Universal Journal of Agricultural Research 6(1): 31-39, 2018 http://www.hrpub.org
DOI: 10.13189/ujar.2018.060105

The Scenario of Research and Development in Agriculture Innovation in Bihar, India

Vikas Kumar

Gujarat National Law University, Gandhinagar, Gujarat: 382426, India

Abstract This research paper pays particular attention to the evolving structure of Research and Development in Bihar. It, broadly, hinges on two distinct yet interrelated set of argument: 1) much of the increased collaboration since 1960 that has attracted the attention of policy makers, critics and university administrators represents a revival of long standing relationships, rather than something unprecedented in Bihar and 2) this renewed collaboration, which has potential costs as well as benefits, relies as much on the unusual structure of the university system and the role of Agricultural Innovation play through crisscrossing institution and society. The recent changes in government policy, R&D strategies, and national competition have produced significant structural change in Bihar. Further, the research tease out silent feature of inter connections between various actors working in a complex system- namely, public and private companies, civil society, and banks- who are playing vital role in shaping the agriculture system. The study is based on primary and secondary method.

Keywords Research and Development, Agriculture, Innovation, Rice, Wheat, Bihar, India

1. Introduction– The Contextual Background of This Study

Research and Development (R&D) is becoming an engine to push the growth of any sector of the economy. Similarly, as Alston et.al.[1] point out that agricultural research and development play a vital role to boost of the agriculture growth thereby effect on poverty. In Bihar, R&D of agriculture has come under scrutiny in recent past as uneven performance of crop farming becomes vivid. Apparent scope for diversification and intensification of agriculture to achieve a faster growth of the state economy is quite evident since Gangetic Plains of Bihar is endowed with fertile soils, rich in water resources (groundwater and river systems) and favorable agro-climatic conditions for intensive cropping systems. This sector provides nutritional security, employment generation, and ecological benefits. Thus, there is wide scope for meaningful diversification of sustainable agriculture, and profitable marketing including exports. Agriculture is contributing substantially to overall economic development. Though, based on the PRS [2] the average economic growth of Bihar has declined from 8.2 percent in 2005-10 to 7.8 percent in 2010-15. According to Fourth Annual Employment and Unemployment survey, the contribution of the service sector is 60%, followed by 23% by agriculture and 17% of manufacturing in Bihar's economy. In-spite of high contribution of the service sector, most of the state's population (56%) is employed in the agriculture sector, followed by the services (36%) and manufacturing (8%) sectors. The Growth rate of Service Sector is shown in Figure. 1.

Source: Central Statistics Office, 2016

Figure 1. Growth Rate of Sectors in Bihar

Figure 1 reveals the growth rate of sectors in the period between 2005-10 and 2010-15. It can be observed from the figure that, Agriculture growth, increased from 3.4% in 2005-10 to 3.6% in 2010-15. In the meanwhile, services sector growth, increased from 8.9% to 10.4%. The point should be noted that, in-spite of high percentage of people are employed in agriculture, it could not come up to mark. However, there are three major challenges facing Bihar agriculture; First, increasing population pressure leading to more food requirement. The second is decreasing per capita food availability and the third is sustainable growth of agriculture. At this point of view, agricultural R&D systems are now forced to raise questions about their continuing relevance, approaches, accountability, and impact. With reduced funding for research and support, the services can no longer be separated from broader developmental questions. Inefficiencies of the public research systems manifested during protected socio-political environment are no longer affordable under the new economic environment. This, coupled with the incremental nature of technological advancements and their impacts raises the question of effectiveness and accountability of public research. Therefore, the objective of the paper is:

- To identify the status of Science and Technology for crop farming in Bihar
- To understand the research approach, processes, and linkages between different actors involved in Research and Development.
- To documents the recent technologies developed for farming in Bihar.

Follow with introduction, this paper has been categorized into six sections. Second section deals with the research approach, processes and linkages. It discusses about the availability of infrastructure for Agriculture Research and Development. Similarly, the third section explores the Organizational setup and discusses about the financial infrastructure for agriculture and technology development. The fourth section deliberates about the collaboration and linkages among the different actors. The fifth section emphasizes on the challenges of agricultural technologies. Later on, sixth section talks about the policy context. Moreover, it talks about the new approach of Research and Development and the last section conclude the discussion.

2. Research Approach, Processes, and Linkages

In terms of the approach to research, Bihar has made significant progress in moving away from the prescriptive tradition toward a participatory and action-oriented research. As noted, R&D activities in the region are heavily influenced by the ATMA and State Agriculture University frameworks. A number of key elements of the system-oriented participatory approaches, i.e. the farming systems perspective; household systems as units of analysis; using diagnostic information in research, planning and priority setting; and involving beneficiaries in the design, implementation, and evaluation of research—are embedded in the R&D systems in Bihar.

