Linkage of Food Security: Social Network Analysis and Stakeholder Analysis in Agricultural Innovation Systems in North Eastern India

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Abstract

For better efforts in development of the farming community, agricultural extension services have always focused on farmers' resources, activities and capabilities. And this has proved to be an important standing point in the rice growing state Tripura of North East India for attaining self-sufficiency in food grain and developing the economic condition of the farmers. System of Rice Intensification (SRI) has been a boon to the rice farmers and also has posed as an example especially in similar other conditions around the world. This paper seeks to understand how the stakeholders involved in the Agricultural Innovation Systems (AIS) in SRI influence the spread of the technology not only among the farmers but at an organizational level in the Tripura state of India. A descriptive research design was followed to study the position of stakeholders in the SRI Innovation Systems. Modified power/interest matrix of Mandelow was used to study stakeholder positions in the innovation system and social network analysis using UCINET 6 software to understand the flow of information and strength of linkage among the actors. The farmers, though had very high interest, were perceived to have low to medium power in terms of decision making in policy issues and implementation. Department of Agriculture, Government of Tripura, State Agriculture Research Station, and Krishi Vigyan Kendras (Farm Science Centres) were the key actors maintaining strong linkage with other actors. Farmers were primary stakeholders in the network. Knowledge management, sharing and learning in SRI has been effective because of the integration of stakeholders in the state and this can be applied for other crops/technologies to enhance innovation and promote development.

Key words: Agricultural Innovation Systems, Extension, Stakeholders, Panchayati Raj Institutions, Network.

Introduction

Agricultural extension, which was originally thought of as a part of the "knowledge triangle" (Rivera and Sulaiman, 2009) of research, education and extension has broken free of the stereotyping to help farmers to organize themselves, linking farmers to markets and some complementary parts such as environmental and health information services (Swanson, 2006; World Bank, 2007b; Rivera and Sulaiman, 2009). The innovation systems perspective gives a by and large view of all the factors responsible for development, dissemination and use of knowledge and also puts emphasis on the relationship of stakeholders who does so (Spielman, 2005). Agricultural Innovation Systems is the "new generation" of development model which emerged through policy debates in developed countries in the 1970s and 1980s. It is a network of diverse group of actors that voluntarily contribute knowledge and other resources to jointly develop or improve a social or economic process or product (World Bank, 2007a; Ekboir and Rajalahati, 2012). Spielman (2005) argued that Innovation Systems (IS) perspective on agriculture is critical to shifting socio-economic research beyond technological change "induced" by various factors beyond the concept of linear technology transfer as an engine of change. Stakeholders carrying out various functions in different capacities with effective linkage form agricultural innovation systems that provide platforms to foster

innovation. The roles of stakeholders are getting increasingly recognized in innovation systems context in agricultural extension settings.

Stakeholder Analysis

The concept of innovation has changed in recent times from a research driven process to an interactive process with much broader range of activities among the stakeholders. One of the earliest definitions of stakeholder has been given by Freeman (1984) according to which a stakeholder in an organization is any group or individual who can affect or is affected by the achievement of the organization's objectives. They are individuals and institutions that are concerned with or have interest in what they have stake in (Calow et al., 1999; McElroy and Mills, 2000). Being affected by the project, etc., they have a power to be a threat or benefit to it and may have a moral and in cases, non-negotiable right to influence the outcomes (Gibson, 2000; Bourne and Walker, 2005) or simply may have a democratic right to be involved in the project (Allen and Kilvington, 2010). Stakeholder analysis originated in business science but is widely being used in other streams like natural resource management, economics, political sciences, health sector and environmental science. Different authors have presented various methods and approaches to stakeholder analysis. World Bank (2001) identified stakeholders on the basis of power and interest as promoters (high power, high interest), defenders (high power, low interest), latents (low power, low interest) and apathetic (low power, low interest). Through stakeholder analysis in natural resource management, the stakeholders can be prioritised in various aspects for better decision making (Grimble and Wellard, 1997; Mushove and Vogel, 2005). Key stakeholders have power and legitimacy I the system while primary stakeholders are the beneficiaries who use them (Yamaki, 2017). In developing and implementing policies and programs, stakeholder analysis gives an important way of gathering and analysing qualitative information as whose interest should be taken into account (Schmeer, 1999). Stakeholder analysis is not an exact science and the stakeholders will be variously influential in a project which will again change over time but it is the first step in building the participatory policy and will give all the stakeholders a clear understanding of the roles others' play in successful development and implementation of any project (Kennon et al., 2009; Allen and Kilvington, 2010).

