be selected through a stratified sampling procedure (to reflect conditions in different agro climatic regions and irrigation status), the CCE sample can also be so designed to capture these differences. But these would not provide any information on the readiness of sample crop plots for harvest or the dates of actual harvest. Experience of the current GCES has highlighted the difficulties of ensuring that field workers responsible for conducting the experiments are actually present at harvest and conduct the crop cuts in the sampled plots. This problem needs to be examined.

5.5.4.3 As already noted, even with higher resolution imagery and microwave sensors, the composition of mixed crops and of crops like vegetables and fruits grown in small scattered patches cannot be identified accurately. Estimation of area under individual elements of these categories is also difficult. Moreover vegetables and fruits, crops like cotton are not harvested at a single point of time, but several times during each season. Because of this, crop cutting experiments in statistically chosen sample plots are unsuitable for estimating yields of the above categories of crops. They call for a different approach based on sampling of territorial units, stratified according the extent of area under such crops and use of a combination of sample surveys to assess quantities harvested and of surveys of households growing these crops in the sample villages. It is particularly important to ensure that these surveys get data on multiple pickings/cuttings. Designs to address these problems have already been developed and tested by IASRI. These designs are already being used to estimate horticultural production. Here again the responsibility for generating unbiased and reliable estimates at the state and national levels must be with the NCSC.

5.5.5 Organisational Arrangements

5.5.5.1 Setting up the NCSC as an autonomous and professionally managed body in the Ministry of Agriculture is of critical importance for success of the restructuring of the agricultural statistics system as recommended in this report. It will be key institution responsible for (a) providing reliable, and unbiased estimates of land use, crop areas and yields at the state and national levels along the lines using crop estimation surveys outlined in the interim report; (b) promoting the use of RS on a wider scale for generating more detailed, disaggregated data of specified crops and regions by developing, testing and validating the methodology and demonstrating their efficacy; and (c) determine the relative roles of field surveys and RS, individually and in combination, and suggest a strategy for using them in optimal combination.

5.5.5.2 We would like to reiterate the importance of having a governing body with specialists having extensive knowledge and experience in design and conduct of sample surveys of agriculture (in institutions like the Indian Statistical institute in Kolkata and the IASRI, New Delhi), and in use of Remote sensing for crop area and yield estimation along with agricultural scientists and administrators. The design, conduct and supervision of crop estimation surveys requires technical staff of high professional quality for sampling design, working out field work procedures, supervision and inspection of field work. The actual field work will be done by staff of SASA of various states specifically appointed and dedicated for this purpose. The cost will be borne by the government based a clear understanding and acceptance by the states regarding the role of NCSC in all aspects of the design and conduct of surveys, the role of its inspectors, and in recruitment and training of field investigators and their local supervisors. This requires a collective consensus between states and the centre through discussion in appropriate forums for inter-state consultations. Thereafter formal MOUs specifying the details of the arrangements have to be signed with each state government. These tasks will be the responsibility of the Ministry. State-wise operational plans and procedures will then be decided by the NCSC board in which users of data will be represented by senior and experienced professionals from SASA/ State DES .

5.5.5.3 Besides designing and organizing current crop estimation surveys and getting its inspectors to post-verify the field work in a subsample of villages/plots, it is important for NCSC to have a high quality professional group for continuing analytical research, to improve the methodology and procedures in all aspects of crop estimation surveys and the use of Remote sensing for generating agricultural statistics.

5.5.5.4 The RS unit should take over the responsibility for providing advance forecasts of area under major crops after restructuring the current FASAL. It will lay down clear priorities regarding the crops and spatial detail at which advance estimates are to be made. The methodology, operational procedures for estimation and validation, and supervision of their application in the field will be developed in collaboration with SAC/NRSC. NRSC will provide State /regional remote sensing centres the necessary satellite imageries for interpretation and estimation of crop area and production as required. The results will be reviewed regularly at the end of each season jointly by NRSc and SRSACs.

5.5.5.5 All these must be based on clearly specified mutually agreed contracts between RS unit on the one hand and NRSC and SRSACs on the other. RS unit should commission NSSO or its own team for validation of RS estimates of specified characteristics based on data by independent inspections of the ground level situation in statistically sampled locations. Results of inspection will be compared with estimates from remote sensing to assess the error margins of the latter. Necessary action to address and remedy deficiencies must be taken by NCSC.

5.5.5.6 Besides overseeing crop area forecasts, this unit should take the lead in sponsoring collaborative studies by NRSC and agricultural research organizations on the feasibility and efficacy of using satellite imagery for estimating bio mass and yields of different crops, prepare and implement a long term programme in collaboration with NRSA for utilizing existing and new technologies to generate more detailed, reliable and disaggregated estimates of land use and cropping. These should be field tested in select locations through SRSCs and their results independently validated. This process may have to be repeated till its capability and efficacy relative to those attained by NCSC surveys using conventional field survey based approaches to area estimation. If the estimates by these two approaches are close, the case for adopting RS using high resolution imagery for area estimation would be credible. This would then help plan and implement a programme to encourage and assist to adopt RS to generate these data at sub district and even village levels.

5.5.6 Improving Analytical Capacity in Ministry

5.5.6.1 The above scheme, if properly implemented and sustained, will help improve the quality of basic data needed for reliable forecasts of current crop conditions in different seasons, but also for tracking the trends in land use, crop patterns, crop wise area and yields. But this does not meet all the requirements of planning and policy. That calls for data on several other aspects such as, to mention but a few of the more important ones, extent and sources of irrigation, meteorological variables, extent of area under different seed varieties, fertilizers , prices of inputs and- all these by regions and crop wise for irrigated and rainfed areas. Such data are being collected by numerous agencies in government, academic institutions, consulting organizations and industries.

5.5.6.2 These are not always systematically collated, assayed and used. Wide differences between estimates made by different agencies are a common problem. Critical scrutiny of these differences to form an informed judgment of their relative merits is important. So is the need for systematic analysis of the data not just for estimating growth rates, but also for understating the role of different factors underlying them and their variations across space and time. Academic research on these aspects is severely hampered by lack of data as much as difficulty of accessing data that are collected. Much greater transparency on the concepts and methodology used and free accessibility to these data for researchers will stimulate more and better analysis.

5.5.6.3 It is equally important that top echelons of the Ministry takes serious interest in demanding data based analytical research inputs for its decision making both on current policy issues and those relevant for tackling development problems in a longer term perspective. This must backed by efforts to build a strong in house capability to meet these demands. In both respects the present situation in the Ministry leaves considerable room for improvement.

5.5.6.4 The Directorate of Economic and statistics which is supposed to provide information and analysis to support policy is ill equipped for the task organizationally and in terms of the pool of expertise. It is largely focused on meeting the information requirements of policy makers and that too in a fragmented way by different sections more or less independently. Huge data sets from diverse sources (TRS/EARAS, FASAL, various commodity boards, processing industries, Cost of cultivation surveys, agricultural census, reports on procurement, distribution, and stocks of food grains……) collected at great expense, remain largely unused. There is hardly any collective effort to look critically at the inadequacies and inconsistencies of different data sets, or to assess their relative merits. The directorate is not geared for, nor is it much pressured to do serious analysis. There is an urgent need to restructure it into a unified department under a strong professional leadership and with a broader mandate to better serve the policy process.

6. Summary of Conclusions and Recommendations

6.1 Existing System

6.1.1 India's current agricultural statistics system relies on village patwaris to compile plot wise data on land use and crop-wise area and estimates **of** crop yields based on crop cutting experiments in statistically selected sample villages and plots. That the system is not providing comprehensive, reliable, and timely data on crop area and production has been highlighted in numerous academic forums, conferences and reports of official committees. So are apprehensions that its performance in all these respects has deteriorated. The latest review by the National Statistics Commission provides a comprehensive assessment of the nature of deficiencies in the organisation and functioning of the system. They have emphasized the need for reforms to improve the existing system, upgrade the status and professionalism of state statistical organizations and explore the possibilities of using remote sensing.

6.1.2 Following this suggestion, the Ministry of agriculture appointed the present Committee to

(1) review current methodology used in TRS/ EARAS/ ICS and GCES for estimating land use, crop area, yield and production estimates and suggest institutional framework for improvement of agricultural statistics; and

(2) review experience of RS technology for estimating area and yield of various **crops**, assess its potential for generating reliable and timely data and suggest measures to effectively exploit this potential.

6.2 Deficiencies of the Existing System

6.2.1 Detailed analysis of supervision reports of land use and crop area records maintained by patwaris and yield estimates from CCEs under the ICS scheme clearly shows that the system does not deliver complete, timely and reliable data. A special survey of 102 villages showed that areas under different crops grown on sample plots as recorded by FOD supervisors in ICS villages (and village khasra in non ICS villages) are at considerable variance compared to information obtained from farmers on the crops they actually grew on these plots in that year.

6.2.2 The deficiencies in the current system of both area and yield estimation are not due to deficiencies in its design. The selection of sample villages for collecting data on land use and crop area, sampling of plots for crop cutting experiments are based on rigorous and statistically sound principles. The procedures for collection, recording, reporting and supervision of the data have been worked out with considerable care. Properly implemented, the system should generate estimates at the state and central levels within an acceptable margin of statistical (sampling) error.

6.2.3 That it has failed to do so **is** partly due to the scale of effort involved : area estimates require complete enumeration of plots in 120000 villages by exclusive reliance on a large number of poorly trained, over burdened, and poorly supervised village officials. **F**ragmentation of responsibilities for data compilation, supervision and validation among different organizations working more or less independently has compounded the problem. Indiscriminate increase in the number of crop cutting experiments to generate yield estimates at district and sub district levels has made it very difficult to ensure that they are done properly and without any bias.

6.3 Restructuring the existing system

6.3.1 A radical restructuring of the system is necessary to ensure objective, reliable and timely estimates of crop wise area and yields. Changing the present arrangements for collection of primary data in all villages is a huge and difficult task. It needs to be tackled in a phased manner by training of village level functionaries and stricter supervision of their work by the state statistical organizations.

6.3.2 The immediate focus should be on putting in place an institutional arrangement that would provide reliable and timely data needed for monitoring agricultural trends and for policy making at the state and national levels. This objective can be achieved by properly designed and carefully monitored collection of data on land use and crop area based on complete enumeration and crop yields based on crop cutting experiments on a smaller scale. On a rough estimate, a sample of 15000 villages (compared to the 120,000 covered under TRS) and 90000 CCEs (as against the planned 170,000 experiments and 880,000 actually done at present) would be adequate to generate reliable state and national level estimates. The personnel required to canvas data and ensuring effective control over data quality through strict supervision of their work will be of manageable proportions and at affordable cost. But it is essential that all the operations involved be planned, managed and supervised by a unified, autonomous and professionally managed organization. For this purpose we recommend setting up of a National Crop Statistics Centre (NCSC) as an autonomous, professional organization in the Ministry of Agriculture of the Government of India.

6.3.3 The NCSC should have a governing body chaired by a person of high professional standing with first hand experience in design, organisation and conduct of sample surveys of agriculture and include experts in sample surveys and image analysis, senior officials of DE&S and representatives of state statistical agencies. Executive head of the Centre should be a qualified Statistician with experience in conduct of sample surveys.

6.3.4 Primary data on land use in sample villages to be collected by complete enumeration and conduct of sample crop cutting experiments will be done by State statistical agencies enabled and empowered to function as autonomous and professional organizations. The staff they need for this purpose and for supervising them should be dedicated to this scheme with the costs being funded entirely by the NCSC. In addition NCSC inspectors will supervise the conduct of village level workers in a sub sample of the selected villages to verify accuracy of the data collected. NCSC will be responsible for ensuring that deficiencies in the working of field agencies are corrected.

6.3.5 Reliable village level data on land use and crop area are necessary for micro level planning and policy by state and local governments. The present system of recording these data must continue but steps must be taken to bring the responsibility for collection and supervision under State statistical agencies empowered to function as autonomous professionally managed organisations independent of administrative departments. The central government should support and encourage states to undertake these reforms.

6.4 Role of Remote Sensing

6.4.1 The advent of satellites has opened the possibility of using remote sensing for estimating land use, crop area and yield. Its technical feasibility has been explored and demonstrated by studies of the National Remote Sensing agency. Its capability is increasing with technological advances in satellite design and sensors. RS also could greatly reduce dependence on human agency and attendant errors in collecting data. Recognising this, the Ministry of Agriculture has been working with ISRO since 1987 leading to the launch of the project, in 2002, for Forecasting Agricultural Output Using Space, Agro-meteorology and Land based observations (FASAL).

6.4.2 FASAL has developed and used methodology for estimating area under different land uses and crops. It provides the Ministry advance estimates of area of major crops at the national state, and in some cases, district levels. Our review highlights the fact that the feasible level of crop and spatial detail, as well accuracy of estimates, is limited by the capability of satellites and sensors currently in use; that the current methods of validation of RS estimates, or for that matter estimates from conventional methods, are inadequate; and that not much progress has been made in using RS to estimate crop yields. Our pilot study in selected villages to explore the use of RS to track land use and cropping at the village level shows the limited capacity of LISS III for this purpose. However, the advent of higher resolution satellites makes it possible to get more accurate and detailed data on land use, crops and crop down at all levels down to the village.

6.4.3 The present RS programme should be expanded and reorganized to provide reliable and validated in-season forecasts and end-season estimates of area for a wider range of crops at the state and national levels; as well as comprehensive and detailed plot level data of land use and crops at the village level. It must be complementary to, rather than a substitute for, improving conventional methods of collecting these data. The availability of independent estimates of these aspects from the two approaches for common spatial units and validated by independent verification of actual conditions on the ground, will help assess their reliability with greater confidence. As the capacity of RS to generate reliable and spatially disaggregated data is established, we could consider using it to reduce dependence on the human agency for collecting primary village level data.

6.4.4 Considerable amount of work on methodology, estimation and validation needs to be done for establishing the capability of RS to provide reliable estimates of yield. The future programme of RS research to develop appropriate models and test their efficacy using data from controlled experiments in ICAR research stations and Agricultural universities. This has to be planned and implemented as a coordinated programme involving RS experts, and agricultural research institutions. In the meanwhile, the possibilities should be explored for using high resolution imagery to help in sampling design, and improve the conduct of crop cutting experiments by providing more reliable information on the harvest-readiness of crops in sample plots

6.4.5 For crops that cannot be covered by RS, and those (like vegetables, fruits, and cotton) that are harvested, a different approach needs to be adopted for getting detailed estimates of both area and yield (based on stratified sampling of territorial units, and using a combination of sample surveys of households growing them to assess quantities harvested)

6.4.6 Programmes to exploit these potentials have to be based on careful planning of appropriate satellite configurations and sensors to provide them at reasonable cost; improve, test and validate the methodology and protocols for estimation in the light of changing technology; and set up an organizational to implement programme in a professional.

6.5 Hardware support

6.5.1 These programmes will need careful planning of the configurations of hardware facilities taking advantage of technological advances in imaging technology as well as sensors that local officials can use for recording plot level land use, irrigation and crops. Satellites are now equipped with both LISS III and LISS IV cameras. While LISS IV has a much higher resolution, its swath and repetivity are much smaller. In order to substantially improve the possibility of obtaining cloud free imagery with optical cameras, more than one satellite, in a similar sun synchronous orbit but displaced from each other to repetitively image same areas at shortest intervals of time is needed.

6.5.2 The appropriate configuration of the satellites and sensors has to be decided after careful review of the requirements (in terms of scope, periodicity, level of detail and precision) of the user (Ministry of Agriculture). The Committee has suggested a minimal configuration of three identical remote sensing satellites, each carrying WIFs, LISS-III, LISS-IV and a C-Band microwave synthetic aperture radar, imaging from the same sun synchronous orbital altitude but displaced by 6-8 days apart in their equatorial crossing longitude. While WIFs and LISS-III are ideally suited to collect relevant agricultural data at state and national levels, LISS-IV will be helpful in collecting data at district and village levels. The availability of microwave sensor data will ensure capability of imaging even under heavy cloud conditions.

6.5.3 Hand held sensors (GPS) are now available with the capability to identify lat-long coordinates, and the nature of, and the area under, land use, irrigation status and crops grown on each plot in the cadastral map. They can greatly reduce the effort required to collect the basic data at the village level, improve its accuracy and get them transmitted to a central data network. We recommend that such sensors should be used for village level data collection.

6.6 Organisational Aspects

6.6.1 The proposed NCSC should be the nodal agency to undertake the above activities in collaboration with the Department**s** of Agriculture and Space. Its primary and continuing responsibility will be to provide reliable and timely estimates, at the state and national levels of area under major crops through complete enumeration of plots in selected sample villages and of crop yields based on properly conducted crop cutting experiments. The suggested composition of the governing council and the professional staff is meant to ensure that these are done professionally and in a transparent and objective manner.

6.6.2 The RS unit which will be an integral part of the NCSC will work under the guidance of its governing council. It should provide independent estimates of land use and crop area in the villages selected for NCSC's field survey for a rigorous comparison of RS estimates with estimates based on plot wise data collected in these villages. In addition it should be responsible for developing improved techniques of image analysis and validation; arranging for training of personnel in the state and regional remote sensing centres; providing technical advice and analysis needed for informed decisions on the design of satellites and hardware to meet the data needs of users at affordable cost; and help in planning strategies for expanding the scope and scale of RS techniques. In all these activities, the unit is expected to function under the overall policy guidance of the NCSC governing council and work in close collaboration with the Ministry, NRSA and agricultural research organizations.

6.6.3 **Reorganising DE&S**: While implementation of our recommendations will contribute to improving the scope and quality of data on key agricultural data, their effective use for better understanding of emerging trends and their underlying causes, and for policy advice depends crucially on building the analytical capacity in the Ministry. The present organization and staffing of DE&S is inadequate and measures to address this inadequacy need urgent attention.

Annexure 1

Main features of the components of the Scheme "Improvement of Agriculture Statistics"

TRS Timely Reporting Scheme	**EARAS** Establishment of an Agency for Reporting Agricultural Statistics	**ICS** Improvement of Crop Statistics
1. Commencement Started in 1968-69	Started in 1975-76	Started in 1973-74
2. Coverage Covers **19** temporarily settled States where revenue agencies maintain records of land utilisation statistics namely, Andhra Pradesh, Assam, Bihar, Chattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamilnadu, Uttar Pradesh, Uttarakhand, Puducherry and Delhi.	Covers **3** permanently settled States of Kerala, Orissa, West Bengal and **4** North Eastern States namely, Arunachal Pradesh, Nagaland, Sikkim and Tripura.	Covers 22 States/UTs of Andhra Pradesh, Assam, Bihar, Chattisgarh, Gujrat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamilnadu, Uttar Pradesh, Uttarakhand, Delhi and Puducherry and Kerala, Orissa & West Bengal
3. Pattern of assistance 100% by Government of India **Budget for 2007-2008** Rs. 928.00 lakh **Budget for 2008-2009** Rs. 1042.60 lakh **Budget for 2009-2010** Rs. 1323.60 lakh **Budget for 2010-2011** Rs. 1490.00 lakh	100% by Government of India Rs. 2991.00 lakh Rs. 3217.00 lakh Rs. 4145.00 lakh Rs. 4050.00 lakh	100% by Government of India Rs. 668.00 lakh Rs. 718.40 lakh Rs. 1007.90 lakh Rs. 1070.00 lakh
4. Regular Manpower Statistical staff: 602 Secretarial Assistance: 47 Peons: 69 **Total: 718**	Supervisory Staff: 52 Field Staff: 2499 Secretarial Assistance: 127 Peons: 70 **Total: 2748**	Supervisors of Supervisory Staff: 23 Supervisory Staff: 320 Secretarial Assistance: 40 Peons: 79 **Total: 462**

TRS Timely Reporting Scheme	**EARAS** Establishment of an Agency for Reporting Agricultural Statistics	**ICS** Improvement of Crop Statistics
Andhra Pradesh 57 Assam 50 Bihar 43 Chattisgarh 16 Gujarat 41 Haryana 21 Himachal Pradesh 22 Jammu & Kashmir 37 Jharkhand 22 Karnataka 106 Madhya Pradesh 63 Maharashtra 61 Rajasthan 54 Tamilnadu 39 Uttar Pradesh 74 Uttarkhand 3 Delhi 6 Puducherry 3	Kerala 860 Orissa 1553 West Bengal 254 Arunachal Pradesh 19 Nagaland 16 Tripura 43 Sikkim 3 (There are 138 staff on honorarium basis in Sikkim)	Andhra Pradesh 43 Assam 10 Bihar 38 Chattisgarh 15 Gujarat 29 Haryana 18 Himachal Pradesh 14 Jammu & Kashmir 15 Jharkhand 24 Karnataka 10 Madhya Pradesh 59 Maharashtra 22 Rajasthan 22 Tamilnadu 22 Uttar Pradesh 117 Uttarkhand 2 Puducherry 2
5. Main Objective To obtain reliable and timely estimates of area under principal crops in each season with break up of area under irrigated/ un-irrigated, traditional and high yielding varieties of crops and land utilisation statistics, which is used to design crop estimation survey by conducting priority Girdawari in 20% of villages every year. Villages are selected in such a way that all the villages are covered in a state in five years. The scheme is implemented in the States that are cadastrally surveyed.	To generate estimates of area and production of principal crops in each season through surveys in 20% selected villages through staff recruited for this purpose only. Villages are selected in such a way that all the villages are covered in a state in five years. In the sample village, crop area is to be reported based on complete enumeration of all fields/survey numbers. Surveys are specially required as no agency in these States is engaged in updating land use statistics.	The objective of this scheme is locating through joint efforts of the Central and State Agencies, deficiencies in the system of collection of crop statistics and suggests remedial measures for effecting lasting improvement in the system. The scheme accomplishes its objective by conducting sample checks on the primary field work through: a) physical verification of the crop enumeration done by the primary workers in a sample about 10,000 villages in each season b) Checking of the aggregation of crop-wise area in the khasra register of these villages and c) Supervision of about 30,000 crop cutting experiments at harvest stage in a year.

TRS Timely Reporting Scheme	**EARAS** Establishment of an Agency for Reporting Agricultural Statistics	**ICS** Improvement of Crop Statistics
6. Data collection at Grass-root level Government of India does not fund primary data collection by Patwari under TRS. It covers sampling design of TRS for priority data collection, timely completion of consolidation at district and State level.	Primary data collection and its supervision by Revenue Inspectors under Directorate of Land Records in West-Bengal and staff engaged under the EARAS scheme in other States and its consolidation at district and State level.	1) Central agency – NSSO (not funded) 2) State – Supervisory Staff engaged by States under the Scheme.
7.Need for Scheme Land Record Manual in different States contains instructions on period of crop enumeration and procedure for compilation of crop area at village and successive higher levels with the expectation that crop abstract would become available by the time the final forecast for different crops become due. Experience has shown that there has been considerable time lag in the availability of reliable and correct statistics of area sown under different crops. This has greatly handicapped catering to the needs of monitoring the plans and timely policy formulations. TRS provide for consolidation of area statistics through advance enumeration of adequate number (20%) of villages selected at random.	In the non-land record States, the State agencies do not update land utilisation records and therefore there exist gap in the data. The scheme provides for setting up of a full fledged agency to cover a sample of 20% of the villages every year, to generate basic land use statistics. In each sample village complete enumeration is done to record areas under crops. Supervision is also done under the scheme.	The scheme is needed to locate lacuna, if any, in the State system of collection of agricultural statistics and suggest measures to effect lasting improvements in this system, through joint efforts of the Central and State authorities. The joint efforts are in the form of sample check on (I) area enumeration, (ii) page totaling of khasra registers and (iii) conduct of crop cutting experiments.

TRS Timely Reporting Scheme	**EARAS** Establishment of an Agency for Reporting Agricultural Statistics	**ICS** Improvement of Crop Statistics
8.Methodology/ Procedure The basic approach of the scheme is to organise selection of 20% villages and to complete on top priority the crop area enumeration in selected villages by the primary workers in tune with the sowing season of different crops and by suitably advancing the same, when needed. The crop enumeration organised through TRS facilitates the frame for Crop Estimation. The special emphasis on timeliness and accuracy of crop area enumeration in a large sample of villages bring about the improvement in the system of collection and compilation of statistics of area under crops.	In West Bengal and Orissa, the crop wise area enumeration work is done in all Mouzas/Villages selected under EARAS. Besides area statistics, EARAS provides frame to select plots for conduct of crop cutting experiments to estimate yield rates. In Kerala, for collection of area statistics, the State is divided into 811 investigator zone. A sample of 100 key plots is selected from each investigator zone. With respect to each key plot a cluster consisting of 5 sub survey division numbers is formed and land utilisation statistics are collected from these 100 clusters of 5 sub survey division numbers.	The sample check on area enumeration consist of selecting and locating a sample of 20 survey/sub-survey numbers within each selected village with the help of Khasra register and village maps and then recording the actual utilisation by the supervisor. The sample check on preparation of crop abstract consists of checking of page wise totals of area figures recorded under crops and utilisation in the khasra register and recording the totals of crop areas and utilisation. Supervision on crop cutting experiments at harvest stage covers specified major crops and consist of examining whether the State primary worker conducts the experiments conforming to the procedure laid down under the General Crop Estimation Surveys of the State. The aspect of check includes the selection of survey numbers/ sub-survey numbers, fields and random coordinates, marking of plots and harvesting and weighing of produce.

Annexure 2

Composition of Committee to review present schemes of TRS, EARAS and ICS for Improving Agricultural Statistics and to examine use of Remote Sensing applications in Agricultural Statistics

1.	Prof. A. Vaidyanathan, Eminent Agriculture Economist, Chennai	Chairman
2.	Prof S.P. Mukherjee, Chairman, Calcutta Statistical Association	Member
3.	Prof. U.R. Rao, Former Chairman, Space Commission	Member
4.	Dr. S. M. Jharwal, Principal Adviser, Department of Agriculture & Cooperation, Ministry of Agriculture	Member
5.	Economic and Statistical Adviser, Directorate of Economics & Statistics, Ministry of Agriculture	Member
6.	Additional Director General, NSSO, FOD, Ministry of Statistics and Programme Implementation	Member
7.	Dr. S. D. Sharma, Additional Director General, ICAR, New Delhi	Member
8.	Dr. Prem Narain, Agriculture Scientist	Member
9.	Shri P.C.Mohanan, Deputy Director General, Ministry of Statistics and Programme Implementation	Member
10-13.	Director, State Agricultural Statistics Authority (SASA) of Uttar Pradesh, West Bengal, Andhra Pradesh and Gujarat	Members
14.	Adviser (ASI), Directorate of Economics & Statistics, Ministry of Agriculture	Member Secretary

Dates and Venues of Different Meetings held by the Committee

First meeting - 3rd and 4th April, 2009 at ISEC, Bangalore

Focus was on area estimation

Second meeting - 5th and 6th May, 2009 at the International Guest House, NASC Complex, Pusa, New Delhi

Presentation was made by ADG, FOD, NSSO highlighting the findings of reports of inspection of ICS villages on degree of non-compliance with prescribed procedure for timely collection and transmission of crop area statistics for each season under TRS/ EARAS and of crop yield under GCES.

The presentation was made by SAC highlighting that Estimates of land use at the State level have been made for some years and Area estimates for wheat, kharif rice and winter potato are made at different stages of the relevant crop season and sent to the Ministry of Agriculture. Estimates are made at the national level and for major growing states using medium resolution imagery, which is considered adequate to get state level estimate with an acceptable degree of sampling error.

Third Meeting - 10th July, 2009 at Krishi Bhavan, New Delhi

First phase fieldwork for 2008-09 for the selected 102 villages on the accuracy of village records and actual observance of procedures for collection of agricultural statistics to be taken up.

A special committee comprising Prof. Mukherjee, Dr S.M. Jharwal, Dr. AK Yogi, Dr. Parihar, Mr. Mohanan, Mr. Sanjay and Dr Daleep Singh to work out details of organizational modalities and TORs of this exercise, articulate and formulate a programme and provide an estimate of the financial requirement for carrying out the work. Ministry of Agriculture to meet the costs.

Fourth Meeting – 23rd February, 2010 at Krishi Bhawan, New Delhi

The presentation was made by DES on the core findings from the ICS.

The presentation was made by SRSACs of three States namely Uttar Pradesh, Gujarat and Karnataka about the progress made in Phase-II survey.