The state of Bihar is regularly faced natural disasters like drought and flood. However, Agricultural research and development in the state is supported by various institutes, organization and universities such as Rajendra Agricultural University, Pusa (Samastipur) (RAU) and its network of Krishi Vigyan Kendra,(KVK), Bihar Agriculture University, (BAU), Indian Council of Agriculture Research eastern zone complex at Patna, National Research Centres for Litchi, Makhana and Pan. Small Farmer's Agri-business Consortium (SFAC) and ATMA[3]. Though, these institutions reflect the growth of research, but it does not determine to innovation. One of the major issues could be linkages. In this context, to tackle this challenge The National Agriculture Research System (NARS) concept has brought which brings together to several actors (such as National Agriculture Research intuitions (NARIs) and their methods and participatory approach. It has led to increased grassroots collaborations and interactions between researchers, extension staff and farmers. In this context, the Bihar's government has taken initiative to develop science and technology infrastructure to accelerate the growth of production and farmer's livelihood. The details have been shown in table 1.

Table 1. Science, Technology Infrastructure for Crop Farming in Bihar

S.no.	Research and education Institute and technology transfer agencies/ ATMA/KVK	No.	Activities undertaken
A	**Research and Development**		
1	Central Agriculture University	01	All
2	State Agricultural Universities	01	All
2	Research institutes/colleges	10	Region specific
3	National/International Linkage	09	Indian Council of Agricultural Research, Department of Science and Technology, Consultative Group of International Agriculture Research, Rajiv Gandhi Vikas Yojna, International Rice Research Institute, International Maize and Wheat Improvement Center, International Crop Research Institute Semi-Arid Tropics, International Plant Nutrition Institute, Bihar Rajya Beej Nigam
B	**Transfer agencies**		
1	ATMA	04	
2	Agriculture extension Krishi Vigyan Kendra	29	
3	State Agriculture Department	1	
C	**Seed Production/Distribution/Marketing**	4	Region specific

Source: Author Compilation, 2017; Through Various Reports

It has been observed from the table that, there is involvement of market agents and input suppliers in the R&D processes. Nevertheless, the current status of linkages and collaboration among the various stakeholders is far from ideal. To a large extent, these organizations still act independently of each other with minimum coordination, which undermines the feedback loop necessary for developing responsive research agendas and compromises access to knowledge. Increasingly, farmers' organizations now voice the needs of their members in various forums on policy making and orienting service provision. Over the years, achievements in R&D and increased awareness have resulted in adoption of recommended practices and technologies by the farmers. However, the extent of dissemination of the technologies has not been adequate. The weak linkage between research and extension is a serious impediment to low adoption of technologies at the field level. Educating the farmers about improved technology and ensuring its continuous access and adoption is a major challenge for the effective deployment of the agricultural R&D system.

3. The Evolving Socio-technical Ensemble of Crop Farming in Bihar

Table 2. Status of Public Sector Research System for Crop Farming

S.I.No.	Name of Universities/College	Place
1	Bihar Agriculture University, Sabour	Bhagalpur
2	Rajendra Agriculture University, Pusa	Samstipur
3	Borlog Institute of South Asia	Pussa
4	College of Agricultural Engg, Pusa,	Samstipur
6	Dumraon Agriculture College	Buxar
7	Bhola Paswan Sashtri Agriculture College	Purnea
9	Mandan Bharti Agriculture College	Saharsa.
10	Tirhut College of Agriculture	Muzzafarpur

Source: Compiled by Author, 2017; http://targetstudy.com/colleges/agriculture-colleges-in-bihar.html accessed on 13/09/2016

The first agricultural research institute was established in 1905 at Pusa, Samastipur which is well known as the Imperial Agricultural Research Institute (IARI). Unfortunately, it had to be shifted to New Delhi in 1936 because of the devastating earthquake in 1934. Bihar Agriculture College at Sabour is one of the oldest agricultural colleges in the country. It was established in 1908 [4]. There are several agricultural research and educational institutions have been set up in the state (shown in table 2). At present Rajendra Agricultural University at Pusa and Bihar Agriculture University at Sabour are the only two agricultural Universities in the state. Five agricultural colleges at Dholi, Sabour, Saharsa, Purnea and Dumraon are its constituent units. Rajendra Agriculture University has set up post graduate courses in Bio Technology and Agri Business Management. Indian Council of Agriculture Research has its eastern regional headquarter at Patna [5]. A specialized research centre of Borlaug Institute of South Asia is being set up in Pusa. This institute will be the first international research institute in the state. The agriculture research system has achieved laudable success in the evolution of several new varieties and cultivation technologies. The educational institutions have the distinction of producing eminent scientists and extension workers.