Social Network Analysis (SNA)

Not just understanding the roles other stakeholders play in innovation systems, but the relationship and connection between them ensure the existence of mutual interactions and relational influences between them (Yamaki, 2017). Social Network Analysis (SNA) is used to analyze the characteristics and social structure of specific outcomes of aggregated social networks among stakeholders for enhancing knowledge transfer, resource mobilization and consensus building (Coleman, 1988; Pretty and Ward, 2001; Adger, 2003; Borgatti and Foster, 2003; Bodin and Crona, 2009; Ernston et al., 2010; Newig et al., 2010; García-Amado et al., 2012). SNA helps in analyzing the social interaction of stakeholders in innovation systems and identify the structural pattern of the relationship going beyond formal institutional settings (Sandstrom, 2011; Lienert et al., 2013). In farming context, learning takes place in smaller networks and habits and practices of network partners influence the inexperienced farmers (Conley and Udry, 2004). Knowledge flows and connections, instead of being influenced by geographic proximity, are influenced by farm-level absorptive capabilities (measured in terms of human resources, experience, and experimentation) such that information tend to flow

through a core group of farms with advanced absorptive capabilities and a similar knowledge base (Giuliani and Bell, 2005). Innovation systems, according to Matsaert et al. (2005) are made up of a range of actors involved in generating and using new knowledge, technologies, management practices, marketing processes. Cohesive groups with active exchange of information and collaboration among its members have been observed to have higher diffusion of innovations (Crona and Bodin, 2006; Darr and Pretzsch, 2006). While many of the actors being central to a network core form cliques and have high centrality, others with far reaching ties are much more likely to bring new information and opportunities to innovation networks (Spielman et al., 2011) which is consistent with Granovettor's theory of "strength of weak ties." The study of SNA also can be used to recommend ways to increase the efficiency of information flow among the actors. While stakeholder interactions can be based on trust and communication (Pryke, 2004), this study focuses on exchange of knowledge and information regarding System of Rice Intensification (SRI) among the stakeholders in Tripura state of India.

Methodology

The present study is an attempt to understand the power and interest of the stakeholders in the agricultural innovation systems in System of Rice Intensification (SRI) in Tripura state of North East India and the implications of their network on the innovation systems as a whole.

Study area

Selection of study area: Seventy eight percent of the cultivable area of Tripura is covered by rice and food security of the state heavily depends on rice, it being the principle and staple crop of the state (SRI-India, 2013). SRI was introduced in the state in 2001 by Department of Agriculture, Government of Tripura (DoA), demonstrations in farmers' field picked up in around 2006-'07 and in six years' time, area under SRI has grown from six per cent to 33 per cent of the total area under rice (DoA, 2013). Intensive extension activities have made Tripura one of the leading states in SRI in the country and in North East India. Being a late starter with SRI, Tripura has seen a spread of scale not reported anywhere else in the country. In two years' time the number of SRI farmers has increased from less than 1,000 to more than 70,000 (Uphoff, 2008). But even though Tripura is a forerunner in rice cultivation following SRI, only few studies on the socio-economics of the technology in the state have been found after an extensive literature search on the internet and books, while none were found to deal with the extension and innovation systems perspective. And for this reason study was carried out in the state of Tripura, North East India. For the study, two districts West Tripura and Dhalai were selected having the highest and lowest area under SRI respectively.

Description of study area: Tripura, located in North Eastern part of India, is a sub-tropical state with 10,492 sq. km. area, of which only 27 per cent is cultivated. Only four per cent is irrigated but rice is the principal crop in the state (SRI-India, 2013) and a major contributor to livelihood security of the farmers. For the study, two districts – West Tripura and Dhalai – were selected based on highest (42% of total area) and lowest area (7% of total area) under SRI. Rice being the principle crop of the state, it is cultivated in three seasons – Aush (April – June), Aman (July – November) and Boro (December – March). While in West Tripura rice is preferably cultivated in Aman and Boro, in Dhalai Tripura Aush and Aman are preferred due to scarcity of water in Boro (Suchiradipta and Saravanan, 2014).

