Inevitability of Interdisciplinary Statistical Laboratories for Food and Agricultural Research in Developing Countries: The case of Pakistan

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ABSTRACT

The economy of Pakistan is predominantly dependent on Agriculture, which is the largest sector of the economy and contributes about 21% to the Gross Domestic Product. Most of the population depends on agriculture either directly or indirectly as it accounts for half of the employed labor force and is the largest source of foreign exchange earnings for the country. The Agricultural sector is also one of the key determinants of social welfare. As such, agricultural productivity growth is essential for poverty reduction and the provision of food for the existing population. Due to its importance, agriculture poses various policy implications for policy makers and researchers. However, there exist several deficiencies in agricultural research. A survey study is conducted about the actual statistical facilities in agricultural research in Pakistan and found that there is no proficient system for the proper designing of experiments, data collection, statistical analysis, or interpretation and communication of results. Furthermore, the sector lacks an adequate mechanism for statistical advice to improve research projects or proposals, which are the basic ingredients in promoting food and agricultural research. Even those agricultural centers that have statistical facilities are either not functioning properly or lack sophistication with the use of statistical programs and packages. Agricultural universities/faculties/colleges are facing a broad deficit of adequate and highly qualified statistical personnel, except for a few statisticians on executive boards with many responsibilities. Agricultural and food research institutes and centers in Pakistan are not provided with expert statisticians. Both policy makers and researchers need timely and accurate official statistics, ranging from the data of annual rainfall to an average annual temperature, and statistical models and analyses that apply these data for planning purposes to make better decisions and policy. Thus, there exists a need to integrate the work of agricultural scientists

with statisticians. Hence, in this paper we propose to create a statistical collaboration laboratory to play this vital role in integrating statistical knowledge with agricultural research. The tentative name of this statistical laboratory will be the "**P**akistan **La**boratory for **S**tatistical **C**ollaboration (PLASCO)." The main objectives of PLASCO will be to provide an integrated platform for statisticians and researchers to collaborate to advance agriculture; to train the next generation of statisticians to become useful agricultural statisticians; to build the statistical capacity of agricultural researchers through collaborations with statisticians, seminars, workshops, conferences, and refresher courses; and to create a healthy statistical computing environment with access to statistical software. This laboratory will create bridges between statisticians and researchers (non-statisticians) from various departments and will play an important role in improving the quality of agricultural research. The support and mentorship provided to agriculture researchers at the laboratory will improve their ability to design experiments, collect and analyze data, and interpret and communicate the results. Establishing such a laboratory will require financial resources and commitments from agricultural researchers and administrators at the agriculture and food institutes in Pakistan. National and international funding agencies will be contacted and briefed about the importance of the project and how it will be conducted. Mutual funding from more than one agency may be possible if all the agencies adhere to a mutually agreeable standard. Moreover, because of the great need for improved statistics in agricultural research, many laboratories will be established on the same standard throughout Pakistan. This is not only a single project but can serve as a laboratory test case and a role model for other developing countries.

Keywords: Statistical Capacity Building, Agricultural Research, Research Integration, Statistical Collaboration Laboratory

1. Introduction

Pakistan traditionally is a country with an agricultural economy. The majority of its population (about 70%) heavily depends on agriculture or related activities with strong backward and forward linkages. Moreover, the food security for the masses and raw material production for domestic agro-based industries are also relying on this sector. As the largest sector of the economy, it contributes 20.9% for the Gross Domestic Product (GDP) and 43.5% of the employment (Economic, 2015). This sector has four sub-sectors namely: crops, livestock, fisheries, and forestry. It is also mentioned in the draft report of "Agriculture and Food Security Policy" that Pakistan's Government is really interested in value added growth of the agriculture sector in terms of domestic and export markets. According to the Ministry of Planning and Development, the agriculture sector needs to grow at 5 percent to reduce poverty and ideally should reach the growth targets of 7-8 percent to improve the national economy of Pakistan (MNFSR, 2016). A positive relationship between agricultural growth and GDP exists such that a one percent increase in the agriculture growth rate can bring a 0.34% increase in the GDP growth rate (Hussain & Khan, 2011).