Fifth Meeting – 26th April, 2010 at Krishi Bhawan, New Delhi

Presentation made on Draft Interim Report on Phase I

Sixth Meeting – 5th June, 2010 at Krishi Bhawan, New Delhi

Discussion on Draft Interim Report on Phase I and presentation was made by SRSACs of four States namely Andhra Pradesh, Uttar Pradesh, Gujarat and Karnataka about the progress made in Phase-II survey.

Seventh Meeting – 10th August, 2010 at Krishi Bhawan, New Delhi

Issues relating to remote sensing, imageries and its interpretation were discussed. Results of Phase II survey were also discussed.

Eighth Meeting – 21st October, 2010 at Krishi Bhawan, New Delhi

Discussion on draft report on remote sensing and village studies circulated earlier by Chairman and to suggest way forward.

Ninth Meeting – 13-14th January, 2011 at ISRO, Antriksh Bhawan, Bangalore

Review and approval to the final draft circulated by Chairman after incorporating changes suggested by Members.

Sub-Committee Meetings:

1. 5th & 6th June, 2009 - Visit of Prof. S.P.Mukherjee, Shri P.C.Mohanan, Ms Shobha Marwah and Dr Dalip Singh to Space Application Centre (SAC), Ahmedabad to understand the methodology being used to estimate area under each of the major crop including statistical consideration therein with a view to minimizing errors of mis-classification.

2. 25th August, 2009 at Krishi Bhawan at New Delhi

Phase-II exercise consisting of two distinct and separate components: Estimation of land use pattern and area under different crops in Kharif, Rabi and Summer seasons using (1) RS methodology; and (2) complete plot by plot enumeration by an independent team with the aim to assess the extent of detail and accuracy that can be achieved with RS.

3. 7th September, 2009 at Krishi Bhawan, New Delhi

Finalise the programme of the Phase-II Field work

4. 25th March 2010 at ISRO, Antarikash Bhavan, Bangalore

Under the Chairmanship of Prof. Mukherjee with Shri P.C. Mohanan, Dr. Prem Narain, Shri Dalip Singh reviewed the results of the Phase II pilot study on technical and operational problems for crop acreage estimation by remote sensing at village level.

List of invitees and other officers who participated in the meetings are as follows:

1. Dr. K. Radhakrishnan, Chairman, ISRO/Secretary, DOS
2. Shri K.V. Krishnan, ex-Principal Adviser, DAC
3. Shri R.C. Ray, ex-Economic & Statistical Adviser, DES
4. Dr. V.S. Hegde, Director, EOS/ Scientific Secretary, ISRO
5. Dr. R.R. Navalgund, Director, SAC, ISRO
6. Dr. J.S. Parihar, Deputy Director, RESA & Mission Director, EOAM, Ahmedabad
7. Dr. P.G. Diwaker, Associate Director, EOS, ISRO HQ
8. Dr. K.M. Reddy, Director General, SRSAC, Andhra Pradesh
9. Shri K.V.V. Ramesh, Senior Scientific Officer, APSRSAS, Andhra Pradesh
10. Shri T.P. Singh, Director, BISAG, Gandhinagar, Gujarat
11. Dr. Prabhu Raj, Director, Karnataka SRSAC, Bangalore
12. Dr. V. Sreedhara, Scientist, KRSAC, Bangalore
13. Shri P.C. Gupta, Scientist, SRSAC, Uttar Pradesh
14. Dr. A.K. Yogi, ex-ADG, NSSO (FOD)
15. Shri A.K. Srivastava, DDG, NSSO (FOD)
16. Shri H.E. Rajashekharappa, Director, DES, Karnataka
17. Shri Dalip Singh, Additional Statistical Adviser, DES, New Delhi

Annexure 4.1

ERRORS IN COMPLETION OF AREA ENUMERATION

The data collected by the NSSO and SASAs as part of the ICS are tabulated by the Agricultural Statistics Wing of the Field Operations Division of NSSO. The findings from these supervision exercises are published for each state both in respect of area enumeration and crop cutting experiments.

The details of land utilisations for each of the selected survey numbers in the selected clusters are noted by the supervisors, after visiting the field. After recording these, the entries as made by the Patwari are noted form the relevant registers (Khasra for example) in the prescribed schedule. Patwari records the entries in Khasra while conducting Girdawari. The period of conducting Girdawari is prescribed in each State for different seasons and time schedule for sample check on area enumeration under ICS is also prescribed. The findings of ICS are compiled in a Publication, **"Review of Crop Statistics in India through scheme for Improvement of Crop Statistics"** of NSSO. The findings noted below and in Annexures 4.2, 4.3, 4.4, 7, 8 and 9 are from the results published by NSSO.

Table 1 - TIMELINESS IN COMPLETION OF GIRDAWARI – Time series for 22 States covered under TRS

For Central Sample

Year	Percentage of villages where Girdawari was completed											
	Early Kharif			Late Kharif			Rabi			Summer		
	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*
2007-08	46	6	48	48	11	41	47	11	41	44	13	42
2006-07	47	8	43	50	10	39	46	11	42	50	13	35
2005-06	46	7	46	51	10	38	49	12	38	49	13	36
2004-05	47	7	44	55	11	34	51	12	36	52	11	36
2003-04	46	9	45	52	12	34	51	13	36	49	11	39
2002-03	44	7	49	54	12	34	50	15	35	48	17	34
2001-02	43	9	48	60	13	27	54	11	33	55	12	31
2000-01	48	7	45	54	12	33	54	13	32	53	12	35
1999-00	43	9	46	53	13	33	48	18	32	51	11	37
1998-99	38	10	52	52	13	33	53	13	33	50	12	36
1997-98	32	16	50	54	15	31	52	13	33	49	13	36

For State Sample

Year	Percentage of villages where Girdawari was completed											
	Early Kharif			Late Kharif			Rabi			Summer		
	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*
2007 -08	45	21	33	57	27	14	55	27	16	47	26	23
2006 -07	49	23	27	62	23	12	62	21	13	52	24	20
2005 -06	46	30	24	61	26	10	62	24	11	51	24	18
2004 -05	48	29	20	64	23	10	64	21	10	54	25	16
2003 -04	53	22	21	62	25	9	64	22	11	55	27	14
2002 -03	52	25	22	64	26	8	66	23	9	57	27	13
2001 -02	53	23	19	65	26	7	60	28	9	59	25	12
2000 -01	52	22	20	66	23	8	61	27	8	52	30	11
1999 -00	48	26	22	64	24	10	57	31	9	56	27	13
1998 -99	39	28	27	61	26	10	60	25	12	55	25	17
1997 -98	41	25	23	63	25	10	63	24	9	59	24	14

**NC - Not Completed till Sample check visit*

Table 2 - STATE-WISE TIMELINESS IN COMPLETION OF GIRDAWARI FOR 2007-08

For Central Sample

State	Percentage of villages where Girdawari was completed											
	Kharif						Rabi					
	Early Kharif			Late Kharif			Rabi			Summer		
	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*
Andhra Pradesh				2	1	98	4	1	95			
Assam	0	0	100	0	0	100	0	0	100	0	0	100
Bihar	1	1	97	1	0	99	0	0	100	0	1	99
Chhattisgarh				91	0	9	71	12	17	25	0	0
Gujarat				5	2	91	1	1	98	1	0	99
Haryana				94	6	1	97	1	2	69	14	18
Himachal Pradesh				97	3	0	100	0	0			
Jammu & Kashmir				89	8	3	99	0	0			
Jharkhand	0	0	100	0	0	100	0	0	100	0	0	100
Karnataka				75	11	14	59	16	23	67	12	21
Kerala	88	9	3	100	0	0				99	1	0
Madhya Pradesh				88	8	4	88	9	3			
Maharashtra				21	13	66	32	6	61			
Orissa	100	0	0	99	1	0				95	5	0
Punjab				43	40	17	45	45	9	84	16	0
Rajasthan				80	19	1	90	7	0	95	4	1
Tamil Nadu	91	0	9	84	2	15	97	0	3			
Uttar Pradesh				35	19	45	36	28	36	45	25	30
Uttarakhand				80	4	16	85	12	3	74	26	0
West Bengal	19	26	54	16	38	44	30	31	37	33	28	38
Delhi				80	20	0	70	30	0			
Puducherry				100	0	0	100	0	0	100	0	0

For State Sample

State	Percentage of villages where Girdawari was completed											
	Kharif						Rabi					
	Early Kharif			Late Kharif			Rabi			Summer		
	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*	In time	Late	NC*
Andhra Pradesh				36	51	11	42	49	8			
Assam	0	0	100	0	0	100	0	0	100	0	0	100
Bihar	8	8	84	6	27	67	7	22	71	1	6	92
Chhattisgarh				88	11	0	84	11	3	0	0	0
Gujarat				11	7	80	15	1	84	9	2	84
Haryana				100	1	0	100	1	0	0	0	0
Himachal Pradesh				99	1	0	88	8	0			
Jammu & Kashmir				87	0	6	85	5	4			
Jharkhand	35	42	23	36	28	36	21	25	52	2	34	64
Karnataka				78	20	0	80	18	0	82	16	1
Kerala	96	4	0	100	0	0				91	9	0
Madhya Pradesh				90	10	0	90	8	0			
Maharashtra				38	47	4	43	35	2			
Orissa	100	0	0	100	0	0				100	0	0
Punjab				36	63	0	35	63	0	36	53	0
Rajasthan				74	26	0	77	21	0	85	10	0
Tamil Nadu	77	2	17	90	0	0	88	2	5			
Uttar Pradesh				51	44	3	52	42	2	57	39	1
Uttarakhand				79	20	1	81	19	0	76	24	0
West Bengal	15	62	21	31	50	18	32	48	16	36	48	16
Delhi	Sample checks not carried out though planned											
Puducherry				100	0	0	100	0	0	89	0	0

**NC - Not Completed till Sample check visit*

Annexure 4.2

TIMELINESS IN SUBMISSION OF TRS STATEMENT

All seasons - Central Sample

Year	Percentage of Villages for which							
	TRS Statement submitted					TRS Statement not Submitted		
	Without completing Girdawari		After completing Girdawari		Information regarding date of submission not known	Though Girdawari completed	Girdawari not completed	Information regarding TRS submission not available
	By due date	After due date	By due date	After due date				
2007-08	2	2	35	13	1	13	32	1
2006-07	4	2	37	11	1	13	29	2
2005-06	6	1	37	11	1	12	29	1
2004-05	7	1	37	14	1	12	29	1
2003-04	6	1	34	13	1	15	28	2
2002-03	6	1	31	15	1	17	28	1
2001-02	6	1	32	15	1	16	25	1
2000-01	6	1	34	14	1	15	27	1
1999-00	7	1	34	15	1	14	27	1
1998-99	6	1	36	12	1	14	28	1
1997-98	7	1	34	16	1	13	26	1

All seasons - State Sample

Year	Percentage of Villages for which							
	TRS Statement submitted					TRS Statement not Submitted		
	Without completing Girdawari		After completing Girdawari		Information regarding date of submission not known	Though Girdawar i complete d	Girdawari not completed	Information regarding TRS submission not available
	By due date	After due date	By due date	After due date				
2007-08	3	3	44	26	3	4	13	2
2006-07	5	2	50	22	3	3	11	3
2005-06	3	3	50	23	2	7	7	3
2004-05	5	3	49	25	3	6	6	3
2003-04	4	3	51	27	2	4	5	4
2002-03	5	4	49	31	2	3	5	2
2001-02	5	4	44	32	2	3	4	2
2000-01	6	3	45	32	3	3	5	1
1999-00	7	4	46	30	3	3	5	1
1998-99	5	4	45	32	3	3	5	1
1997-98	5	3	46	32	3	4	3	1

TIMELINESS IN SUBMISSION OF TRS STATEMENT DURING 2007-08

Sl No	State	Season	Agency	Percentage of Villages for which							
				TRS Statement submitted					TRS Statement not Submitted		
				Without completing Girdawari		After completing Girdawari		Information regarding date of submission not known	Though Girdawari completed	Girdawari not completed	Information regarding TRS submission not available
				By due date	After due date	By due date	After due date				
1	2	3	4	5	6	7	8	9	10	11	12
1	Andhra Pradesh	Kharif	C	30.1	48.3	6.9	1.1	1.8	2.6	3.2	0.0
			S	24.5	16.3	14.1	33.1	1.2	8.6	0.0	0.8
		Rabi	C	0.0	0.0	4.5	0.0	1.1	89.2	4.2	1.1
			S	15.0	0.7	41.3	1.5	3.1	38.3	0.0	0.0
2	Assam	Early Kharif	C	0.0	2.6	0.0	0.0	0.0	0.0	97.4	0.0
			S	0.0	25.6	0.0	0.0	0.0	0.0	74.4	0.0
		Late Kharif	C	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
			S	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
		Rabi	C	1.3	2.6	0.0	0.0	0.0	0.0	90.8	0.0
			S	0.0	0.7	0.0	0.0	0.0	0.0	99.3	0.0
		Summer	C	2.0	1.4	0.0	0.0	0.0	0.0	96.6	0.0
			S	0.0	4.4	0.0	0.0	0.0	0.0	95.6	0.0
3	Bihar	Bhadhai	C	0.0	5.8	0.8	0.0	0.0	2.9	90.0	0.0
			S	0.5	3.3	3.3	10.9	0.0	0.0	82.0	0.0
		Aghani	C	0.0	0.0	0.4	0.0	0.0	0.0	99.6	0.0
			S	2.6	18.9	7.1	20.4	1.5	0.0	49.0	0.0
		Rabi	C	0.0	2.5	0.0	0.0	0.0	0.0	97.5	0.0
			S	0.0	18.2	3.2	15.0	0.0	8.6	53.6	0.0
		Summer	C	0.0	0.0	0.0	1.3	0.0	0.0	98.7	0.0
			S	0.0	5.1	0.0	6.5	0.0	0.9	87.6	0.0
4	Chhattisgarh	Kharif	C	0.0	0.0	77.8	9.1	0.0	9.1	4.0	0.0
			S	0.0	1.0	79.0	15.0	1.0	2.0	0.0	2.0
		Rabi	C	13.1	0.0	72.7	12.1	0.0	0.0	2.0	0.0
			S	7.0	1.0	50.0	36.0	0.0	5.0	0.0	0.0
		Summer	C	25.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0
			S								
5	Gujarat	Kharif	C	0.0	0.0	0.6	1.5	2.1	7.6	86.8	1.5
			S	30.6	3.5	12.5	3.1	7.6	2.8	34.4	4.9
		Rabi	C	0.9	0.6	0.3	0.0	1.8	1.8	91.7	3.0
			S	0.0	4.5	15.3	1.4	6.6	26.4	35.1	10.8
		Summer	C	0.0	2.4	0.9	0.3	1.2	2.9	92.3	0.0
			S	18.0	3.3	7.8	2.0	9.0	0.0	46.7	9.4
6	Haryana @	Kharif	C	0.0	0.5	90.0	0.5	0.0	8.5	0.5	0.0
			S	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
		Rabi	C	0.0	0.0	84.3	1.0	2.5	11.1	0.5	0.0
			S	0.0	0.5	99.5	0.0	0.0	0.0	0.0	0.0
		Summer	C	0.0	0.0	35.0	5.0	0.0	42.5	1.0	16.5
			S								

Sl No	State	Season	Agency	Percentage of Villages for which							
				TRS Statement submitted					TRS Statement not Submitted		
				Without completing Girdawari		After completing Girdawari		Information regarding date of submission not known	Though Girdawari completed	Girdawari not completed	Information regarding TRS submission not available
				By due date	After due date	By due date	After due date				
1	2	3	4	5	6	7	8	9	10	11	12
7	Himachal Pradesh	Kharif	C	0.0	0.0	55.1	16.7	0.7	27.5	0.0	0.0
			S	0.0	0.0	36.1	58.3	1.9	3.7	0.0	0.0
		Rabi	C	0.7	0.0	84.8	1.4	0.0	8.7	4.3	0.0
			S	0.0	0.0	80.0	19.0	0.0	1.0	0.0	0.0
8	Jammu & Kashmir	Kharif	C	0.0	0.0	63.1	1.5	0.0	30.8	4.6	0.0
			S	6.4	0.0	81.7	0.0	0.9	3.7	1.8	1.8
		Rabi	C	0.0	0.0	61.8	0.0	1.5	33.8	0.0	2.9
			S	0.0	0.0	81.0	3.6	3.6	7.1	0.0	4.8
9	Jharkhand	Bhadhai	C	32.2	8.5	0.0	0.0	0.0	0.0	59.3	0.0
			S	0.0	1.9	25.0	51.9	7.7	1.9	11.5	0.0
		Aghani	C	10.2	22.0	0.0	6.8	0.0	0.0	61.0	0.0
			S	0.0	0.0	50.0	28.0	2.0	0.0	20.0	0.0
		Rabi	C	0.0	0.0	18.6	33.9	0.0	0.0	47.5	0.0
			S	0.0	0.0	0.0	37.5	0.0	0.0	62.5	0.0
		Summer	C	0.0	0.0	13.8	31.0	0.0	0.0	55.2	0.0
			S	0.0	0.0	14.0	14.0	0.0	10.0	62.0	0.0
10	Karnataka	Kharif	C	2.0	0.3	56.9	12.8	0.3	15.8	11.1	0.3
			S	0.0	0.7	73.6	22.1	1.7	0.0	0.3	0.0
		Rabi	C	1.0	1.4	43.6	12.5	1.7	15.5	22.0	1.7
			S	0.3	0.0	74.1	21.8	1.4	0.3	0.0	0.7
		Summer	C	0.0	1.0	59.9	9.7	2.0	9.7	17.1	0.7
			S	0.0	0.0	80.6	16.4	1.3	0.0	0.7	1.0
11	Kerala	Autumn	C	0.0	0.0	45.5	27.3	0.0	24.7	2.6	0.0
			S	0.0	0.0	81.6	17.1	0.0	1.3	0.0	0.0
		Winter	C	1.3	0.0	72.4	18.4	0.0	7.9	0.0	0.0
			S	0.0	11.8	100.0	0.0	0.0	0.0	0.0	0.0
		Summer	C	0.0	0.0	67.5	18.2	0.0	13.0	0.0	1.3
			S	0.0	11.8	75.0	9.2	0.0	9.2	0.0	6.6
12	Madhya Pradesh	Kharif	C	0.8	0.0	87.5	4.7	1.7	3.9	0.8	0.3
			S	0.0	0.0	94.4	5.6	0.0	0.0	0.0	0.0
		Rabi	C	1.4	0.0	88.3	5.6	0.6	2.8	1.1	0.3
			S	0.0	0.0	90.0	6.9	2.2	0.0	0.0	0.6
		Summer	C								
			S								
13	Maharashtra	Kharif	C	12.0	5.0	14.3	5.0	2.5	12.0	46.1	3.0
			S	0.0	1.1	39.4	15.5	17.5	8.7	1.1	15.5
		Rabi	C	0.0	0.7	16.7	6.4	4.8	26.9	44.1	0.5
			S	4.5	1.5	37.5	17.5	19.0	2.4	0.3	14.5
		Summer	C	1.8	0.9	14.8	8.0	1.1	38.6	34.1	0.0
			S	1.4	2.4	27.0	25.6	20.4	2.8	1.4	16.6
14	Orissa	Autumn	C	0.0	0.0	95.0	1.4	1.8	0.9	0.0	0.9
			S	0.0	0.0	99.5	0.0	0.0	0.0	0.0	0.5
		Winter	C	0.0	0.0	96.8	0.9	0.5	1.8	0.0	0.0
			S	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0

Sl No	State	Season	Agency	Percentage of Villages for which							
				TRS Statement submitted					TRS Statement not Submitted		
				Without completing Girdawari		After completing Girdawari		Information regarding date of submission not known	Though Girdawari completed	Girdawari not completed	Information regarding TRS submission not available
				By due date	After due date	By due date	After due date				
1	2	3	4	5	6	7	8	9	10	11	12
		Summer	C	0.0	0.0	96.8	3.2	0.0	0.0	0.0	0.0
			S	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
15	Punjab	Kharif	C	0.0	0.0	20.5	21.5	0.5	44.0	13.0	0.5
			S	0.0	0.5	22.7	61.6	6.1	6.6	0.0	2.0
		Rabi	C	0.0	0.5	22.5	29.5	2.0	38.5	7.0	0.0
			S	0.0	1.0	14.8	73.0	5.6	4.6	0.0	0.0
		Summer	C	0.0	0.0	40.0	10.9	0.0	49.1	0.0	0.0
			S	0.0	0.0	11.6	23.2	10.7	7.1	0.0	45.5
16	Rajasthan	Kharif	C	0.3	0.0	52.7	44.0	0.7	1.0	1.3	0.0
			S	0.0	0.0	66.3	28.9	3.3	0.4	0.0	0.7
		Rabi	C	0.3	0.0	61.3	34.7	2.3	1.0	0.0	0.0
			S	0.0	0.0	44.9	50.7	1.8	1.1	0.0	0.7
		Summer	C	0.0	0.0	78.9	19.3	0.9	0.0	0.9	0.0
			S	0.0	0.0	63.2	19.1	12.5	0.7	0.0	4.4
17	Tamil Nadu	Phase-I	C	7.3	1.9	29.2	61.2	0.0	0.4	0.0	0.0
			S	0.4	0.4	25.8	68.1	0.4	0.0	0.0	0.0
		Phase-II	C	0.0	1.5	88.0	3.5	0.8	6.2	0.0	0.0
			S	0.0	10.4	89.6	0.0	0.0	0.0	0.0	0.0
		Phase-III	C	0.0	0.0	99.2	0.8	0.0	0.0	0.0	0.0
			S	0.0	3.8	81.9	8.5	0.0	5.4	0.0	0.0
18	Uttar Pradesh	Kharif	C	0.0	1.0	17.9	27.9	0.3	10.0	42.6	0.3
			S	1.7	2.6	25.7	61.4	3.6	1.8	2.2	0.3
		Rabi	C	0.0	0.9	15.1	39.3	0.0	10.2	34.1	0.1
			S	0.0	1.0	21.6	70.1	2.8	1.7	1.7	0.0
		Summer	C	0.0	0.0	14.3	40.2	0.6	15.4	29.3	0.1
			S	0.0	2.1	20.7	67.7	3.9	3.2	1.4	0.7
19	Uttrakhand	Kharif	C	0.9	0.0	56.4	11.8	0.0	13.6	17.3	0.0
			S	0.0	0.0	46.2	46.2	3.8	1.0	0.0	0.0
		Rabi	C	0.0	0.0	80.9	6.4	0.0	1.8	3.6	0.0
			S	0.0	1.0	57.1	34.3	5.7	0.0	0.0	0.0
		Summer	C	0.0	0.0	69.6	28.3	0.0	2.2	0.0	0.0
			S	0.0	0.0	52.2	47.8	0.0	0.0	0.0	0.0
20	West Bengal	Aus	C	0.0	0.0	11.2	22.4	0.4	15.6	49.6	0.8
			S	0.0	0.0	23.3	51.0	2.3	2.0	21.0	0.0
		Amman	C	0.8	0.0	28.6	6.5	1.6	29.4	30.2	1.2
			S	0.0	0.0	51.3	25.3	1.1	3.9	17.9	0.0
		Rabi	C	0.0	0.0	35.6	12.0	0.0	18.8	33.6	0.0
			S	0.0	0.0	45.4	31.3	3.7	3.4	16.2	0.0
		Summer	C	0.0	0.0	38.0	10.4	3.2	17.6	30.8	0.0
			S	0.0	0.0	44.9	32.7	3.6	3.1	15.6	0.0
21	Delhi	Kharif	C	10.0	0.0	0.0	0.0	0.0	30.0	60.0	0.0
			S	Sample checks not carried out though planned							
		Rabi	C	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0

Sl No	State	Season	Agency	Percentage of Villages for which							
				TRS Statement submitted					TRS Statement not Submitted		
				Without completing Girdawari		After completing Girdawari		Information regarding date of submission not known	Though Girdawari completed	Girdawari not completed	Information regarding TRS submission not available
				By due date	After due date	By due date	After due date				
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
			S	Sample checks not carried out though planned							
22	Puducherry	Kharif	C	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
			S	0.0	0.0	66.7	33.3	0.0	0.0	0.0	0.0
		Rabi-I	C	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
			S	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
		Rabi-II	C	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
			S	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
FOR STATES COVERED		Early Kharif	C	3.0	2.2	27.8	19.0	0.4	5.4	41.8	0.3
			S	0.2	3.3	35.3	32.5	1.0	0.7	25.8	0.1
		Late Kharif	C	3.8	4.7	39.1	11.1	0.9	10.4	28.7	0.5
			S	5.3	4.2	49.3	24.6	3.2	2.9	8.3	1.8
		Rabi	C	0.6	0.6	37.6	12.9	1.2	17.1	29.0	0.5
			S	2.4	1.8	45.5	25.1	3.7	8.5	10.2	1.9
		Summer	C	0.5	0.5	26.4	13.7	0.8	15.0	37.6	1.7
			S	1.7	1.9	34.4	25.6	4.8	2.2	19.3	5.5
All seasons			**C**	**1.9**	**2.2**	**34.6**	**13.0**	**0.9**	**13.2**	**32.0**	**0.8**
			S	**3.1**	**2.8**	**43.6**	**25.7**	**3.5**	**4.4**	**12.8**	**2.4**

Note:

1. * Central sample data repeated
2. @ The Field work was not carried out for State sample during Summer season

Annexure 4.3

ERRORS IN RECORDING CROP AREA

The different types of errors observed by the supervisory personnel are tabulated and presented in the ICS findings. The errors are categorized as: e_0 (no error), e_1 (not reporting the crop which is actually grown in the survey numbers, e_2 (recording a crop as sown in survey number when actually no crop is grown in the survey number) and e_3 (under or over assessment of the area under crop). The overall assessment is one of the significant differences in the observations of the supervisor and the primary worker. There is marginal improvement in the quality of work as errors have reduced over the years except in Early Kharif season as shown in Tables below. In State sample, the percentage of survey numbers where no error in enumeration was observed by the supervisor is approximately 20% more than in case of Central Sample. There are some states, where there is improvement in the quality of work, in the sense that percentage of survey numbers with no error has decreased. These are Chattisgarh, Haryana, Kerala, Madhya Pradesh, Punjab, Rajasthan and West Bengal. In Maharashtra and Karnataka although the quality of work has improved, but still the percentage of survey numbers with no error is less than 40%.