Selection of stakeholders

Based on literature available from the state and discussion with key communicators (Agricultural Extension Officers, Village Level Workers, local administration heads and contact farmers of Department of Agriculture), stakeholder organizations of SRI Innovation Systems were identified. Respondents from stakeholder organizations were identified through criterion sampling (Given, 2008), criteria being working experience in SRI for minimum five years. Criterion sampling and consultation with key communicators was used for identification of respondent farmers who have been practicing SRI for minimum three years. Stakeholder organizations and respondents identified are given in Table 1.

Table 1. Stakeholders and respondents of the study

Stakeholders	Respondents	Stakeholder category
Ministry of Agriculture, Government of India (MoA, GoI)	-	
Directorate of Rice Research (DRR)	-	
Indian Council of Agricultural Research – Research Complex for North East Hill Region, Tripura Centre (ICAR-RC for NEH Region, Tripura Centre)	-	Public sector
Department of Agriculture, Government of Tripura (DoA, GoT)	40	
State Agricultural Research Station, DoA, GoT	2	
Panchayati Raj Institutions (PRIs)	4	
Farm Science Centre/Krishi Vigyan Kendra (KVK)	2	
Farmers	60	Individuals and groups
Self Help Groups	6	
Local newspapers (Daily Desher Katha and Dainik Sambad)	Focus discussions with agriculture correspondents	Media
Radio (Akashvani Agartala)		
Local and national television (Doordarshan Kendra, Agartala; e-TV Bangla; Bangladesh Television)		

Since representatives of MoA, GoI and DRR were not available in the state, respondents were not selected from these organizations. MoA, GoI is an apex body for agricultural development in the country and more concerned with policy formulation and administration of rules and regulations related to agriculture. DRR deals with rice research and acted as a consulting body to the DoA, GoT without direct involvement. ICAR-RC for NEH Region, Tripura Centre had been an active part of SRI Innovation system in the beginning, aiding research, transfer of technology, awareness creation and policy implementation, though during the study they have moved to other technology like Integrated Crop Management (ICM) and were not actively involved other than providing resource persons for related training programmes and workshops. Though these three public sector organizations were not actively involved in the SRI innovation system, as important functions (policy implementation, awareness creation, transfer of technology, and research) and actions (brokering, facilitating, advocating, coaching, disseminating, and research and development) were carried out by them, they were considered stakeholders in the innovation systems.

Selection of respondents: Farmers and respondents from stakeholder organizations were selected through criterion sampling. Sixty six farmers were selected along with the representatives from six

stakeholder organizations from each district making a total respondent strength of 114. Agricultural Extension Officers, Village Level Workers and Farmers' Friends (community extension workers) were selected from Department of Agriculture, Panchayat Heads from Village Panchayats (local administrative bodies), Subject Matter Specialists from Farm Science Centre, Salema and officials from State Agricultural Research Station were selected as respondents.

Data collection

Snowball sampling technique was used for data collection with a pre-structured schedule. Schedule was prepared by consultation with extension experts both from academia and field and pre-tested in a non-sampling area. Respondents were personally interviewed at their convenient time and place. Questions were repeated to make sure the respondents fully understood them and answered correctly. Focus Group Discussions were also conducted whenever necessary.

Data analysis

Stakeholder Analysis: Various models of stakeholder analysis have been given by different authors and one is the power/interest matrix. The matrix was originally given by Mandelow (1981) in the context of environmental scanning and included dynamism of environment and power of stakeholders in a 2X2 matrix (Fig. 1). In the matrix, power ranges from low to high and dynamism ranges from static to dynamic. It was later modified by Johnson and Scholes (1999) and dynamism of environment was changed to interest of stakeholders.

