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Triple Helix for Communication of Innovations: Case Study of Bt Cotton in India

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Abstract: In the past few decades regulation of biotechnology has posed essential challenges towards the imagination of technoscientific innovations in the world. The case becomes increasingly urgent in the regulation of agribiotechnology at the grassroots level, and is attributed more often to the lack of proper information. The Triple Helix of university-industry-government is seen as a key to innovation and the socio-economic development in knowledge societies. A lot of Triple Helix literature emphasises on knowledge creation, exchange and use at research and development level, with very little focus on the diffusion and use of that knowledge. With the increasing trends towards knowledge capitalisation and use in sophisticated technologies, it has been observed that communication of innovations with the end users is essential to maximise returns. This article is an attempt to understand the local level interaction among the actors of the Triple Helix spiral as well as the 'public'. The article argues that a proper mechanism to channel this interaction may yield useful implications for communication of innovations at the local level.

Key words: Agriculture innovation system, Genetically Modified (GM) crops, Triple Helix, Bt cotton, information and awareness.

Introduction

The agriculture sector provides an excellent example of the transitions from traditional to hybrid technology arrangements, blending the modern with the traditional in hitherto unknown ways. Having a very crucial place in Indian economy, there is a continuous concern and emphasis in the policy circles to improve the efficiency of agriculture through technological innovations. Since independence, the setting up of agricultural research institutes,

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universities, extension departments, green revolution technologies and recent thrust for GM technologies show a continuous effort in this direction. Despite the efforts, the gains from the agriculture sector are not very impressive. Among other technical, economic and environmental factors, lack of communication between the actors producing the technology and the actors using it is an important factor contributing to improper diffusion, use and regulation and hampering the returns of the technological innovations as expected. The regulation of agribiotechnology is a major challenge in the Indian scientific as well as political discourses.

It has been repeatedly prompted in the policy announcements to promote agricultural innovations as a condensed effort like other industrial sectors such as ICTs or pharmaceuticals. Banking on this, a blending of insights from the agricultural and industrial innovation literature has resulted in the concept of agricultural innovation systems (AIS) (Hall *et al.* 2001; Klerkx *et al.* 2010; Röling 2009). It has been argued recently that in place of the usual actors of the government machinery which were prominent in the green revolution era, the Triple Helix of university-government-industry (Etzkowitz and Leydesdorff 2011; Etzkowitz 2001) may play a crucial role in the growth and development of AIS. In Triple Helix literature, there is much emphasis on knowledge creation, exchange and use at the research and development level, with very little focus at 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). The present article is an attempt to add to this dimension.

The article tries to understand the dynamics of Triple Helix at the local level in India, with an emphasis on communications of innovations. First, it tries to situate the understanding of the Triple Helix in the theoretical arena of knowledge production and use. Then it locates the relevance of the Triple Helix in the context of AIS. The regulation of agribiotechnology at the grassroots level is essentially problematic due to uneven and multiple sources of information transfer, resulting in confusion and lack of proper information to the end users. The transition of world economies from industrial to knowledge societies places special emphasis on the relation

between the Triple Helix and the communication of innovation with the end users, in this case the farmers.[1] In the next section, drawing from the insights of the fieldwork and interviews with a variety of actors in AIS, the study focuses on the empirical significance of the Triple Helix in a specific local setting for communication of innovations. The study concludes with policy suggestions and implications for future research.