PERCENTAGE OF SURVEY NUMBERS IN, WHICH ERRORS IN RECORDING CROP AREA WERE OBSERVED

For Central Sample

Year	Percentage of survey numbers with different types of errors in enumeration of area during															
	Kharif								Rabi							
	Early Kharif				Late Kharif				Rabi				Summer			
	e_0	e_1	e_2	e_3	e_0	e_1	e_2	e_3	e_0	e_1	e_2	e_3	e_0	e_1	e_2	e_3
2007-08	75	12	3	10	61	14	5	20	66	13	4	17	78	9	2	11
2006-07	64	18	4	13	60	15	5	20	67	12	4	16	76	10	2	12
2005-06	65	17	3	15	57	16	6	21	64	13	4	18	76	10	2	12
2004-05	64	21	4	12	57	15	6	22	63	14	4	19	75	12	2	10
2003-04	60	19	7	13	57	16	6	21	64	14	4	18	77	9	2	11
2002-03	63	19	4	13	54	18	6	22	61	16	4	19	74	13	2	11
2001-02	63	19	4	14	52	17	6	25	57	17	4	21	73	12	2	13
2000-01	65	18	4	13	53	18	6	23	61	15	4	20	54	26	4	16
1999-00	61	20	7	13	53	18	6	23	63	14	4	18	59	24	3	14
1998-99	66	19	5	10	53	18	7	22	66	13	4	17	55	25	3	17
1997-98	64	21	4	11	53	18	6	23	62	15	4	19	55	26	3	15

For State Sample

Year	Percentage of survey numbers with different types of errors in enumeration of area during															
	Kharif								Rabi							
	Early Kharif				Late Kharif				Rabi				Summer			
	e_0	e_1	e_2	e_3	e_0	e_1	e_2	e_3	e_0	e_1	e_2	e_3	e_0	e_1	e_2	e_3
2007 -08	78	15	4	4	87	4	2	6	84	6	3	7	85	6	2	7
2006 -07	71	18	5	7	83	6	3	9	83	7	3	7	89	6	2	3
2005 -06	70	20	5	5	83	6	2	9	82	7	3	8	81	8	3	8
2004 -05	63	23	5	9	81	6	3	10	78	9	3	9	77	7	3	12
2003 -04	71	16	4	9	79	7	3	11	81	8	3	9	80	8	2	9
2002 -03	76	14	4	6	79	7	3	11	82	8	2	8	79	6	2	13
2001 -02	70	20	4	6	78	7	3	13	79	8	3	10	83	6	2	9
2000 -01	73	17	4	6	78	7	3	12	81	7	2	10	71	11	3	14
1999 -00	71	18	5	6	78	7	3	12	80	7	2	10	63	14	3	20
1998 -99	72	16	6	5	77	7	3	13	79	8	3	11	72	10	4	15
1997 -98	70	22	3	4	73	9	3	15	79	8	2	11	71	15	4	11

Table 1: Time-series Ratio of Patwari's entries and that of Supervisor for area

Centre Sample

Year	Paddy Late Kharif	Maize	Cotton	Sugarcane	Wheat	Gram
1	2	3	4	5	6	7
2007 -08	1.0037	0.9719	0.9754	0.9441	0.9463	0.9392
2006 -07	0.9908	0.9935	0.9113	0.9773	0.9593	0.9253
2005 -06	0.9739	0.9392	1.0076	0.9734	0.9562	0.9637
2004 -05	0.9777	0.9863	0.9835	0.9546	0.9529	0.9406
2003 -04	0.9729	0.9419	0.9975	0.9614	0.9553	0.9050
2002 -03	0.9504	0.9160	1.0063	0.9171	0.9270	0.9261
2001 -02	0.9636	0.9539	1.0276	0.9642	0.9423	0.8909
2000 -01	0.9872	0.9625	0.9826	0.9344	0.9549	0.9343
1999 -00	0.9871	0.9916	0.9580	0.9765	0.9455	0.9243
1998 -99	0.9817	0.9821	0.9714	0.9103	0.9646	0.9104

State Sample

Year	Paddy Late Kharif	Maize	Cotton	Sugarcane	Wheat	Gram
1	2	3	4	5	6	7
2007 -08	0.9908	0.9939	0.9873	0.9681	0.9835	0.9765
2006 -07	0.9953	0.9908	0.9923	0.9582	0.9808	0.9794
2005 -06	0.9861	0.9799	0.9865	1.0015	0.9796	0.8923
2004 -05	0.9919	1.0032	1.0019	1.0106	0.9646	0.9805
2003 -04	0.9858	1.0020	0.9983	0.9890	0.9839	0.9525
2002 -03	0.9849	0.9694	1.0114	0.9956	0.9830	0.9756
2001 -02	0.9925	0.9931	1.0002	0.9806	0.9686	0.9646
2000 -01	0.9812	1.0250	1.0031	0.9825	0.9850	0.9704
1999 -00	0.9806	0.9874	1.0034	0.9608	0.9801	0.9409
1998 -99	0.9882	0.9931	0.9892	0.9694	0.9622	0.9616

Table 2: State-wise Ratio of Patwari's entries and that of Supervisor for Area - 2007-08

Central Sample

Sl No	State	Paddy Late Kharif	Maize	Cotton	Sugarcane	Wheat	Gram
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	Andhra Pradesh	0.733	1.000	0.906	1.820		
2	Chhattisgarh	0.989	1.039				
3	Gujarat	1.003	0.939	0.860		0.411	0.612
4	Haryana	0.986	1.000	1.036	0.994	1.002	1.103
5	Himachal Pradesh	1.054	1.029			0.989	
6	Jammu & Kashmir	0.975	0.996			0.888	
7	Karnataka	1.023	0.958	0.961	0.895	0.792	0.962
8	Kerala	1.000					
9	Madhya Pradesh	1.013	0.940	0.962		0.946	0.926
10	Maharashtra	1.008		0.991	0.888	0.822	0.924
11	Orissa	0.998					
12	Punjab	0.999	0.988	0.988	0.995	1.012	1.000
13	Rajasthan		0.999	0.927	2.190	0.985	0.971
14	Tamil Nadu	0.988		0.991	0.856		
15	Uttar Pradesh	1.018	1.002		0.987	0.976	1.008
16	Uttaranchal	1.078			0.999	0.894	
17	West Bengal	0.965				1.052	
For all states covered		**1.004**	**0.972**	**0.975**	**0.944**	**0.946**	**0.939**

State-wise Ratio of Patwari's entries and that of Supervisor for Area - 2007-08

State Sample

SlNo	State	Paddy Late Kharif	Maize	Cotton	Sugarcane	Wheat	Gram
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	Andhra Pradesh	0.995	0.994	0.998	0.966		
2	Chhattisgarh	1.005	1.005				
3	Gujarat	1.057	0.969	0.957		0.942	0.941
4	Haryana	1.004	1.000	1.000	1.015	1.003	1.012
5	Himachal Pradesh	0.972	1.000			1.007	
6	Jammu & Kashmir	0.989	1.004			1.000	
7	Karnataka	0.955	1.004	0.955	1.005	1.000	1.011
8	Kerala	1.000					
9	Madhya Pradesh	0.998	0.982	0.964		0.971	0.977
10	Maharashtra	1.005		0.999	0.992	0.929	0.939
11	Orissa	1.000					
12	Punjab	1.000	0.988	0.994	1.000	0.997	
13	Rajasthan		0.987	1.000	0.887	1.021	0.994
14	Tamil Nadu	0.998		0.959	0.987		
15	Uttar Pradesh	0.957	0.997		0.991	0.973	0.978
16	Uttaranchal	0.925			0.729	1.137	
17	West Bengal	1.032				1.113	
For all states covered		**0.991**	**0.994**	**0.987**	**0.968**	**0.983**	**0.976**

State-wise Number of Patches distributed by range of variation in crop area through farmer's enquiry and as recorded in ICS Schedule/ Khasra

The committee conducted a special survey during October-November 2009 with the help of retired officials of FOD in 102 villages from 19 states: 51 from the ICS sample and an equal number from non-ICS sample. ICS sample villages were those TRS villages, where supervision by NSSO were undertaken. During the survey, in a prescribed proforma, information on survey/plot-wise crops grown and area under the crops were enquired from the cultivators of the plot for Kharif and Rabi season of the agriculture year 2008-09. Plot-wise comparison of crops grown and area under the crop informed by the farmer to that of figures reported in ICS schedule by the supervisors of NSSO in ICS villages have been made. Similar comparison of farmer's figure was also made with the figure reported in the Khasra for 2008-09 and made available to the enumerator during the period of survey in non-ICS villages.

The variation between the two observations was calculated as (1-ICS or Khasra/F), for all those patches where same crop was reported by both farmer and recorded in ICS schedule/Khasra register. Here F is the area reported by farmer and ICS/Khasra is the area recorded in schedule/register.

In the Tables below, .00 indicates those patches, where area under the crop obtained through farmers enquiry and as recorded in ICS schedule or Khasra is same, 1.00 indicates that Farmer has informed that some crop is grown in the patch, but in ICS schedule or Khasra, there was no entry and x indicates that although there was entry in ICS schedule or Khasra, but Farmer informed that no crop is grown in the patch.

All States			**Karnataka**		
Range of variation	Number of patches		Range of variation	Number of patches	
	ICS Villages	Non-ICS Villages		ICS Villages	Non-ICS Villages
<-.50	349	44	<-.50	31	0
-.50-.31	34	19	-.50-.31	3	1
-.30-.11	47	17	-.30-.11	1	0
-.10-.01	107	46	-.10-.01	22	0
.00	1901	1468	.00	110	72
.01-.10	135	38	.01-.10	10	0
.11-.30	107	32	.11-.30	2	1
.31-.50	75	20	.31-.50	8	1
.51-.99	182	29	.51-.99	30	0
1.00	624	796	1.00	23	129
x	1040	311	x	137	17
Total	4601	2820	Total	377	221

Range of variation	Number of patches		Range of variation	Number of patches	
	ICS Villages	Non-ICS Villages		ICS Villages	Non-ICS Villages
Andhra Pradesh			**Maharashtra**		
<-.50	85	4	<-.50	130	7
-.50-.31	2	9	-.50-.31	13	0
-.30-.11	1	0	-.30-.11	19	4
-.10-.01	0	0	-.10-.01	8	6
.00	6	53	.00	147	194
.01-.10	7	2	.01-.10	13	1
.11-.30	4	1	.11-.30	31	3
.31-.50	0	0	.31-.50	16	2
.51-.99	2	0	.51-.99	44	4
1.00	44	75	1.00	28	28
x	42	10	x	54	1
Total	193	154	Total	503	250
Assam			**Madhya Pradesh**		
<-.50	0		<-.50	9	5
-.50-.31	0		-.50-.31	0	0
-.30-.11	1		-.30-.11	0	1
-.10-.01	6		-.10-.01	3	0
.00	110		.00	101	80
.01-.10	1		.01-.10	3	1
.11-.30	1		.11-.30	5	0
.31-.50	0		.31-.50	2	0
.51-.99	4		.51-.99	3	1
1.00	2		1.00	12	42
x	46		x	25	13
Total	171		Total	163	143
Bihar			**Orissa**		
<-.50	5		<-.50	2	0
-.50-.31	0		-.50-.31	0	0
-.30-.11	2		-.30-.11	0	0
-.10-.01	31		-.10-.01	10	0
.00	97		.00	44	48
.01-.10	8		.01-.10	0	0
.11-.30	11		.11-.30	0	0
.31-.50	3		.31-.50	2	0
.51-.99	0		.51-.99	5	0
1.00	96		1.00	5	5
x	83		x	55	3
Total	336		Total	123	56

Range of variation	Number of patches		Range of variation	Number of patches	
	ICS Villages	Non-ICS Villages		ICS Villages	Non-ICS Villages
Chhatisgarh			**Punjab**		
<-.50	1	0	<-.50	4	5
-.50-.31	0	0	-.50-.31	1	0
-.30-.11	3	0	-.30-.11	3	1
-.10-.01	0	0	-.10-.01	2	3
.00	62	28	.00	18	63
.01-.10	2	0	.01-.10	11	2
.11-.30	1	0	.11-.30	9	0
.31-.50	1	0	.31-.50	5	1
.51-.99	0	2	.51-.99	13	0
1.00	17	54	1.00	15	16
x	14	0	x	15	9
Total	101	84	Total	96	100
Gujarat			**Rajasthan**		
<-.50	3	2	<-.50	11	1
-.50-.31	1	1	-.50-.31	3	0
-.30-.11	1	0	-.30-.11	0	0
-.10-.01	1	0	-.10-.01	2	0
.00	42	11	.00	62	67
.01-.10	2	0	.01-.10	20	0
.11-.30	4	0	.11-.30	4	2
.31-.50	4	0	.31-.50	3	3
.51-.99	4	0	.51-.99	6	1
1.00	49	111	1.00	26	53
x	98	4	x	26	18
Total	209	129	Total	163	145
Himachal Pradesh			**Tamil Nadu**		
<-.50	1	0	<-.50	6	0
-.50-.31	0	1	-.50-.31	0	0
-.30-.11	0	0	-.30-.11	1	0
-.10-.01	1	0	-.10-.01	0	0
.00	200	123	.00	97	60
.01-.10	0	0	.01-.10	1	0
.11-.30	0	0	.11-.30	1	0
.31-.50	2	0	.31-.50	4	0
.51-.99	0	0	.51-.99	0	0
1.00	5	4	1.00	52	0
x	1	0	x	84	0
Total	210	128	Total	246	60

Range of variation	Number of patches		Range of variation	Number of patches	
	ICS Villages	Non-ICS Villages		ICS Villages	Non-ICS Villages
Haryana			**Uttar Pradesh**		
<-.50	0	0	<-.50	18	9
-.50-.31	0	0	-.50-.31	6	2
-.30-.11	1	0	-.30-.11	6	4
-.10-.01	0	0	-.10-.01	8	4
.00	33	77	.00	166	72
.01-.10	19	0	.01-.10	13	2
.11-.30	8	0	.11-.30	13	6
.31-.50	1	1	.31-.50	15	6
.51-.99	12	0	.51-.99	7	14
1.00	50	6	1.00	28	106
x	6	7	x	107	20
Total	130	91	Total	387	245
Jharkhand			**Uttrakhand**		
<-.50	1		<-.50	2	1
-.50-.31	0		-.50-.31	0	0
-.30-.11	1		-.30-.11	2	0
-.10-.01	0		-.10-.01	0	0
.00	112		.00	78	51
.01-.10	10		.01-.10	0	0
.11-.30	2		.11-.30	1	0
.31-.50	0		.31-.50	0	0
.51-.99	4		.51-.99	1	2
1.00	22		1.00	15	56
x	7		x	10	13
Total	159		Total	109	123
Kerala			**West Bengal**		
<-.50	20	9	<-.50	20	1
-.50-.31	3	5	-.50-.31	2	0
-.30-.11	2	7	-.30-.11	3	0
-.10-.01	5	33	-.10-.01	8	0
.00	294	298	.00	122	171
.01-.10	10	30	.01-.10	5	0
.11-.30	5	19	.11-.30	5	0
.31-.50	5	6	.31-.50	4	0
.51-.99	24	5	.51-.99	23	0
1.00	51	37	1.00	84	74
x	111	131	x	119	65
Total	530	580	Total	395	311

Annexure 6

State-wise Method of Estimation of Crop Yield

State	Method adopted for assessment of yield		
	CCE	Special Surveys	Oral Enquiry
Andhra Pradesh	Paddy, Jowar, Bajra, Maize, Ragi, Small Millets, Moong, Urad, Kulthi, Gram, Groundnut, Sesamum, Castorseed, Sunflower, Soyabean, Cotton, Sugarcane, Mesta, Tobacco and Chillies		Arecanut, Tapioca, Wheat, Safflower, Linseed, Potato, Sweet Potato and Rapeseed & Mustard
Bihar	Rice, Maize, Moong, Ragi, Jute, Mesta, Sugarcane, Potato, Barley, Gram, Wheat, Lentil, Keshari, Tur, Rapeseed &Mustard, Potato, Onion, Chillies and Banana.	Nil	Sanhemp, Cotton, Urad, Kulthi, Other Pulses, Small Millets, Jowar, Bajra, Sesamum, Groundnut, Nigerseed, Sunflower, Peas, Tobacco, Sweet Potato, China, Linseed, Safflower, Castorseed, Garlic, Ginger and Coriander
Chhattisgarh	Paddy, Jowar, Maize, Tur, Small Millets, Soyabean, Groundnut, Sesamum, Wheat, Gram, Barley, Linseed Rapeseed & Mustard Khsari, Potato, Onion, Chillies	Nil	Urad, Moong, Small Millets, Bajra, Nigerseed, Sunflower, Castorseed, Cotton, Safflower, Sugarcane, Sanhemp, Sesamum, Garlic, Mesta, Coriander, Tobacco, Peas, Lentil, Turmaric
Gujarat	Paddy, Bajra, Jowar, Maize, Ragi, Wheat, Gram, Groundnut, Cotton, Sesamum, Castorseed, Tobbaco, Potato, Tur, Rapesed & Mustard, Guarseed, Moong, Urad, Banana, Onion, Garlic	Nil	Nil
Haryana	Paddy, Cotton, Bajra, Maize, Tur, Sugarcane, Wheat, Gram, Barley, Oilseeds and Sunflower	Nil	Nil
Himachal Pradesh	Maize, Wheat, Barley, Rice, Potato, Ginger	All other Crops by CCE through traditional method	Nil
Kerala	Coconut, Sesamum, Paddy and Sugarcane, Arcanut, Tapioca, Black Pepper, Banana, Cashewnut and all other minor crops	Nil	For advance estimates of various crops.

State	Method adopted for assessment of yield		
	CCE	Special Surveys	Oral Enquiry
Madhya Pradesh	Paddy, Jowar, Bajra, Maize, Sesamum, Groundnut, Small Millets, Soyabean, Tur, Cotton, Wheat, Gram, Linseed, Rapeseed & Mustard, Barley, Khesari, Potato, Onion, Chillies, Banana, Lentil, Coriander and Garlic	Nil	Moong, Urad, Sugarcane, Tobacco, Kulthi, Castorseed, Sunflower, Sanhemp, Ginger, Nigerseed, Safflower, Turmeric, Small Millets, Sweet Potato, Mesta, Peas and Sesamum.
Maharashtra	Paddy, Jowar, Bajra, Ragi, Maize, tur, Moong, Urad, Groundnut, Sesamum, Nigerseed, Sunflower, Soyabean, Cotton, Sugarcane, Wheat, Safflower, Linseed, Sesamum and Tobacco	Nil	Nil
Orissa	Paddy, Wheat, Maize, Ragi, Moong, Urad, Kulthi, Sesamum, Groundnut, Rapeseed & Mustard, Nigerseed, Jute, Potato and Sugarcane	Cotton, Nigerseed and Tur	Jowar, Bajra, Small Millets, Gram, Other Pulses, Sunflower, Safflower, Linseed, Sweet Potato, Mesta, Sunhemp and Onion
Punjab	Paddy, Maize, Cotton, Sugarcane, Wheat, Barley, Gram, Rapeseed & Mustard, Moong, Urad, Tur, Seasmum, Masur and Sunflower	Nil	Jowar, Bajra, Linseed and Peas
Tamilnadu	Paddy, Jowar, Bajra, Ragi, Maize, Small Millets, Tur, Kulthi, Urad, Moong, Groundnut, Sugarcane, Sunflower, Gingelly, Cotton, Chillies, Onion, Turmeric, Tapioca, Potato, Ginger, Cashewnut, Coriander, Banana and Sweet Potato	Nil	Cocunut, Arcanut
Uttar Pradesh	Jowar, Bajra, Paddy, Maize, Urad, Tur, Sesamum, Groundnut, Moong, Soyabean, Sugarcane, Small Millets, Wheat, Cotton, Gram Rapeseed & Mustard, Barley, Linseed, Sunflower, Peas, Potato, Lentil, Onion and Tobacco	Nil	Guarseed, Chillies, Ginger, Sweet Potato, Coriander, Garlic and Banana

Annexure 7

STATE-WISE COVERAGE OF HORTICULTURE CROPS

Agency	States	Crops
NHB	All States/ Union Territories	11 fruits, 10 vegetables, 4 plantation crops, 10 spices, flowers, aromatic plants, almond/walnut, honey and mushroom – Apple, Banana, Citrus, Grape, Guava, Litchi, Mango, Papaya, Pineapple, Pomegranate, Sapota, Brinjal, Cabbage, Cauliflower, Okra, Peas, Tomato, Onion, Potato, Sweet Potato, Tapioca, Cashewnut, Arecanut, Cocoa, Coconut, Chilly, Turmeric, Garlic, Ginger, Tamarind, Coriander, Cumin, Pepper, Fenugreek and Fennel
DES	All States/ Union Territories	17 horticulture crops - Arecanut, Banana, Black Pepper, Cardamom, Chillies, Coconut, Coriander, Garlic, Ginger, Guarseed, Onion, Potato, Sunhemp, Sweet Potato, Tapioca, Tobacco and Turmeric
CES-F&V	11 States- Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh	7 fruit crops – Apple, Mango, Citrus, Pineapple, Grapes, Banana and Guava 5 vegetable crops - Potato, Cabbage, Cauliflower, Onion, Tomato 2 spice crops- Ginger and Turmeric

Annexure 8

SUPERVISION OF CROP CUTTING EXPERIMENTS UNDER ICS BY NSSO (FOD)

1. The objective of the Improvement of Crop Statistics (ICS) scheme is to locate, through the joint efforts of the Central and State authorities, deficiencies in the system of collection of crop statistics in each State/ Union Territory and to suggest remedial measures. The programme of work under the scheme consists of examining (i) crop enumeration activities by village primary workers (ii) preparation of crop abstracts and its consistency with the entries in the Khasra register and (iii) conduct of crop cutting experiments as per prescribed procedure.

2. The number of crop cutting experiments under CES has witnessed a continuous growth over the years. In the year 1974-75 the number of experiments planned on various crops stood at 193639. The number of experiments increased to 268782 (an increase of 38%) during the year 1979-80. The number of experiments increased constantly ever since to the tune of around 20% over a period of every five years. However there was a sudden jump in the number (816315) during the year 2004-05 when a whopping increase of 70.95% was observed over the number of experiments (477514) during 1999-2000. While the earlier increase may have been due to addition of more crops under coverage but the sudden spurt in the year 2004-05 attributed to introduction of National Agriculture Insurance Scheme (NAIS). Perhaps, the State Governments needed data on yield estimates at district level for the purpose.

3. For the purpose of supervising crop cutting experiments a sample of about 30,000 experiments is chosen every year, in the form of two non-overlapping samples of approximately equal size for supervision by the two agencies namely, NSSO and States.

4. NSSO (FOD) with the SASA Hqrs. selects the sample villages, both for the Central and State supervision. Sample selection is completed well in advance of the commencement of State programme for crop cutting experiments under General Crop Estimation Survey.

SAMPLING DESIGN

5. In selection of villages for sample check on crop cutting experiments, district is treated as stratum. Two sets of non-overlapping sample villages are chosen in each district, one for supervision by the officials of SASA and the other for supervision by NSSO.

6. The selection of sample villages for supervision of crop cutting experiments is done in two stages. In the first stage, villages are selected from the list of villages already selected for sample check on area enumeration, which is a sub-sample of TRS villages and in which crop cutting experiments are planned. If there is any shortfall in the number of villages required for supervision of crop cutting experiments, additional number of villages are selected in the second stage from the remaining villages selected for Crop Estimation Survey (CES). In case the required number of experiments planned in a district for supervision is not available, the shortfall in the required number is made up by shifting the balance to the neighboring district.

7. The village official performs the crop cutting experiments, the Supervising official inspects the activities ensuring that various steps of locating and marking of plot, harvesting and threshing of the produce is performed.

Special Situations

(*i*) *States where planning is done separately for each season :*

8. In some States (e.g. Rajasthan) two sets of common villages under CES are selected, one for kharif and the other for rabi.

(ii) States where villages under CES are planned, separately for individual crops or group of crops:

9. In some States (e.g. Punjab, Uttar Pradesh) planning under CES is done separately for individual crops or group of crops (e.g. sugarcane).

Methodology followed in Non-Land Record States

West Bengal

10. If mouzas, which fall under the selected mouzas for sample check on area enumeration are equal to half of the number of experiments planned on a certain crop, all the mouzas are selected for sample check on crop cutting experiments. If crop cutting mouzas are more than half of the number required, required number of mouzas are selected with simple random sampling without replacement. If crop cutting mouzas are less than half of the number of mouzas required, the short fall is made good by selecting from the mouzas falling outside the mouzas selected for sample check on area enumeration. In case no crop cutting mouza falls under the mouzas selected for area enumeration under ICS, the State crop-cutting plan should only be used as a frame.

Orissa

11. The programme of Crop Cutting Experiments has been integrated with that of the complete area enumeration. The list of villages selected for sample check on area enumeration serves as the frame for villages to be selected for check on crop cutting experiments. A set of crops has been taken as programmed crops on which Crop Cutting Experiments are conducted under CES. A sub-sample of the complete area enumeration villages is selected for crop cutting experiments on minor crops. A further sub-sample of the villages selected for minor crops are taken for crop cutting on Principal crops.

Kerala

12. The entire area under each Block/Corporation/Ward are grouped or divided into a number of Investigator Zones of approximately equal area. In each Investigator Zone, 100 clusters of 5 surveys Sub-division numbers each are being surveyed by Investigator. These 100 clusters are apportioned between the area under wet and dry land. Investigator Zones selected for area enumeration check constitutes the sampling frame. The selection of Zones is carried out combined for all crops. The number of Investigator Zones for a crop, which requires the highest number, is selected first. Out of these, required number of Investigator Zones for various crops will be taken following the order of selection separately for each crop.

Supervision of Crop Cutting Experiments

Liaison with States

13. Before the start of the field work, the field officer contacts the State Government officials concerned to enable him to carry out the field work effectively. The officer visits the District Statistical Office to ascertain whether the selection of sample field has been completed and also to know the approximate dates of the harvest, for ascertaining rout particulars of the selected village and to establish contact with the concerned primary workers. Attendance at the state training centres for crop cutting experiments is also utilized to make preliminary contacts with the primary workers and to make necessary arrangements for the conduct of the crop cutting experiments. It is emphasized that a proper rapport with State Government officers at every level associated with ICS work is the essence of successful supervision by NSSO officers.

Field work

14. The objective of the sample check is to locate departures from the procedures prescribed for the conduct of experiments and inaccuracies in reporting ancillary information under the Crop Estimation Survey (CES), thereby improving the quality of yield data. Sample checks on crop cutting experiments are a concurrent supervision. The supervisor is required to be present at the time of conduct of the experiment and to note whether the primary worker has followed the State instructions in all its aspects. He is also required, after noting the deficiencies to correct the primary worker by providing necessary guidance on the spot itself so that the experiment is conducted properly.

15. In exceptional cases, when the Superintending Officer / State Supervisor is unable to supervise the experiment at harvest stage for one reason or the other, the supervision is carried out at post-harvest stage. An experiment is treated as **missed**, if although conducted by the primary worker, it could not be supervised at the harvest stage by the supervisor. An experiment is considered as **lost** if the primary worker did not conduct it at all. For experiments missed, the inspection is to be carried out at post-harvest stage and the relevant findings recorded in the schedule. For experiments lost, the supervisor is to fill in all relevant blocks and items of the schedule, which can be filled-up at the post harvest stage.

Training of primary worker & d**elegation of work**

16. The name and designation of the primary worker to whom the experiments are allotted is indicated along with the month and year in which he was last trained in the work pertaining to Crop Estimation Surveys. If the primary worker had not received any training, he is identified as untrained.

If the person, who actually conducts the experiment, is different from the one whose particulars are mentioned, his particulars are recorded. This is intended to collect information on number of cases in which the primary worker to whom the work was allotted delegated the work to others. It may happen that on the date of harvest the primary worker deputes his junior to conduct the experiment on the ground that he has other pressing work. In this situation the Superintending Officer supervises the work and makes suitable reporting.

Selection of (a) survey number, (b) sub-survey number and (c) field:

17. The mistake noticed in the selection of (a) survey number, (b) sub-survey number and (c) field are recorded in the schedule. All information is records-cum-enquiry based. It may be noted that if more than one type of mistakes is noticed, all the relevant codes for mistakes are given. Whether the mistake was rectified or not is also indicated.

Measurement of the field and selection of random coordinates

18. Particulars regarding the measurement of the field and the selection of random coordinates along its length and breadth for the location of the experimental plot are recorded. For each experiment two lines are provided in the schedule, one for entering the information recorded by the primary worker and the other for recording the findings of the Superintending Officer/State Supervisor.

Location and marking of plots

19. Various types of mistakes noticed, if any, in the marking of the experimental plot are recorded. The shape and size of the plot for the crop is already specified and the primary worker is not expected to make any alterations.

Coverage of stages of harvesting

20. The date of harvest originally fixed for the conduct of experiment, the date on which the experiment was actually conducted, the dates of threshing of the produce and its first weighment are recorded to ascertain the timeliness in conduct of experiment. It may be noted that dates of harvest and threshing may be different in some cases, especially for crops like, tur, sesamum, etc. In such cases the Superintending Officer / State Supervisor pay a subsequent visit and check the threshing and weighing operations. The schedule is dispatched only after the first weighment has been checked.

21. The description of the harvested produce for which the first weight is recorded. The description is given clearly and unambiguously, such as grain, ear-head, cobs (with or without sheath), pods, kernel, plants, fibre etc. The weight of the produce is given in kilograms upto three places of decimals.

22. If any mistake has been noticed in weighment, the same is recorded with the note that the mistake was rectified.

Details on supply and use of equipments

23. The position regarding supply of equipment in the case of supervised experiments and also regarding the use of supplied equipment is recorded to ascertain element of error introduced due to equipments.. If an item was not supplied and locally procured item, which was not standard was used, the appropriate remarks is given.

Details regarding post harvest operations

24. The details on post harvest operations are also observed in the exercise. If the produce kept for driage is available for supervision, the weight of the produce on the date of supervision is recorded. If driage experiment is planned, whether the arrangement for storage of the produce is satisfactory or not is ascertained.

Details on inputs

25. The inputs such as seed, irrigation, fertilizers, manures and pesticides, which have direct bearing on the yield. This information is collected for the experimental fields for analyzing the yield rates obtained through supervised experiments.