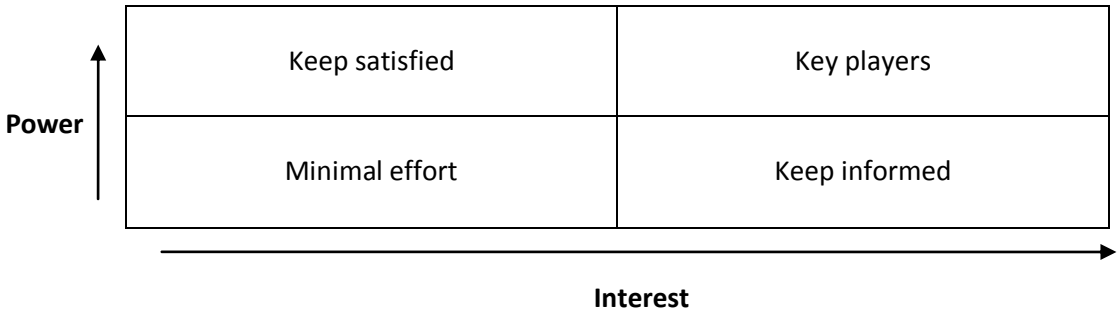

Figure 1. Mandelow's power/interest matrix

Social Network Analysis: To analyze the knowledge flow among the stakeholders, Network Analysis was used. Network analysis is a tool used to study social relations among a set of actors. It studies not the individual but an entity consisting of a collection of individuals and the linkages among them. Software UCINET 6 and NetDraw (Borgatti, Everett and Freeman, 2002) were used to tabulate and visualize the network of information flow among the stakeholders of innovation systems in SRI in Tripura. The data obtained from the field was tabulated in a matrix form and used for the analysis. In this study, reciprocity, transitivity, clustering, external internal (E-I) index, clique, reachability and betweenness were used to study the social network of the stakeholders in the innovation system.

Reciprocity was studied to understand how individual pattern of communication among stakeholders gave rise to a holistic pattern of networking in the innovation system. Ties in a network is stringer to the extent they are reciprocated. Reciprocity of ties relates to both balance and degree of hierarchy in a network. Transitivity is a measure of stability and institutionalization of actors' position in social networks. It refers to the extent to which the relation between two nodes in a

network that are connected by an edge is transitive. In social networks, partial transitivity is more likely because of increased chance of 'friend of a friend being a friend rather than a random stranger in the network'. Clustering is a centrality measure in network analysis and is the probability that pair of neighbor is connected. Overall graph clustering coefficient is the average of the densities of the neighborhoods of all the actors. Weighed overall graph clustering coefficient is the weight of neighborhood densities assigned proportional to their size. Comparing cluster coefficient with overall density gives a better idea about the degree of clustering. nPairs indicates the size of each actor's neighborhood (reflected by the number of pairs of actors in it). External Internal (E-I) Index is the measure of group embedding based on number of ties within and between groups (Krackhardt and Stern, 1988). E-I Index ranges from -1 (all internal ties) to +1 (all external ties). The direction of the ties is generally ignored in E-I Index. Cliques help in building a strong network among the actors in a bottom up manner and in understanding how the network as a whole may behave. A clique is the maximum number of actors with maximum possible ties between them. Edge betweenness concentrates on the relationships which are more central in a network. A relation, according to Freeman (1987), is between to the extent that it is a part of the geodesic between pair of actors. Betweenness is zero if there is no tie or if the tie is not part of geodesic paths. High betweenness indicates that without the tie, one actor would be isolated from the network (Hanneman and Riddle, 2005).

Results and Discussion

Power Interest matrix of the stakeholders in AIS

The position of the stakeholders has been studied separately for farmers and extension personnel in both the districts as farmers in either district had no idea about Directorate of Rice Research (DRR) in SRI innovation systems. The farmers of Dhalai Tripura district did not have idea about the working of State Agricultural Research Station (SARS) as the organization was located in West Tripura district and they rarely went there for agricultural purpose. Hence, due to the variable perception of the stakeholders, their perception was studied separately (Fig. 2-5).

