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Maintenance and analysis of agricultural data: a challenge

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Abstract: Agriculture is the backbone of India and agriculture research is required for sustainable and modern agriculture. In India there are more than 1,00,000 agricultural scientists working for agricultural research and development ICAR, SAUs, KVKs, CSIR, IITs, NGOs, etc. large number of data are being produced by different scientist, researcher and student involved in various research work conducted on farm. The availability of huge data from the field of agriculture is needed to be translated in valuable and easily understandable format. Several data collecting agencies are working on state, central and international level. In spite of good no. of available software's, the information obtained through the analysis of data are, somehow, lacking in meeting their fate of serving the targeted communities-farmers, researcher and student. Loss of data means loss of national money. So there is need of proper Maintenance and analysis of agricultural data. Here vast information is collected related to the topic from different countries to evaluate what type of system are being used by them to solve the problem and also to prepare a strategy by adopting which maintenance and analysis of agricultural data in India will be possible. This will save not only the money but also the time for generating the same data and the valuable man power.

Key words: Agricultural Data; Analysis Tools; Storage; Management plan

Introduction

India has the total geographical area of 328.73 million hectors and Indian Agriculture is dependent on total sown area of 141.58 million hectors (46.3% of total area). With limited available land resources Indian Agriculture have to feed 1.267 billion (126.7 crore) Indian population. In India there are more than 1,00,000 agricultural scientists working for agricultural research and development. Most of the agricultural scientists are working in Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs), Krishi Vigyan Kendras (KVKs), Council of Scientific and Industrial Research (CSIR), IITs, Central and State Government departments, Private Companies, NGOs, etc. ICAR is the premier research organization for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. With 99 ICAR institutes and 65 agricultural universities spread across the country this is one of the largest national agricultural research systems in the world. Rural population and agricultural workers have been increased from 97.2 million in 1951 to 263 million in 2011 out of 1210.2 million population of India. Food grains productions have been increased from 50.82 million ton in 1951 to 255.36 million ton in 2012-13. Agriculture is the backbone of India and agriculture research is required for sustainable and modern agriculture.

The availability of huge data from the field of agriculture is needed to be translated in valuable and easily understandable format. For this particular purpose statistical analysis is done. Many software have been used since the use of computer in agriculture.

Agriculture is the backbone of Indian Economy. By agricultural development through productivity growth rural income can be raised and rural poverty is alleviated. The concept of productivity growth gained importance for sustaining the output growth over the long run as input growth is insufficient to generate output growth because of diminishing returns to input use [1]. In consequence of India's success in the spheres of globalization and economic reforms the agricultural sector seeks attention and meticulous planning to enjoy its benefits of increased productivity growth in the agricultural sector [2]. Training the farmers, educating them appropriately and reorienting them to take up new activities through adaptation of new technologies are of utmost importance. Precision agriculture is mainly aided by Information Technology (IT), which enables the maker to collect information and data for better decision making and better output. The concept of precision agriculture offers the promise of increasing productivity while decreasing production cost and minimizing environmental impacts.

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In spite of good no. of available software's, the information obtained through the analysis of data are, somehow, lacking in meeting their fate of serving the targeted communities-farmers and consumers to the desired level. There is need to try to identify the key features that are lacking in this context. Two main reasons may be there-either the data are analyzed in the right way to convey the information or the information is conveyed in the wrong manner.

First of all we need to understand what data is and how it differs from information. Data can be defined as "Data: A representation of facts, concepts or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means." (Hicks [1993: 668] quoted by Checkland and Holwell [1998]). Definitions of information depend on the way in which the term "data" is defined. "By themselves, data are meaningless; they must be changed into a usable form and placed in a context to have value. Data becomes information when they are transformed to communicate meaning or knowledge, ideas or conclusions." (Senn [1982: 62] quoted by Introna [1992]). Before we talk about all these let us have a look over the position of India in the world with respect to different agricultural products.

