THE ROLE OF TRIPLE HELIX SYSTEM IN AGRICULTURE INNOVATION: A CASE OF RICE AND WHEAT PRODUCTION IN BIHAR, INDIA

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ABSTRACT

This article is an attempt to understand the local level interaction among the actors of the Triple Helix system in agriculture especially with production of rice and wheat in Bihar. Besides this, it also tries to describe the function of these components as a set of activities specific to the Triple Helix Spaces. The article argues that the system does exit in local scenario and university-industry-government is seen as a key to innovation and the socio-economic development in societies. During the period of green revolution there were many actors involved in India to shape wheat production and irrigation technology. The question then is whether the principles and insights arising from the innovation systems concept, and the perspective on innovation capacity development that it implies, can be converted into operational tools for policies and projects that address the practical challenges of agricultural development. This study tries to answer that question in the context Bihar. It assesses the usefulness of the innovation systems concept in guiding investments to support the development of agricultural technology, and it develops an operational agricultural innovation systems concept.

Keyword: Triple Helix, Agriculture Innovation, Rice, Wheat, Production, Bihar

INTRODUCTION

During the period of independence, the extension system in Bihar has focused on four major strategies, reflecting the dominant agricultural and rural development goals during each period. Many scholars suggest that investments in agricultural research and extension have served the country well, particularly in achieving food self-sufficiency (Mellor and Desai, 1985). In April 1959, an agricultural production team sponsored by the Ford Foundation highlighted the importance of food self-sufficiency and suggested that food production can be increased through using a combination of technical know-how and concentrating manpower and resources. At that time, it was the beginning of the Intensive Agricultural District Program (IADP) or, as more commonly known, the ***Package Program***. In the 1974-75 Training and Visits (T&V) Extension system had been launched in the Chambal Command area of Rajasthan and Madhya Pradesh. Although, it was a pilot basis but it was an important milestone in the history of extension. The basic premise was that there was enough technology available awaiting diffusion to and adoption by farmers. Based on positive feedback, it was further extended to other 17 states in 1978–79. The T&V System was effective in disseminating *Green Revolution* technology, especially in the high potential, irrigated areas, but it had little effect on the productivity and incomes among farmers in rain fed areas. In mid-1990s, the Government of India and the World Bank began exploring new

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approaches to extension that would address these system problems and constraints resulting in new, decentralized extension approach, which would focus more on diversification and increasing farm income and rural employment (NIAEM, 2004).

With this view, science and technology (S&T) as the drivers of economic growth, and agricultural R&D is expected to play a significant role in the process of development in Bihar's economy. Within this context rapid changes are taking place in the structure and authority of governments, the global economy, the structure of the farming sector, and the global and local food industries and retail businesses. The institutional landscape is also changing dramatically. Cross-sectorial linkages between agriculture and other sectors are becoming more important. Through, the route from production to consumption system, provides new opportunities for innovation which is based on links. At the first glance, the rice and wheat sectors may seem less dynamic, but the quality considerations and the differentiation of production by end use for example, grain, bread, or cake influences the organization and, in turn, the social process of discovery and innovation (World Bank, 2005). This is an important point to consider in the context of the Triple Helix, because it gives insight into knowledge among government, industry and university do they think as worth consideration. This is also of interest since it gives us an insight into the ways in which different farmers interact with different actors in different helices and in the Triple Helix as a whole. Furthermore, it is well-known that innovation system is a process involving institutions engaged in productive interaction for the purpose of producing novel products. In the case of agriculture, the Innovation and Triple helix System comprises the following three:

I: Public institutions: a) the National Agricultural Research System (NARS) consisting of a) the ICAR and its 40 research institutes, b) agricultural universities (both State Agricultural Universities and those directly supported by the central government); c) general universities (those supported directly by the central government and those directly supported by the state governments); d) international research institutions such as the International Crop Research Institute for Semi-Arid Tropics (ICRISAT), of the CGIAR system, and the International Centre for Genetic Engineering and Biotechnology (ICGEB);

II: a) private seed industry; and b) agricultural research foundations supported by the seed industry,

III: the central government at the national level and regional governments at the state level. In fact, agriculture is a subject that comes under the purview of state/regional state governments. Therefore, it can be argued that the Triple Helix forms a significant part of the whole set of networks and interactions existing in Agriculture Innovation System (AIS). The intensity of Triple Helix interaction from research and development level to the field level in the case of AIS generally decreases. For AIS to function and enhance innovation capacity in developing countries' agricultural sectors, there is a need to emphasise on strengthening the intensity of Triple Helix interaction at the grassroots level through fostering shared visions, have well-established linkages and information flows amongst different public and private actors, conducive institutional incentives, legislative and policy environments and well developed human capital (Hall et.al. 2001; Biggs, 2007).