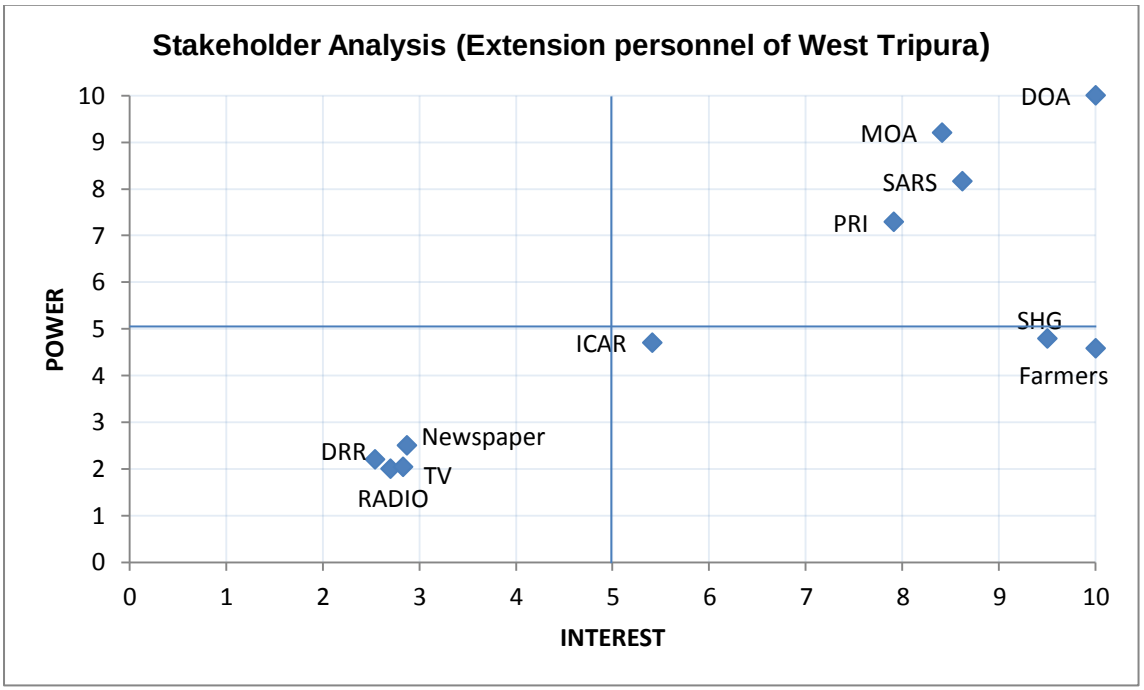

Fig. 2 Stakeholder position in West Tripura district as perceived by the extension personnel

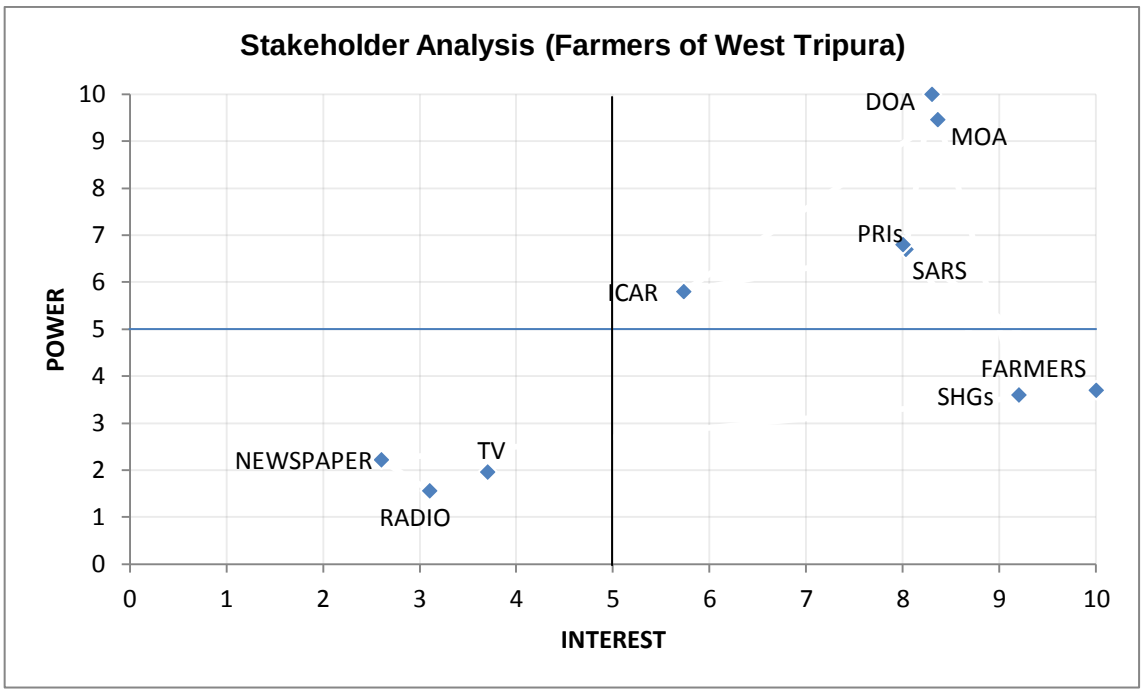

Fig. 3 Position of stakeholders as perceived by the farmers of West Tripura district