Field	Rank	Date
Apple Production, output of 2,203,000 tons	5	2013
Bananas Production, output of 29,800,000 metric tons	1	2013
Bean Production, output of 4,870,000 tons	1	2010
Black Pepper, 19% of world output	2	2008
Buffalo, milk output of 56,960,000 tons	1	2008
Cardamom Production, output of 15 thousand metric tons	2	2012
Cashew Apple Production, output of 613,000 metric tons	2	2010
Cauliflowers and Broccoli Production, output of 5,014,500 tons	2	2008
Chicken Population, output of 648,830,000	5	2004
Chickpea Production, output of 5,970,000 tons	1	2008
Coconut Production, output of 10,824,100	3	2010
Coffee Production, output of 300,300,000 kg	6	2011
Cotton Production, output of 27.0 million bales	2	2011
Cow Stock, 281,700,000 cows	1	2009
Fish Production, output of 6,318,887 tons (capture 3,481,136 & aquaculture 2,837,751)	3	2005
Garlic Production, output of 833,970 tons	2	2010
Ginger Production, output of 380,100 tons	1	2008
Goat Meat Production, output of 480,000 metric tons	2	2008
Goat Milk Production, output of 4,000,000 metric tons	1	2008
Goat Numbers, 125,700,000 goats	2	2008
Jute Production, output of 17,43,000 tons	1	2008
Lemon & Lime Production, output of 2,060,000 tons	1	2007
Lentil Production, 950,000 tons	2	2009
Mango Production, output of 16,340,000 tons	1	2011
Milk Production, output of 110,040,000 metric tons (cow milk 50.3 million metric tons)	1	2009
Millet Production, output of 8,810,000 tons	1	2009
Onion Production, output of 13,372,100 metric tons	2	2010
Orange Production, output of 5,000,000 tons	3	2010
Peanut Production, output of 6.25 metric tons	2	2009
Pineapple Production, output of 1,341,000 tons	7	2010
Potato Production, output of 36,600,000 metric tons	2	2010
Rice Production, output of 120,600,000 metric tons	2	2010
Saffron Production, output of 2,300 kg	3	2005
Sheep Stock, output of 65,000,000	3	2008
Silk Production, output of 77,000,000 kg	2	2005
Sorghum Production, output of 7,900,000 metric tons	3	2008
Soybean Production, output of 9.8 metric tons	5	2010
Sugarcane Production, output of 285,029,000 tons	2	2009
Sweet Potato Production, output of 1,100,000 tons	7	2009
Tea Production, output of 991,180 metric tons	2	2010
Tomato Production, output of 11,979,700 tons	3	2010
Wheat Production, output of 80.7 million metric tons	2	2010

Materials and Methods

Now we can realize the importance of agriculture and, at the same time, analysis of data of agriculture, the analysis of which starts with data collection. Data collection is at the heart of knowledge creation and its use in private decision making, public policy and applied research. Yet, knowing what data to collect and how to analyze it can be difficult. Statistical methods have helped guide the process of data collection and analysis. They have provided valuable tools that help us become more effective in improving our understanding of the economy. An integrated analysis of data availability, choices, survey cost, and statistical methods can improve the flexibility, precision and usefulness of data collection and analysis. This paper presents a brief overview of these issues. First, it reviews what statistical theory offers as guidance in the process of collecting and analyzing data. This covers the evaluation of survey design and summary measures related to both attributes and choices made by particular decision makers. It also covers the econometric analysis of decision rules made by individuals as part of the functioning of the economy, and the evaluation of welfare outcomes. India is predominantly agriculture based country with more than two thirds of its population living in rural areas where agriculture is the main occupation of people. Due to the large spatial variation of agriculture field environment (e.g. soil, climate, terrain, etc.), spatial data plays a very important role in identifying the issues critical for crop growth management. Agricultural operation5 is closely connected with the natural resources that have an obvious spatial character which is considered as an essential character of Geographic Information Systems (GIS). Thus spatial data has an important function to play in agriculture production, especially in field irrigation and soil texture application.

