R&D Management as a Driver for Sustainable Agricultural Innovation and Adoption: Evidence from India

K Singh¹ and A Srivastava²

¹Assistant Professor, Institute of Business Management, GLA University, Mathura, India
²Assistant Professor, City College of Management and Technology, Lucknow, India
E-mail: krishanveer.singh@gla.ac.in

Abstract. The present study aims to identify the drivers of innovation for sustainable farming among various models of farming and understand the influence of innovations in sustainable agriculture and their impact in enhancing the sustainable agricultural value chain. This research has been conducted in Uttar Pradesh (UP), which is the largest agricultural producing state of India. Data were collected using questionnaire from 600 farmers of thirty districts in UP and nonparametric test were used to analyse the data in the study. The results document that various R&D based modern and innovative technology/technical know-how has significant impact on agriculture produce of the farmers. It was also found that various organisations play an important role in know-how and knowledge creation among the farmers in India. The findings should be very useful for policymakers to implement R&D advancement in sustainable agriculture and systematic overhaul in agriculture sector. The findings of the study should be very useful for policymakers, practitioners and regulators to promote and implement sustainable agricultural innovation and adaptations in India.

Keywords: Sustainable agricultural value chain; R&D management; Sustainable agricultural innovation; Indian agriculture sector.

1. Introduction

Agriculture sector has traditionally played a crucial role in the economic growth of Indian economy. Its contribution in the overall GDP is now approximately 11.9% and agriculture exports amounts to 10 percent of total country’s exports [1]. The overall contribution of agriculture in GDP has fallen from about 24.94% in year 1991 to 11.6% in 2018-19. Despite a gradual decline of agriculture’s share in GDP, it is still a major economic sector that employs approximately 42% of the country’s population and is definitely playing a key role in the overall socio-economic development of India. Agriculture in India significantly depends on monsoons but the methods of farming and research and development (R&D) tools have an important role in delivering value in this sector [2]. R&D has a serious concern with the growth rate in the agricultural sector [3]. Despite such concern very few attempts have been made to examine the impact of R&D on the Indian agricultural sector with special reference to the state of Uttar Pradesh (UP). The orientation of R&D program of an underdeveloped country is also an important issue as it is supposedly different from the orientation of R&D programs of a developed nation [4]. This study is an attempt to understand how agriculture is benefitted by various R&D based modern techniques and technological know-how in the largest agriculture state of India and also to identify how such things are able to add value in the overall performance of agriculture. The essence of the study lies in how various R&D based techniques contribute to value chain of agriculture in India. The study has been conducted in the state of Uttar Pradesh.
2. Background

2.1. Sustainable agricultural value chain

A ‘Value Chain’ in agriculture refers to key actors and their course of actions for value addition by facilitating agricultural produce from field production to final consumption. An agriculture value chain is a vertical linkage between different organizations involved in the activities like processing, packaging, transportation, storage and distribution of agricultural product [5]. An agricultural value chain consists of processes from beginning to end. The technical know-how/technology adaptations are imperative as it can speed up these processes with more efficacy than before [6]. Thus, R&D becomes an important enabler for efficient completion of agricultural activities and improving agricultural productivity.

2.2 Differences in developed and developing countries’ sustainable agricultural R&D program

The 21st century has seen various evolutionary developments in almost all the sectors of the economy so in agriculture. Although agriculture contribution in the country’s GDP has fallen, the overall production is rising year by year. This remarkably is the consequence of investments in agricultural R&D projects basically by few rich countries and gradually the whole world has become dependent on agricultural research output provided by the same projects [7]. During the period the research agenda of developed nations has shifted from enhancing the productivity to enhancing certain attributes of food [8]. It is observed that food security concern still assumes the center stage in developing countries [9]. The research agenda of developing countries are different due to different issues requiring innovation at different levels. On the other hand, farmers of developed countries warrant advanced technological equipment’s that may not necessarily required in subsistence agriculture [10]. At present, the technologies are emanating with evolving agribusiness demand for agri-products with specific attributes for value addition processes at specific stages [11]. Developing countries are likely to differ from developed countries in various ways. Particularly, it is observed that the lesser amount of investment in agriculture related R&D and avoidance from the private sector are likely to be more distinct in developing countries in comparison to developed countries [12].