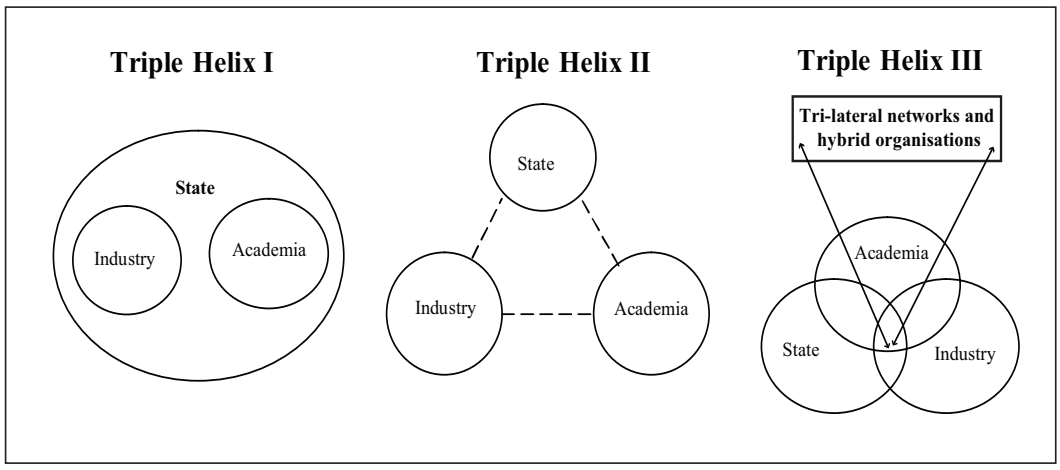
Situating the Triple Helix

The nature of knowledge production, distribution and use is in transition. The rise of biotechnology, information and communication technologies, nanotechnology, system and computational biology and new materials research spans existing delineations (e.g., disciplinary) within the scientific community. The linear model of innovation explained in terms of 'market push' or 'technology pull' does not hold in such a situation (Etzkowitz and Leydesdroff 2000, 2003). Science and technology policies need to move towards a 'bottom-up' and 'network' approach in order to address these developments. As a response to the strictly economic interpretations of science and technology, where innovation was simply a side tool, various scholarly initiatives have helped in shaping the concepts and field of innovation studies. Evolutionary economists have stressed the rigidities created by trajectories within the economy (Nelson 1993; Dosi 1982). Policy analysts have emphasised the interactive and feedback terms in the so-called chain-linked models of innovation (Leydesdroff 2011; Kline and Rosenberg 1986). Science, Technology and Society (STS) researchers, introduced mode 2 (Gibbons et al. 1994), network approaches (Callon 1998), and post-normal science (Functowicz and Ravetz 1993) in order to understand, explain and perhaps extrapolate the transition of mode 1 to mode 2 and linear to non-linear models. These initiatives established the importance of innovation as an important process, and the reason behind economic growth. Within innovation studies, a focus on the operation of innovation systems in terms of their internal dynamics (interaction, exchange and learning) has led to the Triple Helix model (Leydesdorff and Van den Besselaar 1998).

The overlay of reflexive communications between universities, industries, and governmental agencies are the central theme of the Triple Helix. Basic research is linked to utilisation through a series of intermediate processes such as government initiated programmes that facilitate university-

industry interaction (Van Lente and Hassels 2008). In order to explain the evolution of innovation systems, and the current conflict regarding which path should be taken in university-industry relations, Etzkowitz and Leydesdorff (2000) proposed three ways through which various institutional arrangements of university-industry-government can be understood. 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. In one form or another, most countries and regions are presently trying to attain some form of the Triple Helix III configuration.

The objective of a Triple Helix III arrangement is to realise an innovative environment consisting of university spin-off firms, tri-lateral initiatives for knowledge-based economic development, and strategic alliances among firms (both large and small), operating in different areas, and with different levels of technology, government laboratories, and academic research groups (Etzkowitz and Leydesdorff 2000).



Source: Etzkowitz and Leydesdorff (2000).

Although it has been argued that the most sought after model to enhance the innovative environment for a country is Triple Helix III, model I and II are prominent in different contexts and at different stages of innovation in National Innovation Systems. The extent to which these models can be

effectuated in a knowledge economy is a challenging task in front of nation states, as creating and fostering effective linkages amongst heterogeneous sets of actors (i.e., the formation of adequate innovation configurations) is often hindered by different technological, social, economic and cultural factors (Hall 2006, 2008). Such factors include, for example, different incentive systems for public and private actors and differences between local indigenous knowledge systems and formal scientific knowledge systems. In India, there is a continuous attempt to move towards Triple Helix III and attract private investments in research, development and innovation.[2] This article attempts to understand the interaction between university-industry-government in AIS for communication of agribiotechnology innovations (specifically Bt Cotton; since it is the only commercialised genetically modified crop in India and has a local outreach) in a regional context.

Agriculture Innovation System

A traditional way of looking at innovation systems in the context of agriculture is the Transfer of Technology model (Briggs 1990 as cited in Hall 2008), with a division of labour between 'knowledge search' and 'knowledge use'. Knowledge use, according to this model, generally refers to using knowledge for technology creation, which once created will diffuse on its own in society. The traditional Triple Helix model roughly relies on this model, with maximum emphasis on knowledge search or knowledge creation. There is a growing concern about the appropriateness of traditional agricultural research arrangements and the apparent inability of these to adapt to the changing agricultural scenario (Hall 2008).