However, agriculture policy and rural development are important areas of Centre – State relations: for example, polices relating to seed, credit, inputs such as chemical fertilizers and pesticides and infrastructure like irrigation, roads, power supply etc. are formulated by the central/national government. With this aim the study tries to understand the dynamics of Triple Helix at the local level in Bihar, with an emphasis on production of rice and wheat. The main objectives of the paper are following:

1. First, it tries to situate the understanding of the Triple Helix in the theoretical arena of knowledge production and use.
2. It locates the relevance of the Triple Helix in the context of Agriculture Innovation System (AIS) in Bihar.
3. Consequences of Agriculture Innovation on Rice-Wheat production in Bihar

With the following introduction, the article has been categories into five section. The second section deals with the triple helix as a theoretical background of this paper. This led to the third section which emphasize on the components and relevance of Triple Helix in the context of agriculture. The forth section covers to the consequence of agriculture innovation on rice-wheat production in Bihar. Then, finally the paper concludes in the fifth section.

TRIPLE HELIX SYSTEM: A THEORETICAL BACKGROUND

A triple helix of academic-industry-government relations is likely to be a key component of any national or multi-national innovation strategy in the late twentieth century. The focus on interactions between institutions of fundamental research with firm is reflected through technological policies as well as technological studies. In this context the basic characteristic of the triple helix innovation model is to bring together different perspectives and actors and to benefit from their interactions in order to provide understanding of the innovative process and its key determinants (Rickards, 1985).

Triple Helix systems as an analytical construct defined from the perspective of systems theory as a set of:

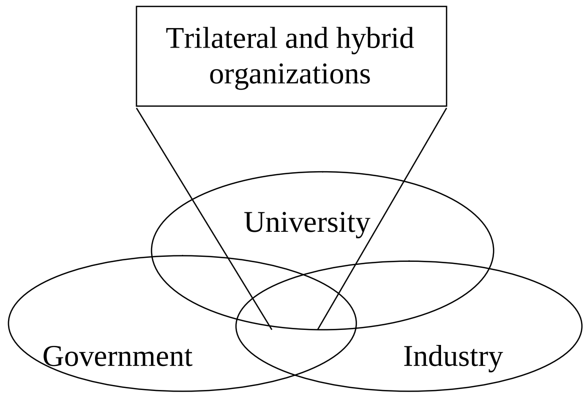
(i) Components: the institutional spheres of University, Industry and Government, each encompassing a wide-ranging set of actors;

(ii) Relationships between components: collaboration and conflict moderation, collaborative leadership, substitution and networking;

(iii) Functions: described as a set of activities specific to the “Triple Helix Spaces”: The Knowledge, Innovation and Consensus Spaces.

Burns and Stalker (1966) argued that the triple helix model is seen as a holistic approach to innovation based on the networking of diverse organizations and disciplines. As a networking system, it seeks to promote rapid learning through closeness and collaboration between the main actors. Each actor in the system would study the innovation process according to its own interests. Etzkowitz and Leydesdorff (1996) have proposed to add to the Triple Helix model of innovation where university, industry and government relations are analyzed “in terms of three interlocking dynamics: institutional transformations, evolutionary mechanisms and the new position of the university. They propose three variants of university –government – industry collaboration which can shape the evolution of innovation systems. In Triple Helix I, the nation state encompasses academia and industry and directs the relations between them. A second policy model – Triple Helix II – consists of separate institutional spheres with strong borders dividing them and highly circumscribed relations between the spheres. Finally, Triple Helix III consists of generating a knowledge infrastructure in terms of overlapping institutional spheres, with each sphere taking on the role of the other and hybrid organisations emerging at the interfaces (Etzkowitz and Leydesdorff 2000).