2.3 Strengths and Weaknesses of Indian Agriculture sector

2.3.1 Strengths

Geographically India has a range of natural resources like land, water, climate, rainfall, forests and rivers. The weather conditions in India are also healthy for agricultural activities. The National Agricultural Research System and other Governmental agencies are there for technological and financial support. In Indian economy agriculture has a significant role whether it is about GDP share or about providing employment to the labor force. Seventy years after the independence, the Indian agriculture sector has achieved more than four times increase in production of food grains whereas the population growth was increased by three times [13]. India holds the second largest area in the world under cultivation and highest area under irrigation (55.8 million hectare). The country also holds top (first/second) position in production of various crops like pulses, cereals, vegetables, livestock and milk. India also stands at 3rd position in the world in terms of farm mechanization [14]. It is the strength of Indian agriculture sector that it was hardly affected by the global recessions of the past that severely impacted many major developed economies of the world [15].

2.3.2 Weaknesses

Indian agriculture, despite of green revolution, has a number of weaknesses lying due to unawareness, poor education and financial resources and somewhat on unpredictable weather conditions. Due to these reasons Indian agriculture faces low yield, lower growth rate and wastage of agricultural produce [16]. Small and scattered land holdings, poor market infrastructure, electricity, roads, storage, credit support make situation more difficult for the farmers. Private sector in India has low interest in
agricultural R&D due to several reasons. Most notable reason is the excessive control of government and lack of agriculture market reforms in India. The government of India has not been able to develop and implement technological advancements in agriculture methods to the small and marginal farmers in India. This is reflected in huge farmer distress and dismal agriculture growth in India [17]. The negligible approach towards the farm based technological inventions and innovations are hindering the development of farmers and farming system in India [18], [19]. Majority of farmers in India still depends upon traditional methods of agriculture having no direct linkages with any financing institutions or organized industry. In this modern age, the technological innovations are needed to be penetrated to the very ground level so that innovations can be adopted by farming community. The technology is of no use unless and until it reaches for whom it is intended [20].

2.4 Overview of Uttar Pradesh, the largest agriculture producing state in India

Uttar Pradesh is fourth largest state by land area in India and most populous state with almost 200 million people. The larger Gangetic plain is in north of India that includes the Ganges-Yamuna Doab, the Ghaghra plain and the terai. Uttar Pradesh has a humid subtropical climate and normally experiences four seasons in a year. These highly fertile conditions of Uttar Pradesh make agriculture a very important portion in the economy of Uttar Pradesh. More specifically the Ganga-Yamuna plains not only provide highly productive land and food to the people but also raw materials to many farm-based industries [21]. During the year 2017-18, UP produced all time high 49.51MT food grains, which was an increase of almost 10% from last year [1]. This state has contributed 20% of the country’s total food grain production in year 2017-18. It has produced 13% of the country’s overall rice, 35% of the wheat, 13% of the pulses and 8% of the coarse cereals yield in year 2017-18. The stats show that production percentages have risen in past few years [22].

3. Research Methodology

The present study is exploratory in nature. The research is designed to describe the various implementations of R&D and its influence on the value chain of agriculture in India. For the purpose of data collection the largest agriculture state of India, Uttar Pradesh (U.P.) was divided into eastern, central and western regions. A stratified random sampling has been applied for the purpose of collecting data. Thirty districts (10 districts from each region) from 70 districts were selected from an alphabetical list of districts. The respondents of the study were farmers. These respondents were administered the questionnaires at the Galla Mandis of the districts. A total of 600 questionnaires were filled by 20 farmers from 30 districts each. Out of the 600 questionnaires, only 432 questionnaires could be used due to missing information. SPSS was used for data analysis.

3.1 Objectives of Study

The aims of the study are;

- To identify the drivers of innovation/technical know-how for sustainable farming among various models of farmers in state of Uttar Pradesh.
- To understand the influence of innovations in sustainable agriculture and their impact in enhancing the value of agricultural value chain.
- To understand the role of various organisations in propagating the knowledge of R&D based modern and innovative technology/technical know-how among the farmers.