In many senses the contemporary scenario is markedly different to earlier eras. Unlike the Green Revolution, which was the product of technological innovation in the international public domain supported by non-profit national and international agricultural research institutions, universities and multilateral aid agencies, the Gene Revolution is being shaped by dominant forces in the international private domain where the technological innovation process is determined, largely, by private capital and its quest for profit, market share and shareholder value (Parayil 2003). In this emerging formation, knowledge has become the primary wealth and different nation states are in a rush to capture it through mechanisms such as patents and intellectual property rights (Jasanoff 2005). Owing to

changes in the patterns of knowledge production, the use and dissemination of knowledge to the end user has become a complex task. The private sector has emerged as a much more important player, in terms of research, product and service delivery. The role of the State has been altered, often radically and new trends in governance are impacting many areas of research and development practice. Institutional structure has changed enabling a greater degree of proprietary ownership of knowledge and materials, new patterns of partnership between scientific disciplines and between public and private sectors (Hall 2006).

According to the World Bank (2007), AIS can be seen as 'a network of organizations, enterprises and individuals focused on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge'. Beyond researchers, extension agents and farmers, AIS consists of all types of public, private and civil society actors, such as inputs and processing industry actors, agricultural traders, retailers, policymakers, consumers and NGOs (Klerkx and Leeuwis 2009). For specific innovation processes, flexible and dynamic innovation networks are formed from the network of actors present in national AIS or across different national AIS (Klerkx and Leeuwis 2009). Here, it could be argued that the Triple Helix forms a significant part of the whole set of networks and interactions existing in AIS. The intensity of Triple Helix interaction from research and development level to the field level (for communicating innovations to the village 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).

Central to the notion of an agricultural system of innovation (and also to this artilce) is the degree of substantive interconnection in terms of institutions and information, among the actors of the system. Here, it is important to discriminate between 'knowledge' and 'information'.

Information only becomes useful knowledge if the receiver perceives it to be so (Clark 2002). Thus, unlike economic commodity flows, information flows only take on value where there is a deep and shared understanding of what that information means on the part of both the sender and the recipient. From an organisational standpoint the capacity to convert information into useful knowledge, and hence technical change is, therefore, contingent on internal organisational conditions and the relationship of the organisation to the receiver adding to their judgment of trust and reliability (Clark 2002).

In the context of agriculture, this task was traditionally assigned to the agriculture extension system (AES). Over the years, it has been realised that the top down and centralised programmes are insufficient and inefficient in catering to the diverse information needs of the farmers. In the 1990s, discussion on Agricultural Knowledge and Information Systems (AKIS) brought into focus the importance of a wider set of information sources and the value of creating systems that assisted in the generation and dissemination of knowledge (Röling 1994). AKIS highlighted the need for strengthening the capacity of the different systems (mainly research, extension and education) and the linkage mechanisms among these systems. This shifted the focus of agricultural extension to decentralised, participatory, and demand-driven approaches (Birner and Anderson 2007; Sulaiman and Hall 2008; Swanson 2006).

However, the changes are more prevalent in developed countries with contract farming becoming more of a norm; and developing countries are still catching up with the new and extended role of AES. In the AIS approach, new emphasis is given to the concept of an innovation intermediary or innovation broker (Klerkx and Leeuwis 2008). 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). 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.

In India, a large number of organisations have emerged post Green Revolution, 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 such as Agriclinics and Agribuisness Centres and ICT mediated services (Rajasthan State Agriculture Department Report 2011). Agriclinics and agribusiness centers (ACABC) are public-private initiatives that provide agricultural advisory services to farmers through technically trained agricultural graduates at the village level, known as 'agripreneurs'; in this way providing employment to agriculture graduates and information to farmers. The central and some state governments have adopted the approach and added their own additional subsidies for agriclinic implementation (Global AgriSystem 2008). From a Triple Helix point of view, these intermediaries could be looked upon as the interface organisations of the university-industry-government linkages. However, as mentioned earlier, the extent to which these linkages exist varies, depending on individual organisations and their operative environments. A lack of participation by agribusiness companies in the implementation of the scheme, unattractive credit packages for agripreneurs starting agriventures, and complicated procedures for obtaining a license for the sale of inputs (Working Group on Agricultural Extension 2007) are the barriers which account for the very limited number of such initiatives in Rajasthan, with none having been studied in the field area. 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. A brief overview of the constitution and perception of 'public' in the literature in general and for the current context in particular is thus in order.