Figure: 1. The Triple Helix of University–Industry–Government relations



Source: Etzkowitz and Leydesdorff (2000).

It has been pointed by many scholars that the Triple Helix model of university-government-industry (Etzkowitz and Leydesdorff 2011; Etzkowitz 2001) can be seen in the green revolution era. Literature of Triple Helix has emphasised more on knowledge creation, exchange and use at the research and development level, but there is less focus at the level of the implementation of knowledge for socio-economic aspects (Andersen 2010; Viale and Ghiglione 1998). The internal multi-actor and local level dynamics of AIS may have important reflections for the Triple Helix. There is a growing body of literature which tries to focus on field level interaction among the actors of the Triple Helix (Aslesen et.al. 2009; Ballantyne 2009).

This perspective builds upon the structure/process of conceptual construction of innovation systems (Bergek et al. 2008) that complements the structure of innovation systems with a process dimension, which focuses on the dynamics and achievements of the system rather than on its structural components and separates structure from content. Possibly, newly emerging network functions in relations between universities and industry have been codified sufficiently at some places in order to carry new scientific discourses which combine, for example, theorizing, engineering, and management perspectives. Under which, the inter-organizational discourse is specific enough to carry intellectual development (Rosenberg, 1982).

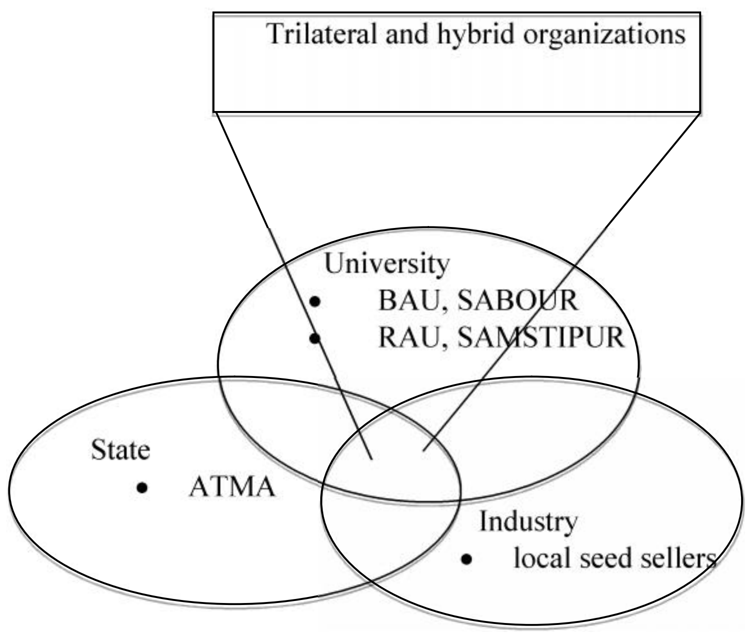
In this regard, it has been noted that the new dependencies may lead to deprivation of the university from its autonomous and cultural functions, and thereby endanger the economy in longer-term respects (Rosenberg and Nelson, 1994).). The internal multi-actor and local level dynamics of AIS may have important reflections for the Triple Helix. The study tries to focus on field level interaction among the actors of the Triple Helix i.e. university-government-industry. The study tries to understand the dynamics of Triple Helix at the local level in Bihar. The transition of world economies from industrial to knowledge societies places special emphasis on the relation between the Triple Helix and agriculture innovation with the end users, in this case the farmers. An innovation intermediary is an organisation or body that acts as an agent in any aspect of the innovation process between two or more parties (Howells 2006).

COMPONENTS OF TRIPLE HELIX IN AGRICULTURE INNOVATION AT LOCAL LEVEL

The Triple Helix model plays a crucial role in the growth and development of AIS (Etzkowitz and Leydesdorff 2011; Etzkowitz 2001). In Triple Helix literature, most of the work has been done on knowledge creation, exchange and use at the research and development level but very few work exists on the level of the implementation of knowledge for socio-economic aspects (Andersen 2010; Viale and Ghiglione 1998).