3.2. Proposed Hypotheses of the Study

H0: There is no value addition by adopting new variety seeds/planting materials in case of food grains and cash crops.
H0: There is no value addition by adopting new farm equipments and machineries in case of food grains and cash crops.

H0: There is no value addition by adopting new techniques & know-how in case of food grains and cash crops.

H0: There is no value addition by adopting processing of agricultural produce in case of food grains and cash crops.

H0: There are no benefits of R&D based modern techniques and technical/technological know-how knowledge dissemination by various department/agencies.

4. Results and Discussion

In order to test the significant differences between the group means, first the normality was checked. To test the normality Kolmogorov-Smirnov test was used. The result shows that the data is not normally distributed.

| Agricultural Activity | Area of Research & Development | Adopted | Kolmogorov-Smirnov |
|------------------------|--------------------------------|---------|--------------------|
|                        |                                |         | Statistic | df  | Sig.     |
| Food Grains            | New variety seeds / planting materials | Yes     | .420      | 429 | .000     |
|                        | Fertilizers & pesticides       | Yes     | .417      | 432 | .000     |
|                        | Farm equipments& machinery     | No      | .485      | 15  | .000     |
|                        |                                | Yes     | .425      | 417 | .000     |
|                        | New techniques & know how      | No      | .454      | 33  | .000     |
|                        |                                | Yes     | .414      | 399 | .000     |
|                        | Processing of Agricultural Produce | No     | .336      | 24  | .000     |
|                        |                                | Yes     | .422      | 408 | .000     |
|                        | New variety seeds / planting materials | Yes     | .407      | 429 | .000     |
|                        | Fertilizers & pesticides       | Yes     | .401      | 432 | .000     |
|                        | Farm equipments& machinery     | No      | .366      | 15  | .000     |
|                        |                                | Yes     | .419      | 417 | .000     |
|                        | New techniques & know how      | No      | .342      | 33  | .000     |
|                        |                                | Yes     | .425      | 399 | .000     |
|                        | Processing of Agricultural Produce | No     | .246      | 24  | .001     |
|                        |                                | Yes     | .418      | 408 | .000     |
| Cash Crops             | None                           |          | .414      | 9   | .000     |
|                        | Govt. Agriculture/other departments/agencies |          | .277      | 399 | .000     |

As the test shows that data is not normally distributed, the analysis is done with the help of Man Whitney Test that is non-parametric alternative of ANOVA.
H0: There is no value addition by adopting new variety seeds/planting materials in case of food grains and cash crops.

HA: There is value addition by adopting new variety seeds/planting materials in case of food grains and cash crops.

In order to study the significance of the above hypothesis a comparison of use of New Variety Seeds/Planting Materials on food grains and cash crops respectively was performed.

**Table 2. Result of value addition by adopting new variety seeds/planting materials in case of food grains and cash crops**

| Ranks | Adopted (new variety seeds/planting materials) | N  | Mean Rank | Sum of Ranks |
|-------|-----------------------------------------------|----|-----------|--------------|
|       | Food grains                                   |    |           |              |
|       | No                                           | 3  | 365.00    | 1095.00      |
|       | Yes                                          | 429| 215.46    | 92433.00     |
|       | Total                                        | 432|           |              |
|       | Cash Crops                                   |    |           |              |
|       | No                                           | 3  | 411.50    | 1234.50      |
|       | Yes                                          | 429| 215.14    | 92293.50     |
|       | Total                                        | 432|           |              |

**Test Statistics**

|                       | Food Grains | Cash Crops |
|-----------------------|-------------|------------|
| Mann-Whitney U        | 198.000     | 58.500     |
| Wilcoxon W            | 92433.000   | 92293.500  |
| Z                     | -2.537      | -3.833     |
| Asymp. Sig. (2-tailed)| .011        | .000       |

The null hypothesis is rejected in both the cases of food grains and cash crops as the sig. value for these two groups found to be less than 0.05 i.e. 0.011 and 0.00 respectively. It suggests that there is some value addition by using new variety seeds/planting material.

H0: There is no value addition by adopting new farm equipment’s and machineries in case of food grains and cash crops.

HA: There is value addition by adopting new farm equipment’s and machineries in case of food grains and cash crops.