Estimation of Average Yield

26. The concurrent inspection of crop cutting experiments at harvest stage consists of examining whether the conduct of the experiments by the State primary workers conforms to the procedures prescribed under the GCES. However, the yield data from the supervised experiments are used for obtaining the average yield rates of specified crops and their standard errors. These estimates are forwarded to the Ministry of Agriculture & Cooperation. They serve as one of the sources for preparation of advance estimates of crop production.

Annexure 9

DELEGATION OF WORK AND CONDUCT OF CROP CUTTING EXPERIMENTS BY UNTRAINED WORKERS

Centre Sample
For States Covered

Year	Late Kharif		Rabi		Summer	
	Percentage of Experiments for which work was delegated	Percentage of Experiments conducted by untrained workers	Percentage of Experiments for which work was delegated	Percentage of Experiments conducted by untrained workers	Percentage of Experiments for which work was delegated	Percentage of Experiments conducted by untrained workers
2007-08	2	2	3	2	4	1
2006-07	3	2	2	2	4	4
2005-06	3	2	3	2	4	4
2004-05	2	1	3	1	4	1
2003-04	2	2	3	2	1	1
2002-03	2	1	2	1	4	3
2001-02	2	1	2	1	1	1
2000-01	2	1	3	1	2	1
1999-00	2	1	3	2	2	1
1998-99	2	1	1	0	1	0
1997-98	2	1	1	1	1	1

Centre Sample
State - Uttar Pradesh

Year	Late Kharif		Rabi		Summer	
	Percentage of Experiments for which work was delegated	Percentage of Experiments conducted by untrained workers	Percentage of Experiments for which work was delegated	Percentage of Experiments conducted by untrained workers	Percentage of Experiments for which work was delegated	Percentage of Experiments conducted by untrained workers
2007-08	10	9	12	11	36	11
2006-07	17	13	13	12	44	39
2005-06	12	10	14	11	44	44
2004-05	6	4	14	7	34	13
2003-04	9	6	11	10	10	10
2002-03	9	6	9	7	33	24
2001-02	7	4	6	5	10	9
2000-01	7	5	7	5	5	5
1999-00	6	5	9	7	11	11
1998-99	6	4	2	2	0	0
1997-98	6	4	5	4	10	5

Annexure 10

INCIDENCE OF ERRORS ON CROP CUTTING EXPERIMENTS

Crop Cutting Experiments (CCE) is conducted in a randomly selected plot in the crop field. The shape and size of the CCE plot varies from state to state and also within state for different crops. Generally it is of square shape of 5m x 5m size or rectangular shape of 10m x 5m size. But it is of triangular shape in Uttar Pradesh for most of the crops and circular in West Bengal. In the selected CCE plot, ripe crop is harvested in presence of the supervisor in ICS villages, which are selected from among TRS villages. The produce of prescribed description, viz. cobs, earheads, pods, plants, fibre, grain etc are weighed and its weight is recorded in kg upto three places of decimals. Driage experiments are not supervised under ICS.

There are reasons, due to which error in measurement of area can occur. These are use of non-standard pegs, chains and tapes. Error in measurement of weight of produce can occur due to error in measurement of area, use of non-standard balance and weight, immature harvesting of crop and weighing of un-prescribed description of produce. The various incidences of errors on crop cutting experiments observed by the supervisors are categorized as follows:

e_1= Error in selection of survey/sub-survey nos.

e_2= Error in selection of field within survey/sub-survey nos.

e_3= Error in measurement of field

e_4= Error in selection of random nos., location and marking of plots

e_5= Error in weighment of produce

e_6= Error in reporting ancillary information

e_7= Inadequate arrangements for storing of produce for driage and incorrect reporting of constituents in crop mixture

e_8 = Others

Over the years there is no improvement in quality in conducting CCE, as evident from the **Table** below:

Centre Sample
All Seasons

Year	**% of Experiments where no error noticed**	**Percentage of experiments where errors noticed**							
		e_1	**e_2**	**e_3**	**e_4**	**e_5**	**e_6**	**e_7**	**e_8**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
2007 -08	71	1	1	4	3	3	11	2	12
2006 -07	75	1	1	2	2	4	10	2	9
2005 -06	74	1	1	3	3	2	13	2	7
2004 -05	74	1	1	3	4	3	13	1	8
2003 -04	76	1	2	6	4	4	13	3	6
Year	**% of Experiments where no error noticed**	**Percentage of experiments where errors noticed**							
		e_1	**e_2**	**e_3**	**e_4**	**e_5**	**e_6**	**e_7**	**e_8**
2002 -03	74	1	1	4	5	4	14	4	5
2001 -02	74	1	3	8	5	4	14	3	6
2000 -01	73	2	1	7	11	1	18	5	5
1999 -00	76	1	1	5	7	1	16	4	5
1998 -99	79	0	0	3	5	1	16	3	3
1997 -98	75	1	1	4	7	1	17	7	4

State Sample
All Seasons

Year	% of Experiments where no error noticed	Percentage of experiments where errors noticed							
		e_1	e_2	e_3	e_4	e_5	e_6	e_7	e_8
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
2007 -08	68	1	0	2	1	1	8	4	22
2006 -07	74	0	0	1	1	0	6	4	18
2005 -06	71	0	0	2	1	1	6	2	19
2004 -05	66	1	0	2	1	1	6	3	23
2003 -04	78	0	0	2	1	0	7	2	11
2002 -03	77	0	0	1	1	0	5	1	13
2001 -02	79	0	0	2	1	0	6	1	9
2000 -01	80	0	0	3	2	0	6	2	11
1999 -00	80	0	0	3	1	0	7	1	10
1998 -99	84	0	0	1	1	0	7	1	8
1997 -98	85	0	0	2	2	0	6	2	7

Annexure-11

Loss and miss of Crop Cutting Experiments for the year 2007-08
(Out of Experiments processed- Central Sample)

Name of the State	Season	Planned	Number of Experiments			Remarks
			Checked at Harvest stage	Missed	Lost	
Andhra Pradesh	Early Kharif					
	Late Kharif	860	839	6	7	
	Rabi	300	293	0	4	
	Summer					
Assam	Early Kharif	170	158	6	6	
	Late Kharif	120	112	2	6	
	Rabi	190	160	6	16	
	Summer	40	36	2	0	
Bihar	Early Kharif	120	88	4	24	
	Late Kharif	240	210	6	24	
	Rabi	350	320	4	22	
	Summer	40	34	0	6	
Chhatisgarh	Early Kharif					
	Late Kharif	200	188	8	4	
	Rabi	150	132	10	8	
	Summer					
Gujarat	Early Kharif					
	Late Kharif	750	719	27	0	
	Rabi	240	232	0	0	
	Summer					
Haryana	Early Kharif					
	Late Kharif	320	319	1	0	
	Rabi	380	367	13	0	
	Summer					
Himachal Pradesh	Early Kharif					
	Late Kharif	150	134	0	16	
	Rabi	150	116	0	34	
	Summer					

Name of the State	Season	Planned	Number of Experiments			Remarks
			Checked at Harvest stage	Missed	Lost	
J & K	Early Kharif					
	Late Kharif	160	74	28	52	
	Rabi	120	80	0	40	
	Summer					
Jharkhand	Early Kharif	40	40	0	0	
	Late Kharif	80	78	0	2	
	Rabi	100	98	0	2	
	Summer					
Karnataka	Early Kharif					
	Late Kharif	620	558	34	17	
	Rabi	200	179	19	2	
	Summer	80	64	14	2	
Kerala	Early Kharif	140	140	0	0	
	Late Kharif	100	97	0	3	
	Rabi					
	Summer	280	278	1	0	
Madhya Pradesh	Early Kharif					
	Late Kharif	628	610	8	10	
	Rabi	524	506	6	12	
	Summer					
Maharashtra	Early Kharif					
	Late Kharif	850	758	58	24	
	Rabi	450	404	8	37	
	Summer					
Orissa	Early Kharif	260	260	0	0	
	Late Kharif	390	383	1	6	
	Rabi					
	Summer	180	180	0	0	
Punjab	Early Kharif					
	Late Kharif	380	373	3	4	
	Rabi	320	314	22	3	
	Summer					

Name of	Season	Planned	Number of Experiments			Remarks
Name of the State	Season	Planned	Number of Experiments			Remarks
			Checked at Harvest stage	Missed	Lost	
Rajasthan	Early Kharif					
	Late Kharif	520	502	3	13	
	Rabi	420	387	0	29	
	Summer					
Tamil Nadu	Early Kharif	60	58	0	2	
	Late Kharif	680	615	4	38	
	Rabi					
	Summer	40	39	0	1	
Uttar Pradesh	Early Kharif					
	Late Kharif	1380	1359	16	3	
	Rabi	830	824	2	4	
	Summer	90	90	0	0	
Uttarkhand	Early Kharif					
	Late Kharif	130	128	2	0	
	Rabi	60	55	4	1	
	Summer					
West Bengal	Early Kharif	180	163	2	5	
	Late Kharif	160	160	0	0	
	Rabi	220	208	3	7	
	Summer	190	189	0	1	
Delhi	Early Kharif					
	Late Kharif	50	30	0	20	
	Rabi	20	18	0	2	
	Summer					
Puduchery	Early Kharif					
	Late Kharif	10	10	0	0	
	Rabi	10	10	0	0	
	Summer	10	10	0	0	
All India	Early Kharif	970	907	12	37	
	Late Kharif	8238	7775	207	249	
	Rabi	5754	5363	95	223	
	Summer	770	741	17	10	

Loss and miss of Crop Cutting Experiments for the year 2007-08
(Out of Experiments processed -State Sample)

Name of the State	Season	Planned	Number of Experiments			Remarks
			Checked at Harvest stage	Missed	Lost	
Andhra Pradesh	Early Kharif					
	Late Kharif	860	817	4	0	
	Rabi	300	270	2	0	
	Summer					
Assam	Early Kharif	170	109	2	4	
	Late Kharif	120	92	0	0	
	Rabi	190	124	8	4	
	Summer	40	28	0	0	
Bihar	Early Kharif	120	56	26	4	
	Late Kharif	240	134	56	12	
	Rabi	350	199	124	0	
	Summer	40	32	0	0	
Chhatisgarh	Early Kharif					
	Late Kharif	200	194	6	0	
	Rabi	150	134	12	4	
	Summer					
Gujarat	Early Kharif					
	Late Kharif	750	541	18	11	
	Rabi	240	142	118	0	
	Summer					
Haryana	Early Kharif					
	Late Kharif	320	312	2	2	
	Rabi	380	376	0	4	
	Summer					
Himachal Pradesh	Early Kharif					
	Late Kharif	150	71	0	6	
	Rabi	150	46	2	0	
	Summer					

Name of the State	Season	Planned	Number of Experiments			Remarks
			Checked at Harvest stage	Missed	Lost	
J & K	Early Kharif					
	Late Kharif	160	48	60	10	
	Rabi	120	27	69	0	
	Summer					
Jharkhand	Early Kharif	40	24	6	2	
	Late Kharif	80	34	18	4	
	Rabi	100	33	22	0	
	Summer					
Karnataka	Early Kharif					
	Late Kharif	620	594	6	0	
	Rabi	200	192	2	0	
	Summer	80	78	2	0	
Kerala	Early Kharif	140	135	0	0	
	Late Kharif	100	100	0	0	
	Rabi					
	Summer	280	276	0	0	
Madhya Pradesh	Early Kharif					
	Late Kharif	628	564	16	0	
	Rabi	524	490	24	0	
	Summer					
Maharashtra	Early Kharif					
	Late Kharif	850	511	34	14	
	Rabi	450	244	39	4	
	Summer					
Orissa	Early Kharif	260	260	0	0	
	Late Kharif	390	385	0	4	
	Rabi					
	Summer	180	180	0	0	
Punjab	Early Kharif					
	Late Kharif	380	328	41	5	
	Rabi	320	295	22	1	
	Summer					

Name of the State	Season	Planned	Number of Experiments			Remarks
			Checked at Harvest stage	Missed	Lost	
Rajasthan	Early Kharif					
	Late Kharif	520	499	6	15	
	Rabi	420	332	11	27	
	Summer					
Tamil Nadu	Early Kharif	60	53	0	0	
	Late Kharif	680	640	6	4	
	Rabi					
	Summer	40	40	0	0	
Uttar Pradesh	Early Kharif					
	Late Kharif	1380	1076	45	5	
	Rabi	830	689	3	0	
	Summer	90	66	0	0	
Uttarkhand	Early Kharif					
	Late Kharif	130	124	6	0	
	Rabi	60	56	0	0	
	Summer					
West Bengal	Early Kharif	180	172	2	6	
	Late Kharif	160	158	0	2	
	Rabi	220	214	3	3	
	Summer	190	188	0	2	
Delhi	Early Kharif					
	Late Kharif					
	Rabi					
	Summer					
Puduchery	Early Kharif					
	Late Kharif	10	10	0	0	
	Rabi	10	10	0	0	
	Summer	10	10	0	0	
All India	Early Kharif	970	809	36	16	
	Late Kharif	8238	6651	324	94	
	Rabi	5754	4561	455	47	
	Summer	770	720	2	2	

COMPARISON OF ESTIMATES OF YIELD UNDER ICS CENTRAL & STATE SAMPLE DURING 2007-08

Sl No	State	Estimated Yield Rate in Kg/Hac		Percentage Difference
		ICS-Central Sample	ICS-State Sample	
RICE (KHARIF)				
1	Andhra Pradesh	3085	3185	-3.14
2	Chhattisgarh	1766	2081	-15.14
3	Gujarat	1929	1381	39.68
4	Haryana	3581	3475	3.05
5	Karnataka	2503	2625	-4.65
6	Kerala	2565	2354	8.96
7	Madhya Pradesh	996	871	14.35
8	Orissa	1804	1738	3.80
9	Punjab	4490	4338	3.50
10	Tamil Nadu	2708	2485	8.97
11	Uttar Pradesh	2146	2178	-1.47
12	West Bengal	2568	2227	15.31
13	Puducherry	2459	2771	-11.26
RICE (SUMMER)				
1	Andhra Pradesh	3538	3763	-5.98
2	Karnataka	3056	2874	6.33
3	Kerala	2410	2401	0.37
4	Orissa	2371	2322	2.11
5	Tamil Nadu	2849	3319	-14.16
6	West Bengal	3346	3382	-1.06
7	Puducherry	1828	2438	-25.02
MAIZE				
1	Andhra Pradesh	5308	4366	21.58
2	Chhattisgarh	1248	1041	19.88
3	Gujarat	1669	1486	12.31
4	Haryana	2580	2546	1.34
5	Karnataka	2756	3797	-27.42
6	Punjab	3530	2772	27.34
GROUNDNUT				
1	Andhra Pradesh	1222	1197	2.09
2	Karnataka	924	800	15.50
3	Madhya Pradesh	1031	849	21.44
4	Tamil Nadu	1847	1954	-5.48

Sl No	State	Estimated Yield Rate in Kg/Hac		Percentage Difference
		ICS-Central Sample	ICS-State Sample	
SUGARCANE				
1	Andhra Pradesh	65785	83191	-20.92
2	Haryana	63492	65570	-3.17
3	Karnataka	95765	82150	16.57
4	Punjab	61696	64428	-4.24
5	Tamil Nadu	132304	93959	40.81
6	Uttar Pradesh	53362	51695	3.22
WHEAT				
1	Haryana	4140	4168	-0.67
2	Karnataka	1083	1111	-2.52
3	Madhya Pradesh	1916	1571	21.96
4	Punjab	4548	4496	1.16
5	Uttar Pradesh	2612	2728	-4.25
6	West Bengal	2593	2646	-2.00
GRAM				
1	Haryana	291	552	-47.28
2	Karnataka	533	579	-7.94
3	Madhya Pradesh	754	700	7.71
4	Punjab	1200	1226	-2.12
5	Uttar Pradesh	683	569	20.04
6	West Bengal	881	1132	-22.17

Annexure 13

COMPARISON OF ESTIMATES OF CROP YIELDS BETWEEN DES & GCES DURING 2006-07

Sl No	State	Estimated Yield Rate in Kg/Hac		Percentage Difference
		DES	GCES	
1	*2*	*3*	*4*	*5*
RICE (KHARIF)				
1	Andhra Pradesh	2631	2632	-0.04
2	Assam	1302	1321	-1.44
3	Bihar	1584	1552	2.06
4	Chhattisgarh	1354	1425	-4.98
5	Gujarat	1799	1594	12.86
6	Haryana	3238	3239	-0.03
7	Himachal Pradesh	1559	1559	0.00
8	Karnataka	2402	2687	-10.61
9	Kerala	2408	2413	-0.21
10	Madhya Pradesh	824	864	-4.63
11	Maharashtra	1669	1669	0.00
12	Orissa	1580	1580	0.00
13	Punjab	3868	3868	0.00
14	Tamil Nadu	4914	3451	42.39
15	Uttar Pradesh	1878	1869	0.48
16	West Bengal	2026	2411	-15.97
17	Delhi	4203	2940	42.96
18	Puducherry	2195	2872	-23.57
RICE (SUMMER)				
1	Andhra Pradesh	3682	3681	0.03
2	Assam	2019	2017	0.10
3	Bihar	1499	1675	-10.51
4	Karnataka	2761	3046	-9.36
5	Kerala	2622	2882	-9.02
6	Orissa	2293	2293	0.00
7	Tamil Nadu	4325	3757	15.12
8	West Bengal	3226	3226	0.00
9	Puducherry	2719	2688	1.15

Sl No	State	Estimated Yield Rate in Kg/Hac		Percentage Difference
		DES	GCES	
1	*2*	*3*	*4*	*5*
MAIZE				
1	Andhra Pradesh	2402	2398	0.17
2	Bihar	1532	1696	-9.67
3	Chhattisgarh	1225	1225	0.00
4	Gujarat	698	451	54.77
5	Haryana	2286	2308	-0.95
6	Himachal Pradesh	2326	2325	0.04
7	Karnataka	2839	2861	-0.77
8	Madhya Pradesh	976	977	-0.10
9	Orissa	1655	2625	-36.95
10	Punjab	3123	3123	0.00
11	Rajasthan	1085	1086	-0.09
12	Uttar Pradesh	1326	1334	-0.60
COTTON				
1	Andhra Pradesh	381	390	-2.31
2	Gujarat	625	566	10.42
3	Haryana	582	581	0.17
4	Karnataka	276	255	8.24
5	Madhya Pradesh	220	222	-0.90
6	Maharashtra	253	217	16.59
7	Punjab	750	750	0.00
8	Rajasthan	363	363	0.00
9	Tamil Nadu	374	374	0.00
GROUNDNUT				
1	Andhra Pradesh	301	301	0.00
2	Gujarat	725	1745	-58.45
3	Karnataka	434	361	20.22
4	Madhya Pradesh	948	940	0.85
5	Maharashtra	743	737	0.81
6	Rajasthan	1310	1310	0.00
7	Tamil Nadu	1329	1736	-23.44
8	Uttar Pradesh	730	748	-2.41

Sl No	State	Estimated Yield Rate in Kg/Hac		Percentage Difference
		DES	GCES	
1	*2*	*3*	*4*	*5*
SUGARCANE				
1	Andhra Pradesh	82167	81777	0.48
2	Assam	39074	39634	-1.41
3	Bihar	45953	46043	-0.20
4	Haryana	68429	68450	-0.03
5	Karnataka	87944	92000	-4.41
6	Maharashtra	74898	78080	-4.08
7	Punjab	60808	60830	-0.04
8	Rajasthan		57729	-100.00
9	Tamil Nadu	105123	115461	-8.95
10	Uttar Pradesh	59626	59850	-0.37
WHEAT				
1	Assam	1117	1066	4.78
2	Bihar	1908	2001	-4.65
3	Chhattisgarh	1002	1045	-4.11
4	Gujarat	2498	2592	-3.63
5	Haryana	4232	4232	0.00
6	Himachal Pradesh	1385	1647	-15.91
7	Jammu & Kashmir	1893	1824	3.78
8	Karnataka	762	891	-14.48
9	Madhya Pradesh	1835	1901	-3.47
10	Maharashtra	1325	1520	-12.83
11	Punjab	4210	4210	0.00
12	Rajasthan	2751	3017	-8.82
13	Uttar Pradesh	2721	2772	-1.84
14	West Bengal	2282	2281	0.04
15	Delhi	4341	3920	10.74
GRAM				
1	Bihar	818	843	-2.97
2	Gujarat	870	950	-8.42
3	Haryana	843	841	0.24
4	Karnataka	473	483	-2.07
5	Madhya Pradesh	980	995	-1.51
6	Maharashtra	706	707	-0.14
7	Punjab	1000	1010	-0.99
8	Rajasthan	863	863	0.00
9	Uttar Pradesh	742	744	-0.27
10	West Bengal	769	766	0.39

Comparison of final forecast of area under selected crops at different level by Remote Sensing and final estimates of State Agricultural Statistics Authority

SASA figures are "actuals" based on the complete girdawari in TRS states and "estimates" based on 20% sample in EARAS states. Projected figures, are forecast from SAC and final estimates by DES.

Percentage variation = (SAC-SASA)/SASA*100

or (SAC-DES Final estimates)/ DES Final estimates*100

Wheat crop

In Bihar the district-wise SAC area figures are available; the SASA fully revised area data is not available for the year 2007-08 onwards.

In Himachal Pradesh SAC area figures are not available for 2007-08.

In Uttar Pradesh SAC area figures are not available for 2007-08 and SASA area figures are not available for 2008-09.

Kharif Rice

In Orissa the district-wise SAC area figures are available; the SASA district wise estimates of area are not available for the year 2007-08 onwards.

In Andhra Pradesh the district-wise SAC area figures are not available for the year 2005-06 onwards; the SASA district wise estimates of area are available for the years' upto 2008-09.

Sugarcane

In Karnataka SAC area figures are not available for 2007-08.

In Maharashtra SAC area figures are not available for 2007-08 and SASA area figures are not available for 2008-09.

In Uttar Pradesh SASA area figures are not available for 2008-09.

Kharif Ragi

In Orissa the district-wise SAC area figures are available; the SASA district wise estimates of area are not available for the year 2007-08 and 2008-09.

Mustard

In Assam SAC area figures are not available for 2007-08 and SASA area figures are not available for 2008-09.

In Gujarat SAC area figures are available for 2007-08 and 2008-09 and SASA area figures are not available.

In Madhya Pradesh SAC area figures are not available for 2007-08.

In Uttar Pradesh SAC area figures are not available for 2007-08 and SASA area figures are not available for 2008-09.

In West Bengal SAC area figures are not available for 2007-08.

Cotton

In Gujarat SAC area figures are available for 2007-08 and 2008-09, but SASA area figures are not available.

In Rajasthan SAC estimates are available for one district only for 2007-08 and 2008-09, but SASA area figures are not available for 2007-08.

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2005-06

Area in '000 hectare

Sl. No.	State	2004-05				2005-06			
		SAC	DES Final estimate	% Variation	SASA	SAC	DES Final estimate	% Variation	SASA
1	Bihar	2099	2028	3.5	2022	2050	2004	2.3	2002
2	Haryana	2318	2322	-0.2	2317	2390	2304	3.7	2303
3	Madhya Pradesh	4126	4136	-0.2	4188	3910	3693	5.9	3773
4	Punjab	3340	3482	-4.1	3481	3440	3466	-0.8	3464
5	Rajasthan	2315	2010	15.2	2010	2140	2124	0.8	2124
6	Uttar Pradesh	8840	9000	-1.8	9373	9040	9164	-1.4	9316
All India Projected		23038	26383	-12.7		22970	26484	-13.3	
Sl No	**State**	**2006-07**				**2007-08**			
1	Bihar	2230	2050	8.8	2067	2300	2163	6.4	2163
2	Haryana	2400	2376	1.0	2377	2410	2462	-2.1	2461
3	Madhya Pradesh	4040	3993	1.2	4262	3690	3742	-1.4	4089
4	Punjab	3450	3467	-0.5	3467	3470	3488	-0.5	3487
5	Rajasthan	2590	2565	1.0	2565	2700	2592	4.2	2592
6	Uttar Pradesh	9120	9198	-0.8	9198	9190	9115	0.8	9115
All India Projected		23830	27995	-14.9		27250	28039	-2.8	

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2008-09 to 2009-10

Area in '000 hectare

Sl No	State	2008-09				2009-10			
		SAC	DES Final estimate	% Variation	SASA	SAC	DES Final estimate	% Variation	SASA
1	Bihar	2360	2158	9.3	NA	2720	2227	22.2	NA
2	Haryana	2400	2462	-2.5	2461	2450	2492	-1.7	
3	Madhya Pradesh	3620	3785	-4.4	4010	4160	4276	-2.7	
4	Punjab	3460	3526	-1.9	3526	3470	3538	-1.9	
5	Rajasthan	2360	2295	2.8	2295	2100	2394	-12.3	
6	Uttar Pradesh	9340	9513	-1.8	NA	9380	9668	-3.0	
All India Projected		26960	27752	-2.9		28330	28521	-0.7	

For 2009-10, DES estimates are 4th advance estimates

Comparison of final forecast of area under Kharif Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2005-06

Area in '000 hectare

Sl. No.	State	2004-05				2005-06			
		SAC	DES Final estimate	% Variation	SASA	SAC	DES Final estimate	% Variation	SASA
1	Andhra Pradesh	2402	2215	8.4	2215	2713	2526	7.4	2526
2	Assam	1619	2065	-21.6	2072	1619	2106	-23.1	2106
3	Bihar	3270	3006	8.8	3075	3235	3141	3.0	3138
4	Chhattisgarh	2741	3747	-26.8	3773	2340	3747	-37.6	3774
5	Haryana	1267	1028	23.2	1024	1030	1052	-2.1	1042
6	Jharkhand		1275		NA	1070	1355	-21.0	NA
7	Karnataka		1056		1047	1020	1076	-5.2	1070
8	Madhya Pradesh	1252	1623	-22.8	1662	1580	1658	-4.7	1686
9	Orissa	4133	4199	-1.6	4199	4200	4154	1.1	4154
10	Punjab	2585	2647	-2.3	2646	2630	2642	-0.5	2647
11	Tamil Nadu	1609	1713	-6.1	1042	1600	1876	-14.7	1853
12	Uttar Pradesh	5068	5337	-5.0	5934	5440	5572	-2.4	5869
13	West Bengal	4407	4407	0.0	4407	4640	4401	5.4	4401
All India Projected		**31313**	**38364**	**-18.4**		**36766**	**39335**	**-6.5**	

Comparison of final forecast of area under Kharif Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2006-07 to 2007-08

Area in '000 hectare

Sl No	State	2006-07				2007-08			
		SAC	DES Final estimate	% Variation	SASA	SAC	DES Final estimate	% Variation	SASA
1	Andhra Pradesh	2924	2641	10.7	3978	2150	2578	-16.6	3984
2	Assam	1669	1877	-11.1	1878	1540	2001	-23.0	2001
3	Bihar	3382	3248	4.1	3357	3350	3462	-3.2	NA
4	Chhattisgarh	2188	3724	-41.2	3760	2200	3752	-41.4	3759
5	Haryana		1041		1033	1020	1075	-5.1	1073
6	Jharkhand	1257	1604	-21.6	1209	1450	1644	-11.8	1198
7	Karnataka	900	1066	-15.6	1061	1020	1051	-2.9	1078
8	Madhya Pradesh	1618	1661	-2.6	1660	1410	1559	-9.6	1621
9	Orissa	4020	4136	-2.8	4136	4050	4118	-1.7	4118
10	Punjab	2610	2621	-0.4	2319	2610	2610	0.0	2609
11	Tamil Nadu	1599	1767	-9.5	1813	1520	1637	-7.1	1671
12	Uttar Pradesh	5777	5903	-2.1	5820	5660	5690	-0.5	5756
13	West Bengal	3600	4286	-16.0	4286	4170	4208	-0.9	4208
All India Projected		**36164**	**39601**	**-8.7**		**35660**	**39454**	**-9.6**	

Comparison of final forecast of area under Kharif Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2008-09 to 2009-10