From a Triple Helix point of view, these intermediaries could be looked upon as the interface organisations of the university-industry-government linkages in Bihar, in order to cater to the innovation intermediary needs in AIS. These include state sector initiatives such as agriculture extension system, Agricultural Technology Management Agency (ATMA), and Farmer Field Schools; university initiatives such as *Krishi Vigyan Kendras* (KVKs); industry initiatives such as e-chopal; along with some public private initiatives. The local seed sellers (seed shops) have inevitably assumed this role in the context of AIS, serving as the node for information exchange between seed, fertiliser and pesticide companies and the farmers. The implementation of such initiatives also depends on the intent and extent to which the public could engage with such initiatives. At the broader level, engaging the public with the Triple Helix (which is largely neglected in the mainstream Triple Helix literature) at the field level could bring interesting insights to the AIS.

Figure: 2. The Triple Helix framework in Bihar with reference to Rice-Wheat



Source: Adopted by Authors, 2016 form Etzkowitz and Leydesdorff (2000).

As shown in figure and discussed that government is one of the component that is playing a role to enhance agriculture through ATMA model, this model has to link with other components like Bihar Agriculture University and Rajendra Agriculture University and local seed sellers.

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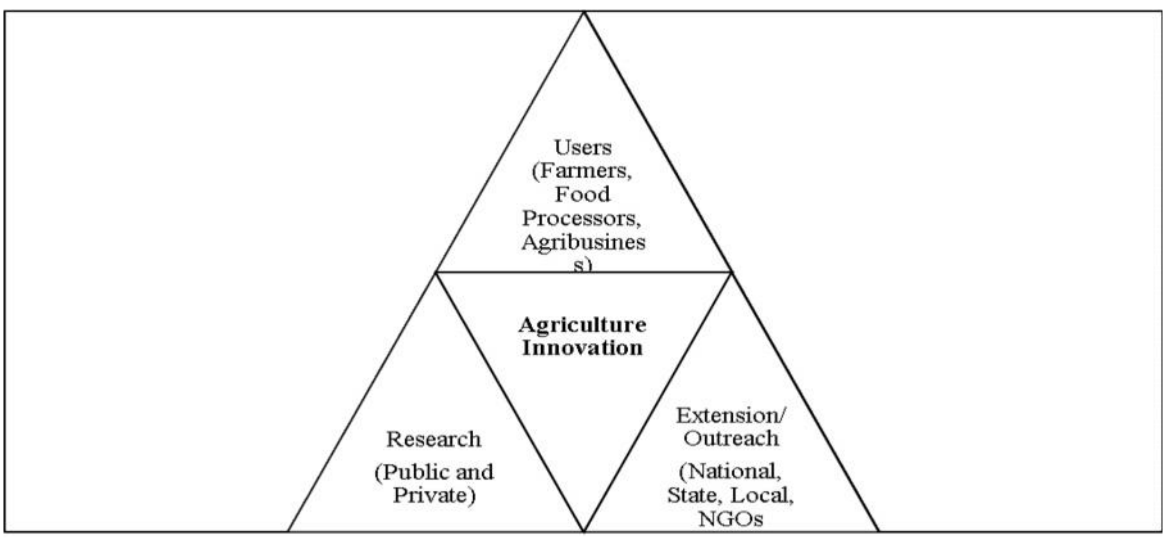
RELEVANCE AND THEIR COLLABORATION OF COMPONENTS IN BIHAR'S AGRICULTURE INNOVATION

The triple helix model concerns regarding agricultural research, development and extension, have stimulated effort to better intrigrate agricultural research and extension education and to make public sector research organizations more response to the needs and priorities of a broad range of farmers, consumers and others. This leads towards building partnership and collaboration among the various stakeholders in terms of domestically as well as internationally (i.e. governmental and nongovernmental agencies, research and extension organizations, farmers etc.). Busch and Lacy (1983) argued that, there is need to situate researchers, both type of organization, extension educators and users as social actors for more effective and functioning of the public sector organization.

Although, there are several models such as scientific pull and push model, sociological model given by the various authors to describe about the relationship between and among the generators of scientific and technical knowledge. In these models basically, scientist develops new technologies and extension and commercial educator then spreads them to the farmers and user. The main objective of these models were to increase the rate of adoption of agriculture innovation. But, later this model was failed because of scientist were not directly connected with end of users. This situation originate to the demand model or induced innovation model where different interest groups and the state have often interfered to create both a supply and demand for the agriculture innovation. Thus, in this sense this interaction and collaboration for knowledge takes shape in triangular shown in figureno.3.