This agrarian economy is moving towards industrialization with an advancement in technology and adoption of modern trends in agriculture. Therefore, there must be precise consultations, collaborations, and policy recommendations to lay down the foundation for agriculture-led growth in the country. On the other hand, several deficiencies exist in the agricultural research system of the country. There is no proficient system for the proper designing of experiments, data collection, statistical analysis, and communication of results. In addition, this sector lacks an adequate mechanism for seeking statistical advice to improve research projects or proposals, which are the basic ingredients in promoting food and agricultural research. The agricultural and food research institutes and centres are working in Pakistan, but there is a lack of expert statisticians in these institutes and centres. Both policy makers and researchers need timely,

relevant, and accurate official statistics, ranging from the data of annual rainfall to an average annual temperature, and statistical models and analyses that apply these data for planning purposes and making better decisions. Thus, there exists a need to integrate the work of agricultural scientists with statisticians.

The current paper is a review of an attempt to bridge the relationship between statisticians and non-statisticians (researchers), especially agricultural researchers, with the proposal of creating a unique kind of statistical collaboration laboratory to play a vital role in the integration of statistical knowledge and capacity building with agricultural investigations. The trained statisticians of this laboratory will collaborate with agricultural researchers to provide innovations and ultimately solutions to raise the incomes of impoverished farmers. This idea of developing statistical collaboration laboratories in the agricultural research system was also proposed by Msemo and Vance (2015a). They describe that this type of laboratory can be considered to be a collection of statisticians that emphasizes building relationships with researchers that are collaborations rather than just consultations. The trained statisticians of such laboratories focus on helping their clients to answer their research or business questions (colloborations) rather than helping them just answer their statistics questions (consultations). Another beneficial feature of such laboratories is their ability to build statistics capacity by training young statisticians and to create new statisticial knowledge via research on applied problems (Vance 2015).

This is not an empirical study, rather it is a brief analysis of one of the problems plaguing agricultural research in Pakistan and a proposal of a potential solution to increase agricultural productivity in Pakistan. We are not attempting to reform the current agricultural research institutes. Instead we are proposing to introduce an innovative model to improve the essential statistical aspects of agricultural research. This model, if successful, will spread organically throughout the agricultural research enterprise to improve collaborations between statisticians and agricultural researchers and will, ultimately, lead to increased agricultural productivity and improvements in the livelihoods of Pakistani farmers.

Sections 2 and 3 in this paper describe the problems and current state of the agriculture sector in Pakistan. Section 4 describes the proposed model of a statistical collaboration laboratory to become part of the worldwide LISA 2020 network. Section 5 concludes with some of the challenges facing the agriculture section of Pakistan and our attempts to overcome them to achieve our goal of improving agricultural productivity through the creation of unique kind of statistical laboratory.

2. Problems of Agriculture Sector in Pakistan

The agricultural sector of Pakistan is the backbone of the country's economy. But the growth of this sector is facing many problems. This is the reason of very low per acre yield as compared to other developed agricultural countries, and it is true that the magnitude of the agricultural problems undoubtedly crippled the economy. In 1947, the share of this sector to GDP was 53% which has shrunken down to around 21% last year. These problems of the agricultural sector can be categorized into four main and 28 subsections as below in Table 1 (Mughal, 2016).