**Table 3. Shows result of value addition by adopting new farm equipment’s and machineries in case of food grains and cash crops**

| Ranks           | Adopted (Farm Equipment’s & Machinery) | N | Mean Rank | Sum of Ranks |
|-----------------|----------------------------------------|---|-----------|--------------|
|                 | Food grains                             |    |           |              |
|                 | No                                      | 15 | 322.40    | 4836.00      |
|                 | Yes                                     | 417| 212.69    | 88692.00     |
|                 | Total                                   | 432|           |              |
|                 | Cash Crops                              |    |           |              |
|                 | No                                      | 15 | 295.70    | 4435.50      |
The null hypothesis is rejected in both the cases of food grains and cash crops as the sig. value for these two groups found to be less than 0.05 (i.e. 0.00). It clearly suggest that by adopting farm equipment’s and machineries farmers can add more value in processing of food grains and cash crops both.

H0: There is no value addition by adopting new techniques & know-how in case of food grains and cash crops.

HA: There is value addition by adopting new techniques & know-how in case of food grains and cash crops.

Table 4. Shows result of value addition by adopting new techniques & know-how in case of food grains and cash crops

| Ranks |
|-------|
| Adopted-New Techniques & Know How | N | Mean Rank | Sum of Ranks |
| Food grains | No | 33 | 210.09 | 6933.00 |
| | Yes | 399 | 217.03 | 86595.00 |
| | Total | 432 | | |
| Cash Crops | No | 33 | 165.50 | 5461.50 |
| | Yes | 399 | 220.72 | 88066.50 |
| | Total | 432 | | |

Test Statistics

| Test Statistics | Food grains | Cash Crops |
|-----------------|-------------|------------|
| Mann-Whitney U  | 6372.000    | 4900.500   |
| Wilcoxon W      | 6933.000    | 5461.500   |
| Z               | -.377       | -3.448     |
| Asymp. Sig. (2-tailed) | .001    | .001       |

The null hypothesis is accepted in case of food grains as the sig. value for these two groups found to be less that 0.05 (i.e. 0.706) for Food Grains and the null hypothesis is rejected in case of cash crops as the sig. value for these two groups found to be less than 0.05 (i.e. 0.001) in case of Cash Crops. The result indicates that adoption of new techniques & know-how does not play role in value addition in processing of food grains but on the other hand it is useful in adding value to the cash crops processing.

H0: There is no value addition by adopting processing of agricultural produce in case of food grains and cash crops.

HA: There is value addition by adopting processing of agricultural produce in case of food grains and cash crops.
**Table 5.** Shows result of value addition by adopting processing of agricultural produce in case of food grains and cash crops

| Ranks | Adopted - Processing of Agricultural Produce | N  | Mean Rank | Sum of Ranks |
|-------|---------------------------------------------|----|-----------|--------------|
|       | Food grains                                 |    |           |              |
| No    |                                            | 24 | 258.50    | 6204.00      |
| Yes   |                                            | 408| 214.03    | 87324.00     |
| Total |                                            | 432|           |              |
|       | Cash Crops                                  |    |           |              |
| No    |                                            | 24 | 218.38    | 5241.00      |
| Yes   |                                            | 408| 216.39    | 88287.00     |
| Total |                                            | 432|           |              |

**Test Statistics**

| Food Grains | Cash Crops |
|-------------|------------|
| Mann-Whitney U | 3888.000   | 4851.000 |
| Wilcoxon W    | 87324.000  | 88287.000|
| Z             | -.2081     | -.107    |
| Asymp. Sig. (2-tailed) | .037      | .915     |

The null hypothesis is rejected in case of food grains as the sig. value for these two groups found to be less than 0.05 (i.e. 0.037) and the null hypothesis is accepted in case of cash crops as the sig. value for these two groups found to be less than 0.05 (i.e. 0.915). The result specifies that Processing of Agriculture Produce has a positive impact in adding value to the food grains’ production but on the other hand it does not have any positive impact in value addition for cash crops’ production.

H0: There are no benefits of R&D based modern techniques and technical/technological know-how knowledge dissemination by various departments/agencies.

HA: There are benefits of R&D based modern techniques and technical/technological know-how knowledge dissemination by various departments/agencies.