Figure: 3. Interaction and Collaboration for Knowledge Generation and Commercialization



Source: Authors, 2016

Basically, in this figure farmers play a major role because of creating demand for technology and extension and on the other hand, scientist and extension educators create supply of technology. Perhaps, each groups have an own perspective for research. For instance, a farmer would like adopt lower production benefit technology, Agribusiness may be would like to use of more fertilizer or those technology which gives more benefit, Government agencies may be want new seeds or techniques which secure the food security and maintain the environment. Thus, it is complexity of the different groups where come on the point for negotiation to develop such type of technology which create benefit to all.

1. Role of organization as Extensional Support to the farmers

The Agricultural Technology Management Agency play role as extensional provider at the local level. It has registered under the Societies Registration Act of 1860. It is an independent organization which has considerable operational flexibility such that it can receive and distribute government funds, enter into contracts, maintain revolving funds, collect fees and charge for services. In broadly it can be said that, it operates under the direction and guidance of a Governing Board (GB) which determines program priorities and assesses program impacts. It is controlled by the Project Director or PD under the NATP, and reports directly to the GB as Member Secretary. The PD serves as chair of the ATMA Management Committee (AMC), which includes the heads of all line departments and the heads of research organizations within the district, including the Krishi Vigyan Kendra (KVK) and Zonal Research Station (ZRS). Most of the districts have a KVK; therefore, this multidisciplinary ***Farm Science Center*** which, plays a critical role in both on-farm research, and training farmers in new production and value-added processing technologies (Singh, et.al. 2009). ATMA introduced various types of seed (shown in Table 1. and 2.) for cultivation of rice-wheat to the farmers. It may be considered a good effort in right direction but proper monitoring of this scheme could have made this effort more useful. In 2011 also, a large quantum of ***Daincha*** seeds for green manure, and hybrid rice seeds have been distributed among farmers but desired result may not be obtained due to poor monitoring of the scheme. Seed replacement rates of rice and wheat increased from less than 10 per cent in 2001-05 to 31% and 29%, respectively in 2010-11 (GoB, 2016).

Table: 1. Types of Seeds Introduced by ATMA for Rice Cultivation in Bihar

Types of land	Types	Period (in days)	Production Capacity	Time of sow seed
Upper layer	Turenta	70-80	20-30	June to august
	Hera	70-80	20-30	5 June to august
	Rashi	115-120	35-40	15 June to 15 July
	Pusha2-21	110-115	30-35	15 June to 15 July
	Saket-4	115-120	35-40	15 June to 15 July
	I.R.-36	120-125	35-40	15 June to 15 July
	Virsha paddy-1	100-110	25-30	15 June to 15 July
	Virsha paddy-2	100-110	25-30	15 June to 15 July
Middle layer	Ratna	120-125	35-50	2nd week of June
	Sita	130-135	40-45	June mid July
	Rajender 201	130-135	40-45	June mid July
	Sujata	130-135	40-45	June mid July
Medium niche (water can stay 30 cm)	Kanak	140-145	45-50	1st week of June
	Mahasuri	145-150	30-35	Last week of June
	Jaishri	145-150	45-50	Last week of June
	Radha	150-155	45-50	Last week of June
	Rajshri	145-150	45-50	Last week of June
	Pankaj	150-155	45-50	Last week of June
Medium niche	Sakuntla	140-145	35-40	2nd week of June and 1st week of July
Down layer	B.R.-8		25-30	1st week of June
	B.R-34	-	25-30	1st week of June and last week of July
	Rajshri	145-150	35-40	1st week of June and last week of July

	Vadhi		30-40	1st week of June and last week of July
Deep water	Sudha		15-25	February to may
Medium deep	Jankari		15-25	February to may
Very deep (More from 2m)	T.C.a.-176		15-25	February to may
	Sughanda	-	25-30	June to July
	Kamani(B.R.-9)			
	Pusha basmati	130-135	30-35	2nd week of June
	Kustari	130-135	30-35	2nd week of June