Triple Helix and the Idea of Public Participation

In recent years, owing to the shortcomings of the top down approaches to policy as well as controversies surrounding issues of expert judgment in areas such as climate change, nuclear debates and GM crops, an urgency has been felt – both at national and international level – to 'educate' 'involve' and 'engage' the 'public'.[3] The 'public' nevertheless remains an ambiguous overarching domain from which categories are extracted as per

the requirements of the exercise in consideration. Many such categories are frequently observed in STS (Science and Technology Studies) such as 'layperson' in relation to experts (Collins and Evans 2002) and 'scientific citizen' in response to nation states (Irwin 2001). Michael (2003) defines 'public' in relation to science; 'Public in General' in relation to 'Science in General', for example in the National Science Foundation's science education programmes and 'Public in Particular' in relation to 'Science in Particular', for example public response and activism towards particular issues such as GM crops and AIDS. Jasanoff (2005) identifies the national dynamics of public knowledge making as civic epistemology. In this 'public' is constituted by (and also constitutes) the issue in question at the site of knowledge making. The site of knowledge making could be law, policy document, court proceedings, decision making bodies, etc.

In the context of GM crops in India at the international, national, and regional level, the conception of 'public' as a well defined and organised category is difficult to sustain (Ferrati 2007; Jasanoff 2005; Levidow 2009; Leydesdorff and Etzkowitz 2003; Leydesdroff 2011). Since the idea of public is quietly absent in the realms of the Triple Helix, it calls for a concern on the reflexivity of the concept as well as its robustness in terms of extension beyond laboratories and research units. In this regard, many studies advocate the involvement of actors other than university-government-industry in the helix of innovation. Many such suggestions include the quadruple helix of innovation (Carayannis and Campbell 2010; Mehta 2002), the co-production of knowledge (Nowotny *et al.* 2001), twin-Triple Helix (Etzkowitz and Zhou 2006), and the n-tuple helix (Leydesdorff 2011).

Attempts to generalise the 'public' as a structured entity in the form of the fourth helix would narrow the public into another private sphere (as is sometimes done when NGOs are assumed to represent the 'public'), rather than seeing it as the foundation of the enterprise of innovation (Leydesdorff and Etzkowitz 2003). This not only implies a basic proposition that the 'public' is the very substrate of innovation but also that the composition and structure of the public is very dynamic and fluid. Thus, the conception of 'public' and its interaction and linkages to the individual helices as well as the Triple Helix as a whole need extensive context specific research for communication of innovations to the grassroots level.

In the context of this study, the overarching category of 'public' is narrowed down to farmers. 'Farmers' in itself is 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 its artifacts. Farmers are also dynamic in the sense that many of them are innovators on their own and thus they also serve as producers of knowledge (by experimenting at the field level) rather than only consuming it. This is an important point to consider in the context of the Triple Helix, because it gives insight into whose 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.

Methodology and Sample Description

The study is based on both primary and secondary sources. Primary sources involve several rounds of interviews with various stakeholders for agriculture biotechnology. Scientists from government departments such as Indian Agriculture Research Institute, New Delhi; Research and Development Section, Rajasthan State Agriculture Department (*Pant Krishi Bhawan*), Jaipur, Rajasthan; and scientists from academic institutions such as Agricultural University (Department of Biotechnology and Department of Entomology and Agriculture extension), Udaipur were interviewed. Interviews were also conducted with industry players such as seed company representatives from five major companies selling Bt cotton seeds in Rajasthan for the past five years; and other industry representatives such as salespersons selling non-GM hybrid seeds and tissue cultured plants. Agriculture officers from various departments such as Marketing, Seeds, Training and Extension, Research Division, Quality Control in *Pant Krishi Bhawan*, Jaipur (Rajasthan), were also interviewed. Members of two leading NGOs were also interviewed.