**Table 6.** Shows results of benefits of R&D based modern techniques and technical/technological know-how knowledge dissemination by various departments/agencies

| Ranks | From where did you receive the technology/technical know how | N  | Mean Rank |
|-------|-------------------------------------------------------------|----|-----------|
|       | No                                                          | 9  | 89.00     |
| To what extent you are benefited from the R & D based modern techniques & technologies? | Govt. Agriculture/Other Departments/Agencies | 399| 228.85 |
|       | Private Sector/Industry (Domestic Companies/MNCs)           | 3  | 185.00    |
|       | Farmers                                                     | 15 | 41.00     |
|       | News Paper & Media                                          | 3  | 41.00     |
|       | F.M. Radio                                                  | 3  | 41.00     |
|       | Total                                                       | 432|           |

**Test Statistics**

|                         |                           |
|-------------------------|---------------------------|
| Chi-Square              | 66.628                    |
| df                      | 5                         |
| Asymp. Sig.             | .000                      |
On the basis of above result it is found that the farmers are benefitted by such dissemination of knowledge by various agencies/departments. To check the significant differences among the various department/agencies, Man Whitney test was performed.

Table 7. Results of difference in dissemination of knowledge by various agencies/departments

| Pair | From where did you receive the technology/technical know how | N  | Mean Rank | Sum of Ranks |
|------|-------------------------------------------------------------|----|-----------|--------------|
| 1    | No                                                          | 9  | 74.5      | 670.5        |
|      | Govt. Agriculture/Other departments/Agencies               | 399| 207.43    | 82765.5      |
|      | Total                                                       | 408|           |              |
| 2    | Govt. Agriculture/Other departments/Agencies               | 399| 213.98    | 85380        |
|      | Farmers                                                    | 15 | 35        | 525          |
|      | Total                                                       | 414|           |              |
| 3    | Govt. Agriculture/Other departments/Agencies               | 399| 202.8     | 80916        |
|      | News Paper & Media                                         | 3  | 29        | 87           |
|      | Total                                                       | 402|           |              |
| 4    | Govt. Agriculture/Other departments/Agencies               | 399| 202.8     | 80916        |
|      | F.M. Radio                                                 | 3  | 29        | 87           |
|      | Total                                                       | 402|           |              |
| 5    | Private Sector/Industry (Domestic Companies/MNCs)           | 3  | 17        | 51           |
|      | Farmers                                                    | 15 | 8         | 120          |
|      | Total                                                       | 18 |           |              |

Test Statistic

| Pair | From where did you receive the technology/technical know how | Asymp. Sig. (2-tailed) |
|------|-------------------------------------------------------------|------------------------|
| 1    | No                                                          | 0.000                  |
|      | Govt. Agriculture/Other Departments/Agencies               |                        |
|      | Farmers                                                    | 0.000                  |
| 3    | Govt. Agriculture/Other Departments/Agencies               | 0.004                  |
|      | News Paper & Media                                         |                        |
| 4    | Govt. Agriculture/Other Departments/Agencies               | 0.004                  |
|      | F.M. Radio                                                 |                        |
| 5    | Private Sector/Industry (Domestic Companies/MNCs)           | 0.002                  |
|      | Farmers                                                    |                        |
On the basis of the result obtained from Man-Whitney test it is found that there are few cases where the null hypothesis is accepted and in some cases it is rejected. The cases where the null hypothesis were rejected and alternate ones were accepted are the departments/agencies playing importance role in disseminating R&D based technical knowledge to the farmers. The departments/agencies found to be primarily involved in R&D knowledge dissemination among farmers are- government agriculture/other departments/agencies, private sector/Industry, other farmers and newspaper & media.

5. Conclusion
This research aims to identify the role of R&D tools on sustainable agricultural value chain in India and the results are found to be significantly positive. In majority of issues the findings suggests that the R&D tools have very important role throughout the sustainable agricultural value chain activities. Farming of both food grains and cash crops is benefited by using new variety seeds/planting material and adopting farm equipment and machineries. It is also found that adoption of new techniques & know-how is not significant in value addition in processing of food grains but on the other hand it benefits the value adding process of cash crops. The processing of agriculture produce has a positive impact in adding value to the food grains’ production but on the other hand it does not have any positive impact in the value chain of cash crops’ production. This study has several practical implications for various stakeholders in agriculture sector. The findings should be very useful for policymakers to implement R&D advancement in sustainable agriculture and systematic overhaul in agriculture sector. This study also suffers from certain limitations. Only 432 respondents were used in the study and this study was limited to U.P. Future studies may include more state and large sample size.