Source: Compiled by Author; ATMA 2016

Table: 2. Types of Seeds Introduced by ATMA for Wheat Cultivation in Bihar

Sl.no	Hybrid types	Period of crops (in days)	Production capacity
1	H.D 2733	130-135	55-60
2	H.P.1731(rajlakshmi)	125-130	45-50
3	H.P1761(jagdish)	125-130	45-50
4	H.U.W.468	125-130	45-50
5	P.B.W.443	120-125	45-50
6	P.B.W343	130-135	50-55
7	N.W.1012	125-130	45-50
8	K.9107	125-130	40-45
9	H.D.28249(purva)	125-130	55-60
10	H.P.1633(sonali)	105-110	30-35
11	H.P.1744(rajeshwari)	105-110	35-40
12	H.D.2643(ganga)	105-110	35-40
13	P.B.W.373	110-115	35-40
14	N.W.1014	110-115	35-40
15	H.W.2045	105-110	35-40
16	N.W.2036	110-115	35-40
17	H.U.W.234	105-110	30-35
18	D.B.W.14	110-115	35-40
19	H.D.2285	85-90	20-22
20	H.D.2307	85-90	20-22
21	H.D.2402	85-90	20-22
22	C.306	135-140	25-30
23	K.8027	135-140	25-30
24	H.P.1493	135-140	25-30
25	M.A.C.AC.6145	135-140	25-30
26	H.D.r.77	100	22-25
27	K.8962	110	26-30

Source: Compiled by Author; ATMA 2016

2. Role of University

In the second sphere, the role played by university for the agriculture research and development. Edquist (2005) argued that, Universities are one of the major elements in innovation systems for the knowledge production and product development. There are many studies on innovation which shows the importance of universities and their interaction between big firms, universities and other research organization. Although, on the other side universities also connect with societies in which they operate on their different perspective. It also plays a role as a mediators and translators in collaboration and partnership (Hansen and Lehmann, 2006). With this sense, in context of Bihar, *Kisan Vikas Kendra* is run by agriculture university where directly links with farmers or a group of community. Broadly, there are two agriculture university in Bihar namely, Bihar Agriculture University, (BAU)

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and Rajendra Agriculture University (RAU). It works as a knowledge sharing and to solve the problem of farmer's issue related to farming technique.

3. Role of Local Seed Seller

In terms of marketing, the local seed seller play role for the diffusion of seed varieties. In the context of this study, the overarching category of public is narrowed down to farmers. Farmers on their own are not a uniform category as it might appear to be, since farmers vary from each other in various ways. Not only do they differ on the basis of age, land holding, social hierarchy (and thus, access to resources), education and gender (not to leave out caste which is also important in an Indian context), but also in the manner in which they approach science and technology.

CONSEQUENCES OF AGRICULTURE INNOVATION ON RICE-WHEAT PRODUCTION IN BIHAR

Agriculture innovation in terms of Seeds, fertilizers and irrigation are the major inputs in agricultural production. A sustained increase in agriculture production and productivity is dependent on continuous development of innovation to the farmers. Mechanization and agrochemicals are the other major inputs. The spread in modern input application has been much slower in the state as compared to other states in the country. The conventional approach concentrates on the farmer and his farm operation as the units of analysis, and assumes that the practice recommended by agricultural scientists constitutes an adequate universe of innovations.

1. SEEDS

Seed is known for increasing agricultural production, good quality seeds alone can increase 30 per cent of agricultural production. In Bihar, high yielding varieties cover 65 per cent area under rice, 95 per cent area under wheat but farmers are using poor quality seeds because most of these seeds are home grown. The State Government has been making sincere efforts to popularise and make available quality seeds to farmers since 2009. Under Chief Minister *Beej Vistar Yojana*, rice and wheat foundation seeds were provided to farmers for production of quality seeds but only 25 per cent of produced rice and 31 per cent of produced wheat seeds could be utilised as seed in the next season (Singh, 2012).

Proper application of HYV seeds and maintaining desired Seed Replacement Rate (SRR) are important determinants of productivity. Since there is dearth of firms for the supply or certified seeds, the Seed Replacement Ratios (SRR) is often low in Bihar. The major initiatives of the present government in providing quality seed are Chief Ministers' Crash Seed Programme, Seed Village Programme (*Beej Gram Yojana*), provision of subsidy for the production and use of certified seeds, revival of previously dormant *Bihar Rajya Beej Nigam* (BRBN), strengthening of Bihar seed certification agency, and multiplication of seeds by state farms. Recently, the scheme called *'Mukhyamantri Tibra Beej Vishtar Karyakram'* has helped farmers immensely for hybrid rice cultivation. These all seeds distributed through ATMA programme. Table 2.5.1.3. reveals that SRR has exceeded 33 percent for all major crops in 2011-12.