Basically, a university helps to build networks and outsourcing by providing information about agriculture related problems. The role of the appropriate information package and its dissemination assumes a portal role. It is not only important to generate information, but also to see that the required information is delivered to the end users at the earliest and that too without any dissemination loss. KVK is a front line extension system and a lighthouse for the farming community in fulfilling this need. The Directorate of Extension Education has created a network of 29 such KVK located in 29 districts spreading all over the three agro-climatic zones of the state. They are responsible for the purity and supply of breeder seed and inbred line for hybrid seed production of rice-wheat.

KVK continue to receive prime attention in view of their utility as a centre of excellence in spreading agricultural knowledge to the rural masses. They also encourage catering of post- harvest handling of the agricultural products and develop entrepreneurial skill among the rural youth. The KVK's functions in five mission mode, viz. on honey bee, seed production, including seed villages, conservation agriculture, integrated farming and vermicomposting. Extensive reforms received attention through the Agriculture Technology Management Agency.

Over the period of time, the research milieu has undergone several changes, for instance, nowadays the private sector playing a critical role in meeting R&D needs which were almost non-existent in agricultural research about four decades ago. The role of private initiatives in agriculture research is getting more and more important to develop the hybrid varieties [6]. The private sector is very prominent in the production and supply of multi micro nutrients, bio fertilizers, bio pesticides. It is imperative to get maximum benefit from private research with adequate advisories to farmers for any farming related issues.

3.1. Financial Investment in Agriculture R&D for Crop Farming

The Rajendra Agriculture University, Bihar Agriculture University and other colleges are autonomous institutions in meeting the educational and research needs of the Bihar states and these are managed by the board of management and academic council. It is largely funded by state governments, but they also get regular grants from the ICAR, Department of Science and Technology, CGIAR, RKVY and BRNS [7]. In the past, the research and extension system has achieved much success. It is believed that compared to other alternatives, the investment in

agricultural research and extension is much more productive in accelerating the pace of development. It has been shown empirically that the investment in agricultural research and extension is the main source of growth in agricultural total-factor productivity in India, and the rates of return are impressive [8; 9; 10]. In this context, Bihar is also following the same path and the extension activities of the SAUs are implemented and coordinated by the Director of Extension. This extension mandates of the SAUs has conventionally been operationalized through the three major units of training, communication and information and KVKs or Farm Science Centers. A single-window facility of the ATIC is also currently established in ATMA for delivery of research products, information and other services. In the recent years with the advent of the ATMA as a national extension model to implement location-specific programs related to agricultural development, the SAUs have been restricted to consultancy roles [11].

Table 3. Proposed Outlay on Crop on Agriculture Research & Education 2014-2015 (Amount in Lakh)

Sl. No.	Institutions	Proposed Outlay
1	Strengthening of RAU	94
2	Agriculture College at Dumraon	5158
3	Agriculture College at Purnea	3640
5	Bihar Agriculture University, Sabour	14445.75
6	Agriculture College Kishanganj	10985
	Total	34322.75

Source: Computed by Author, 2017 from GoB, Report

There are other expenditures also with the name of different schemes to enhance the production for rice, wheat and agriculture growth as a whole. The Agriculture Technology Management Agency is constituted as the registered society in all 38 districts of the state. Government of India under a centrally sponsored scheme of extension reforms is funding 90 percent of the work components listed under the cafeteria of activity. State government from its own resources will meet the establishment cost of ATMA for additional posts not covered under centrally sponsored schemes besides 10 percent matching share of the central fund. Bihar Rajya Beej Nigam has played an instrumental role in implementation of Chief Minister's Crash Seed program where in its responsibility lie in the timely supply of foundation seed to farmers. Similarly, for the Seed Production on government seed multiplication farms, all the 245 government seed multiplication farms are now engaged in foundation/certified seed production. The foundation seed produced on these farms is processed by BRBN and it finds its use in the CM Crash Seed program. It is proposed to give additional subsidized at a rate of 200 per quintal for Paddy and Wheat and 800 per quintal from state plan. Similarly, there are various schemes such as E-Kisan Bhavan, Integrated cereal development programme for rice-wheat etc. run through by state and central governments. The detail of particular schemes, expenditure has been provided in the table 4.