Area in '000 hectare

Sl No	**State**	**2008-09**				**2009-10**			
		SAC	DES Final estimate	% Variation	SASA	SAC	DES 4th advance estimate	% Variation	
1	Andhra Pradesh	2540	2803	-9.4	2803	1900	2063	-7.9	NA
2	Assam	1820	2124	-14.3	NA	1610	2077	-22.5	
3	Bihar	3290	3391	-3.0	NA	2750	3080	-10.7	
4	Chhattisgarh	1930	3734	-48.3	3789	2110	3671	-42.5	
5	Haryana	1030	1210	-14.9	1211	950	1205	-21.2	
6	Jharkhand	1450	1670	-13.2	1221	1260	977	28.9	
7	Karnataka	1060	1130	-6.2	1118	1050	1102	-4.7	
8	Madhya Pradesh	1490	1682	-11.4	1695	1160	1446	-19.8	
9	Orissa	3800	4124	-7.8	4124	3620	4100	-11.7	
10	Punjab	2640	2735	-3.5	2734	2510	2802	-10.4	
11	Tamil Nadu	1460	1767	-17.4	1786	1360	1770	-23.2	
12	Uttar Pradesh	5780	6012	-3.9	NA	4400	5170	-14.9	
13	West Bengal	4100	4379	-6.4	4379	3520	4200	-16.2	
All India Projected		**35970**	**40794**	**-11.8**		**28200**	**37486**	**-24.8**	

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: BIHAR Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
1	Araria	60.6				50.7		61.1	57.6	6.1
2	Aurangabad	56.0	52.5	6.8	60.0	47.9	25.3	61.4	61.3	0.1
3	Banka	24.3	21.5	12.7	23.3	23.3	0.0		28.8	
4	Begusarai	64.3	52.6	22.2	0.0	52.4			52.8	
5	Bhabhua	65.3	64.5	1.2	60.3	65.7	-8.3	61.1	61.1	0.1
6	Bhagalpur	44.4	56.4	-21.2	0.0	46.0		43.9	44.2	-0.6
7	Bhojpur	70.1	49.8	40.8	73.5	55.0	33.6	70.7	75.3	-6.0
8	Buxur	60.8	66.0	-7.8	58.0	62.2	-6.7	59.5	60.7	-2.0
9	Darbhanga	65.4	69.7	-6.1	62.3	64.0	-2.7	65.5	67.2	-2.5
10	East Champaran	76.0	98.0	-22.5	79.1	98.4	-19.6	81.6	98.7	-17.3
11	Gaya	55.7	48.8	14.1		60.2		57.1	73.7	-22.5
12	Gopalganj	68.4	84.4	-19.0		42.5		77.7	83.2	-6.6
13	Jahanabad + Arwal	33.5	34.3	-2.5		32.0		31.8	32.8	-3.0
14	Jamui	21.4	15.2	40.7	21.1	9.6	119.5	21.5	11.8	82.3
15	Katihar	43.4	36.2	19.7	49.3	44.7	10.3	47.6	35.3	34.8
16	Khagaria	42.6	41.3	3.1		37.4		46.8	32.2	45.2
17	Kishanganj	27.9	28.1	-0.7	29.9	22.6	32.3		21.7	
18	Lakhisarai	20.3	21.1	-4.2	0.0	21.4		19.2	30.1	-36.1
19	Madhepura	44.0	38.5	14.3	43.9	36.2	21.1	47.9	36.6	30.8
20	Madhubani	56.2	92.3	-39.1	52.0	87.7	-40.6	0.0	82.2	

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: BIHAR

Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
21	Munger	21.0	18.4	13.8		19.2		20.1	18.2	10.6
22	Muzaffarpur	78.7	92.9	-15.2	78.6	85.9	-8.4	83.0	85.5	-2.9
23	Nalanda	84.1	81.5	3.2	87.5	82.3	6.2		82.2	
24	Nawada	47.6	43.4	9.6		38.8		45.8	45.2	1.4
25	Patna	66.9	59.9	11.8	65.1	60.0	8.6	66.9	57.6	16.0
26	Purnea	61.9	51.9	19.4	61.9	46.6	32.7	62.2	46.3	34.3
27	Rohtas	138.8	119.1	16.5	128.0	130.3	-1.7	130.1	135.6	-4.1
28	Saharsa	35.0	44.9	-22.0	37.4	42.6	-12.3		42.6	
29	Samastipur	60.6	52.1	16.2		51.9		64.4	51.4	25.3
30	Saran	71.7	94.7	-24.3	76.2	87.7	-13.1	73.7	88.1	-16.3
31	Sheikhpura	16.0	15.9	0.7	0.0	15.8		14.5	20.5	-29.6
32	Seohar	11.1	10.9	1.1	0.0	15.5		12.3	14.1	-12.4
33	Sitamarhi	58.6	49.8	17.7	56.1	53.3	5.4	68.0	68.2	-0.3
34	Siwan	78.0	85.6	-8.9	72.9	95.4	-23.6	73.7	91.9	-19.8
35	Supaul	60.5	58.2	3.9	0.0	53.9		57.8	50.8	13.7
36	Vaishali	48.1	44.7	7.6	45.5	44.2	2.9	47.1	47.9	-1.6
37	West Champaran	78.3	80.1	-2.3	0.0	78.7		78.5	83.6	-6.1
Total		**2017.2**	**1975.3**	**2.1**	**1321.8**	**1961.8**	**-32.6**	**1752.5**	**2076.7**	**-15.6**
Projected		2099.0	2027.6	3.5	2050.0	2003.7	2.3	2230.0	2049.7	8.8

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: HARYANA

Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
1	Hisar	206.0	202.4	1.7	201.7	203.2	-0.7	204.2	212.0	-3.7
2	Fatehabad	163.6	170.2	-3.9	178.4	178.8	-0.2	179.4	182.5	-1.7
3	Sirsa	235.0	247.9	-5.2	248.8	250.8	-0.8	248.9	258.3	-3.6
4	Bhiwani	130.4	126.6	3.0	125.4	118.6	5.7	124.7	133.2	-6.3
5	Rohtak	86.0	87.4	-1.6	86.7	87.9	-1.4	88.7	94.7	-6.4
6	Jhajjar	95.0	84.1	13.0	83.4	85.1	-2.0	84.6	96.3	-12.2
7	Sonipat	130.9	132.7	-1.4	137.8	142.0	-3.0	142.9	140.7	1.6
8	Gurgaon	126.7	115.5	9.7	117.4	47.6	146.5	46.2	52.5	-11.9
9	Faridabad	137.2	135.8	1.1	136.7	104.6	30.7	102.8	104.8	-1.9
10	Karnal	169.4	170.7	-0.8	171.6	172.8	-0.7	173.5	166.7	4.1
11	Panipat	81.5	83.8	-2.7	84.2	83.0	1.5	82.3	81.6	0.9
12	Kurukshetra	109.2	113.9	-4.1	114.1	109.2	4.5	109.7	110.3	-0.5
13	Kaithal	174.0	174.3	-0.2	176.4	172.9	2.0	172.6	171.7	0.5
14	Ambala	82.8	82.3	0.5	80.9	83.0	-2.5	84.4	81.7	3.3
15	Panchkula	17.0	17.5	-2.9	18.2	17.0	7.1	18.4	16.9	9.2
16	Yamunanagar	69.5	72.3	-3.8	72.8	72.3	0.7	72.3	71.3	1.4
17	Jind	207.3	206.9	0.2	205.6	204.6	0.5	203.4	213.3	-4.6
18	Mahendergarh	42.4	40.6	4.5	41.3	38.4	7.7	39.9	43.6	-8.5
19	Rewari	47.7	44.9	6.4	44.5	41.1	8.3	42.3	51.7	-18.2
20	Mewat	0.0				90.0		92.6	93.5	-0.9
Total		**2311.5**	**2309.7**	**0.1**	**2325.7**	**2302.7**	**1.0**	**2313.8**	**2377.1**	**-2.7**
Projected		2318.0	2322.0	-0.2	2390.0	2304.0	3.7	2400.0	2376.1	1.0

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 to 2008-09

STATE: HARYANA Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Hisar	0.0	227.1		226.5	223.1	1.5
2	Fatehabad	0.0	186.7		187.6	185.7	1.0
3	Sirsa	247.4	280.6	-11.8	266.2	279.1	-4.6
4	Bhiwani	127.7	153.2	-16.6	142.9	151.3	-5.5
5	Rohtak	92.6	98.7	-6.2	94.1	103.2	-8.8
6	Jhajjar	88.8	98.8	-10.1	91.8	93.7	-2.0
7	Sonipat	142.6	141.1	1.1	142.2	14.4	890.3
8	Gurgaon	48.9	51.1	-4.3	51.9	48.8	6.3
9	Faridabad	101.6	103.9	-2.2	102.7	33.7	205.1
10	Karnal	173.2	168.7	2.7	179.5	166.5	7.8
11	Panipat	83.7	84.0	-0.3	81.4	88.0	-7.4
12	Kurukshetra	106.4	112.3	-5.2	111.6	115.1	-3.0
13	Kaithal	172.8	173.0	-0.1	180.7	171.9	5.1
14	Ambala	83.2	82.2	1.3	82.0	83.6	-1.9
15	Panchkula	17.7	15.7	12.9	16.8	15.5	8.3
16	Yamunanagar	72.9	74.5	-2.1	72.9	84.8	-14.0
17	Jind	210.4	213.4	-1.4	208.9	215.2	-2.9
18	Mahendergarh	45.1	46.9	-3.9	49.9	42.6	17.1
19	Rewari	42.0	50.9	-17.5	44.8	45.8	-2.2
20	Mewat	94.0	98.1	-4.2	95.5	71.5	33.7
Total		**1951.0**	**2460.6**	**-20.7**	**2429.9**	**2233.5**	**8.8**
Projected		2328.0	2462.0	-5.4	2400.0	2462.0	-2.5

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2008-09

STATE: HIMACHAL PRADESH Area in '000 hectare

Sl. No.	District	2004-05			2005-06		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Bilaspur	26.7	28.1	-5.0	25.8	26.3	-1.7
2	Hamirpur	33.3	34.7	-4.0	32.9	33.6	-2.2
3	Kangra	93.2	94.4	-1.3	89.0	94.0	-5.3
4	Kullu					26.8	
5	Mandi	64.4	66.5	-3.2	64.0	64.3	-0.5
6	Sirmaur					26.0	
7	Solan	22.7	24.7	-8.3	23.6	23.9	-1.4
8	Una	31.6	32.4	-2.5	33.4	31.4	6.1
Total		271.8	280.8	-3.2	268.6	326.3	-17.7
Projected		356.4	362.0	-1.5	353.0	358.5	-1.5
Sl. No.	**District**	**2006-07**			**2008-09**		
1	Bilaspur	25.9	26.9	-3.5	25.4	26.5	-4.3
2	Hamirpur	33.1	33.9	-2.3	32.7	34.1	-4.2
3	Kangra	94.9	90.4	5.0	95.0	93.9	1.2
4	Kullu		26.0			0.2	
5	Mandi	64.8	67.6	-4.2	64.1	65.8	-2.6
6	Sirmaur		26.1		26.9	25.1	7.2
7	Solan	22.7	24.4	-6.9	22.6	25.4	-10.8
8	Una	31.0	32.8	-5.5	31.9	32.5	-1.8
Total		**272.4**	**328.1**	**-17.0**	**298.5**	**303.4**	**-1.6**
Projected		357.9	362.2	-1.2	358.1	360.0	-0.5

Chamba, Kinnuar, Kullu, Lahaul & Spiti, Shimla & Shirmopre districts not covered by SAC

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE : MADHYA PRADESH Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
1	Betul	80.2	91.1	-12.0	92.7	85.1	9.0	94.3	93.8	0.5
2	Bhind	72.1	70.7	2.1	71.1	71.7	-0.8	68.4	72.8	-6.1
3	Bhopal	65.0	67.2	-3.3	67.5	69.5	-2.8	67.0	70.4	-4.9
4	Chhatarpur		143.4		139.4	142.0	-1.8	104.4	101.8	2.6
5	Chhindwara		84.3		50.6	91.9	-45.0	56.7	106.0	-46.5
6	Damoh	73.1	67.6	8.0	67.6	69.0	-2.0	69.9	69.6	0.4
7	Datia	67.9	68.5	-0.9	69.7	73.6	-5.2	71.9	97.5	-26.3
8	Dewas	74.9	102.1	-26.7	71.7	75.8	-5.4	72.8	105.2	-30.8
9	Dhar	133.0	166.9	-20.3	123.6	93.2	32.7	141.9	188.4	-24.7
10	Dindori	32.6	33.3	-2.0	33.3	32.7	1.7	35.5	34.5	3.1
11	Guna+Ashoknagar	194.9	194.3	0.3	195.1	183.6	6.2	153.3	197.2	-22.2
12	Gwalior	65.0	92.0	-29.4	93.1	91.4	1.9	96.6	87.0	11.0
13	Harda	89.7	110.4	-18.7	111.7	115.1	-3.0	90.9	115.8	-21.5
14	Indore		117.2		72.0	62.1	16.0	100.9	132.3	-23.8
15	Hoshangabad	179.0	192.7	-7.1	175.0	202.6	-13.6		209.2	
16	Jabalpr	80.2	85.3	-5.9	77.2	85.3	-9.4	93.6	87.9	6.5
17	Katni	67.0	71.2	-5.9	74.4	71.3	4.3		56.2	
18	Mandla	39.4	29.5	33.5	36.6	30.0	22.2	30.7	29.0	6.0
19	Mandsaur	48.4	51.0	-5.1	40.2	26.0	54.5	68.9	70.8	-2.7
20	Morena	69.0	67.8	1.8	71.1	68.2	4.3		75.2	

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE : MADHYA PRADESH Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
22	Neemach	26.7	25.9	3.0	32.3	24.3	33.0	32.9	39.9	-17.7
23	Panna	68.3	71.9	-5.0	71.1	70.8	0.5	71.8	61.7	16.4
24	Raisen	184.2	178.7	3.0	191.0	178.0	7.3		178.4	
25	Raigarh	51.2	65.3	-21.7	59.6	43.0	38.7	59.3	69.8	-15.0
26	Ratlam	55.2	70.5	-21.7	52.3	45.3	15.4	65.4	83.1	-21.3
27	Rewa		167.6		155.5	169.5	-8.3		155.6	
28	Sagar	162.2	163.8	-1.0	176.4	163.8	7.7		163.7	
29	Satna	162.0	157.6	2.8	168.5	153.9	9.5	142.5	142.0	0.4
30	Sehore	150.0	170.6	-12.1	155.7	34.5	351.0	159.3	162.0	-1.6
31	Seoni	74.0	93.0	-20.5	95.7	103.0	-7.1	75.5	104.7	-27.9
32	Sheopur		34.9		36.8	145.3	-74.7		38.4	
33	Shajapur		85.4		78.7	52.0	51.2	82.8	86.5	-4.3
34	Shivpuri	145.4	121.5	19.7	119.3	108.8	9.6		99.3	
35	Ujjain		148.8		124.1	69.8	77.9	145.2	183.2	-20.7
36	Tikamgarh	104.6	107.0	-2.3	89.1	94.4	-5.6	65.7	58.1	13.1
37	Vidisha	226.6	214.5	5.7	211.1	206.6	2.2		213.5	
Total		**2841.7**	**3842.5**	**-26.0**	**3612.0**	**3457.4**	**4.5**	**2386.6**	**3893.4**	**-38.7**
Projected		4126.0	4136.2	-0.2	3910.0	3692.8	5.9	4040.0	3992.8	1.2

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 to 2008-09

STATE: MADHYA PRADESH Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Betul	101.3	99.1	2.3	76.3	105.4	-27.6
2	Bhind	42.8	74.0	-42.1	76.5	84.1	-9.1
3	Bhopal	53.0	68.2	-22.3	45.1	67.4	-33.1
4	Chhatarpur	37.4	57.7	-35.2	116.5	128.1	-9.1
5	Chhindwara	70.8	110.1	-35.7	52.5	82.8	-36.6
6	Damoh	76.5	63.1	21.3	68.6	67.0	2.4
7	Datia	47.5	88.5	-46.3	57.3	117.6	-51.3
8	Dewas	120.2	118.8	1.2	81.4	101.3	-19.6
9	Dhar	140.0	216.3	-35.3	130.0	141.2	-7.9
10	Dindori	19.9	29.7	-33.0	28.9	30.6	-5.6
11	Guna+Ashoknagar	181.7	184.2	-1.4	197.6	189.8	4.1
12	Gwalior	60.7	67.9	-10.6	80.9	89.3	-9.4
13	Harda	109.1	125.8	-13.3	102.0	117.0	-12.8
14	Indore	102.8	126.8	-18.9	89.6	57.9	54.7
15	Hoshangabad	199.3	217.6	-8.4	201.3	219.0	-8.1
16	Jabalpr	83.9	85.5	-1.9		92.3	
17	Katni	45.1	44.9	0.4		65.4	
18	Mandla	28.3	29.1	-2.8		29.4	
19	Mandsaur	54.6	61.1	-10.6	25.9	50.0	-48.2
20	Morena	45.1	78.3	-42.4	69.1	80.4	-14.0

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 to 2008-09

STATE: MADHYA PRADESH Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
21	Narsinghpur	65.7	55.0	19.5	73.1	62.3	17.3
22	Neemach	21.7	28.0	-22.4	24.6	32.2	-23.5
23	Panna	28.2	53.6	-47.4		60.7	
24	Raisen	161.7	167.9	-3.7	139.5	168.4	-17.2
25	Raigarh	58.8	72.3	-18.6	45.9	56.1	-18.2
26	Ratlam	80.4	78.5	2.4	51.6	63.2	-18.3
27	Rewa	71.3	147.0	-51.5	123.0	155.7	-21.0
28	Sagar	116.5	139.6	-16.5	176.4	150.1	17.6
29	Satna	107.3	127.8	-16.0	137.5	137.9	-0.3
30	Sehore	158.9	165.4	-3.9	103.4	153.1	-32.4
31	Seoni	86.2	110.5	-22.0		103.1	
32	Sheopur	37.5	42.4	-11.6		40.2	
33	Shajapur	84.8	87.5	-3.0	37.2	66.0	-43.6
34	Shivpuri	66.1	90.4	-26.9	78.6	114.8	-31.6
35	Ujjain	191.1	200.0	-4.4	49.9	98.8	-49.5
36	Tikamgarh	23.4	22.8	2.9	103.0	107.4	-4.1
37	Vidisha	208.4	179.9	15.8	184.0	172.7	6.5
Total		**3188.0**	**3714.8**	**-14.2**	**2827.2**	**3658.6**	**-22.7**
Projected		3410.8	3742.3	-8.9	3534.0	3785.2	-6.6

Anuppur, Balaghat, Barwani, Burhanpur, Khandwa, Khargaon, Shahdol, Sidhi,Umaria are not included.

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: PUNJAB   Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
1	Amritsar	361.0	372.0	-3.0	366.6	371.0	-1.2	191.8	185.0	3.7
2	Tarantaran							175.9	183.0	-3.9
3	Bathinda	234.4	241.0	-2.7	236.1	243.0	-2.8	237.6	245.0	-3.0
4	Barnala									
5	Faridkot	114.4	114.0	0.3	113.1	116.0	-2.5	113.9	117.0	-2.6
6	F. Sahib	79.6	85.0	-6.3	87.1	84.0	3.7	86.7	85.0	2.0
7	Firozpur	377.5	386.0	-2.2	382.0	386.0	-1.0	376.9	389.0	-3.1
8	Gurdaspur	220.8	227.0	-2.7	219.2	227.0	-3.4	221.5	229.0	-3.3
9	Hoshiarpur	149.3	145.0	3.0	140.6	145.0	-3.0		142.0	
10	Jalandhar	169.0	171.0	-1.2	171.3	170.0	0.8		165.0	
11	Kapurthala	111.2	115.0	-3.3	109.2	111.0	-1.6		109.0	
12	Ludhiana	257.5	258.0	-0.2	257.7	257.0	0.3		257.0	
13	Mansa	158.0	167.0	-5.4	168.0	163.0	3.1	163.9	165.0	-0.7
14	Moga	168.3	173.0	-2.7	167.8	174.0	-3.6	169.3	175.0	-3.3
15	Muktsar	193.0	200.0	-3.5	200.1	200.0	0.0	197.5	202.0	-2.2
16	Nawan Shahar	71.1	76.0	-6.5	73.1	72.0	1.5		72.0	
17	Patiala	256.4	266.0	-3.6	267.3	260.0	2.8	261.4	244.0	7.1
18	Rupnagar	87.1	89.0	-2.1	88.3	91.0	-3.0		57.0	
19	Sas Nagar							43.4		
20	Sangrur	386.0	397.0	-2.8	393.9	396.0	-0.5		396.0	
Total		**3394.5**	**3482.0**	**-2.5**	**3441.4**	**3466.0**	**-0.7**	**2239.8**	**3417.0**	**-34.5**
Projected		3340.0	3482.0	-4.1	3440.0	3468.0	-0.8	3450.0	3467.0	-0.5

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 to 2008-09

STATE: PUNJAB Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Amritsar	192.6	184.4	4.4	186.4	187.1	-0.4
2	Tarantaran	182.5	185.1	-1.4	181.0	186.3	-2.8
3	Bathinda	237.0	246.6	-3.9	242.2	249.2	-2.8
4	Barnala	111.6	112.1	-0.4	111.9	114.1	-1.9
5	Faridkot	115.8	117.2	-1.2	115.6	117.8	-1.8
6	F. Sahib	84.6	85.0	-0.5	85.7	85.1	0.7
7	Firozpur	377.9	395.3	-4.4	391.9	394.9	-0.8
8	Gurdaspur	215.6	230.7	-6.5	226.3	230.9	-2.0
9	Hoshiarpur	137.9	144.5	-4.6	142.8	154.4	-7.5
10	Jalandhar	169.5	166.6	1.8	170.3	170.6	-0.2
11	Kapurthala	105.0	110.2	-4.7	107.9	110.6	-2.4
12	Ludhiana	259.6	258.4	0.5	259.2	259.1	0.1
13	Mansa	165.2	169.2	-2.4	167.8	170.9	-1.8
14	Moga	175.0	174.6	0.2	174.2	176.7	-1.4
15	Muktsar	202.8	201.8	0.5	200.2	201.6	-0.7
16	Nawan Shahar	73.6	71.9	2.3	73.8	75.9	-2.7
17	Patiala	249.1	239.5	4.0	248.4	242.3	2.5
18	Rupnagar	58.6	62.1	-5.6	58.7	64.1	-8.4
19	Sas Nagar	42.6	48.4	-11.9	43.7	49.1	-11.0
20	Sangrur	282.9	283.1	-0.1	280.9	285.4	-1.6
	Total	**3439.4**	**3486.7**	**-1.4**	**3468.9**	**3526.0**	**-1.6**
Projected		3470.0	3488.0	-0.5	3470.0	3526.0	-1.6

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE : RAJASTHAN Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
1	Alwar	190.6	157.4	21.1	191.4	159.5	20.0	198.8	180.5	10.1
2	Banswara	73.8	77.5	-4.9	78.4	82.2	-4.6	83.6	85.8	-2.6
3	Baran	40.8	55.2	-26.1	45.6	65.1	-29.8	54.0	86.0	-37.2
4	Bharatpur	147.0	111.3	32.1	148.6	119.2	24.7	156.6	147.8	5.9
5	Bundi		81.2		83.6	94.9	-11.9	96.9	111.6	-13.2
6	Chittaurgarh	56.2	96.3	-41.6	66.8	96.3	-30.6	83.6	92.7	-9.8
7	Dausa	76.9	78.8	-2.4	78.3	73.0	7.2	79.4	76.0	4.5
8	Dholpur	47.6	42.0	13.4	47.2	46.6	1.3	51.0	47.7	6.9
9	Dungarpur	22.6	37.8	-40.2	29.7	35.6	-16.6	30.4	40.9	-25.7
10	Ganga Nagar & Hanuman Garh		306.9			367.5		346.3	379.1	-8.6
11	Jaipur		155.4		134.7	139.8	-3.6	152.4	136.1	12.0
12	Jalore		22.3		33.6	22.3	50.6	38.4	43.4	-11.4
13	Jhalawar	32.8	49.4	-33.7	42.0	37.2	12.9	47.5	72.5	-34.5
14	Jhunjhunun	58.5	59.7	-2.0		69.7		35.5	68.4	-48.0
15	Kota	56.7	64.9	-12.6	61.8	64.8	-4.5	69.3	81.6	-15.0

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE : RAJASTHAN Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
16	Pali	28.2	25.6	10.4	27.1	28.7	-5.3	35.3	77.6	-54.5
17	Sawai Madhopur & Karauli	103.6	95.0	9.1	111.3	96.4	15.5	113.5	95.8	18.5
18	Sikar	78.3	86.7	-9.6		84.6		63.4	84.4	-24.0
19	Sirohi	16.1	16.3	-1.2	18.3	27.2	-32.8	23.7	46.2	-48.8
20	Tonk		60.6		61.3	54.7	12.2	64.2	63.4	1.3
Total		**1029.7**	**1680.3**	**-38.7**	**1259.9**	**1765.1**	**-28.6**	**1823.6**	**2017.0**	**-9.6**
Projected		2315.0	2010.1	15.2	2140.0	2123.9	0.8	2590.0	2564.8	1.0

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 to 2008-09

STATE: RAJASTHAN Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Alwar	205.2	191.4	7.2	183.3	170.2	7.7
2	Banswara	87.3	90.8	-3.9	74.3	76.1	-2.4
3	Baran	67.9	106.7	-36.4		95.8	
4	Bharatpur	163.4	157.4	3.8	151.9	223.2	-32.0
5	Bundi	115.9	129.9	-10.8	112.4	117.8	-4.6
6	Chittaurgarh	102.7	122.4	-16.1	84.6	84.1	0.7
7	Dausa	81.9	77.5	5.7	75.6	77.4	-2.3
8	Dholpur	54.0	51.2	5.5	50.9	50.8	0.2
9	Dungarpur	30.9	41.5	-25.5	23.9	18.3	30.6
10	Ganga Nagar & Hanuman Garh	395.0	418.5	-5.6	394.9	421.8	-6.4
11	Jaipur	168.3	132.0	27.5	169.5	136.8	23.9
12	Jalore		31.5		32.9	23.6	39.4
13	Jhalawar	56.2	57.4	-2.1	43.2	58.8	-26.5
14	Jhunjhunun	51.0	75.9	-32.8	58.7	71.8	-18.3
15	Kota	81.0	110.1	-26.4		86.6	
16	Pali		69.5		31.4	30.2	4.0
17	Sawai Madhopur & Karauli	121.8	102.6	18.7	100.5	116.2	-13.5
18	Sikar	73.6	85.2	-13.6	78.4	85.7	-8.5
19	Sirohi		39.4		22.2	247.9	-91.0
20	Tonk	69.4	70.0	-0.8	44.3	40.6	9.0
Total		**1925.5**	**2160.7**	**-10.9**	**1732.9**	**2233.7**	**-22.4**
Projected		2593.7	2591.8	0.1	2304.7	2294.8	0.4

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: UTTAR PRADESH Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
1	Agra	127.4	124.3	2.5	125.1	128.4	-2.6	129.2	124.3	4.0
2	Aligarh+ Haathras	253.9	311.0	-18.3	269.6	296.7	-9.1	275.5	308.1	-10.6
3	Allahabad+ Kushambi	276.2	272.6	1.3	269.6	296.0	-8.9	278.0	276.8	0.5
4	Azamgarh	205.1	223.4	-8.2		222.0		223.8	221.3	1.1
5	Badaun	279.2	301.0	-7.2	269.1	288.7	-6.8	278.9	283.6	-1.7
6	Bahraich+ Shravasti	223.1	213.2	4.7	216.4	217.1	-0.3	222.4	211.6	5.1
7	Ballia	128.9	143.5	-10.2		144.4			143.5	
8	Banda+ Chitrakut	180.2	188.1	-4.2	172.8	186.8	-7.5	171.5	179.1	-4.2
9	Barabanki	148.7	163.9	-9.3		162.0		162.4	165.9	-2.1
10	Bareilly	141.5	208.8	-32.2	186.8	178.7	4.5	189.5	196.8	-3.7
11	Basti+ Sant K. Nagar	188.4	204.8	-8.0		186.0		186.9	204.5	-8.6
12	Bijnor	111.0	111.6	-0.5	109.6	105.2	4.2	111.6	112.7	-1.0
13	Bulandshar	178.6	190.3	-6.2	169.1	190.3	-11.1		178.4	
14	Deoria+Kushi Nagar	268.6	265.7	1.1		263.2		236.0	244.1	-3.3
15	Etah	210.3	223.9	-6.1	204.9	206.8	-0.9		227.6	
16	Etawah+ Auraiya	163.1	183.1	-10.9	171.1	180.6	-5.2		182.8	
17	Faizabad+ A. Nagar	206.3	197.6	4.4	211.0	190.9	10.5	216.6	193.8	11.8