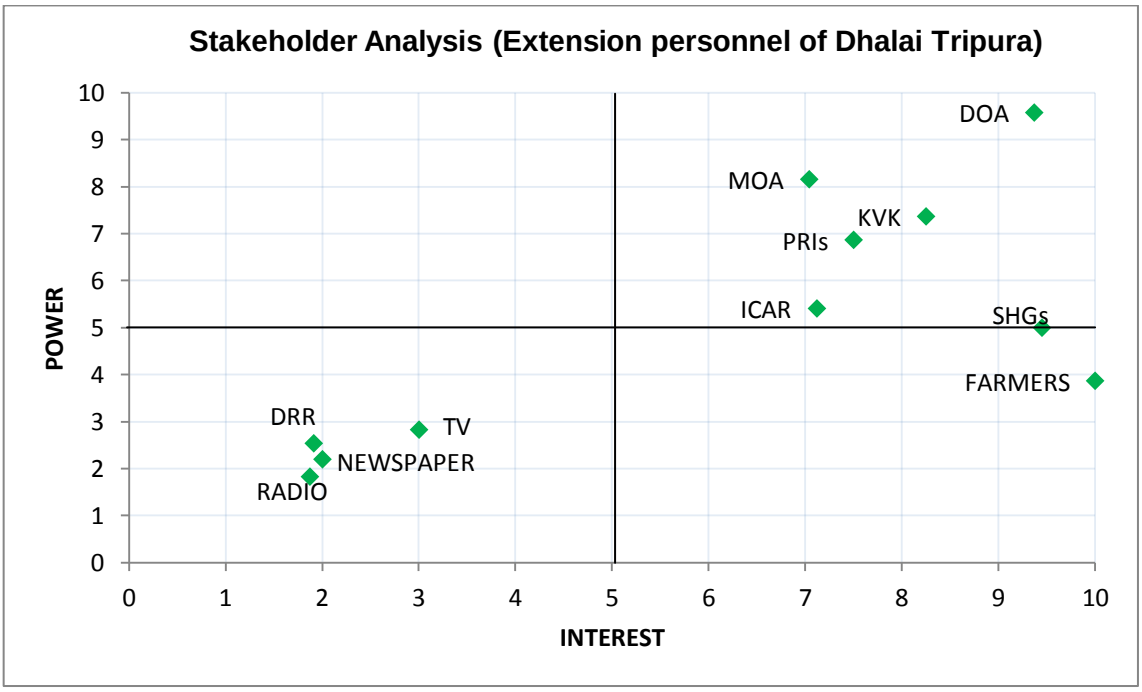

Fig. 4 Stakeholder position in Dhalai Tripura district as perceived by the extension personnel