Table 4. Proposed Outlay on Crop Farming in Bihar 2014-15 (Amount in Lakh)

SI. No	Scheme	Proposed Outlay
1	**Seed Production by BRBN including CM Crash Seed Programme**	**4000**
2	Seed production on Govt. Farms	6000
3	Kisan Salahkar Yojna	9100
4	Maintenance and Establishment of Agriculture departments Buildings/Labs	7884.97
5	Seed certification agency	315
6	Promotion of Farm Mechanization	18400
7	Application of Information & Communication Technology in Agriculture	252
8	Rajya Kisan Aayog	100
9	Purchase/Maintenance/Hiring of Vehicle	650
10	Integrated Watershed Development Project	200
11	RSVY	58916
12	Kisan Salahkar Yojna	9100
13	Strengthening of soil, seed and fertilizer laboratory	1000
14	National Mission for Sustanable Agriculture	4500
15	National Food Security Mission	2000
16	National Mission on Agriculture Extention and Technology	4500
17	Development of Agriculture Marketing	1000
18	Soil conservation work	2300
	Total	**130217.97**

Source: Computed by Author, 2017 from GoB Report

However, it is clear that the traditional agricultural research and extension roles of the SAUs alone cannot sufficiently address the challenges of the new trends in agricultural development. It is, thus, a suitable mechanism is required for periodic assessment of the scientific and technical work force requirement for agricultural R&D institutions in Bihar. This will help maintain a reasonable balance between the work force generated and opportunities for their gainful employment.

4. Collaboration and Linkage among Actors in the Innovation System

It has already been argued that innovation requires a dense network of interaction. Networks might crystallize around different innovation tasks at different times. In the case of agricultural innovation in Bihar, interactions of multiple actors were important for the development of the sector [12]. The existence of a range of organizations established to coordinate various activities, including marketing, access to technical and financial capacity or services, assistance in meeting or setting quality standards, and political lobbying. The coordinating body consisted of public organizations, NGOs or foundations, industry associations and consortia of private and public organizations. These coordinating bodies were established to foster the interaction. Interactions between actors and networks are central to an effective innovation system. In this context, the triple-helix model of innovation [13] emphasis on the importance of interaction among knowledge institutes, including those in academia, industry and government. Linkages can be defined as coordinated channels for the exchange or flow of technology, information and resources between organisations in an agricultural innovation system [14]. Such exchange can be achieved in different ways by establishing linkage mechanisms that address specific purposes or functions. Linkage mechanisms are procedures that enhance technology generation and exchange and enable the flow of information and resources.

To understand patterns of interaction between various actors, it is important first to map linkages in a general way and then to understand the nature and purpose of those linkages shown in table no.5. During the field study several types of linkage pattern have been observed which indicate its purposes and actors involved in innovation shown in the table. This information is important, as it helps to distinguish between the links an organization might have with an input supplier (important as they may be) and the links it may have for accessing a technology or collaborating on a joint project, which are clearly more important for learning and innovation. This classification of linkages helps to identify the sorts of linkages that might need to develop for continuous innovation to take place.