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: UTTAR PRADESH Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
18	Farrukhabad+ Kannauj	151.2	146.3	3.4	149.1	149.1	0.0	145.6	144.9	0.5
19	Fatehpur	143.5	151.4	-5.3	147.2	150.1	-1.9	155.9	147.2	5.9
20	Firozabad	110.4	102.8	7.4	104.0	100.0	4.1	105.6	105.4	0.1
21	Gaziabad+ G.B.Nagar	102.5	136.6	-25.0	102.6	156.9	-34.6		134.6	
22	Gazipur	152.1	166.2	-8.5		166.9		167.8	166.4	0.8
23	Gonda+ Balrampur	254.6	241.5	5.4	239.5	246.4	-2.8	238.1	237.9	0.1
24	Gorakhpur	173.7	184.3	-5.8		187.4		176.7	184.3	-4.1
25	Hamirpur+ Mahoba		138.7		142.8	139.4	2.4	148.1	151.2	-2.1
26	Hardoi	269.8	313.0	-13.8	287.7	300.5	-4.3	290.4	307.7	-5.6
27	Jalaun	142.1	116.5	22.0	149.4	121.0	23.4	145.8	116.5	25.2
28	Jaunpur	187.0	193.4	-3.3	192.4	174.8	10.1	192.0	193.4	-0.7
29	Jhansi	133.8	105.3	27.0	134.8	126.8	6.3	135.0	112.8	19.6
30	Kanpur Rural		116.8		126.1	99.6	26.6	129.0	112.3	14.9
31	Kheri		204.1			201.5		199.0	190.5	4.5
32	Lalitpur	100.1	95.9	4.5	92.2	93.4	-1.3	93.9	96.7	-2.8
33	Lucknow	81.9	85.0	-3.6		82.1		84.4	84.1	0.4
34	Mahrajganj	131.5	148.0	-11.1		143.0			143.9	
35	Mainpuri	128.3	117.9	8.9	119.2	102.3	16.4		119.1	
36	Mathura	187.7	188.9	-0.7	185.6	198.4	-6.4	187.6	188.9	-0.7
37	Mau	96.5	92.2	4.6		88.0		101.1	87.6	15.4
38	Meerut+Bagpat	133.4	137.1	-2.7	139.3	136.7	1.9		137.8	

Comparison of final forecast of area under Wheat by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: UTTAR PRADESH Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
39	Mirazapur+ Sonebhadra	107.2	150.3	-28.7	98.4	147.1	-33.1	97.9	153.5	-36.3
40	Moradabad+ J.B. Nagar	295.4	308.3	-4.2	297.4	286.9	3.7	294.2	285.2	3.2
41	Muzaffarnagar	128.0	129.3	-1.0	127.0	123.9	2.5	128.2	125.9	1.9
42	Pilibhit	127.9	173.3	-26.2	135.6	152.4	-11.0	137.4	155.4	-11.6
43	Pratapgarh	143.7	147.3	-2.4	148.2	144.4	2.7	153.6	147.3	4.3
44	Raebarelli	181.6	183.5	-1.0	180.0	184.8	-2.6	181.8	184.2	-1.3
45	Rampur	132.5	144.0	-7.9	133.0	121.3	9.6	134.3	140.2	-4.2
46	Saharanpur	129.2	120.1	7.6	120.4	116.2	3.6		114.3	
47	Shahjahanpur	230.3	252.6	-8.8	257.3	247.1	4.1	258.4	252.6	2.3
48	Sidharthnagar	132.6	145.1	-8.6	150.8	145.0	4.0	156.5	152.8	2.4
49	Sitapur	197.9	210.0	-5.8		202.6		203.7	191.0	6.7
50	Sonebhadra									
51	Sultanpur	179.4	167.0	7.4	171.8	164.9	4.1	177.8	165.8	7.2
52	Unnao	204.3	223.7	-8.7	189.2	218.6	-13.4	188.2	223.0	-15.6
53	Varanasi+ Chandauli+ S.R.D.Nagar	183.7	208.6	-11.9	177.9	211.1	-15.7	178.9	198.5	-9.9
Total		**8344.3**	**9271.1**	**-10.0**	**6873.9**	**9074.3**	**-24.2**	**7669.2**	**9108.0**	**-15.8**
Projected		8840.0	8999.8	-1.8	9040.0	9163.9	-1.4	9120.0	9197.6	-0.8

Comparison of final forecast of area under Rabi Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 to 2008-09

STATE: ANDHRA PRADESH Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	East Godavari	169.10	169.10		165.50	169.90	-2.6
2	West Godavari	184.00	191.80	-4.1	175.40	195.00	-10.1
3	Krishna	112.30	93.80	19.7	93.60	120.70	-22.5
4	Guntur	25.60	23.90	7.1	61.60	51.40	19.8
5	Prakasam	80.20	80.40	-0.2	61.60	84.00	-26.7
6	Nellore	162.60	188.50	-13.7	171.30	191.50	-10.5
7	Nalgonda	145.40	147.70	-1.6	158.90	168.10	-5.5
8	khammam	36.40	30.50	19.3	35.10	36.50	-3.8
9	warangal	64.60	71.90	-10.2	38.90	78.00	-50.1
10	Karimnagar	173.80	152.00	14.3	156.40	175.60	-10.9
11	Nizamabad	54.40	56.70	-4.1	88.60	78.40	13.0
12	Chittoor	30.60	37.10	-17.5	28.20	37.90	-25.6
13	Mahaboobnagar	31.30	46.10	-32.1			
Total		**1270.30**	**1289.50**	**-1.5**	**1235.10**	**1387.00**	**-11.0**
Projected		1386.80	1406.00	-1.4	1386.40	1584.00	-12.5

Comparison of final forecast of area under Rabi Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 to 2008-09

STATE: ORISSA Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Cuttack	2.9	5.4	-46.3	4.4	4.7	-6.4
2	Jagatsinghpur	1.2	1.8	-33.3	2.1	2.9	-27.6
3	Kendrapara	2.2	2.4	-8.3	2.3	5.0	-54.0
4	Bhadrak	11.0	11.3	-2.7	12.6	14.7	-14.3
5	Balasore	26.9	35.7	-24.6		34.1	
6	Baragarh	57.9	64.4	-10.1	53.7	61.4	-12.5
7	Sonepur	26.5	26.4	0.4	26.6	28.4	-6.3
8	Kalahandi		52.1		42.1	50.1	-16.0
9	Khurda		7.3		7.1	6.4	10.9
10	Puri		47.7		40.6	52.1	-22.1
11	Sambalpur		17.8		15.9	20.2	-21.3
Total		**128.6**	**272.3**	**-52.8**	**207.4**	**280.0**	**-25.9**
Projected		NA	333.7		294.8	331.0	-10.9

Comparison of final forecast of area under Kharif Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05

STATE: ANDHRA PRADESH Area in '000 hectare

Sl. No.	District	2004-05		
		SAC	SASA	% Variation
1	Srikakulam	175.3	190.8	-8.1
2	Vizanagaram	101.2	125.2	-19.2
3	East Godavari	223.0	224.5	-0.7
4	West Godavari	240.3	244.2	-1.6
5	Krishna	242.9	245.3	-1.0
6	Guntur	233.5	240.4	-2.9
7	Prakasam	25.3	27.4	-7.9
8	Kurnool	69.0	61.5	12.2
9	Warangal	104.1	108.4	-4.0
10	Nizamabad	52.3	60.3	-13.2
11	Medak	36.1	49.3	-26.9
12	Khammam	135.4	136.4	-0.7
13	Adilabad	31.7	35.6	-11.0
14	Karimnagar	27.3	65.5	-58.2
15	Mahbubnagar	60.7	58.5	3.7
16	Nalgonda	110.8	117.4	-5.6
Total		**1868.7**	**1990.7**	**-6.1**
Projected		2088.6	2215.0	-5.7

Comparison of final forecast of area under Kharif Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: ORISSA Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
1	Angul	125.8	117.0	7.5	120.2	114.0	5.4	117.1	113.0	3.6
2	Bolangir	197.1	231.0	-14.7	201.0	229.0	-12.2	209.7	214.0	-2.0
3	Balasore	218.4	240.0	-9.0	215.4	247.0	-12.8	207.6	251.0	-17.3
4	Baragarh	219.2	297.0	-26.2	233.2	290.0	-19.6	231.3	300.0	-22.9
5	Bhadrak	178.4	178.0	0.2	175.9	178.0	-1.2	169.4	171.0	-0.9
6	Boudh	74.7	69.0	8.2	71.0	68.0	4.4	70.7	71.0	-0.4
7	Cuttack	119.8	147.0	-18.5	132.1	152.0	-13.1	131.6	138.0	-4.7
8	Deogarh	41.4	51.0	-18.8	48.7	54.0	-9.9	48.2	53.0	-9.0
9	Dhenkanal	124.2	123.0	1.0	119.5	122.0	-2.0	115.6	114.0	1.4
10	Gajapati	48.5	36.0	34.7	48.4	33.0	46.7	41.8	39.0	7.2
11	Ganjam	245.0	259.0	-5.4	254.6	248.0	2.7	243.2	274.0	-11.3
12	Jagats. Pur	112.5	97.0	16.0	103.7	91.0	13.9	99.9	93.0	7.4
13	Jajpur	115.1	139.0	-17.2	117.2	138.0	-15.1	120.0	133.0	-9.8
14	Jharsuguda	60.5	59.0	2.6	61.5	61.0	0.8	56.7	61.0	-7.0
15	Kalahandi	211.8	267.0	-20.7	227.9	288.0	-20.9	228.8	262.0	-12.7
16	Kendrapada	123.3	137.0	-10.0	125.7	140.0	-10.2	126.2	136.0	-7.2
17	Keonjhar	222.8	205.0	8.7	211.9	201.0	5.4	207.8	192.0	8.2
18	Khurda	120.2	111.0	8.3	116.8	121.0	-3.4	115.6	122.0	-5.3
19	Koraput	134.7	132.0	2.0	137.4	138.0	-0.5	106.9	132.0	-19.0
20	Malkangiri	89.0	85.0	4.7	93.1	95.0	-2.1	95.0	89.0	6.8

Comparison of final forecast of area under Kharif Rice by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2004-05 to 2006-07

STATE: ORISSA 						Area in '000 hectare

Sl. No.	District	2004-05			2005-06			2006-07		
		SAC	SASA	% Variation	SAC	SASA	% Variation	SAC	SASA	% Variation
21	Mayurbhanj	301.4	326.0	-7.5	310.5	316.0	-1.7	291.6	317.0	-8.0
22	Nabarangpur	164.0	176.0	-6.8	165.5	179.0	-7.6	147.0	163.0	-9.8
23	Nayagarh	106.4	95.0	12.0	101.4	100.0	1.4	89.1	102.0	-12.6
24	Nuapada	102.0	106.0	-3.8	100.1	107.0	-6.5	97.5	109.0	-10.6
25	Phulbani	70.2			63.0			57.6		
26	Puri	121.5	172.0	-29.4	128.2	189.0	-32.2	113.9	180.0	-36.7
27	Rayagada	63.3	67.0	-5.6	80.6	51.0	58.0	51.2	64.0	-20.1
28	Sambalpur	128.8	160.0	-19.5	127.7	151.0	-15.5	130.7	144.0	-9.3
29	Sonepur	89.3	119.0	-25.0	87.3	120.0	-27.3	92.6	133.0	-30.4
30	Sundargarh	203.5	233.0	-12.6	220.8	212.0	4.1	201.5	224.0	-10.0
Total		**4132.8**	**4434.0**	**-6.8**	**4199.9**	**4433.0**	**-5.3**	**4015.7**	**4394.0**	**-8.6**
Projected		4132.8	4199.0	-1.6	4199.9	4154.0	1.1	4015.7	4135.0	-2.9

Comparison of final forecast of area under Sugarcane by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2008-09

STATE: KARNATAKA Area in '000 hectare

Sl. No.	District	2008-09		
		SAC	SASA	% Variation
1	Bagalkote	55.9	84.0	-33.5
2	Belgaum	138.4	191.4	-27.7
3	Chamaraja Nagar	4.1	10.9	-62.5
Total		198.4	286.4	-30.7
Projected			281.0	

Comparison of final forecast of area under Sugarcane by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08

STATE: UTTAR PRADESH Area in '000 hectare

Sl. No.	District	2007-08		
		SAC	SASA	% Variation
1	Saharanpur	159.7	143.8	11.0
2	Muzaffarnagar	230.6	242.4	-4.9
3	Meerut+Bagpat	201.3	212.1	-5.1
4	Bulandshahr	66.6	58.5	13.8
5	Ghanzibad+G.B.Nagar	52.8	69.2	-23.7
6	Bijnor	224.5	220.2	2.0
7	Moradabad+J.P.Nagar	161.9	148.7	8.9
8	Rampur	49.9	25.5	95.7
9	Sitapur	144.8	139.0	4.2
10	Kheri	234.8	226.7	3.6
11	Pilibhit	70.1	73.0	-4.0
12	Bareilly	110.0	97.5	12.8
13	Hardoi	51.1	43.2	18.2
14	Basti+Sant K.Nagar	52.4	41.8	25.2
15	Deoria+Kushinagar	88.2	80.5	9.5
Total		1898.7	1822.2	4.2
Projected		2285.2	2179.0	4.9

Comparison of final forecast of area under Mustard by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 and 2008-09

STATE: HARYANA Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Hisar	59.2	46.1	28.5	48.6	51.3	-5.2
2	Fatehabad	14.1	7.2	97.0	8.2	8.8	-6.3
3	Sirsa	65.0	41.5	56.4	64.1	41.9	53.2
4	Bhiwani	162.7	137.4	18.4	157.2	139.8	12.4
5	Mahendergarh	95.1	86.8	9.5	87.7	93.0	-5.7
6	Rewari	65.6	64.0	2.4	70.3	65.9	6.7
7	Jhajjar	42.8	34.8	23.1	42.1	35.3	19.3
8	Gurgaon	18.9	15.6	21.3	55.6	13.9	299.1
9	Mewat	34.8	30.7	13.3		29.4	
Total		**558.2**	**464.1**	**20.3**	**533.8**	**479.1**	**11.4**
Projected		605.5	499.0	21.3	581.9	515.0	13.0

Comparison of final forecast of area under Mustard by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2008-09

STATE: MADHYA PRADESH Area in '000 hectare

Sl. No.	District	2008-09		
		SAC	SASA	% Variation
1	Bhind	146.0	176.7	-17.4
2	Gwalior	24.8	58.9	-57.9
3	Morena	143.9	151.9	-5.3
4	Sheopur	42.7	83.7	-49.0
Total		**357.4**	**471.2**	**-24.1**
Projected		600.5	712.5	-15.7

Comparison of final forecast of area under Mustard by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 and 2008-09

STATE: RAJASTHAN Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Alwar	176.6	234.5	-24.7	216.1	269.9	-19.9
2	Baran	177.2	83.2	112.9	164.1	108.4	51.3
3	Bharatpur	142.1	192.1	-26.0	184.8	223.2	-17.2
4	Bundi	109.4	62.7	74.4	87.5	84.3	3.8
5	Dausa	65.8	76.2	-13.6	71.3	85.9	-17.0
6	Dholpur	58.9	50.9	15.8	62.7	69.8	-10.2
7	Ganganagar & Hanumangarh	402.1	357.7	12.4	422.0	321.4	31.3
8	Jaipur	102.5	117.3	-12.7	94.2	137.9	-31.7
9	Jalore	85.1	87.6	-2.9	87.0	85.6	1.6
10	Jhunjhunun	43.1	75.3	-42.8	56.3	83.5	-32.6
11	Kota	117.8	73.3	60.6	123.7	90.8	36.3
12	Pali	70.2	64.5	8.9	51.2	39.3	30.3
13	Sawai Madhopur & Karauli	227.3	220.1	3.3	262.9	262.3	0.2
14	Tonk	164.0	162.8	0.7	197.7	240.4	-17.8
Total		**1941.9**	**1858.2**	**4.5**	**2081.5**	**2102.8**	**-1.0**
Projected		2464.7	2496.2	-1.3	2691.6	2837.8	-5.2

Comparison of final forecast of area under Mustard by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2008-09

STATE: WEST BENGAL Area in '000 hectare

Sl. No.	District	2008-09		
		SAC	SASA	% Variation
1	Bardhaman	31.6	27.1	16.6
2	Birbhum	36.2	34.3	5.7
3	Dakshin Dinajpur	21.7	23.2	-6.3
4	Malda	40.5	32.7	23.9
5	Murshidabad	77.9	83.6	-6.8
6	Nadia	77.0	63.4	21.5
7	Uttar Dinajpur	33.8	38.6	-12.5
Total		**318.7**	**302.8**	**5.3**
Projected		419.3	412.5	1.6

Comparison of final forecast of area under Cotton by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 and 2008-09

STATE : ANDHRA PRADESH Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Krishna	46.9	34.9	34.4	47.3	36.7	28.9
2	Guntur	152.6	149.6	2.0	162.4	166.3	-2.3
3	Mahbubnagar	51.5	68.6	-24.9		90.3	
4	Nalgonda	93.1	106.2	-12.3	125.3	162.5	-22.9
5	Warangal	151.8	160.1	-5.2	155.2	136.4	13.8
6	Khammam	111.1	118.5	-6.2	120.9	176.4	-31.5
7	Karimnagar	142.6	137.4	3.8	171.2	180.1	-4.9
8	Medak		29.0		38.1	49.1	-22.4
9	Adilabad	182.4	211.3	-13.7	174.6	279.4	-37.5
Total		**932.0**	**1015.6**	**-8.2**	**995.0**	**1277.2**	**-22.1**
Projected		1075.8	1134.0	-5.1	1303.9	1399.0	-6.8

Comparison of final forecast of area under Cotton by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2008-09

STATE: HARYANA Area in '000 hectare

Sl. No.	District	2008-09		
		SAC	SASA	% Variation
1	Bhiwani	36.8	29.8	23.5
2	Fatehabad	85.5	84.3	1.4
3	Hisar	117.1	112.2	4.4
4	Jind	42.6	45.1	-5.5
5	Sirsa	164.9	172.3	-4.3
Total		**446.9**	**443.7**	**0.7**
Projected		469.8	455.0	3.3

STATE: KARNATAKA

Sl. No.	District	2008-09		
		SAC	SASA	% Variation
1	Belgaum	20.8	20.0	4.0
2	Bellary	15.8	19.6	-19.4
3	Dharwad	9.7	71.2	-86.4
4	Gagad	4.6	41.8	-89.0
5	Haveri	80.2	91.9	-12.7
6	Raichur	24.4	26.6	-8.3
Total		**155.5**	**271.1**	**-42.6**
Projected		NA	409.0	

Comparison of final forecast of area under Cotton by Remote Sensing and final estimates of State Agricultural Statistics Authority for 2007-08 and 2008-09

STATE: MADHYA PRADESH — Area in '000 hectare

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Badwani	56.4	54.6	3.3	50.3	56.1	-10.3
2	Dewas	37.4	32.0	16.9	32.3	32.1	0.6
3	Dhar	106.7	116.6	-8.5	39.9	110.4	-63.9
4	Khandwa+ Burhanpur		120.4		90.2	119.4	-24.5
Total		**200.5**	**323.6**	**-38.0**	**212.7**	**318.0**	**-33.1**
Projected			630.4			624.8	

STATE: PUNJAB

Sl. No.	District	2007-08			2008-09		
		SAC	SASA	% Variation	SAC	SASA	% Variation
1	Bathinda	138.9	164.8	-15.7	159.0	153.1	3.9
2	Faridkot	27.2	27.9	-2.5	20.7	20.5	1.0
3	Firozepur	146.2	139.2	5.0	131.6	119.7	9.9
4	Muktsar	104.9	128.2	-18.2	93.5	107.2	-12.8
5	Mansa	101.7	100.6	1.1	95.9	90.8	5.6
Total		**518.9**	**560.7**	**-7.5**	**500.7**	**491.3**	**1.9**
Projected		552.0	604.0	-8.6	532.6	527.0	1.1

STATE: RAJASTHAN

Sl. No.	District	2008-09		
		SAC	SASA	% Variation
1	Ganganagar	428.3	94.7	352.3
Total		428.3	94.7	352.3
Projected			302.5	

Methodology of Crop Area Estimation using Satellite Remote Sensing Data under FASAL

The optical data used currently for crop area estimation is IRS LISS III and IRS AWiFS (in earlier years IRS LISS I/II, WiFS data were used). Microwave data is currently used for rice (both Kharif and Rabi) and jute crops. Synthetic Aperture Radar (SAR) data from the Canadian satellite RADARSAT (C band HH polarization) is used. Satellite images coinciding with crop season are acquired following the crop calendar of each study area and satellite orbital calendar.

Pre-processing of remote sensing data

LISS III provides images in digital format that is obtained by partitioning the area of the image into a finite two-dimensional array (matrix) of small, uniformly shaped, mutually exclusive regions called pixels or picture elements, and assigning a representative gray shade to each such pixel. A multi-spectral image consists of more than one such matrix and the digital number (DN) corresponding to a pixel indicates its grayness which ranges between 0 (black) and 255 (white). The raw digital numbers (DN) images are converted to radiance images using the calibration coefficients based on different characteristics of the image.

Synthetic Aperture Radar (SAR) Data: The information generated by this satellite using microwave sensors is transformed into the image data through a series of steps to estimate 'incidence angle' of each pixel in a scanline and the 'backscattering coefficient', which is then scaled to classify and interpret the pixels.

The second requirement for geometric operation is an algorithm for the interpolation of gray values using the above model. As in input image f(x,y), the DN are defined at integral values of x and y, and transformation equation will dictate that DN for g(x,y) be taken at non-integral coordinates. There are various resampling algorithms. Generally cubic convolution is carried out for optical data and nearest neighbour for SAR data. The images are corrected for geometric error, (using a statistical procedure for interpolation of grey values) to create a master image.

All other images (multi-date) are registered with this master image to create a stack of data that match very well with pixel position. This is carried out same way as above, only using image based GCPs that are common to two images. An empirical model is built between the scan line, pixel of the GCP in the master and the slave image and resampling is carried out.

Georeferencing

Satellite data, received by the users, need to be geometrically corrected to match with the features on a map and ground. This step is called geo-referencing. It is done using Ground Control Points (GCP), which are definite locations found both in the image and a reference map, mainly the Survey of India topographic map or GCPs or an already existing geo-referenced image. These GCPs are non-variant features like road crossing, river branching etc. An empirical model of the relation between the longitudes and latitudes of the GCP's in the map and their pixels and scan lines from the image is used for transforming the image into map co-ordinates and this whole process is known as geo-referencing.

Generation of Training Site Signature Statistics

Satellite imagery provides multi spectral data on various features on the earth. The spectral reflectance and emittance properties of different features on the earth manifest are manifest in distinct combinations the components of optical spectrum. The use of imagery for distinguishing between different features on the earth requires establishing the correspondence between their characteristics on the ground with the spectral information contained in pixels.

For this purpose, 'Ground truth information' is required for identifying different surface features on earth and of crops grown which are responsible for occurrence of specific spectral reflectance behavior patterns. Different physical features as well as those relating to different land uses, crops and other vegetation observed on the ground (visually or with the help of digital cameras) in selected 'training sites' are matched with the corresponding spectral information in the pixels from the satellite imagery for these sites. This is done at the time of satellite pass on a sample of area covered by the traverse, which should also coincide with the phase of maximum vegetative cover of crops in each season in all the study sites.

This provides the basis for establishing the 'signatures' by which different features of land use and cropping over the study site can be identified on the basis of the characteristics of individual pixels and their distribution over the study area obtained from the satellite imagery. Using training signature editor, crops grown in different survey numbers identified on the respective imagery of the villages and training signatures are generated for each of the crop type basing on the ground truth data collection.

These signatures are then used for supervised classification by focusing on the image in training sites representative of each category of land cover, land use and crops. Spectral values for each pixel in a training site are used to define the decision space for that class. After the clusters for each training site are defined, the computer then classifies all the remaining pixels in the scene based on the 'maximum likelihood' approach in what is called 'supervised classification'.

Image classification

The overall objective of image classification procedures is to automatically categorize all pixels in an image into land cover classes or themes. A pixel is characterized by its spectral signature, which is determined by the relative reflectance in the different wavelength bands. Multi-spectral classification (Fig. 4) is an information extraction process that analyzes these spectral signatures and assigns the pixels to classes based on similar signatures.

There are two major approaches for image data classification: unsupervised and supervised. Unsupervised classification is the identification of natural groups, or structures, within multi-spectral data. Supervised classification is the process of using samples of known identity (ground truth sites) to classify pixels of unknown identity (i.e. to assign the pixels to one of several informational classes). The field information collected and stored, as ground truth sites are required to carry out any classification and verify its accuracy. All information related to training sites are stored as a ground truth mask image and used for generating the signature. This is called training site statistics. Mean, standard deviation, variance, minimum value, maximum value, covariance matrix and correlation matrix are used for classification.

Parametric Supervised Classifier: There are many classifiers used for supervised classification. The most popular supervised classification and used in CAPE/FASAL project is Maximum Likelihood (MXL) classifier. This classifier takes into account the parameters of the training classes, i.e. mean, variance and covariance. It is based on an assumption that the distribution of pixel values is Gaussian (normally distributed). Under this assumption the distribution of pixel values in any category can be completely described by the mean vector and the covariance matrix. Using mean vector and covariance matrix of training data it computes the statistical probability of a given pixel value being a member of a particular land cover class. The pixel is assigned to the most likely class, or labeled unknown if the probability values are all below a threshold.. The reject percentage acceptable is 5 percent i.e. those pixels having less than 95% probability of belonging to any class are assigned to the 'reject' class as unclassified pixels.

Non parametric supervised classifiers: Decision rule based classification is another approach used for crop identification, particularly when multi-date data is used. The hierarchical decision tree classifier is adopted for classification of multi date AWiFS data. This is based on Normalized Difference Vegetation Index (NDVI) derived from the radiance values of two spectral bands. The NDVI images for multi-dates of each Rabi season are stacked together in time sequence to form time-series of NDVI data. In this way five or more NDVI stacked images are formed for the crop season. A stack of NDVI images is then used to form decision rules to step-wise classify different classes and ultimately the study crop.

A decision-rule classifier has been developed based on a Radiative Transfer (RT) model, to classify multi-date SAR data for rice and jute crop. The rule uses the information of each pixel with its typical temporal behavior (i.e. crop phenology and field background) generated using extensive ground information. Since, SAR is an active sensor and less perturbed by atmospheric effects, one is able to get absolute calibrated signature (backscatter) and formulate hard decisions. The observed scatter in the backscatter values for rice fields are then progressively linked together from first date to the last date using logical combination of 'or' 'and' 'not' and decision rules as 'if … then … else if then … else … end if' structures to identify rice areas versus non-rice areas (two class problem). This approach has the advantage of generating rice area knowledge base of theoretical models and signature banks. Thus, any significant deviation reflects crop condition (flooding, water stress).

Unsupervised classifier: Once, the image is corrected for geometric error, it is called master image. ISODATA clustering algorithm – an unsupervised method is also used. This is an iterative method that uses Euclidean distance as the similarity measure to cluster data elements into different classes is in use. It starts by randomly selecting cluster centers in the multidimensional input data space. Each pixel is then grouped into a candidate cluster based on the minimization of a distance function between that pixel and the cluster centers. After each of the iterations, the cluster means are updated, and clusters are possibly spilt or merged depending on the size and spread of the data points in the clusters.

Currently, this approach is used for classification of crops like mustard, potato, sorghum using multi-date AWiFS data. Time-series of vegetation index data is generated from the multi date AWiFS images using red, NIR, MIR bands. A permanent non-agriculture mask is used and potential agriculture area is then subjected to classification. Thus, one gets clusters of crop classes only. After first iteration, the resulted clusters are compared with the ground truth database to assign crop classes. Further iteration is done, to purify the study crop classes.

<u>Sampling procedure used by FASAL</u>

The aim of CAFÉ/FASAL project is to provide in-season, per-harvest acreage estimate and production forecast. In order to meet the timeliness of forecast and overcome the problem of non-availability of wall-to-wall coverage of RS data etc. a sampling approach is adapted.