Agricultural data are useful to aid better decisions in business, national policy, and international planning and advising. All of these uses demand data that is relevant, accurate, current, and accessible. But, of course, each of these attributes is costly to provide and the creation and distribution of data requires substantial investments. That means we must allocate scarce resources carefully across all data attributes. Among the major choices are who, private or public sources and which agencies, provides which sort of data and how much of which kinds of data will be provided. Information may have public or private good aspects, but data used in analysis of public policy may be considered a public good, and investments in such data may be evaluated as are other investments in knowledge. Although the role of public organizations, including international agencies, in the development and dissemination of data is well established in general, it cannot be taken for granted. A general presumption in studies of agricultural research is that research output is itself an input into creation of something that people value directly. As with other fields of applied science, agricultural data useful for policy is only considered aesthetically pleasing by a few of us (mainly other policy practitioners). There are some who may become enthralled by the prospect of beholding a beautiful set of data, but our numbers are small. It is not promising to analyze the payoff to agricultural commodity data as a pure consumption good. Agricultural data shares this important attribute with other agricultural science contributions. Inventing new crops or better farm practices is also not primarily for aesthetics, even if new theories of evolution may be aesthetically pleasing. 6 Practical agricultural data must (ultimately) affect behavior outside the lab or research institute to have a significant payoff.

Statistical analysis

Statistical analysis is an important tool to extract as much information as possible from the given data. Statistical computing methods enable to answer quantitative biological questions from research data and help plan new experiments in a way that the amount of information generated from each experiment is maximized. Widespread use of computers and specialized high end statistical software packages have helped and greatly improved the ability of researchers to analyze and interpret voluminous data. Developments in computerized statistical analysis have enhanced the ability of researchers to come up with better conclusions. This has helped in improving their statistical, computer-related and networking skills of the researchers. For exploiting and sustaining these developed skills, availability of proper computing and infrastructure facilities to agricultural research in National Agricultural Research System (NARS) is of utmost consequence for improving their skills. The statistical computing support would be useful in improving the quality of agricultural research and make it globally competitive and acceptable by way of publications in International refereed Journals. The present project, therefore, targets at providing technical support on the component of statistical computing by applications of general purpose statistical software package that help in undertaking appropriate, sophisticated and computationally involved statistical analysis of data keeping in mind also the accuracy and precision of analysis. It is expected to create a healthy statistical computing environment for the benefit of the scientists in NARS by way of providing advanced, versatile, and innovative and state-of the art high end statistical packages and enable them to draw meaningful and valid inferences from their research. Collection and analysis of agricultural data is done by various means. Some of them are explained as below:

Statistical functions in MS

Excel software with its purpose Some of the functions mostly used by the agricultural scientists are given below:

(i) Average: Calculates the arithmetical mean or average of the values in a specified range
(ii) Mean: Calculates the mean of the given data
(iii) Steve: Calculates the standard deviation of the given data
(iv) Max: Gives the maximum value within the range specified
(v) Count: Counts how many numbers are there in the list of arguments
(vi) Var: Finds the variance of the given data
(vii) Correl: Find the correlation between two data sets
(viii) T test: Finds the student's t-test of the given data
(ix) Binomdist: Binomial distribution probability
(x) Chidist: One tailed probability of chi-squared distribution
(xi) Ftest: F-test

(xii) Prob: Probability
(xiii) Ztest: One tailed P value of a z – test, etc.