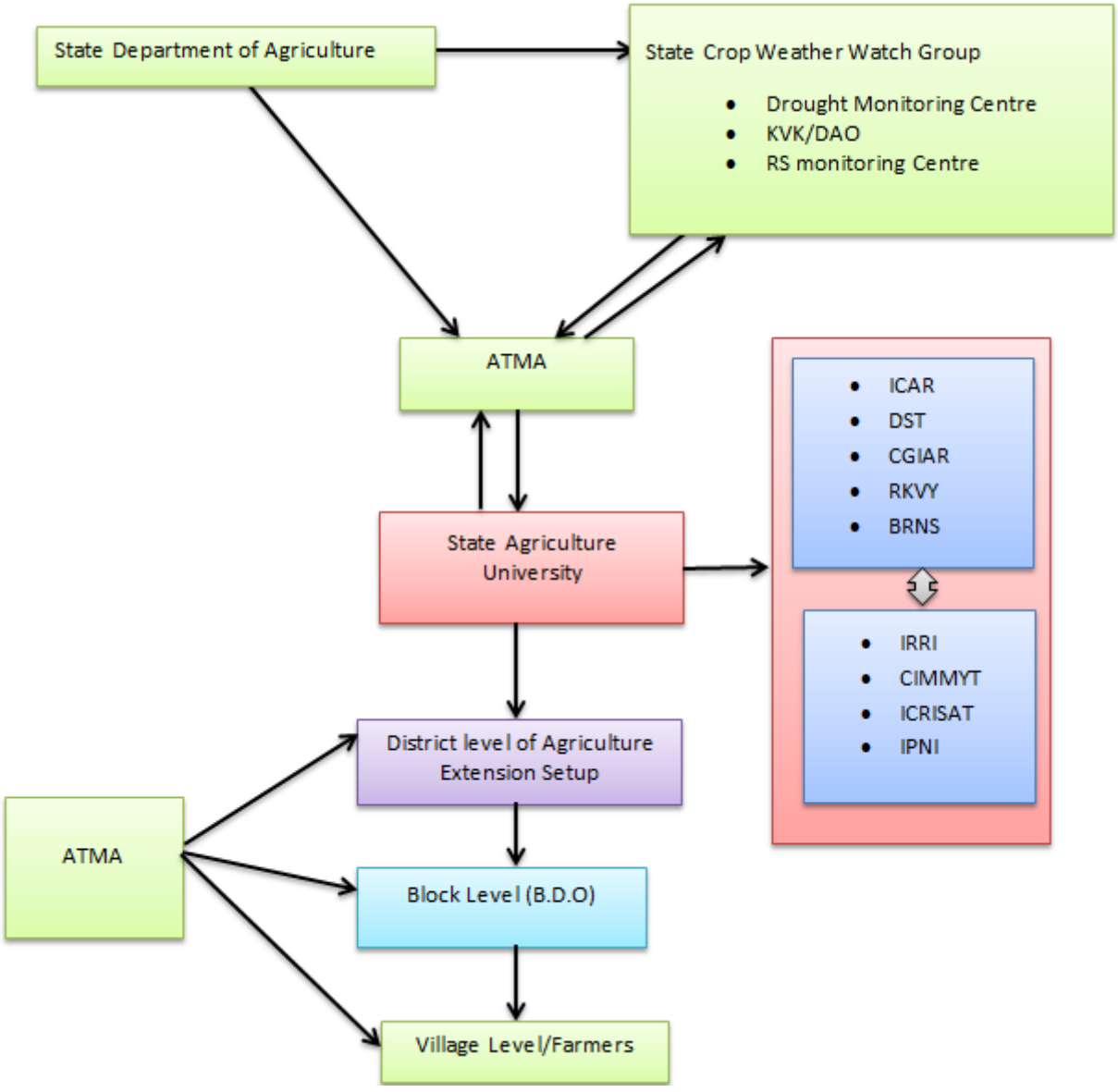
An agriculture Innovation process often requires quite extensive linkages with different knowledge sources. These sources may be scientific and technical, but equally they can be a source of other forms of knowledge, both tacit and codified. Patterns of interaction between different knowledge sources from a central component of an organization's or sector's capacity to innovate the relationships that sustain the acquisition of knowledge and permit interactive learning are critical and can take many forms. It can be partnerships, for example, in which two or more organizations to pool knowledge and resources and jointly develop a product, or it can be commercial transactions, in which an organization purchases technology (in which knowledge is embedded) or knowledge services from another organization, in which case the relationship is defined by a contract or license. Linkages may also take the form of networks, which provide an organization to market and other early-warning intelligence on changing consumer preferences or technology. Networks also embody the actors of knowledge sources, which can be tapped as the need arises. These linkages and the relationships that govern them concern knowledge flows. They must not be confused with the linkages and relationships that govern the movement of commodities through value chains, although many of the same actors may be involved.

Table 5. Types of Linkages and Purpose within various Actors for Rice-Wheat Cultivation in Bihar

Type of linkage	Purpose	Actors Involved
Partnership	Joint problem solving, learning, and mainly learning by innovation. May involve two or more organizations. Focused, objective defined project.	IRRI, CIMMYT, ICRISAT, IPNI, SAU, ATMA
Pattern	Transfer of items, services, and knowledge to consumers with regards training to their performance agendas.	ATMA, KVK, Farmers
Networks	May be formal or informal, but the Learning by main objective is to facilitate interacting and information flows. Also builds social capital, confidence, and trust, and creates preparedness for change, lowering barriers to forming new linkages.	Bihar State Govt., ICAR, DST, CGIAR, RKVY, BRNS, SAU
Advocacy linkages to policy process	Specific links through networks and sector association to inform and influence policy.	Department of Agriculture
Linkages to supply input and output markets	Mainly informal but also formal arrangements connecting organizations to raw materials and input and output markets.	Local Seed Seller, ATMA, Bank