Over the years research carried out has shown that a 5*5 km sampling grid is optimum for this purpose. An all India grid with core sample size of 5*5 km has been generated. Each grid is labeled as agriculture or non-agriculture based on the Land use/cover map (RS based at 250,000 scale). Any grid having =>5 per cent of the total area under agriculture is tagged as the agriculture grid. All these grids form the agriculture population. The district, state and country boundary is integrated in Geographic Information System and using intersection method, each grid is assigned to a district/state. Each grid has thus unique identification in terms of XY and location (district/state/lat. /long.). The ancillary information in terms of road, rail, and major towns/settlements are also integrated.

Under CAPE / FASAL project, sample segment approach is adapted for segment-wise crop classification. Stratification is done based on specific crop area (say wheat, mustard etc.) derived from remote sensing data of a normal crop season in recent past. Frequency based stratification is used to allot each grid as A, B, C, D etc. based on crop proportion. Around 15-20% of samples are selected randomly from each stratum, keeping district as a unit. A database is prepared in a specific format, giving latitude and longitude information of each selected segment and its identification, which is used to extract the exact sample area from the satellite image.

Maximum likelihood classifier is used for such image classification.

- An image consisting of 'n number' of sample segments is first considered for training set definition based on ground knowledge. These training sets would cover the presence of different crops and other vegetation/ features in the area.
- For each of these defined classes, training set signatures are computed, that is, mean vector and variance-covariance matrices are computed.
- These ground truth signatures are further refined by examining the separability of defined the classes.
- Pixels from the Ground truth polygons are classified and a 2-way categorization table (confusion matrix) is constructed to observe how much of

mixing is present amongst different classes. That is, error due to commission and omission are computed and based on this further refinement of ground truth signatures are done.

- Once an accuracy of discernable level is achieved in this process, the ground truth signatures are finalized for classifying all segments in a given scene.
- All sample segments of the scene classified using the finalized ground truth. That is each pixel in a sample segment is tested for its belongingness into a particular class, with respect to ground truth signature, before assigning the pixel to a particular class.
- While doing so, P(X / x belongs to Ci); where Ci , i=1,….k (Ci = classes defined with ground truth signatures computed) is exhaustively computed for all defined classes using maximum likelihood probability density function.
- Subsequently, Max { (P (Xj); j=1,…..N) }, that is, maximum probability amongst all the probabilities computed for all defined ground truth classes, is computed.
- The pixel in question accordingly gets assigned to that class which attains maximum probability from the above processing
- However, Gaussian area curve is further used to decide on the reject classes. That is, those classes which do not satisfy 3σ criteria are not classified into any specified class, rather, they are put under reject class separately. Hence, the criteria for reject threshold is decided upon such considerations for every pixel in question.
- Through the above process sample segments are classified. These classified segments are further evaluated for its correctness with respect to the sample ground truth for further acceptance/ rejection/ re-evaluation process.

By the total number of sample units in the stratum, which are then summed over all strata. This is then adjusted for districts that are not covered by RS to get the overall estimate for the state. The confidence limits of area estimates are calculated using standard statistical procedures.

Analysis and use of Remote Sensing for Crop Yield Estimation

Yield is influenced by a large number of factors such as crop genotype, soil characteristics, cultural practices adopted (e.g. irrigation, fertilizer), weather conditions, and biotic influences, such as weeds, diseases and pests, etc. Spectral data of a crop is an integrated manifestation of the effect of all these factors on its growth. The two approaches adopted for yield modeling using RS data are

(i) RS data or derived parameters which along with weather data are directly statistically related to yield

(ii) RS data, which is used to estimate some of the biometric parameters like LAI, biomass, which in turn are input parameters to a yield model.

Basis of spectral yield models

The spectral reflectance of vegetation in optical region shows low reflectance in the visible part from 0.4 to 0.7 micrometer, with relatively high reflectance at the familiar green reflectance peak (0.54 micrometer). Chlorophyll absorbs energy in wavelength bands centered at about 0.45 and 0.65 micrometer. Hence one observes healthy vegetation as green in color because of high absorption of blue and red energy by plant leaves and relatively high reflection of green energy. In the region 0.7 to1.3 micrometer high reflectance is observed due to the internal cellular structure of the leaf. The internal structure is highly variable among plant species, reflectance measurement in this region is very important for remote sensing purpose. In the wavelength region from 1.3 to 2.6 micrometer reflectance is high but gradually decreases to a low level with increase in wavelengths.

Generally spectral data in red and near infrared bands are used for development of vegetation indices for this purpose. The spectral indices are typically a sum, difference, ratio or other linear combination of reflectance factor or radiance observation from two or more wavelength intervals. Vegetation indices show better sensitivity than individual spectral bands for the detection of biomass.These vegetation indices have been found useful for vegetation density, leaf area index, green leaf density and photosynthetically active biomass. Two of extensively used indices are ratio vegetation index (RVI = NIR/R) and Normalized Difference Vegetation Index (NDVI = (NIR - R)/ (NIR +R)) where R and NIR is mean reflectance in red and near infrared bands, respectively. These indices enhance the contrast between the ground and vegetation; they are less affected by the effect of illumination conditions. The NDVI index is sensitive to the presence of green vegetation so permits the prediction of agricultural crops and is used in different applications for monitoring of vegetation.

(i) <u>Relationship of NDVI and yield</u>

The NDVI of crop changes during its growth period with variation in crop growth, particularly green matter. This temporal pattern of spectral response is called spectral profile. Ideally, NDVI profile of the crop from spectral detection stage (around 30 days of emergence to physiological maturity stage) are used to derive various derivatives like area under the curve, peak value, rate of growth etc. which when used as multiparameter modeling give good correlation with yield. Significant linear relationships were found between peak vegetation indices and grain yield, particularly for cereal crops. For example, peak NDVI (corresponding to peak flowering/anthesis period), explained about 64 per cent of the grain yield variation of wheat crop in Punjab. Thus, for forecasting purpose, mostly peak NDVI is selected as a parameter.

However, spectral yield alone explain at best 50 to 70 percent of variability in the yield in case of grain crops like wheat where biomass or LAI at maximum vegetative growth is related to final grain yield under normal growing conditions during later part of the season. However, spectral yield relationships are poor in case of other crops like cotton, groundnut etc. Thus, meteorological parameters are also used and multi parameter regression models are used to improve the yield forecasting. For example, use of maximum and minimum temperature along with spectral parameter increased the yield model accuracy for wheat crop.

(ii) Use of RS derived parameter in Crop Growth Simulation Model for Yield Estimation.

Crop growth simulation models being mechanistic models are able to relate physiological growth of crops to environmental variables and considered one of the best ways to predict yield, crop condition etc. Simulation models first calculate canopy photosynthesis, after subtracting maintenance respiration, it is partitioned over roots, stems, leaves and grains as a function of the development stage.

However, these models require a large number of input parameters, particularly concerned to in-season inputs like crop sowing period, crop management inputs and weather variables etc. some of which are generally very difficult to obtain particularly for large area application. In this direction, many parameters can be obtained from satellite data, which can be used to simulate these models.

For example, the crop sowing date is a requirement to start the model. This information is derived in spatial domain using remote sensing data. Very high temporal resolution data like INSAT CCD are very useful for this purpose. Then the model can run under potential condition. At peak growth stage, Leaf Area Index (LAI) derived from remote sensing data is then forced to convert the potential yield to actual yield. This is currently used for spatial yield variability of wheat crop at state level.

Leaf Area Index is derived from the vegetation indices like NDVI/Ratio etc. Two approaches are used. One regression based, which is generally location specific. Another of parametric simulation models like PROSAIL, which if calibrated for a crop with various input parameters, is able to predict LAI as a generic one with better accuracy.

Meteorological model

Since, weather is the most dominant influence on crop growth, particularly in India, stand alone agromet yield models are also used. The weather variables are empirically related with crop yield. For any type of crop-weather model there is a need of large temporal database of different parameters. Three types of agromet crop yield models are in use; multiparameter stepwise regression, weighted regression and specific index) based models (like water satishfication index for kharif rice). However, in general, the truncated models (taking data upto peak growth stage) are used for forecasting purpose.

Annexure 17

Number of plots identified under different crops by Remote Sensing and Field Survey in different seasons in selected villages

While compiling the following tables, the crops identified as Jowar and Jowar fodder in Field Survey are assumed to be correctly identified in Remote Sensing, even if it is classified as Jowar. Similarly, other crops such as Maize, Bajra, which may be grown as fodder also and are shown separately in Field Survey, are assumed to be correctly identified in Remote Sensing, even if it is classified as main crop only. Further, wherever in Field Survey, mix crop is reported, it is assumed to be correctly identified in Remote Sensing, if any one of the crops among those is identified in Remote Sensing.

ANDHRA PRADESH

ARKATAVEMULA VILLAGE, KADAPA DISTRICT, season RABI

RS	**Field Study**												
	Fallows	Sunflower	Scrub	NAU	Bengal gram	Black gram	Green gram	Ground nut	mustard	Paddy	Seasmum	Tomatoes	Total
Fallows	343	3	65	45	150	22	3	1	1	2			635
Sunflower		6			1			1				1	9
Scrub	2		16	4	15	7	1					1	46
NAU	2		8	131	24	3				2			170
Cotton	32		55	17	187	18	3	2		7	2		323
Total	379	9	144	197	377	50	7	4	1	11	2	2	1183
% of correct identification	91	67	11	66									

ANDHRA PRADESH

KAMANUR VILLAGE, KADAPA DISTRICT, season RABI

RS	**Field Study**												
	Fallows	Scrub	Paddy	Sunflower	Bengal gram	NAU	Ridge gourd	Sesmum	Ground nut	Musk melon	Teak	Brinjal	Total
Fallows	19		1			2	3	3	11				39
Scrub	7	2	7	5	11	14		5					51
Paddy	8		129	5	12	20		5	5	7			191
Sunflower				6	6								12
Bengalgram	7	1	8		39	5		1			1	2	64
NAU	41			1	9	363		5				1	420
Total	82	3	145	17	77	404	3	19	16	7	1	3	777
% of correct identification	23	67	89	35	51	90							

GUJARAT

VILLAGE SUNDAN (DISTRICT ANAND) KHARIF season

RS	Field Study														
	Bajara	Banana	Brinjal	Castor	Chilly	Cotton	Dil	Jowar fodder	Lemon	Maize fodder	Mango	Mary gold	Mathi	Paddy	Total
Banana	24	232	2	1	19	23		9	1	3	1			225	540
Cotton	12	24	1			15		4	1	1				28	86
Fallow	2	29	1	1		5	1							10	49
Paddy	15	41	2	1	6	39		9	1	1		1	1	169	286
Settlement			1												1
Vegetable	6	14	1			39		2						32	94
Total	59	340	8	3	25	121	1	24	3	5	1	1	1	464	1056
% of correct identification		68				12								36	

GUJARAT

VILLAGE SUNDAN (DISTRICT ANAND) RABI season

RS	Field Study																		
	Banana	Brazil	Brinzal	Chilly	Jowar fodder	Lemon	Maize fodder	Mary gold	Paddy	Papaya	Potato	Rajgara	Ratalu	Rose	Tobacco	Unclips	Vegetable	Wheat	Total
Banana	59	1		5	8		4				8	5		1	162		10	7	270
Ladyfinger	37			2			5	1	1	1	11	2	1		236		3	3	303
Potato	14			2	1		1				3				36	1	6	2	66
Tobacco	62		1	4	3	3	1			1	11	1			155		3	2	247
Maize fodder							1												1
Total	172	1	1	13	12	3	12	1	1	2	33	8	1	1	589	1	22	14	887
% of correct identification	34						8				9				26				

VILLAGE SURPURA (DISTRICT MAHESANA) KHARIF season

RS	Field Study													
	Bajra	Black gram	Canal	Castor	Cotton	Cotton BT	Fallow	Grass	Jowar	Jowar fodder	Math	Mug	Til	Water millon	Total
Castor	58	19	2	190	41	1	67		4	100	2	1	2		487
Cotton	42	9	2	73	19	5	15	1	6	73	5	3	1	1	255
Fallow	4			2			4			4					14
Jowar	22	2		5	3	1	11		2	30		1			77
Total	126	30	4	270	63	7	97	1	12	207	7	5	3	1	833
% of correct identification				70	30	71	4		17	14					

VILLAGE SURPURA (DISTRICT MAHESANA) RABI season

RS	Field Study														
	Bajra	Castor	Cotton	Cotton BT	Cumin	Fallow land	Fennel	Jowar fodder	Lucerne	Methi	Mustard	Non cropping land	Suva	Wheat	Total
Castor		64	17		10	39			4		2			12	148
Cotton	1	72	21	4	14	73	2		1		4			9	201
Fallow Land		80	29	3	52	241			7		14		5	24	455
Non cropping Land		2				1						16			19
Wheat		38	5		1	26		1	3	1	1		1	5	82
Total	1	256	72	7	77	380	2	1	15	1	21	16	6	50	905
% of correct identification		25	29	57		63						100		10	

KARNATAKA

VILLAGE BADANIDIYUR, DISTRICT UDUPI, RABI season

RS	**Field Study**				
	Scrub+ Plantation	Open+ Fallow land	Settlement	Coconut garden	Total
Scrub+ Plantation	110			1	111
Open+ Fallow land	7	107	7		121
Settlement	106	102	44		252
Total	223	209	51	1	484
% of correct identification	49	51	86		

VILLAGE TYAVADAHALLI, DISTRICT MANDYA, RABI season

RS	Field Study														
	Arecanut	Banana	Built up / open pit	Coconut	Coriander	Fallow	Horse gram	Mango	Paddy	Potato	Ragi	Sugarcane	Survey	Teak	Tomato	Total
Built up / open pit +. .						2										2
Coconut	3	2		11				1	2			1			1	21
Fallow					1	13			5		2				1	22
Sugarcane	2						1		2	1	1	23		1		31
Total	5	2	0	11	1	15	1	1	9	1	3	24	0	1	2	76
% of correct identification				100		87						96				

UTTAR PRADESH

VILLAGE ALIABAD, DISTRICT. BARABANKI, KHARIF season

RS	Field Study								
	Arhar	Chilli	Fallow	Jowar	Maize	Paddy	Sugarcane	Urd	Total
Arhar	11					3		1	15
Fallow			9	1	1	1			12
Other Crop	1	2		11	3	9	5	7	38
Paddy		1		2		269	2	2	276
Plantation	5			12		21	1	3	42
Settlement	1			1		5		1	8
Shubabool								1	1
Sugarcane				3		1	12		16
Water Body						3			3
Total	18	3	9	30	4	312	20	15	411
% of correct identification	61		100			86	60		

VILLAGE ALIABAD, DISTRICT BARABANKI, RABI season

RS	Field Study																	
	Arhar	Barley	Brinjal	Cauli Flower	Coriander	Garlic	Gram	Lentil	Peas	Potato	Rapeseed Mustard	Tomato	Varseem fodder	Wheat	Fallow	Water Body	Settlement	Sugarcane	Total
Arhar	1							3	2	1	3		1	4					15
Fallow					1			2	1		2		1	6	29			3	45
Lentil	1	2	1	1	2	2	3	28	10	4	5			75				4	138
Other Crop		4	3	1	6	3	3	31	16	7	21	1	5	104				5	210
Peas							1	3	4	1	2			20				1	32
Plantation		3	3		6	1	2	23	12	5	10		5	75				5	150
Potato			1		2	1		9	3	5	7		1	22				2	53
Rapeseed Mustard		1			2	1	1	10	4	5	13		1	52				3	93
Settlement					3		1	4	4	2	4		2	20			54	2	96
Shubabool													1						1
Sugarcane		2				1		2	1	1	2			8				2	19
Water Body											1		1	3		6			11
Wheat	1	3	1	1	5	3	2	23	12	6	19		7	150				7	240
Total	3	15	9	3	27	12	13	138	69	37	89	1	25	539	29	6	54	34	1103
% of correct identify-cation	33							20	6	14	15			28	100	100	100	6	

VILLAGE BUDIANAKALAN, DISTRICT MUZAFFARNAGAR, KHARIF season

RS	Field Study															
	Arhar	Bajra Fodder	Bottleguard	Brinjal	Cauliflower	Chilli	Fallow	Jowar Fodder	Moong	Paddy	River	Settlement	Sugarcane	Urad	Vegetable	Total
Bajra Fodder		22						16					7	6		51
Fallow		1		1	1	1	108	45		34			147	13		351
Jowar Fodder	2	25	1	1	5	4		548	2	28			266	45		927
Other crop	2	3		2	1	2		81	1	9			97	41		239
Paddy	1	5	1	1		5		92		68			196	30		399
River		5			2	1		49		4	18		16	6		101
Settlement		7		1	10			32		7		104	14	10		185
Sugarcane	1	6		1		2		150	1	23			562	45		791
Vegetable		3						31		1			12	2	23	72
Total	6	77	2	7	19	15	108	1044	4	174	18	104	1317	198	23	3116
% of correct identification		29					100	52		39	100	100	43		100	

VILLAGE BUDIANAKALAN, DISTRICT MUZAFFARNAGAR, RABI season

RS	Field Study																	
	Mustard	Barley	Barseem Fodder	Brinjal	Cauliflower	Fallow	Gram	Jai Fodder	Masoor	Menthi	Mustard	Onion	Potato	Settlement	Sugarcane	Wheat	Oat	Total
Barley										1								1
Barseem Fodder			26		2		2	5	1	1	16		1			43	2	99
Cauliflower		1	4				1	3	1		5	2	1			27	2	47
Fallow			13			232		6	4	4	6	2				28	2	297
Gram		1					1			1							1	4
Mustard			1		1			1	1		3					4		11
Oat			1							1						2		4
Other crop	1	2	51		9			25	16	5	42	3	2			107	6	269
River			10		2						7	2				27	2	50
Settlement			11		11				1	1	7	4	3	113		32	1	184
Sugarcane		5	65	1	5		2	30	2	6	43	2			598	112	17	888
Wheat			61		17		3	5	7	2	65	6	5			672	18	861
Total	1	9	243	1	47	232	9	75	33	22	194	21	12	113	598	1054	51	2715
% of correct identification		0	11		0	100	11				2			100	100	64	0	

VILLAGE BUDIANAKALAN, DISTRICT MUZAFFARNAGAR, ZAID season

RS	Field Study																			
	Bajra	Bitterguard	Bottleguard	Chilli	Fallow	Jowar	Ladiesfinger	Lobia	Maize	Mango	Mint	Moong	Onion	River	Sanai	Settlement	Sugarcane	Tomato	Urad	Total
Bajra	1	2	1		33	26	1	4	58	1	1	2	1		1				6	138
Fallow	5	3	1	1	1031	91		7	68	3		1	3		1				3	1218
Jowar					22	100			28			2			1				4	157
Other Crop	2	3		1	69	79		4	63	3		1	3		4			1	4	237
River	1	1		2	19	26			8				1	28					1	87
Settlement	2		3		90	25			2		1	1	2			50		1	1	178
Sugarcane	5	2	2	1	105	127	2	5	168	6		4	6		6		602	1	4	1046
Total	16	11	7	5	1369	474	3	20	395	13	2	11	16	28	13	50	602	3	23	3061
% of correct identification	6				75	21								100		100	100			

VILLAGE SIYAKHAS, DISTRICT ALIGARH, KHARIF season

RS	Field Study											
	Arhar	Bajra	Fallow	Jowar Fodder	Maize	Moong	NAU	Paddy	Settlement	Urd	Water Body	Total
Arhar	18	13	19	6	10		22	3	12			103
Bajra	8	32	17	17	10		10	4	13	1		112
Fallow	7	8	104	10	7		1	3	6			146
Fodder	5	7	4	7	5		3		3			34
Other Crop	1	12	12	6	3	1	2	1	2			40
Paddy		1	5	2				1	3			12
Settlement	1	1	2	4	1			1	7			17
Water Body											1	1
Total	40	74	163	52	36	1	38	13	46	1	1	465
% of correct identification	45	43	64	13				8	15		100	

VILLAGE SIYAKHAS, DISTRICT ALIGARH, RABI season

RS	Field Study								
	Barley	Barseem	Fallow	Mustard	Potato	Wheat	Lentil	Fodder	Total
Barseem		7		5		9	1		22
Fallow	3	1	109	9	1	25	2	1	151
Mustard	2	6		22		32	3	1	66
Other Crop	6	6		12	1	35	4	5	69
Potato		1		4	4	9			18
Settlement	1	5		7	1	12	3	1	30
Water Body				1		1			2
Wheat	6	6		10	1	100	3		126
Total	18	32	109	70	8	223	16	8	484
% of correct identification		22	100	31	50	45			

VILLAGE SIYAKHAS, DISTRICT ALIGARH, ZAID season

RS	Field Study									
	Bajra	Fallow	Jowar	Mango	Moong	Muskmelon	Onion	Settlement	Urad	Total
Arhar	1	27	1		2	1				32
Bajra	2	40	1		2	1		1		47
Cotton		8			1					9
Fallow	1	167	2	1					1	172
Jowar	3	58	5	1				2		69
Mask Mellon		2								2
Moong		4					1			5
Settlement	2		1		1			49		53
Waterbody		2								2
Total	9	308	10	2	6	2	1	52	1	391
% of correct identification	22	54	50	0		0		94		

Estimates of area under major crops by season from Remote Sensing and Field Survey in selected villages

State **Andhra Pradesh** Area in '000 hectare

Village	Crops	Rabi Season		
		Remote Sensing	Field Survey	% Variation
Arakatavemula	Bengal Gram	0.00	921.66	
	Blackgram	0.00	43.43	
	Cotton	520.36	0.00	
	Greengram	0.00	6.67	
	Groundnut	0.00	3.64	
	Paddy	0.00	6.97	
	Rapeseed & Mustard	0.00	1.84	
	Sesmum	0.00	1.25	
	Sunflower	11.45	11.12	3.0
	Tomoto	0.00	0.52	
Kamanur	Bengal Gram	114.06	286.03	-60.1
	Brinjal	0.00	4.79	
	Groundnut	0.00	14.46	
	Muskmelon	169.02	164.58	2.7
	Paddy	237.39	238.71	-0.6
	Ridgegourd	0.00	1.55	
	Sesmum	216.35	225.51	-4.1
	Sunflower	21.43	29.85	-28.2
	Teak	0.00	0.57	

State **Gujarat** Area in '000 hectare

Village	Crops	Season								
		Kharif			Rabi			Summer		
		Remote Sensing	Field Survey	% Variation	Remote Sensing	Field Survey	% Variation	Remote Sensing	Field Survey	% Variation
Sundan	Bajri							117.00	106.38	10.0
	Banana	378.89	182.92	107.1	268.90	265.52	1.3	268.90	118.19	127.5
	Cotton	7.33	48.00	-84.7						
	Jowar	1.38	7.58	-81.8				35.00	21.24	64.8
	Paddy	67.47	52.70	28.0						
	Potato				36.70	26.86	36.6			
	Tobacco	7.66	116.20	-93.4	148.30	167.43	-11.4			
	Vegetables							4.78	5.14	-7.0
	Other Crop	13.58	33.31	-59.2	16.00	12.09	32.3	0.00	1.47	
Surpura	Bajri	29.50	90.67	-67.5				35.13	8.77	300.6
	Castor	345.72	245.84	40.6	126.90	242.80	-47.7			
	Cotton	185.25	48.32	283.4	170.00	53.16	219.8			
	Cumin					48.65				
	Jowar	116.47	183.50	-36.5				73.55	58.86	25.0
	Wheat				60.20	33.03	82.3			
	Other Crop	0.00	26.00			15.00				

State **Karnataka** Area in '000 hectare

Village	Crops	Season					
		Kharif			Rabi		
		Remote Sensing	Field Survey	% Variation	Remote Sensing	Field Survey	% Variation
Badanidiyur	Arecanut		0.09			0.09	
	Banana		0.70			0.70	
	Blackgram					5.16	
	Cashew		1.56			1.56	
	Coconut		121.43			121.43	
	Cucumber					2.00	
	Jack		0.49			0.49	
	Mango		1.41			1.41	
	Paddy (High Yielding)		22.24			0.77	
	Plam (sugar)		0.32			0.32	
	Plantation				185.56		
	Pumpkin					0.81	
Tyavadahalli	Arecanut		1.27			1.27	
	Banana		0.74			0.74	
	Coconut		2.08		6.08	2.08	192.3
	Paddy		11.39			0.00	
	Pepper		0.60			0.60	
	Potato					0.05	
	Sugarcane		30.92		35.09	30.92	13.5
	Teak		0.11			0.11	

In Uttar Pradesh, those crops, which are treated as crops of other season, such as Sugarcane, are shown in only one season in Field Survey.

State **Uttar Pradesh** Area in '000 hectare

Village	Crops	Season								
		Kharif			Rabi			Zaid		
		Remote Sensing	Field Survey	% Variation	Remote Sensing	Field Survey	% Variation	Remote Sensing	Field Survey	% Variation
Aliabad	Arhar	5.84	4.29	36.1	0.41	0.00				
	Masoor				9.87	10.32	-4.4			
	Paddy	55.74	57.58	-3.2						
	Peas				3.05	4.39	-30.5			
	Potato				3.69	2.72	35.7			
	Rapeseed & Mustard				5.54	6.26	-11.4			
	Sugarcane	4.85	2.68	81.2	0.59	0.00				
	Wheat				40.44	41.42	-2.4			
	Other Crop	19.08	5.78	230.1	23.65	4.94	379.2			

State **Uttar Pradesh** Area in '000 hectare

Village	Crops	Kharif Remote Sensing	Kharif Field Survey	Kharif % Variation	Rabi Remote Sensing	Rabi Field Survey	Rabi % Variation	Zaid Remote Sensing	Zaid Field Survey	Zaid % Variation
Budina Kalan	Bajra	3.20	4.67	-31.5				26.08	1.81	1340.9
	Barley				0.24	0.00				
	Bengal Gram				3.13	1.93	62.3			
	Cauliflower	3.61	2.55	41.6	2.08	4.43	-53.0			
	Cucurbits								5.13	
	Fodder Berseem				11.00	24.27	-54.7			
	Fodder Jowar	139.83	159.17	-12.2						
	Jowar				1.70	0.00				
	Jowar Fodder							31.54	89.45	-64.7
	Maize Fodder							0.00	131.15	
	Paddy	89.89	91.64	-1.9						
	Rapeseed & Mustard				4.59	28.22	-83.7			
	Sugarcane	461.00	467.79	-1.5	235.41	0.00		301.89	0.00	
	Wheat				353.78	351.45	0.7			
	Other Crop	41.78	33.36	25.2	143.84	29.31	390.8	45.58	23.17	96.7

State **Uttar Pradesh** Area in '000 hectare

Village	Crops	Season								
		Kharif			Rabi			Zaid		
		Remote Sensing	Field Survey	% Variation	Remote Sensing	Field Survey	% Variation	Remote Sensing	Field Survey	% Variation
Siyakhas	Arhar	20.97	22.59	-7.2				3.03	0.00	
	Bajra	50.20	50.70	-1.0				4.49	1.06	323.6
	Cotton							0.92	0.00	
	Fodder	23.23	28.11	-17.4						
	Fodder Berseem				1.62	4.22	-61.6			
	Jowar							10.06	3.72	170.4
	Moong							0.37	2.15	-82.8
	Muskmelon							0.31	0.17	82.4
	Paddy	6.24	6.69	-6.7						
	Potato				4.23	4.69	-9.8			
	Rapeseed & Mustard				19.19	20.26	-5.3			
	Wheat				112.85	111.89	0.9			
	Other Crop	27.36	23.97	14.2	17.56	14.08	24.7	0.00	0.94	

Note of Technical Features and Capabilities of Different Satellites and Sensors

<u>Relative merits of LISS III and LISS IV</u>

Spatial resolution, repetivity and swath of the data covered are the three factors that need to be considered for operational forecasting. A large swath ensures probability of getting data for the study districts, which are many and also choice of data acquisition period. As the spatial resolution increases, there is increased need of more field observations. There is always a trade off on spatial resolution depending on the scale of study.

LISS III with 24 day repeat cycle, a swath of 141 km, and 23 m spatial resolution is thus the best choice for district level forecasting. Other advantages of LISS III are the multispectral images in 4 channels spanning from blue-green to short wave Infrared band, which increases crop discrimination and hence the accuracy.