Data Analysis Tools

- ANOVA: Single factor
- ANOVA: Two-Factor with replication
- ANOVA: Two-Factor without replication
- Correlation
- Covariance
- Descriptive statistics
- F-test two-sample for variances
- Histogram
- Regression
- t-test: two sample assuming equal variances
- t-test: two sample assuming unequal variances
- Z-test: two sample for means

Statistical software's for agricultural data analysis:

SPAR 2.0/3.0: Statistical Package for Agricultural Research data analysis (SPAR 3.0) is useful for the analysis of experimental research data in Plant Breeding and Genetics. The package consists of eight modules (i) Data Management (ii) Descriptive Statistics (iii) Estimation of Breeding values (iv) Correlation and Regression Analysis (v) Variance and Covariance Components Estimation (vi) Stability Analysis (vii) Multivariate Analysis (viii) Mating Design Analysis

SPAD: Statistical Package for Augmented Designs (SPAD) is useful for designing agricultural experiments conducted for comparing existing practices / check varieties, called controls, with new practices / varieties / germplasm collections, called tests, where the experimental material for the tests is limited and it is not possible to replicate them in the design. The package generates a randomized layout of an augmented randomized complete block (RCB) design and augmented complete block design with equal or unequal block sizes.

SPFE 1.0: Statistical Package for Factorial Experiments generates the designs for symmetrical and asymmetrical factorial experiments with and without confounding. It also generates the randomized layout of the designs for factorial experiments. The design is generated on listing the independent interactions to be confounded. It also generates fractional factorial plans for symmetrical factorial experiments. The data generated through these designs are analyzed as per usual procedure of designs for single factor experiments.

SPBD Release 1.0: Statistical Package for Balanced Incomplete Block Designs enables a user to select and generate a randomized layout of Balanced Incomplete Block (BIB) Design. The package generates BIB designs with replication numbers up to a maximum of 20 for asymmetric BIB designs and 30 for symmetric BIB designs. The package also provides the analysis of variance with both treatments adjusted and blocks adjusted sum of squares, adjusted treatment means, variance of the estimated treatment contrasts and the contrast sum of squares, etc.

SPAB2.0: Statistical Package for Animal Breeding (SPAB2.0) has been developed keeping in view, the computing requirements of scientists/students, mainly working in Animal Breeding and Animal Genetics research. The package is Window based, Menu driven and works in a User friendly manner. In the present version of the package, 37 useful programs of maximum utility are included.

SSDA1.0: Software for Survey Data Analysis (SSDA 1.0) is useful for the analysis of survey data. SSDA analyzes the data collected using systematic, simple random sampling (SRS), probability proportional to size (PPS), stratified, cluster, two stage and stratified two stage sampling schemes. It provides the estimates of population mean, variance and design efficiency of the sampling scheme in comparison to the simple random sampling without replacement.

WASP - WEB AGRI STAT PACKAGE 2.0
ICAR-Central Coastal Agricultural Research Institute is one of the research institutes established under Indian Council of Agricultural Research (ICAR), New Delhi. This institute has designed and developed the web based statistical software for online data analysis. WASP is the first Web Based Agricultural Statistics Software Package. This package is for the researchers who are not comfortable with standalone statistical packages. Easy to use features of this pack provide comfort and confidence to the researchers in analyzing their own data. This little effort is dedicated to the great statisticians who made agricultural research more meaningful. It has the facility for finding the results for Basic Statistics viz. Descriptive statistics, T-Test, Chi Square Test, Correlation, Regression, Experimental Designs, One Sample T test, Two Sample T test, Paired T test, Completely Randomized Design, Randomized Block Design, Latin Square Design, Factorial Experiments, Split Plot Design, Strip Plot Design, Two Factor Factorial Experiment,

Online analysis of data at IASRI
The following data analysis facilities are available online for agricultural scientists of NARS in India. The website www.iasri.res.in can be used for online statistical analysis :-
Web Based Generation and Analysis of Partial Diallel Crosses:
http://nabg.iasri.res.in/webpdc/login.aspx.
Augmented Block Design Analysis:
http://www.iasri.res.in/spadweb/default.aspx.
General Block Designs Analysis:
http://www.iasri.res.in/WebAnalysis/index.aspx.