Source: Author, 2017

At present, state government functionaries, fertilizer industry, pesticide industry, irrigation department, Seed Industry, transport organizations provide critical inputs to agriculture. These organizations make a significant input to the state-level Crop Weather Watch Group (CWWG) meeting. CWWG make a report and submitted to state government or organisations to make a future plan for particular states. These services are provided in collaboration with a number of other organizations. A collaborative programme sponsored by different organizations on the development of Extended Range Forecast System (ERFS) is being pursued jointly by IMD, Nation Centre for Medium Range Forecast of Weather (NCMRFW), DAC, ICAR, SAC, IITD and IRI to provide spatially and temporally differentiated weather information with a lead time of one month for providing input support services to farmers. Information on agro-advisory is disseminated through multi-modes of delivery, including mass and electronic media like AIR, television, print media, internet as well as group and individual relationships through email, telephone, SMS and IVR (Interactive Voice Response Technology), etc. The Agro meteorological Advisory Service (AAS) has demonstrated the critical role of weather forecasts in increasing the overall preparedness of farmers, leading to substantially better outcomes. For more effective approaches to deliver climate and weather information to farmers through a participatory, cross-disciplinary approach, farmer's awareness programs, also known as roving seminars are organized that bring together research and development institutions, relevant disciplines, and farmers as equal partners. They are jointly organized by ICAR, SAUs, SMD and other stakeholders in order to improve the relationship with the ATMA system and develop a local (village) level of crop production [15] Shown in the figure.



Source: Author, 2017

Figure 2. Collaborating Organizations and their Linkages for Crop Farming in Bihar

The figure (2) indicates that effective linkages and partnerships between organisations are essential to transfer research results to farmers and input suppliers. Linkages are also needed to pass on to policy makers and researchers relevant information on production constraints at the farm level and in general to facilitate inter-organisational experimentation, learning and by implication, innovation [16; 17]. The importance of linkages has been recognized in not only the agricultural innovation literature [18, 19] but also in the innovation literature in general. Effective linkages between actors are a key requirement to promote innovation. Building networks of relevant actors require vision, funding, skills and commitment—all of which are in short supply, explaining why linkages are so often absent. At the same time, they lack of represents a key weakness in many agricultural innovation systems in Bihar. This represents the traditional national public agricultural research system in Bihar, which is formed by a closed group of public research institutes with limited interactions with private actors. Although linkages are in short supply, the demand for them is exploding as innovation systems become more complex. It is observed in the study that only a public research organization has involved in Bihar but there is a need to collaborate with other private organizations also.

4.1. Potential Agriculture Technologies for Crop Farming

Over the years, the Bihar Agriculture University has developed technologies for various farm activities. Studies have shown that improved technologies are capable of making farming operations easy, savings in resources, reducing post-harvest losses, increasing shelf-life and value and finally increasing food production. Hence, technologies in terms of seed (shown in table no.6.) have developed according to meet the farmer's demands as per the local problems they faced and for the development of new varieties and technologies suitable to agro-climatic of Bihar.

The listed technologies cover various aspects, from improved crop production to resource conservation. Hence, developing mechanisms and providing support for wider adoption of the technologies by the farmers will be instrumental in managing the production of rice-wheat. Drawing from the factors responsible for poor and partial adoption of technologies in farmers' field, first and foremost, there is a need to refine technology suited to local conditions and make it available to farmers. The next sections deal with challenges of technologies at farm level:

Table 6. Year wise Agriculture Technologies released by University in Bihar

Year	Crops						
	Rice	Wheat	Maize	Cauliflower	Bael	Litchi	Makhana
2012	SABOUR SURBHIT	N.A	N.A	N.A.	N.A	N.A.	N.A.
2013	SABOUR ARDHAJAL	N.A	N.A	SABOUR AGRIM	SABOUR BAEL 1	N.A.	N.A.
2014	SABOUR DEEP, SABOUR SHREE	SABOUR SHRESHTHA, SABOUR NIRJAL, SABOUR SAMRIDHI	SABOUR SHANKAR MAKKA-1, SABOUR SHANKAR MAKKA-2, DHM-117	N.A.	N.A	N.A.	N.A.
2015	N.A	N.A	N.A	N.A.	N.A	SABOUR LITCHI-1	SABOUR MAKHANA 1
Total No.	4	3	3	1	1	1	1

Source: Computed by Author from university website, 2017

5. The Challenges of Agriculture Technologies: Bridging the Gap between Farmer and Agriculture Technologies

Slow agricultural growth is a concern for policymakers as most of the people depend on agriculture for their livelihood. Current agricultural practices are neither economically nor environmentally sustainable and Bihar yields for many agricultural commodities are low. Poorly maintained irrigation systems and almost universal lack of good extension services are among the factors responsible.