LISS IV data with 5.8 m resolution has a small swath of 23.5 km and with the 24 day repeat cycle (nadir pass) will require many passes to cover the same area, thus, all together missing the optimum date of data acquisition. Also, LISS IV provides data in 3 channels spanning from blue-green to near Infrared band only.

IRS LISS III with 23 m spatial resolution is suitable for thematic mapping like land use/ land cover, including agricultural land and other vegetation up to a scale of 1:50,000. This basically means that a pixel with dimension of 23 m x 23 m gives an average reflectance of an area in the multispectral domain. But, normally when interpreting an image, association is an important parameter for consideration, which is taken into account and hence a group of pixels are considered for interpretation rather than on per-pixel basis. At least a neighbourhood of 3 pixels x 3 pixels is considered while interpretation. Hence, roughly an area of 70 m x 70 m gets interpreted/ analysed, with respect to its neighbourhood, before assigning a feature to a particular class.

While noting the spatial properties for image classification, it is also essential to note the spectral/ radiometric properties of the same. LISS III provides Multispectral images in 4 channels spanning from blue-green to short wave Infrared bands. Discriminability of a feature depends both on spectral and spatial resolution of a group of pixels. Hence, both these properties are used while image classification, while spatial resolution decides on the scale at which a map may be produced due to its basic inherent property of resolving information from the feature the spectral information gives clarity of the pixels in question. Yet another important point to be noted is the total area coverage with respect to an individual image/ scene. In the case of LISS III an area of about 141 km x 141 km is covered which is quite a large coverage for any mapping, while LISS IV covers about 70 km x 70 km per scene.

Considering the above, major classes like agricultural/ crop land (Rabi, Kharif or Summer), large homogenous patches of crop land like paddy, sugarcane, wheat, major forest type, plantations etc could be discerned as long as it satisfies above property of interpretation with respect to a particular scale.

Similar points holds good for an image taken from LISS IV sensor, which produces 5.8 m spatial resolution. Due to greater spatial resolution it is possible to realize thematic maps, which are about 4 times better than LISS III image data (roughly about 1:12,500 scale of mapping is possible in a 5.8 m x 5.8 m pixel domain). Rest of the analogy, as mentioned above, is applicable here also. Point to be noted in terms of digital classification of high resolution multispectral images (ie, LISS IV sensor) is the need for intensive ground truth/ training sets, class mixture resolution, number of iteration of ground truth/ training set validation and classification etc., to achieve necessary accuracy thresholds.

Satellites with micro wave sensors

RISAT1 is basically a microwave remote sensing satellite that would function in C band with multi polarisation and multi mode imaging capabilities. The satellite will be a Synthetic Aperture Radar which will carry out imaging in the range of 3 – 50 m resolutions. As per present plans, it will provide 23 days repeat observations in medium resolution (25m) mode and 12 days repeat observations in coarse resolution mode (50m). The concept of imaging is much different from optical remote sensing, wherein the image interpretation is more dependent on surface roughness, dielectric constant and many other analyses dependent parameters. Microwave remote sensing has a unique capability of being all-weather capable, which means that one can acquire images through cloud penetrating properties of such sensors and the images could be processed for valuable information.

It can be seen from above, as far as spatial resolution of RISAT 1 and optical sensors is concerned, they are closely comparable with respect to resolving power. But, with respect to the imaging modes, multi-polarisation and data analysis it calls for a different type of treatment in microwave remote sensing domain and hence derivable outcomes are different from that of optical remote sensing. Microwave data is more complex in processing and needs much more skills as compared to optical remote sensing data. RADARSAT data processing expertise gained during all these years at SAC, Ahmedabad will be put to use for RISAT1 image processing also.

Repeated imaging from multiple satellites, preferably of similar spatial resolution, could help. However, considering the cloud cover, which is perpetual and a dynamic factor in many of the areas during kharif, the level of cloud-free image acquisition is still going to be a challenge in the optical remote sensing. Hence, use of optical imaging capabilities during kharif season will have uncertainities and remains to be challenge.

As it is well known, AWifs is a wide field sensor, which covers wider areas and its repitivity is also high as compared to other sensors and hence more number of image acquisitions are possible at frequent intervals. Due to these reasons, the probability of obtaining cloud-free images is relatively higher as compared to other optical sensors. However, the spatial resolution of this sensor is 55 m, which is much lesser as compared to LISS III and LISS IV. But for close monitoring of dynamic phenomenon, at a coarser resolution more frequently, this will be a good option.

Presently, microwave remote sensing is effectively being used for rice and jute crop, as only one polarization data from single frequency (C band) is available. However, scope of using microwave data for more crops like cotton, ground nut, soya bean may be considered with the availability of multi polarisation and multi-frequency data (as in case of RISAT 1), for which R & D is going on at Space Application Centre (SAC), Ahmedabad.

In order to get reliable estimates of crop area at the time of maximum vegetation cover, it is advantageous to use data at different points of time. This needs to be seen in view of the type of sensor being considered and how many such sensors are available for imaging in a phased deployment of satellites so that repetivity could be understood. As mentioned above, there are better possibilities with AWifs sensor due to quicker imaging capabilities and larger swath for coarser scale monitoring. However, this needs to be evaluated for LISS IV type of sensor in the future series of satellites. It should be noted that this procedure of using high spatial resolution satellite data could be time and data intensive if image depending on data acquisition and processing. This needs to be carefully examined, planned and operationally implemented.

Some limitations

Crop calendar and differentiability of multiple crops at the same time would always be a challenge if more number of crops are to be differentiated. It is essential to decide on the various crops in different agro-climatic conditions based on the crop calendar and then decides on the number of crops for differentiation. A systematic exercise needs to be undertaken to optimize these efforts based on the prioritization of crops to be covered and their economic values. Hence, based on the existing agriculture statistics if an exercise could be done on the above basis, agro-climatic region wise planning could be examined.

As brought out above, area coverage with respect to the field bunds using LISS III data cannot be considered because of the spatial resolution being 23 m. That is, the reflectance of the field bund features would get merged with the actual field features due to adjacency effect. However, when the same is done using LISS IV there are some possibilities of discerning field bunds purely based on the field conditions and association characteristics. That is, if field bunds are large enough and if they are hosting large bushes/ trees/ plantations and if the adjacent fields provide contrasting features, then there are possibilities of deriving information with respect to field bunds. But, smaller sized field bunds with grasses or scrub type of vegetation, which occupy very small linear patches in-between crop land, could be difficult for a 5.8 m resolution images. Hence, at these resolutions (LISS III and LISS IV) the bund reflectance gets merged with the field reflectance and hence area estimates would include both. For bund related crops and mapping in detail, it is necessary to consider remote sensing data at sub-meter resolutions wherein bunds and their features could be separated.

Image interpretation and GPS technology for land use/crop data collection

I. Visual interpretation of images and vectors for field data depiction

1. Introduction

Satellite remote sensing is extensive used for mapping and monitoring land use/ land cover at large and also different types of crops in particular. Two approaches are possible for mapping. The first one involves multispectral classification, while the second one would be visual interpretation, depending on several image characteristics (ie., color, tone, texture, association, size, shadow, pattern, location and context) in order to identify and deduce the significance of the components of the image. All these characteristics of visual interpretation could not be used in conventional digital classification techniques except of multispectral values and their relationships. Even though, digital classification techniques are considered much less subjective than visual interpretation; land use classes/ agricultural classes vary spatially and spectrally, especially when land covers poses high spatial complexity.

There are even advantages of using visual interpretation as follows:

1) less time required with photo interpretation methods to create a usable product;

2) little expense beyond the acquisition of the image;

3) image illumination problems such as shadows and brightly illuminated surfaces can be used as an interpretation aid; and

4) minimal expertise required to interpret the image.

2. Data preparation & interpretation

2.1. Data usage

IRS LISS 4 images are made available to the user community at 5.8-meter spatial resolution in multispectral channels. Liss 4 contains four bands information, which is represented through 1. Green, 2. Red, 3. Near infra-red and 4. Middle infra red range of the spectrum. Out of these, 3 bands are used (ie., Band 1,2 and 3 or 4) to prepare a false colour composite (FCC) image which contains optimal information for visual interpretation for land use and crop mapping (**Figure – 1**). Alternatively, it is also possible to synthetically generate a 5.8 m resolution color imagery by image fusion which involves merging the content of sharpened Panchromatic image with that of coarser resolution Liss 3 image to produce 5.8 mts high resolution imageries for visual interpretation.

Fig – 1: FCC of LISS 4 - a typical Agricultural area in North Karnataka,

2.2. Image Interpretation

Visual interpretation is performed on these images by specially understanding and developing interpretation keys based on above mentioned indicators/ parameters of interpretation. This interpretation consists of marking the boundaries of areas representing specific interpretation units on the images using on-screen digitizing techniques while also assigning nomenclature as per standardized naming conventions.

Also, extrapolation of similar signatures is done elsewhere in the same image showing similar characteristics as applicable. These are also ground-verified through sample field visits to ensure necessary quality and reliability of mapped units. The Images are georeferenced prior to classification/ interpretation. Simple graphic tools under GIS are enabled for visual interpretation of various features. Attributes for each of these polygons or lines or points would be entered while interpretation. This helps not only in preparation of visually interpreted maps at the end of the session, but also the preparation of a GIS database, which could be used for varieties of purposes in addition to creation of a data repository for building historical data for future references.

Georeferenced images of study area need to be correlated with Topographic map-base for linking with all attribute and ground controls to help in accurate interpretation of the images. The thematic interpretation always needs to be overlaid with some important landmarks and base map details for validation and usage for further ground truth collection. Hence, it is required to generate image-maps for field level data collection.

Further, this is used for interpretation on the workstations with GIS/ graphics facility and images of the study area in the backdrop.

Following are some typical examples of the type of products and images that could be used for the purpose.

1. False Color Composite (FCC) Which highlights vegetation (different crops and other green cover) in different shades of red, water in dark shades and blue, fallow in different shades of grey/ white and so on **(Figure 2a & 2b)**.

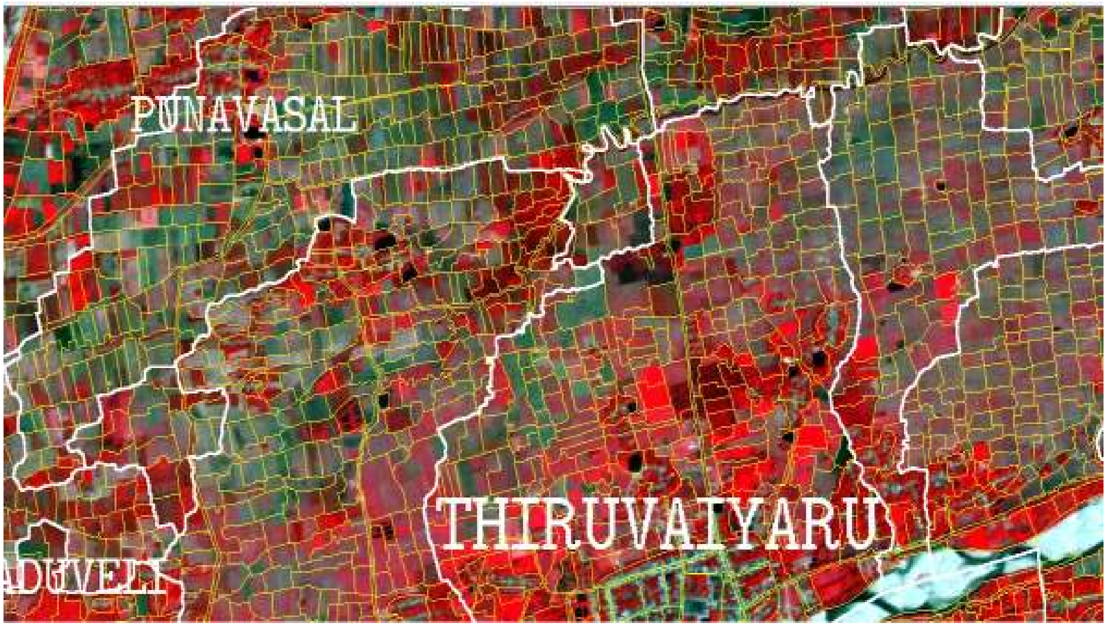

Fig – 2a: FCC with cadastral overlay highlighting crops and other features

Fig – 2b: Interpretation keys for Fig – 2a to facilitate easy usage at field level

2. Natural Color Composite (NCC) for similar areas could also be done to make the interpretation more convenient at field level functionaries, including ground truth verification. In addition to this, it is required to use topographic maps of the study area for establishing correct location on the field while ground truth collection. Current practices also are to provide/ use image-maps at field level for field work. That is, (1) satellite images are first georeferenced, (2) important map features or base map details are digitized as GIS vectors, mostly available for many states at 1:50,000 at respective State Remote Sensing Application Centres (SRSACs), (3) these vectors are superimposed on the enhanced image at high resolution which effectively means that both image information and map information are embedded on to one platform to aid in better usage of such products at field level for ground sampling. The above points are important and are also a pre-requisite while

using GPS instruments at field level for cross verification of land use/ land cover or for ground truth data collection. That is, one has to use either topographic maps or image-maps or both while traversing at village field level identifying various crops and other landuse for mapping and validation, primarily to establish proper spatial locations with respect to the map attributes (**Figure 3a, 3b, 3c & 3d**).

Fig – 3a: NCC with cadastral overlay highlighting crops and other features

Fig – 3b: Interpretation keys for Fig – 3a to facilitate easy usage at field level

Fig – 3c: Vectorised topographic/ base map details on GIS with Ground truth points

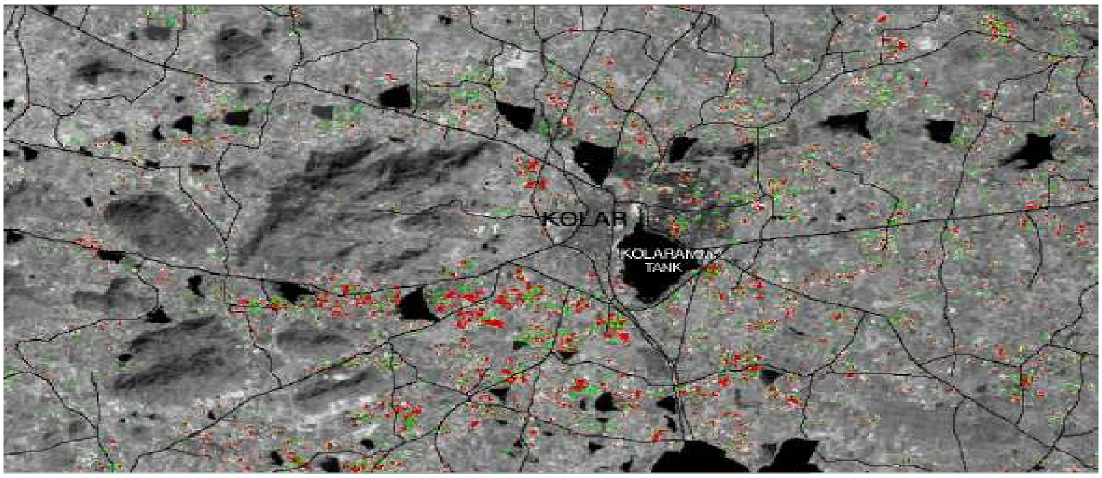

Fig – 3d: Image-map product showing base map vector overlaid on satellite image and mapped pixels from the ground truth of Fig – 3c

3. Image interpretation is done based on the above mentioned approach to prepare land use / land cover maps including details on agriculture and related features (**Fig – 4a**). The interpretation with respect to the field reality and vector overlays are carried out in such a way that both the vector and the underlying features could be seen and cross verified. These vectors and their attributes could be saved as a separate file under GIS format for future reference. It would always be preferable to store these images and corresponding vectors in an well organized manner to evolve a historical data repository for future reference and analysis.

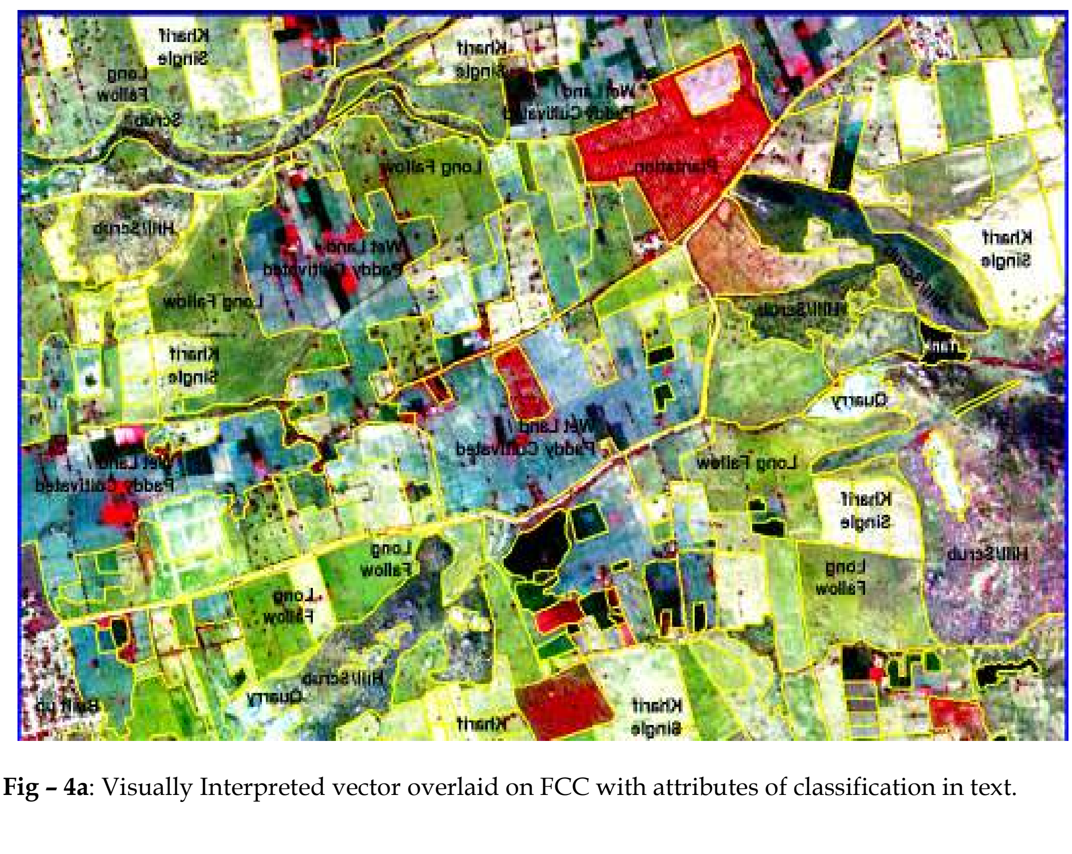

Fig – 4a: Visually Interpreted vector overlaid on FCC with attributes of classification in text.

II. GPS, GIS and Remote Sensing based mapping from the field

1.0 Introduction & Objectives

The current method of field data collection for Agriculture involves field visits and manual methods of updates. Typically, the village auditors (patwaries) provide field level information on the various Agriculture statistics to the Government, which is used by the Statistical departments for various decisions making. This is an old method and the validity of such a data is always subjective and in question. Considering the technologies available for data collection from the field and also the connectivity, it is possible to device alternative and much more scientific and unbiased methods could be considered for the purpose. Hence, it is possible to use an optimum mix of GPS, GPRS, field photo, GIS and IT tools to achieve this goal. Accordingly, a GPS device could be configured to provide the required geospatial coordinates required attributes as desired in a specified format and the field photos as input from field. Hence, it is necessary to use such simple technologies to improve quality and timeliness of such data collection for decision making.

Basic objective of use of such a tool is to provide the following facilities in the form of a simple-to-use software package.

1. Simple software tool on a mobile, with GPS, GPRS and photography facilities, to acquire data from field and transfer the same to local machine and/ or main server

2. Download the data collected in the field on to a local machine/ server system which also hosts a database server

3. Use compatible software tool to spatially depict these datasets collected from GPS device through a web based geographic information system tool.

4. The software tool should have facility to depict line, point and polygon/ area type of features in vector form as an overlay on map or satellite images through the web based platform

5. The tool should be usable as a validating one, where in field status on crops could be attributed for each of the fields visited and the same gets captured on a geospatial platform which could be displayed or queried through a WebGIS software tool. At the same time this will also serve as a historical data, over a period of time, which could be used for monitoring on a regular basis.

6. The technology has a potential to improve upon the existing method of field data collection, which uses rudimentary manual methods and there is no possibilities of cross verification or validation. However, the GPS based data uplink and usage on geospatial domain enables cross verification/ validation and at the same time serves as important input for various decision making at different levels in the Government.

2.0 Brief Methodology

The input (coordinates) data, for any given terrain, will be collected using the GPS facility available on popular Mobile Phone devices, which should essentially have data collection software installed on the device. In addition to the coordinates, there should be a provision to add the attribute data (as desired with respect to Agriculture and landuse mapping) as well as photo to a particular feature, which can later be downloaded to either local machine at taluk/ district level and/ or central server at State HQ. The database structure, as required by the user, need to be designed and enabled both on the mobile phone and database servers facilitating project specific data elements to be stored in the database.

The data, as available through RDBMS on the servers, needs to be synchronized with WebGIS based database through TCP/IP communication link, as these map-depiction tool uses its own database and other scripting languages like PHP. The imported data is organized according to the mapping requirements. A proper unique coding scheme is used to identify each activity through field coordinates and related information i.e survey No, record No, GPS date time, etc.

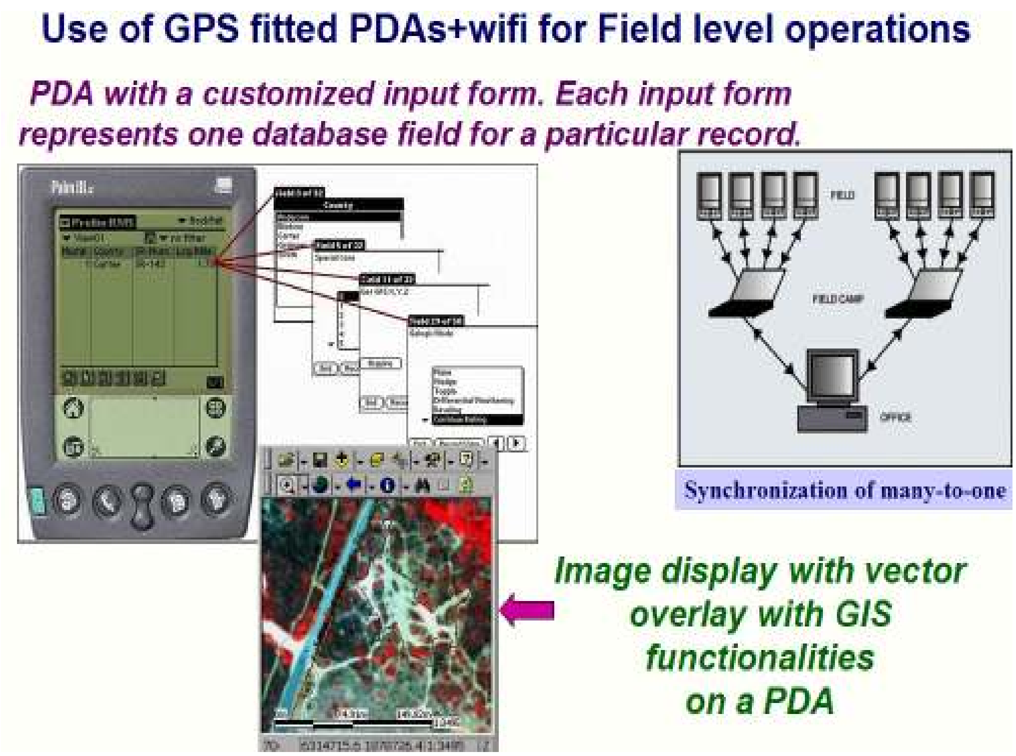

Figure – 5: Use of GPS based PDA/ Mobile for field data collection and organization

After the selection of a particular village, the user could choose a specific field as a subset of the village for survey. Option is provided for selection of the specific landmarks, like, Road crossing, temple etc and subsequently the actual location is mapped with respect to, Agricultural plots, Plantations, Drainage Line, etc. After selections of these details, the user could further add necessary attributes as needed with respect to each plot and use submit button to invoke a link to display the selected plots on a Map or satellite Image. This will display the map or image or both as desired by the user. This is accomplished by invoking public domain images for display while corresponding APIs are used to make the vector overlay of field status at a particular location in the village. Each location with its situational status in the village will be displayed in different colors and also the information like, unique ID, Survey No, Type of feature, GPS points taken, date and time are also provided as a map tool on the display.

3.0 Brief System Architecture

The design consists of three tier architecture. It included User Interface Layer (UIL), Business Object Layer (BOL) and Data Access Layer (DAL). The user can view the system through UIL. This layer is built using HTML, PHP, PostGreSQL and JavaScript. There are just a few client side processes such as "Input Control" which are implemented entirely in UIL. All other processes are passed on to the BOL for processing. BOL is built using PHP. It contains business modules and classes that take the appropriate decision and fetch the required data from public domain images/ maps through the corresponding APIs and from PATH database through DAL.

3.1 Screenshots as implemented for MNREGA project, Tumkur District, Karnataka

Figure – 6: Screenshot demonstrating a query operation on the mapserver.

Figure – 7: Screenshot demonstrating capture of a field boundary + a query

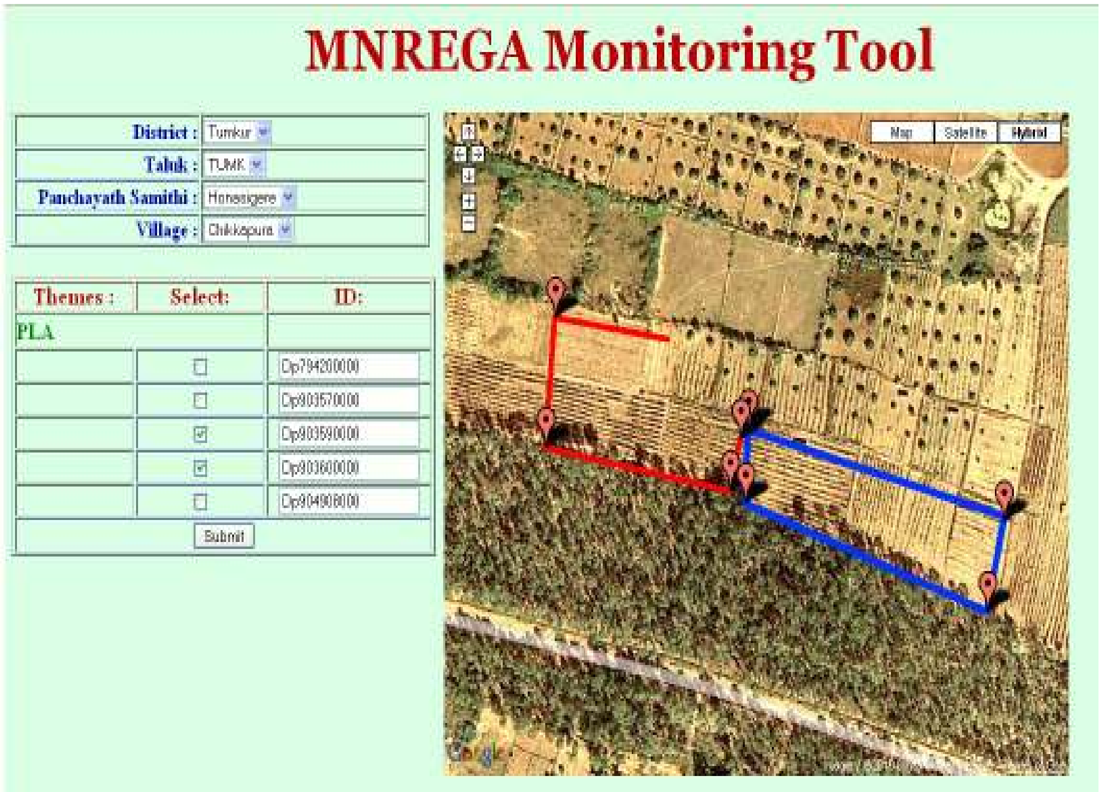

Figure – 8: Screenshot demonstrating capture of multiple polygons for validation.