The major cotton growing areas of Rajasthan are Ganganagar, Hanumangarh, and Alwar districts. Cotton is also grown in regions of Bhilwara, Banswara, Chittorgarh, Kota and Udaipur districts. In regions of

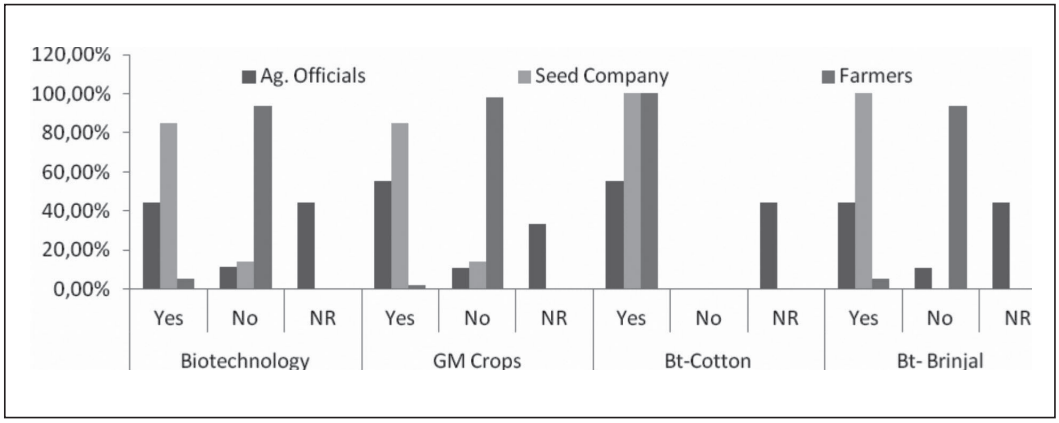
Udaipur, Chittorgarh and Rajsamand, Bt-cotton cultivation is picking up at a high rate. A total number of 50 farmers from seven villages in Rajsamand district were interviewed. The interviews were carried out in the semi-structured format along with audio recordings.

Findings

Bt-cotton was approved for commercial cultivation in Rajasthan (India) in 2005, three years after its approval in other parts of the country. By the time of its official approval in Rajasthan, it was already cultivated there, obtained by illegal means. Thus, unlike Green Revolution technology, GM technology in this region was not introduced alongside a formal information and awareness mechanism channelled by public institutions. With the administrative approval of commercialisation of Bt cotton, many international and national private seed companies began to enter the regional seed market. This was done through seeds salespersons, in-charge of particular regions, contacting the local seed sellers as well as farmers. These seed salespersons provided information about their seeds to the farmers as well as the local seed shopkeepers as an incentive to buy their brand. In this whole chain of events there was no involvement or interaction of the industry actors with the government or academia. Thus, at a time when most of the cotton growing regions in India like Andhra Pradesh, Gujarat, Karnataka and Maharashtra have already attracted the attention of media, NGOs, academicians as well as politicians, in Rajasthan, the specificities were not much recognised. Figure 1 discusses the familiarity of various actors in the information network at the local level for some of the much-used terms in international and national media and political discourses.

One of the important observations regarding Figure 1 is that every respondent from each category has heard of Bt cotton. This is an indication of the fact that Bt cotton has become a phenomenon irrespective of international and local differences. Both the actors – agriculture officials and seed company executives – gave mixed responses for all the other categories but none of the farmers had ever heard of the terms ‘biotechnology’, ‘GM crops’ or ‘Bt Brinjal’. Most of the farmers associate Bt cotton with different meanings. Among many popular understandings of ‘Bt cotton’ were ‘a new brand name’ and ‘a new variety of cotton’, although most farmers knew that it is pest resistant.

Figure 1: Familiarity of Actors with the Commonly Used Terms in Agribiotechnology Discourse



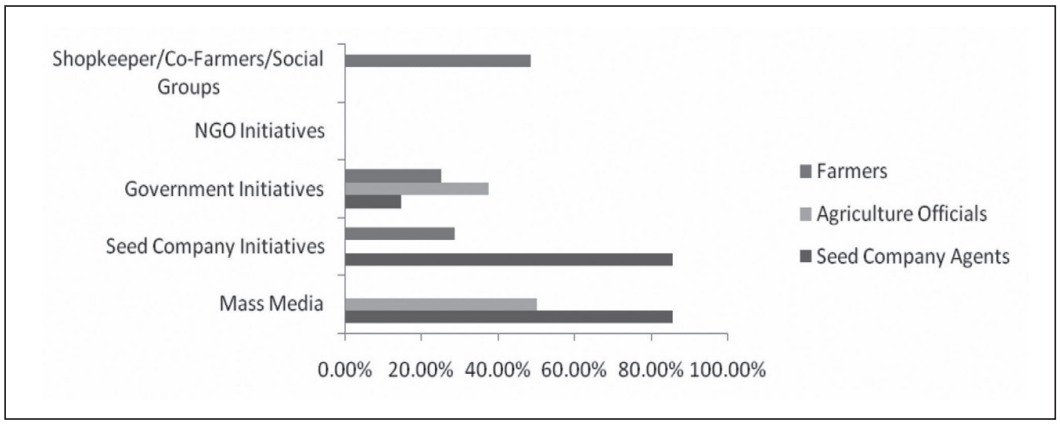
Source: Field Work.