5.1. Technical Aspects

The major problem of agriculture is that limited availability of improved varieties (especially rice) for farmers and the other is some kind of technological 'backwardness' regarding tube-well irrigation in Bihar. It is also known that each and every agriculture technologies cannot be used in various types of soil or land. Therefore, it is usually critical for the government to develop such type of agricultural technologies that are suitable to each local situation. In the case of Bihar, the state government had not been making the necessary effort in this regard, especially for rice varieties. The proper application of such seeds and maintaining a desired level of Seed Replacement Rate (SRR) are important determinants of agricultural productivity. As there was a dearth of firms producing seeds in Bihar, the SRR was often low in Bihar in the past.

Table 7. Distribution of Certified Seeds and Seed Replacement Rate (SRR) for Important Crops

Crops	2012-13			2013-14			2014-15		
	Require-ment	Supply	SRR	Require-ment	Supply	SRR	Require-ment	Supply	SRR
Kharif Crops									
Paddy	297.00	279.70	40.20	353.60	245.70	40.80	373.20	361.50	38.75
Maize	75.00	61.50	82.00	95.00	19.10	20.15	–	–	–
Urad	1.10	5.70	65.90	1.40	0.60	18.80	1.62	–	25.00
Moong	0.60	3.60	82.50	1.30	2.10	79.10	–	–	–
Rabi Crops									
Wheat	840.00	849.90	35.40	840.00	817.20	35.70	864.00	795.50	35.58
Maize	130.00	114.80	85.00	130.00	126.40	85.00	207.00	207.00	90.00
Arhar	3.80	4.10	27.10	4.60	2.50	19.40	5.40	1.05	10.58
Gram	17.30	13.10	16.50	23.00	7.10	9.10	27.60	4.13	5.51
Masoor	12.90	7.30	11.40	20.80	3.57	5.67	25.80	7.08	11.35
Rapeseed/ Mustard	3.30	5.10	100.00	3.30	2.60	39.80	3.46	3.06	49.04

Source: Economic Survey, 2015-16, GoB

* Requirement and supply in '000 qntl./SRR in percentage

5.2. Financial Resources

Another problem is a financial crisis. Due to the high cost of technologies such as paddy trans-planter, quality seeds, etc. farmers could not able to bear at the starting stage. If they spent the money on adaptation or installation of irrigation technologies, it takes time to cover-up that much amount even after getting the subsidy from the government.

5.3. Different Size of Land Holding

In general, the size of agricultural land is very small and most of the farmers belong to marginal and small land holding size class and because of this, sometimes the technologies do not fit into the land or type of soil quality for instance agriculture mechanization. Thus, the farmers are not interested to adopt new mechanization.

6. Policy Prospects and Need of New Approach

The agriculture sector becomes more and more knowledgeable and capital intensive. Due to the changing economic situation and environmental problems such as drought and flood in Bihar, farmers' needs continue and updated information on meteorology, marketing and a number of other aspects have directly or indirectly started affecting crop farming. In fact, there is a need to launch a literacy movement at the farm level covering all aspects like, information related to IPR and Farmers' and Breeders' Right, quality requirements under sanitary and Phyto-sanitary measures and agriculture trades, etc. The Present study, found that there is a gap between implementation of new technologies due to lack of awareness of extension agencies. Mostly, the farmers are not interested to apply new kind of techniques like SRI or Zero tillage cultivation for rice wheat. These techniques are absent in more district as well as village level. The farmers are not adapting to the seeds which are provided by ATMA for cultivation, and hence there is a need to properly monitor the field and find out the problems behind the adoption of new techniques. The availability of timely, location-specific demand driven and value added information is very vital for the growth of crop production.

As observed from the field experience that various technologies have developed and stimulated from method of plant introduction to hybridization and better plant type for specific conditions. Over the years, The SAUs system has developed various improved technologies with the collaboration of different organizations. These technologies have exhibited good potential to increase income and employment and making farming a profitable source of livelihood. The changing situation and policies have made agriculture complex and more knowledge- intensive. In the regimes of trade and IPRs, farmers need more education and recent information to avail benefits. The role of KVK seems more meaningful in providing generic information

under the local situation and empowering farmers with scientific know-how and information on the market and prices.