References
[1] Ministry of Agriculture & Farmer Welfare GOI 2019 Annual report 2018-19 URL: http://agricoop.nic.in/sites/default/files/AR_2018-19_Final_for_Print.pdf [Accessed 15th October 2020]
[2] Khan W, Tabassum S and Ansari S A 2017 Can Diversification of Livelihood Sources Increase Income of Farm Households? A Case Study in Uttar Pradesh Agricultural Economics Research Review 30 27-34
[3] Aggarwal S Cand Goldar B 2019 Structure and growth of employment: evidence from India KLEMS data Indian Growth and Development Review 12 202-228
[4] Naseem A, Spielman D J and Omamo S W 2010 Private-sector investment in R&D: a review of policy options to promote its growth in developing-country agriculture Agribusiness 26 143-173
[5] Donovan J, Franzel S, Cunha M, Gyau A and Mithöfer D 2015 Guides for value chain development: a comparative review. Journal of Agribusiness in Developing and Emerging Economies 15 74-91
[6] Magruder J R 2018 An assessment of experimental evidence on agricultural technology adoption in developing countries Annual Review of Resource Economics 10 299-316
[7] Kumar K, Prakash A and Khan W 2020 Integrating the notion of sustainable development in banking: Analysing historical and conceptual framework. Indian Journal of Economics and Development 16(3) 449-458
[8] Bhullar M S, Pandey M, Kumar S and Gill G 2016 Weed management in conservation agriculture in India Indian Journal of Weed Science 48(1) 1-12
[9] Santangelo G D 2018 The impact of FDI in land in agriculture in developing countries on host country food security Journal of World Business 53 75-84
[10] Aryal J P, Jat M L, Sapkota T B, Khatri-Chhetri A, Kassie M and Maharjan S 2018 Adoption of multiple climate-smart agricultural practices in the Gangetic plains of Bihar India International Journal of Climate Change Strategies and Management 10 407-427
[11] Kumar K and Prakash A, 2019 Managing sustainability in banking: extent of sustainable banking adaptations of banking sector in India Environment, Development and Sustainability 22 5199-5217

[12] Ramasamy C 2013 Indian Agricultural R&D: An Introspection and Way Forward Agricultural Economics Research Review 26 1-20

[13] Ansari S A and Khan W 2015 India’s Agricultural Trade Potential in Post-WTO Period, Agricultural Economics Research Review 28 93-100

[14] Narayan S and Bhattacharya P 2019 Relative export competitiveness of agricultural commodities and its determinants: Some evidence from India World Development 117 29-47.

[15] Kumar K 2020 Emerging phenomenon of corporate sustainability reporting: Evidence from top 100 NSE listed companies in India Journal of Public Affairs e2368

[16] Khan W and Ansari S A 2018 Does agriculture matter for economic growth of Uttar Pradesh (India)? Economy of Region/Ekonomika Regiona 14 029-1037

[17] Khan W, Jamshed M and Fatima S 2020 Contribution of agriculture in economic growth: A case study of West Bengal (India) Journal of Public Affairs 20 e2031

[18] Prakash A, Kumar K and Srivastava A 2018 Consolidation in the Indian banking sector: evaluation of sustainable development readiness of the public sector banks in India International Journal of Sustainable Strategic Management 6(1)3-16

[19] Ranjitha P 1998 The Indian agricultural research system: structure, current policy issues, and future orientation World Development 26 1089-1101

[20] Pray C E and Nagarajan L 2014 The transformation of the Indian agricultural input industry: has it increased agricultural R&D? Agricultural Economics 45 145-156

[21] Kumar K and Prakash A 2019 Developing a framework for assessing sustainable banking performance of the Indian banking sector Social Responsibility Journal 15(5) 689-709

[22] Trienekens J H 2011 Agricultural value chains in developing countries a framework for analysis International Food and Agribusiness Management Review 14 51-82