Some farmers emphasised other characteristics of Bt cotton such as that it is high yielding, has a smaller life cycle than non-Bt cotton, is of good quality and consumes less water. The reasons behind the mechanism through which Bt cotton is helpful in resisting pests also varied among farmers. Despite differences in the understanding the meaning of Bt cotton and its properties, most of the farmers had knowledge about the methods of sowing, watering, and planting Bt crops as well as *refugia* (a non-Bt cotton belt grown along the perimeter of the field of Bt cotton). Many farmers reported not planting *refugia*. Their reasons for so doing were reported to be that 'it is a hindrance in gaining high yields' and 'it promotes infestation by pests'.[4] These observations bring us to crucial assessments about the information and knowledge dynamics related to agribiotechnology at the farmers' level. As discussed in previous sections, information becomes knowledge when there is a shared understanding between the information providers and the recipients. This shared understanding can be attributed to mutual communication, information symmetry, and trust in the organisations. In the field area, university scientists, seed company executives and government extension agents claim to communicate with the farmers on a regular basis but this claim is not reinforced by farmers. Mutual communication between different actors of the Triple Helix appears to be completely lacking. Information provided to the farmers is asymmetrical in many aspects. For example, a lot of emphasis is given to telling them how to grow Bt cotton rather than its other aspects such as social and ethical implications and

regulatory aspects of agribiotechnology. Not only the farmers, but also many seed company executives and agricultural officers were unaware of the regulatory system for agribiotechnology in India.[5] This information too is able to reach only some farmers through the actors of Triple Helix. The language in which this information is provided is too technical and on repetitive questioning by some curious farmers the technical details are omitted rather than explained.

Figure 2 indicates the medium of information delivery to the farmers as well as the actors of the Triple Helix, who are in direct contact with the farmers. An insight into their sources of information will provide an understanding about the level of efforts and seriousness with which research is conducted at the head of the Triple Helix spiral as compared to the level of efforts put in to communicate these innovations to the bottom of the spiral and then to society.

Figure 2: Sources of Information



Source: Field Work.

A majority of seed company executives (85.6 per cent) and agricultural officers (50 per cent) received information about Bt cotton through mass media. The above finding points to the fact that there is a lack of initiatives by the industry as well as government and academia to orient and train the agricultural extension agents and industry executives who will have direct or indirect interaction (through seed shopkeepers) with the farmers in the information provision for new technologies such as Bt cotton.

This also reaffirms the claim that media plays an important role in providing information to the people, even though it could also present a

polarised view about a particular kind of technology. This will depend upon whose views are being presented through popular media.

None of the farmers in the sample reported having information from mass media sources such as radio, television and newspapers. This could be attributed to the fact that at the village level farmers are unable to connect to these sources as an authentic way of gaining information related to farming practices. Most of the farmers use these sources for recreational purposes.[6] For farmers, majority of information (48.6 per cent) is obtained through the local seed shop owners and communication with other farmers who are using the technology. As argued earlier, local seed sellers serve as an important node as innovation intermediaries for the communication of innovations. The local seed sellers gain the trust of farmers as a legitimate source of information as they become embedded into the cultural context and social relations that the local community approves of. This aspect does not hold for the government extension agents (who get transferred every few years) and seed company executives (who are quite external to the social milieu).

In the context of GM crops it has been observed that the government is not capable of tapping the potential of the large agricultural extension system machinery, which was set up and was useful during the Green Revolution. The Agricultural Technology Management Agency (ATMA) programme was initiated by the central government in 2005-06 as a support to the State Extension Programmes for Extension Reforms (SSEPER). This scheme represents a platform for integrating extension programmes across departments, linking research and extension units and inviting farmer participation in decision making (Swanson 2006). In Rajasthan, ATMA initiatives mainly focus on poultry, foliage, and irrigation extension with not a single programme focusing on Bt cotton (Rajasthan State Agriculture Department Report 2011). As reported by the officials in the training and extension department, there is absence of training programmes for Bt cotton, both for farmers and extension workers. A proposition for government controlled extension for innovations (such as Bt cotton) which, from their inception are privately owned, is essentially unrealistic. ATMA has also proved incapable of fostering viable links between ATMA bodies and the ICAR extension unit, the district-level *Krishi Vigyan Kendra* (KVK), and there is a lack of coordination between the scientists of agricultural universities, government system as well as the private players.