7. Conclusions

The role of Research and Development (R&D) in agriculture depends on various key players, government programmes, and government research agencies that are involved in Bihar. The Bihar government's strong commitment to agricultural R&D has been rewarded with high economic and social returns to research investments. Nonetheless, Bihar's research intensity ratio, measured as public agricultural R&D spending as a share of agricultural output, continues to be relatively low. ATMA and the SAU system are making a concerted effort to better target research and to improve coordination of programs across the various institutions. Deliberate efforts are also being made to foster partnership with the farming community and with other stakeholders, so as to accelerate the low access of technology. There are some lessons which can be generalised for Bihar. It is clearly shown that an enabling policy environment and attractive market opportunities play an important role in diversification of R&D through participation of the public sector, but there is also a need to attract private companies as well to sustain the livelihood of farmers. This is essential for enhancing research intensity and making the system more demand-driven. At the same time, it is important to recognise the fact that public research is unlikely to bridge the gap in research intensity in the near future and whatever public funding will come will be mainly for in-house R&D.

Therefore, the presence of strong private R&D is a must. The need for private R&D is also justified in conducting research to enhance the sustainability of natural resources and agricultural production systems which is unlikely to get private attention. Even in the area where the private sector is active (e.g. seeds), public research also required to promote competitiveness of technology markets. The public research system should also keep a balance between upstream strategic research and applied research, and the former should not be a victim of the process of resource generation. Nevertheless, public research organisations can use, commercialisation processes for fostering linkages with end-users of technology and other clients and thereby make the research agenda demand driven.

REFERENCES

[1] Alston, J. M., Pardey, P.G. and Piggott, R.R. 2006. Synthesis of Themes and Policy Issues. In J. M. Alston, P. G. Pardey, and R. R. Piggott, eds. *Agricultural R&D in the Developing World: Too little, too late?* Washington, DC: International Food Policy Research Institute.

[2] PRS Legislative Research http://Bihar%20Budget%20Analysis%202016-17.pdf accessed on 9th September, 2017

[3] Government of Bihar (GoB), 2013, Department of Agriculture, 2013

[4] Government of Bihar (GoB), 2013, Department of Agriculture, 2013

[5] Government of Bihar (GoB), 2013, Department of Agriculture, 2013

[6] Kumar, V. and Sinha, K. 2013. Agricultural Biotechnology, Intellectual Property Rights and Seed Industry in India. *Asian Biotechnology and Development Review*, Vol. 15 No.2, pp 61-79

[7] This information gathers, after having interviewed with Agriculture University www.rau.ac.in accessed on 3/09/2016

[8] Evenson, R. E. and McKinsey, J.W. 1991. Research, extension, infrastructure and productivity change in Indian agriculture, in R. E. Evenson and C. E. Pray (Eds), *Research and Productivity in Asian Agriculture*. Cornell University Press, Ithaca and London.

[9] Rosegrant, M. W. and Evenson, R.E. 1992. Agricultural productivity and sources of growth in south Asia. *American Journal of Agricultural Economics*, Vol. 74, pp 757-761.

[10] Kumar, P. and Rosegrant, M.W. 1994. Productivity and sources of growth for rice in India. *Economic and Political Weekly*. pp 183-188.

[11] National Institute of Agricultural Extension Management (MANAGE). 2004. *Process Change in Agricultural Extension: Experiences under ITD Component of NATP, 2004*.

[12] Kumar, V. and Sinha, K. 2016. The Role of Triple Helix System in Agriculture Innovation: A Case of Rice and Wheat Production in Bihar, India. *Research Front*, Volume 4, No. 3.

[13] Leydesdorff, L. 2005. The Triple Helix Model and The Study of Knowledge- based Innovation Systems. *International Journal of Contemporary Sociology*, Volume 42, No. 1.

[14] Peterson, W., Gijsbers, G. and Wilks, M. 2003. Planning Linkages and Partnerships from the Organization Perspective: *ISNAR Briefing Paper*. The Hague: ISNAR.

[15] This information is gathered by having interview with State University Staff and ATMA staff.

[16] Nooteboom, B. 1999. Innovation and Inter-Firm Linkages: Implications for Policy. *Research Policy*, 28(8), pp. 793–805.

[17] Douthwaite, B. 2006. Enabling Innovation: Technology and System-Level Approaches that Capitalize on Complexity. *Innovations*, 1(4), pp. 93–110.

[18] Merrill-Sands, D. and Kaimowitz, D. 1990. The Technology Triangle: Linking Farmers, Technology Transfer Agents and Agricultural Researchers. The Hague: *International Service for National Agricultural Research*.

[19] Temel, T. 2004. Mapping Organisational Linkages in the Agricultural Innovation System of Azerbaijan. *International Journal of Agricultural Resources*, Governance and Ecology, 3(1), pp. 134–53.