Survey Data Analysis:
http://nabg.iasri.res.in/ssda2web/. IP
Authenticated Portal for Indian NARS Users
Indian NARS Statistical Computing Portal:
http://stat.iasri.res.in/sscnarsportal.
SPAR 3.0: http://iasri.res.in/spar/.
Analysis of Row Column Design:
http://iasri.res.in/css/Home.aspx.
Web Generation of Experimental Designs Balanced for Indirect Effects of Treatments:
http://iasri.res.in/webdbie.
Web Solution of Estimation of Compound Growth Rate: http://iasri.res.in/cgr.
Statistical Package for Factorial Experiments (SPFE Web Ver 2.0):
http://iasri.res.in/spfe/home.aspx.
Online Decision Tree Classification using C4.5 (ODTC4.5): http://proj.iasri.res.in/odtc.
Web Based Fuzzy Clustering Software (wFCM):
http://proj.iasri.res.in/wfcm.
Web generation of polycross designs (webPD):
http://design.iasri.res.in/webpd

Some data storing and maintaining organization of India:

1. Statistical information: all India
2. Fertilizer statistics: annual
3. State level statistics

Agricultural data maintain and analyzing organization in foreign country:

Recent articles by Neil Beagrie, Robert Beagrie, and Ian Rowlands; Jake Carlson; and Florian Diekmann identify many of the studies that have investigated the evolving needs of researchers in the United States and internationally. Data management is critical to researchers throughout the life cycle of data. The advantages of data sharing are many. Scholars may benefit from accessing and using data produced by others, from preserving and sharing their own data, and from the benefits to research and the public good which can derive from the sharing and reuse of data. Christine Borgman points out that data sharing makes it possible to reproduce, verify, advance, and publicly disseminate research. Michael Whitlock suggests that scholars can conduct more thorough analyses, use data in teaching and learning, and reduce the risk of data loss by both publicly and locally archiving data Michael Witt notes that sharing supports the interdisciplinary use and repurposing of data. Data sharing may even, Gail Steinhart argues, enable researchers to address "errors in data in response to feedback from users. Borgman contends, If the rewards of the data deluge are to be reaped, then researchers who produce those data must share them." Researchers, however, perceive and must negotiate a variety of barriers (technological, social, organizational, financial, and other) related to sharing their data. The library and information science (LIS) profession has foreseen and responded to the emergence of new opportunities in data curation. The Association of College and Research Libraries (ACRL) Research Planning and Review Committee identified data curation as a top trend for academic libraries in 2012. The committee cited as recent drivers of the data-curation trend the increasingly common practice of scholarly journals publishing articles with accompanying data sets, as well as the NSF Data Sharing Policy requirement that data management plans accompany grant proposals as appropriate.

The Essential Electronic Agricultural Library (TEEAL) and Access to Global Online Research in Agriculture (AGORA) are programs that will provide low-income countries with access to agricultural journal literature that advances their agricultural research and education objectives. Developed by Cornell University's Mann Library and launched in 1999, TEEAL is a self-contained agricultural research library with full-text articles and graphics of 140 major journals related to agriculture from 1993 through 2003, stored and indexed on over 400 CD-ROMs. In mid-2005, most of the collection also became available for use over local area networks. Launched in October 2003, AGORA is an Internet-based journal delivery system led by the UN Food and Agriculture Organization (FAO), with Mann Library as a principal partner.

Participant Research Projects

Participants were asked to characterize research in their disciplines and to describe one research project in which they had participated. They described qualitative, quantitative, and mixed-methods research. In alignment with the demographics of those who took part (see Table 1), most participants described research in the sciences or social sciences; fewer study members described research in the arts or humanities and agricultural science.