Table 1: Problems in the agricultural sector

Techno-Economic Problems	**Natural Problems**	**Socio-Economic Problems**	**Financial Problems**
Limited cultivable area	*Various plant diseases*	Consumption oriented	Lack of credit

Water logging and salinity	Natural calamities	Farmer's litigation	Poor financial positions of farmers
Slow growth of allied products	Scarcity of HYV seed	Joint family system	*Instability in market price*
Low per hectare yield	Under utilization of land	*Illiteracy and Ill-health*	Shortage of agricultural finance
Inadequate infrastructure		Political instability	
Uneconomic land holdings			
Old methods of production			
Inadequate supply of agriculture inputs			
Lack of irrigation facilities			
Inadequate agricultural research			
Lack of R&D and neglect in education & training of farmers			
Problem of land reforms			
Defective land tenure system			
Subsistence farming			
Low cropping intensity			
Improper crop rotation			

According to the Minister of Finance, Ishaq Dar, the Ministry of National Food Security and Research (MNFSR) has been running without a national agriculture policy since its creation in 2011. Both the World Bank and the Asian Development Bank pointed out that agricultural growth will miss its annual target of 2.7 percent due to a drop in cotton output, which partly offset the improvement in sugarcane and rice crops. Minister Dar also stressed that in order to meet the challenges of food insecurity and malnutrition, it was imperative to employ the latest technological advancements and innovative techniques to improve the productivity of this sector (Dar, 2014). The draft report of "Agriculture and Food Security Policy" has been submitted by this ministry to the Government of Pakistan (MNFSR, 2016). The above problems of the agriculture sector and their possible solutions are mentioned in this draft. The statistical laboratory we propose in Section 4 can play a very important role in most of the recommended solutions especially in those in italics in Table 1 above.

3. Current State of Agriculture Research and Statistics in Pakistan

Some important structural changes have taken place in the agriculture section in the recent years especially in the important subsector of livestock. This sector is contributing a great amount to agricultural GDP. Fisheries and forestry were also minor contributors to agricultural GDP in the past but are now growing rapidly. Cotton is also becoming as important as wheat in terms of value added, with a one-fifth share of total earnings. However, the rice and sugar crops have fallen from a 20 percent share in the early 1970s to 15 percent today.

The Food and Agriculture Organization (FAO) reported in the report of the Nineteenth Session of the Asia and Pacific Commission on Agricultural Statistics that Pakistan had a history of conducting the agricultural census every ten years since 1960 (FAO, 2003). Five agricultural censuses in Pakistan have been successfully conducted in 1960, 1972, 1980, 1990, and 2000. The

latest, which is the sixth one in the series, was conducted in 2010 by the Pakistan Bureau of Statistics (PBS) of the Government of Pakistan with the objectives to generate basic information on the structure of agriculture; to develop detailed basic information about the agricultural resources, state of their utilization, and to find out the degree of acceptability of modern farming practices among the farming community for the purpose of regional, provincial and national development, planning, and research in the field of agriculture; to collect information about livestock population; and to fulfill data needs of the international agencies like FAO which require the country's information for a worldwide study of agricultural resources in order to formulate international policies in matters relating to the supply of food and raw materials on sustainable basis (PBS, 2010).

The first author conducted a telephonic survey study to know about the actual statistical facilities in agricultural research in Pakistan and found that there is no proficient system for the proper designing of experiments, data collection, statistical analysis, or interpretation and communication of results. Currently, Pakistan has a total of 92 agricultural research institutes, including 15 agriculture, animal, and textile universities; 4 agricultural facilities; 6 agricultural colleges and institutes; 64 agriculture research centers; and 3 other agriculture-related educational departments.

The research conducted, techniques taught, and skills imparted in these institutions rarely extend down to the level of small farmers. For example, farmers need to know how to make optimal use of land, how to use fertilizers and pesticides, and what amount of water is exactly useful and necessary for any crop. Lack of management on the part of farmer is another huge problem.