According to 25.2 per cent farmers, Government extension workers or *gram saathi* also provided information about Bt cotton. It was observed during the interviews that those farmers who reported that they came to know about Bt cotton through *gram saathi* were connected to the government system in some way. Either they were retired government teachers, big land owners, member of the block level organisation or related to the government official. Those farmers who had no connection with this system were found to be generally out of the network of government extension agents. Ironically, the role of university agents such as research scholars and agriculture scientists was not mentioned by any of the respondents as the medium or source of information regarding Bt cotton. Some seed company representatives only mentioned their role as shaping their understanding of agribiotechnology during their education in agricultural sciences.[7] Interviews with agriculture research and extension scientists from the local agricultural university as well as research papers focusing on Bt cotton in the field area suggest that farmers do not consider the rare visits of scholars and scientists as engaging in providing information. Rather, some of the farmers suggested that 'people from university come and ask questions about the methods of planting, watering, and applying pesticides on Bt cotton'.[8] This clearly shows the demarcation of how information is provided and what information is assessed as knowledge by the receiver.

The presence of NGOs is very strongly felt at the international and national level in the agribiotechnology debate. Many times they present a strong alternative for agricultural practices in the context of India. This alternative appeared to be missing for Bt cotton in the field area. None of the respondents registered gaining information from NGO sources. When the district town of these villages is a hub of a number of NGOs working on various issues, their absence for Bt cotton in the field is questionable. On the analysis of some reports obtained from the agriculture department on NGO initiated projects,[9] it was found that there were some farmer schools run by the NGOs in the district region; but none in the field area studied and none stated their motive for Bt cotton. As evident by definition, NGOs do not possess centralised and organised resources like government systems and thus their approach towards the society is very much issue based and limited. Taking this into account, it could be argued that although NGOs have a crucial role in shaping Indian agribiotechnology regulatory discourse,

considering NGOs as the fourth helix, or as sole representative of the 'public' is an easy generalisation.

With more and more farmers adopting Bt cotton every year (James 2010), there is an increasing need for stronger intermediaries that can facilitate information access, symmetry and mechanisms to ensure its recognition as knowledge for diverse farmers. This in itself is a daunting task provided the limited number of workforce available as extension agents in the government machinery, leading to inadequate contact by the services, which need to reach a large and complex farming community. Inappropriate, irrelevant or outdated information is also a key hindrance to farmers' use of extension services. The content of the information provided by agricultural extension approaches and the information farmers need are not in sync with each other. Not only this, the traditionally trained members of the government extension system, with no exposure and training to the modern technological developments (in the absence of such programmes), are incompetent in providing proper information.

Seed company executives were accounted for information provision by 28.8 per cent of farmers. This information is rarely in the form of meetings (where groups of farmers are addressed) and mostly in the form of person to person conversation and pamphlets advertising particular brand of seeds. The complete absence of response from the agricultural officials for information through seed company initiatives shows a lack of interaction between the government actors and the industry agents at the department level. At the field level, the individual involvement of the industry players may provide asymmetrical information (only the benefits and not the risks) skewed towards only certain members of a village community (such as landholders or educated farmers).

Discussion and Conclusion

In terms of interaction between the university-industry-government helices, the Triple Helix I and II model is more prevalent at the local level. Complying with it, the interaction between government and industry can only be seen when tenders are required to be passed for seed sale every year since the state system is unable to provide public supply of seeds for Bt cotton, as happened during the green revolution. This interaction involves a

series of negotiations for the price and quality of seeds (testing seeds for Bt gene at government testing centres). University interaction with government and industry can only be seen for the provision of trained manpower in the form of agriculture graduates and extension workers, who get employed at these organisations. KVKs also function with the interaction of government and university but have a very limited outreach. At some instances, industry provides samples of GM crops to universities for controlled field trials (as reported by scientists and MNC executives during field work 2011). The lack of interaction among the actors in the Triple Helix at the bottom level creates a space for a lot of confusion and misinformation to prevail. This may have implications for the adoption of new technologies, as has happened in many parts of the world (Yamaguchi *et al.* 2003; Zechendorf 1994).