Life Cycle Functions and Data Management

Plan: determine what data need to be created or collected; identify standards for data and metadata

Create: produce/acquire data for purposes; store and backup locally

Keep: organize and store data
Produce derived productions in support of research (e.g. data summaries, reports, publications)

Transfer: deposit data and derivatives, including data sets, metadata and scholarly communications and publications, where they will be kept, maintained, managed, and can be shared with others

Share data:

• With others at CSU
• With others outside of CSU
• By depositing data into an institutional repository or subject-data repository
(Such as ICPSR, Dryad, Gene Bank, or other)

Multiple researchers noted that before sharing their data they are careful to consider their compliance with institutional review board requirements for protecting the identity of their human subjects. Additionally, participants emphasized that it is important to them to report their research findings in a published journal article prior to sharing their data. Study members also noted that they expect recipients of their shared data to inform the original researcher before further sharing the data and to attribute the data source in any published work resulting from use of the data.

Data-Management Plans

Data-management plans (DMPs) help researchers plan, articulate, and execute data management, as well as comply with funder or agency requirements. We asked members of the focus groups if they had ever created a DMP. Some had never or only recently become aware of the concept of DMPs. Responses also revealed varied perspectives on what a DMP entails and whether it is only a formal plan or may also name procedural workflows that for many researchers are embedded in their research process.

Data Analysis

Prior to analysis, research team members compared the professional transcripts to the recordings to confirm the accuracy of the transcripts and to note any corrections. The principal investigator and co-investigator conducted a thematic analysis of the focus group transcripts using NVivo software; the thematic coding, template analysis technique defined by Nigel King; and the validation strategy of peer review and debriefing, to ensure the trustworthiness of the analysis.

Data File Formats

The majority of participants mentioned using a core group of file formats in their research. These formats included Word, Excel, and PowerPoint; comma-separated values (CSV) files, in which the values in a table are saved as lines of plain text with the value in each column separated from the next column's value by a comma; portable document format (PDF) files, which enable electronic documents to be distributed with the same layout, formatting, and images as in the original; and relational database applications including Access, Oracle, and others that use Structured Query Language (SQL), a computer programming language used to query, insert, and modify data. Many focus group members also mentioned using Joint Photographic Experts Group (JPEG) and Tagged Image File Format (TIFF), formats used to store digital images; Moving Picture Experts Group (MP3) or other sound files; and for statistics, the Statistical Analysis System (SAS) or Statistical Package for the Social Sciences (SPSS) files.

Data File Sizes

We asked participants to speak to the size of the individual files that their research generates and to the sum size of all files that their research produces over the course of a single project. For the purpose of this discussion we presented the following definitions: small (data sets up to 200 gigabytes [GB]); medium (data sets 200 GB to 10 terabytes [TB]); and large (data sets more than 10 TB).

Data File Standards

A few participants from science disciplines mentioned specific standards that they utilize in their data projects, such as GRIdded Binary or General Regularly-Distributed Information in Binary form (GRIB), used to store forecast weather data, and Binary Universal Form for the Representation of meteorological data (BUFR). Several of those who took part in the study mentioned the importance of using or adhering to standards to share data successfully.

Digitization

One participant pondered whether the libraries could assist with data development and projects that with the digitization of materials, for example might bring together geospatial and historical data: "For instance, there's a map of historic trails in the State and it's on paper. We would be able to use it for all kinds of analyses if we had a digital version of that. But we've never had a project where we could justify doing it." Another participant commented that researchers have limited space for storing the handwritten notebooks containing the work of their students. The individual noted that the value of work contained in these notebooks may become evident only after several years and so digitization of the notebooks could assist both space issues and preservation.

Conclusion

In the above literature the importance of data in agriculture and its analysis is discussed thoroughly. One major aspect of data is its storage mechanism, i.e. how to maintain this valuable data in computerized form. In the survey so many agricultural organizations visited and enquired, the fact found that most of the organizations keeping their data in MS Excel, MS Word, MS Access or MS SQL i.e. a RDBMS. Study and analysis of available data shows that most of the agricultural data are of semi structured type and need to be designed through suitable database mechanism like XML enabled or native XML approach. Several softwares are also available to store and analysis of the data. Different countries have developed a well-organized data maintaining structure on even college level. India should develop such activities to avoid the loss or mishandling of data.

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