Table: 3. Requirement of Certified Seeds and Seed Replacement Rate (SRR) for Rice-Wheat Crops in Bihar (2009-10 to 2011-12)

(Requirement and supply in '000 qntl. /SRR in percentage)

Crops	2009-10			2010-11			2011-12		
	Requirement	Supply	SRR	Requirement	Supply	SRR	Requirement	Supply	SRR
Rice	436.6	373	26.4	423.1	232.7	31	493.6	349.1	38
Wheat	600	580.7	25.3	630	672.5	29.2	840	783.2	34.8

Source: Department of Agriculture, GOB

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It can see from the table that SRR has increased from 26.0 percent in 2009-10 to 38.0 percent in 2011-12 for rice. An increase can also be seen for SRR for wheat increased from 25.3 percent in 2009-10 to 34.8 percent in 2011-12. Such substitution of old and local varieties of seed with the recently evolved seeds would have a long time impact on the productivity of rice and wheat in the state.

2. IRRIGATION

Irrigation is one of the critical inputs for increasing rice-wheat production. Singh 2012 noted that, In Bihar, about 54 percent area is irrigated which is much higher than the corresponding national average 42 percent. Average gross irrigated area increased from 47 lakh hectares in 2001-06 to 47.98 lakh hectares in 2006-11 but it is mainly through private tube wells. State Government has installed few tube wells and handed over their management to individual (officially to committee) but these tube wells are not functioning well in the interest of farming community. State government provided assistance to install 21,036 pump sets in 2009-10 but it had almost insignificant impact on increasing tube well irrigated area which increased by only four thousand hectares from 27.22 lakh hectares in 2008-09 to 27.26 lakh hectares in 2009-10 (Singh, 2012). Hence, almost identical number of tube wells might have turned non-functional during the year. However, eleven medium and major irrigation projects for increasing irrigated area are under progress in Eleventh Five Year Plan. About 55 percent of ground water is still to be exploited for irrigation purposes. Hence, there is vast potential for increasing irrigated area in Bihar which will help increasing agricultural production for not only consumption but for raw materials for agro-industry.

3. FERTILIZER

Fertilizer is known as an essential input for increasing crop production. A spectacular increase in fertilizer consumption has been observed during green revolution period in the country in general and Bihar in particular. In Bihar, per hectare fertilizer (NPK) consumption was only 4 kilograms in early sixties which increased to 19 kilograms in 1975-76 and further increased to about 200 kilograms in 2010-11. Per hectare fertilizer consumption in crop production increased by more than two fold during last 10 years from about 80 kilograms in 2000-01 to 200 kilograms in 2010-11(Singh, 2012). However, increasing use of chemical fertilizers accompanied with declining use of manure would be likely to have adverse effects on soil health. Deficiency of micronutrients (zinc, boron and sulphur) has been reported from different parts of state but there is no facility where farmers could get their soil tested to know the extent of micro-nutrient deficiency. Government of Bihar made unsuccessful efforts to provide soil test (NPK) facility to farmers but a few farmers could get the report of soil test. Recently, Department of Agriculture started a campaign for popularizing organic farming in the state. In this context it is worth pointing out that the rice production in water logged area of north Bihar was totally chemical free up to mid-nineties. It is also a difficult task for farmers to arrange organic/bio-fertilizers for huge area under food grains. Organic certification is another difficult and costly activity, particularly for small and marginal farmers, who constitute more than 90 per cent of farm households and own about 50 per cent of cultivated area in Bihar.

4. PRODUCTION SCENARIO OF RICE -WHEAT

The fertility of soil and the natural endowment of abundant ground water resources enable the farmers of Bihar to produce a variety of crops, both food and non-food. The table indicates that the total production of rice and wheat. It also compares with India's total production. Analysis of food grain production during last 10 years revealed that average area under food grain declined from about 68 lakh hectares during 2001-06 to 67 lakh hectares during 2006-11, but their share in gross cropped area remained constant at 88 per cent during the period (Singh, 2012). Despite decline in area under food grain and unfavourable weather (flood in 2007 & 2008 and drought in 2009 & 2010) food grain production increased by about 18 per cent during last five years over the preceding five years (2001-06). There was spectacular increase in food grain productivity from 1176 kg per hectare during 2001-06 to 1743 Kg per hectare during 2006-11(GoB, 2016).