There are no statistical collaboration laboratories in the country similar the one proposed in Section 4. Even those agricultural centres that have statistical facilities are either not functioning properly or lack sophistication with the use of statistical programs and packages. Furthermore, agricultural universities/faculties/colleges are facing a broad deficit of adequate and highly qualified statistical personnel, except for a few statisticians on executive boards with many responsibilities. Agricultural and food research institutes and centres in Pakistan are not provided with expert statisticians. It is indicated that in the research institutions of Pakistan, a diverse nature of data are generated from various discipline, so the actual insights of these processes can only be well understood by applying the most relevant statistical techniques with advanced statistical programs. The correct interpretation of results obtained needs sufficient knowledge of statistical methods (Hussain, Murshid, & Safeeullah, 2014). It is also observed that a variety of statistical techniques have been used in published articles, but the frequency of advanced statistical methods applied was quite low as compared to journals in more advanced countries (Akhttar, Shah, Rafiq, & Khan, 2016). These gaps can be filled through this proposed laboratory by enhancing the basic skills of junior statisticians by imparting trainings, short courses, and workshops.

Improvement in agricultural research and education is a continuing requirement for development, not only for developing better seeds, improving cultivation methods, and better using other inputs, but also for finding out the best combinations of inputs for conditions in Pakistan. Unfortunately, this area has not received great attention and suffers from financial deficits and lack of skilled personnel. Moreover, there is lack of extension services which is very important in providing farmers with systematic access to new innovations in farming practices, multiple cropping, and use of physical inputs. This can be done through arranging dissemination seminars and other related activities through the proposed statistical laboratory. In order to raise the potential of agricultural production, continuous improvement in the research for agricultural growth is necessary. The specific areas of research include the development of high yielding, short duration, disease and drought resistant varieties of major food and cash crops in Pakistan tailored to the situation prevailing in different areas of the country.

4. Proposed Model of a Statistical Collaboration Laboratory

The LISA 2020 Program was created to build statistics capacity and research infrastructure in developing countries to help scientists, government officials, businesses, and NGOs use data to solve real-world problems and make decisions. In this program, statisticians from developing countries are trained to effectively communicate and collaborate with non-statisticians and helped to create statistical collaboration laboratories modeled after the University of Colorado Boulder's Laboratory for Interdisciplinary Statistical Analysis (LISA) at their home universities or institutions. These new statistical collaboration laboratories foster education in collaborative statistics and promote the proper application of statistics and data science to solve real-world problems (Vance, 2015b). This is important because, when implemented in Pakistan, the statistical laboratory will enable Pakistani agricultural researchers to collaborate with local statisticians to solve local problems and generate real-world impact for the agricultural sector.

The LISA 2020 network is based at the University of Colorado Boulder in USA and is comprised of four statistical collaboration laboratories in Africa and one in Brazil (Msemo & Vance, 2015) (Awe, Crandell, & Vance, 2015) (Goshu, 2016). The program's goal is to create a well-connected network of 20 statistical laboratories in developing countries by the year 2020, including a statistical laboratory in Pakistan to help agricultural researchers better apply statistics. The proposed model is detailed below.

4.1 Pakistan Laboratory for Statistical Collaboration (PLASCO)

Though many details remain to be worked out, we propose to create the **P**akistan **La**boratory for **S**tatistical **Co**llaboration (PLASCO) at Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Pakistan a subsidiary institute of Pakistan Atomic Energy Commission. The overall vision of PLASCO will be to promote effective collaborations between statisticians and agricultural researchers that lead to improvements in agricultural productivity in Pakistan. The mission of PLASCO will be to train statisticians and data scientists to become effective interdisciplinary collaborators, provide research infrastructure for the agricultural sector to enable and accelerate high impact agricultural research, and engage with the agriculture community to improve statistical skills and literacy widely.

Currently, agricultural researchers in Pakistan may receive statistical support from isolated statistics professionals working in various places. PLASCO will be one point of consolidation of statistical resources to act as a bridge between statisticians and other researchers across the country. We envision PLASCO helping to achieve the following objectives:

i) Serve as a center for researchers and statisticians to collaborate to solve agricultural research problems and answer agricultural research questions.
ii) Enhance the existing statistical support services which are difficult to find due to their distribution in different regions.
iii) Develop new statistical methods to address emerging problems in science and technology.
iv) Raise the level of statistical skills and literacy through seminars, workshops, and short courses.
v) Become a source of statistical software for agricultural researchers to access.