In order to realise the full potential of AIS in relation to advanced technologies, besides having an efficient and interactive R&D system, a strong system for communication of innovation is essential. The study showed that 48.6 per cent of the farmers gained information about Bt cotton through other farmers as well as local seed shopkeepers, while 25.2 per cent from government extension services and 28.8 per cent from industry executives. The inability of farmers to connect to government extension services could be attributed to lack of adequate quantity as well as quality of staff, appropriateness of the information about modern technologies, and lack of modern technology specific training initiatives. Farmers' inability to connect to industry actors could be attributed to a focus on areas with sufficient resources and limited to a few crops and areas where profits can be assured (Sulaiman and Van den Ban 2003). The private sector serves a corporate interest, working with individual farmers, and motivating them individually to purchase company specific products, giving biased information and thus not building social capital (Field work 2011, Glendenning et al. 2010). The role of universities in providing information to the farmers is very limited, with very few KVKs and negligible number of field visits. In such a scenario, a more integrated and interactive approach among the various actors involved in the communication of innovation is required.

The study concludes that the mechanism of communication of innovations at the local level is still following the trends of Triple Helix

I and II with very limited initiatives to foster the interaction between the university, industry and the government. Not only the interaction between each other, but also the interaction and linkages between the organisation and institutions of individual helix are very weak for information regarding modern technologies such as Bt cotton. For example, the study found that there is a lack of shared understanding about Bt cotton cultivation among officials in various state agriculture department such as marketing, training and extension, quality control and seed section. The complete control of Bt cotton in the agriculture department is in the hands of the seed section,[10] with other departments very remotely involved. Similarly, the executives from industry derive their information for modern technology such as Bt cotton from mass media and their academic training, without any training and orientation programmes for them either by industry, university or government. Various initiatives to promote the interaction between university-industry-government are taken by government (ATMA, FFS, Agriclinics and Agribuisness centers) to improve the knowledge availability to farmers, but such initiatives complying with the Triple Helix I, suffer from lack of cooperation from industry as well as university. The lack of sufficient information may promote improper handling of technology, and fostering negative feedback in an innovation matrix. Thus, in order to enhance the economic viability and sustainability of AIS, a move towards exploring the Triple Helix III dimensions may be helpful. This may be helpful in communicating innovations in various ways. First, it adds to the trust dimension of information communication, which is many times lacking in the present model, as some farmers do not trust commercial actors due to their profit motives whereas other farmers do not trust government officials due to fears of corruption. This model also provides opportunities to reduce the information asymmetry observed in the above case, as it enables a continuous flow of ideas between various helices. Lastly, Triple Helix III may help in improving the human resources in quantity as well as quality to provide information (insufficient in the government extension system) which is very crucial in case of Indian farmers, as it is noted previously that farmers consider personal and group interaction as the most authentic source of knowledge.

Scope of Further Research

The mechanisms for promoting interaction among the university-industry-government at the grassroots level present an intriguing field for further inquiry. In view of an array of innovations in the emerging technologies waiting to see their fate at the hands of the end users, further research to strengthen the communication of innovation and hence their wider diffusion, is required. This includes questions of what works and why, and what mechanisms help encourage partnerships. Exploring the role of local shopkeepers as innovation intermediaries becomes especially crucial for Triple Helix actors. There is a need for a thorough evaluation of extension approaches in order to identify best practices and understand their impact on farming communities, and to recognise how extension can be strengthened, particularly to reach small and marginal farmers. Additionally, the typology of clients that use private-sector, government, university, or ICT-based approaches to gain information services, the type of information accessed and the willingness to pay for information is scarcely known. Understanding the characteristics of farmers who are accessing different modes of extension services will be useful in identifying the modes of interaction between the Triple Helix members.

Endnotes

1 We specifically use the term 'with' the farmers rather than 'to' the farmers, since we consider communication to be a two way process of mutual learning rather than a unidirectional flow of ideas.

2 Refer to the Science, Technology and Innovation policy 2013.

http://www.dst.gov.in/sti-policy-eng.pdf

3 There are two prevalent discourses of public engagement in Science and Technology Studies: the deficit model which advocates educating the people for issues related to science, and the dialogue model which involves involving and engaging the 'public' in a dialogue with experts and authorities.

4 Field work.

5 Field work.

6 Conversation with farmers during field work.

7 Most of the seed company executives had a bachelors degree in agricultural sciences.

8 Field work.

9 Obtained from training and extension department, the references could not be attached as they are not published.

10 The senior official refused to talk at all on the issue of Bt cotton saying it is highly controversial.

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