Table: 4. Percentage of Contribution of Rice in National production during year 2000-12

Year	Bihar	India	Percentage of sharing in Total production
2000-01	54.42	848.5	6.41
2001-02	52.02	931.9	5.58
2002-03	50.85	716.8	7.09
2003-04	54.47	883.9	6.16
2004-05	24.72	829.9	2.97
2005-06	34.95	916.5	3.81
2006-07	49.89	933.5	5.35
2007-08	44.18	966.9	4.57
2008-09	55.9	991.8	5.64
2009-10	35.95	890.9	4.1
2010-11	33.2	959.79	3.56
2011-12	72.01	1053.1	6.87

Source: Estimated by Author, 2016; Reserve Bank of India

The table denotes that the quantum jump in production figure is due to the high rise in rice production in 2011-12, as compared to last years. Because of the use of new SRI technique and use of newer agricultural implements there was enormous rise in rice production. The level of rice production prior to 2010-11 was not consistent and there was much variation in the production level over the years. This is due to the fact that around 50 percent of net sown areas are bereft of irrigation and dependent on rain. The average production figure was around 50 lakh tonnes during the period from 2007-08 to 2010-11. The table below indicates the sharing of rice production by Bihar in percentage. Bihar is potentially an important rice growing state that average contributes more than 5 % towards national production. But in spite of all natural resources the production is very low in comparison with other states. The major constraints in production are low seed replacement rates, late sowing, low farm mechanization and foliar blight disease.

Table: 5. Percentage of Contribution of Wheat in National production during year 2000-12

Year	Bihar	India	Percentage of sharing in Total production
2000-01	44.38	695.8	6.37
2001-02	43.91	726.7	6.04
2002-03	40.4	656.7	6.15
2003-04	36.88	720.5	5.11

2004-05	32.63	685.6	4.75
2005-06	32.39	692.7	4.67
2006-07	39.11	757.2	5.66
2007-08	44.5	784.9	5.47
2008-09	44.1	806.1	6.14
2009-10	49.74	808.9	4.02
2010-11	46.7	858.1	5.44
2011-12	47.87	948.8	5.04

Source: Estimated by Author, 2016; Reserve Bank of India

Similarly, the production level of wheat has also recorded a positive trend. The average annual wheat production was around 40-45 lakh tonnes from 2007-08 to 2009-10. Thereafter, the production of wheat rose to50.94 lakh tones in 2010-11 and during the next year (2011-12), it further rose to 65.31 lakh tonnes. This is due to introduction of zero tillage method and use of SRI technique. The annual growth rate of wheat production was 6.6 percent during the period of 2007-08 and 2011-12.

CONCLUSION

At the heart of the innovation systems concept is the question of which actors are involved, the nature and intensity of their interaction, and the role that they play in the system. Understanding the diversity of actors is particularly important in relation to recent developments in the agricultural sector. Private sector actors and other actors outside government are becoming important players, and public research organizations must reconfigure their roles and relationships in light of these developments. From an innovative systems perspective, it is essential not only to identify links or missing links but to unpack these links and see which are working well. For example, the seeds of rice-wheat provided by ATMA to farmers for cultivation – is that connection sufficient to continuously improve quality and innovate with new products? Do the scientists listen to the problems of the farmers or just lecture them? Does their advice have any value? How could relationships be improved? These things need to be consider in research.

Although staple rice-wheat production will remain very important, an exciting agricultural trend in many countries is the rapid emergence of many new production-to-consumption systems. The introduction of new agricultural activities is highly volatile, but frequently they provide considerable income and employment opportunities. Their development can make a large contribution to rural-based sustainable development. Many of these new agricultural activities and products emerge when private entrepreneurs respond to new market opportunities. Often the production and marketing efforts for these new products are quite sophisticated. Though the overall value of new agricultural activities can be considerable, the large number of products makes it impossible to develop national research programs for each one, except perhaps in Bihar due to lack of resource. Consequently, State must develop new approaches to support innovation in these knowledge-intensive activities.

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