4.2 Outline of Proposed Implementation Plan

A statistical collaboration laboratory is, in essence, a collection of technically trained statisticians who are also well trained in the essential non-technical skills of communication and collaboration to effectively work with researchers to answer research questions. It will be directed by a Ph.D.-level statistician and supported by other Ph.D. and M.S.-level statisticians as funding availability and demand from researchers dictate. A major source of statistical expertise and workforce in PLASCO will be statistics M.S. and Ph.D. students who are trained to collaborate with agricultural researchers in the designing of experiments, data collection, statistical analysis, and communication of results.

PLASCO will also be a center for applying statistics in agricultural research, and as such will require physical space for collaboration meetings between statisticians and researchers; workshops, short courses, and training seminars in various topics in statistics, and a computer lab equipped with sufficient computers and modern software for statistical analysis of agricultural data.

We envision that several agencies will be recruited to sponsor and fund PLASCO, including the Pakistan Science Foundation (PSF), Pakistan Agricultural Research Council (PARC), Pakistan Atomic Energy Commission (PAEC), Higher Education Commission (HEC), Pakistan Academy of Sciences (PAS), International Food and Agriculture Organizations. NIFA will be primarily responsible for executing the implementation plan and for operation and maintenance of PLASCO.

Leadership from the LISA 2020 Program will provide advice and logistical assistance to PLASCO. For example, members of the LISA 2020 network will provide software recommendations and trainings to build the capacity of the young statisticians in PLASCO. Decision making regarding implementation of this project will be carried out by the local official of NIFA in consultation with the LISA 2020 leadership.

After developing a final implementation plan, the equipment, materials, and commodities necessary for PLASCO will be arranged by NIFA via the support of proposed funding agencies. Likewise, NIFA will host and sustain this laboratory.

Because much of the infrastructure and physical space required to create and run PLASCO will be provided by NIFA, the budgetary requirements of PLASCO are relatively minimal. Initially, PLASCO will engage a full-time Ph.D.-level statistician to direct and manage the statistical laboratory, costing approximately US$ 12,000/annum. It will require an administrative assistant and an accountant to coordinate the lab's activities, costing approximately US$ 12,000/annum. It will require several statistics students to work in PLASCO to gain practical training and experience. These students will be paid a nominal sum of approximately US$ 4,800/student/annum. PLASCO will also require the purchase of new equipment such as a multimedia projector and white screen for presentations and workshops; five computers, monitors, and associated software; statistical books and manuals; equipment for internet connectivity; and a backup electrical generator, costing approximately US$ 13,000, for a total estimate of US$13,000 in start-up costs and approximately US$ 48,000 in annually recurring costs.

5. Conclusion

Pakistan is an agriculture country but the agriculture sector is still facing many challenges. Therefore, the use of modern techniques, provision of credit facilities, basic infrastructure, and agricultural research facilities are needed to overcome them. We believe that some of these issues would be resolved through the creation of the proposed statistical collaboration laboratory (PLASCO). The statisticians within PLASCO will be trained to effectively collaborate with agricultural researchers of all types, including agronomists and agricultural economists, to respond to the practical needs of the agricultural sector in Pakistan. This laboratory will provide an integrated platform for statisticians and researchers to work together to advance agriculture; to build

the statistical capacity of agricultural researchers through collaborations with statisticians, seminars, workshops, conferences and refresher courses; and to create a healthy statistical computing environment with access to modern statistical software. This laboratory will create bridges between statisticians and researchers (non-statisticians) from various departments and will play an important role in improving the quality of agricultural research. Establishing such a laboratory will require financial resources and commitments from agricultural researchers and administrators at the agriculture and food institutes in Pakistan. National and international funding agencies will be contacted and briefed about the importance of the project and how it will be conducted. Moreover, because of the great need for improved statistics in agricultural research, many laboratories may be established in the future on the same standard throughout Pakistan. This is not only a single project but can serve as a laboratory test case and a role model for other developing countries.

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