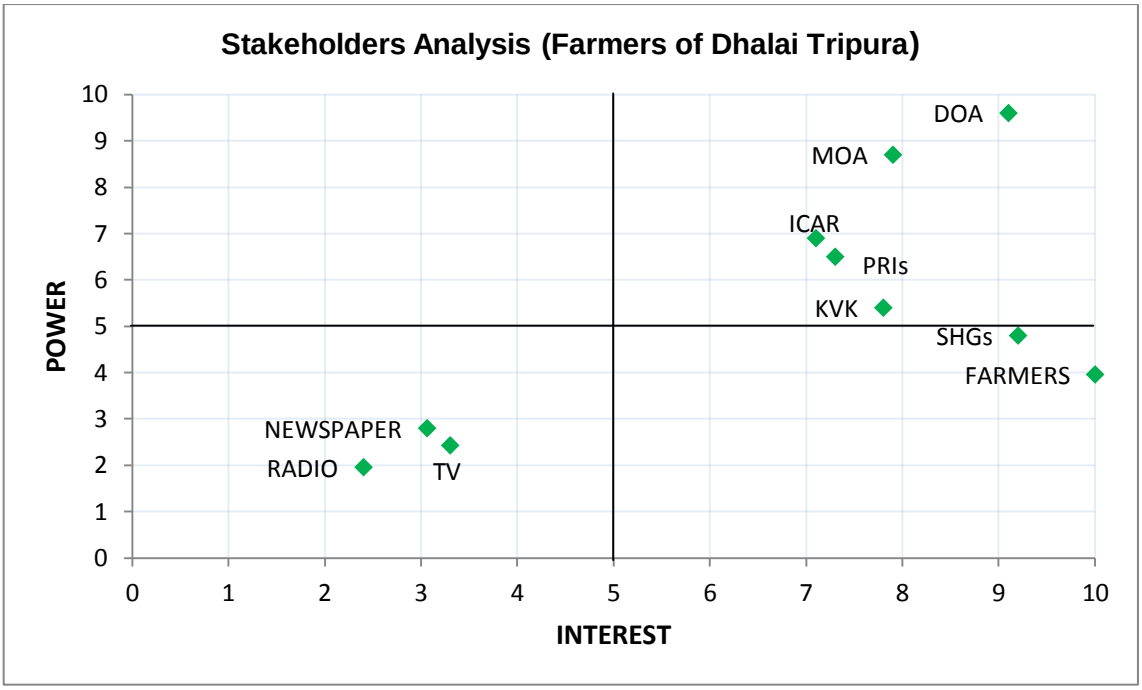

Fig. 5 Stakeholder position in Dhalai Tripura district as perceived by the farmers

In SRI innovation systems in the state, DoA has both high power and interest as the main stakeholder and implementer in the state. After introducing SRI as a tool to gain self-sufficiency in rice in the state, the department has taken much interest in the method. While it has all the power to divert all available resources in SRI, it also has a high stake to achieve its targets by implementing those resources. Being at a high power position, the DoA also has advantage over other stakeholders in allocating their resources in the innovation systems.

That SRI has raised the expectations high not only for the state but also for the country to achieve food sufficiency can be understood from the DoA's reliance on SRI to achieve food sufficiency in the state. The Central Government has also taken up many measures in the form of policies and is assisting states to raise their production and productivity. National Food Security Mission (NFSM)-Rice and National Agricultural Development Scheme (NADS) has paid special attention to SRI by including it as a component under both the policies as a combat tool against poverty (DoA, 2012). The population of the state below poverty line in 1999-2000 was 34 per cent while in 2012-2013 it has come down to 14.05 per cent (The Assam Tribune, 2013). The MoA is believed to have more power than interest in SRI as all the important policies are formulated at the MoA level and implemented in Tripura and is also a major funding source. Depending on the allocation and implementation of funds given to the state Govt. and its disbursement, the MoA has the power to renew or stop the allocation which gives it an upper-hand at power in the state.

Mr. Baharul Islam Majumdar, an agronomist in SARS introduced SRI in the state and spread it among the farmers to gain food security and since then has closely monitored its spread around the state and also has played a pivotal role in it. Being so closely integrated in the innovation systems, SARS is not confined to the R&D activities but has moved beyond it. SARS became a key advocate of policy changes required to support and sustain SRI innovation systems. Along with power, the high interest of the organization has also been recognised by the extension personnel and farmers of the state.

Farm Science Centre, Salema has been recently introduced in SRI innovation systems but its high interest has already made it an important stakeholder in the state. Guided by the goals of the Perspective Plan, it has a high interest in achieving food security and improving the condition of the farmers in the targeted areas. Along with the interest, the Farm Science Centre is also an organization of power with the authority to decide on policy changes related to SRI. The resources allocated to the Farm Science Centre are distributed according to the requirement of the institution and it has full control over the decisions made. But the perception about power of Farm Science Centre varies within farmers and extension personnel. While the farmers perceive it to be under the full control of the DoA, the Farm Science Centre personnel and the extension officers believe to have full control over its resources. But this difference of perception is due to the less acquaintance of farmers to it as it was launched last year and the organization is still dependent on the DoA for much of its functions. However, both the stakeholders are unanimous about the interest of the Farm Science Centre in SRI innovation systems.

Indian Council for Agricultural Research – Research Centre for North East Hill (ICAR-RC for NEH) Region, Tripura Centre is perceived to have a moderate position in SRI innovation systems in Tripura with neither high power not much interest. The reason behind the rating is though ICAR-RC for NEH Region, Tripura Centre has been active for a few years since 2006-'07 seeing the increasing enthusiasm of farmers towards SRI but at present times they are more involved with ICM than SRI and has not been very active other than organizing a few programs like trainings, workshops, etc. and this puts it neither in a high power or interest position in the matrix. ICAR-RC for NEH Region, Tripura Centre is perceived to have medium power and interest in SRI by the extension personnel mostly because of their non-involvement. The farmers of West Tripura perceived ICAR-RC for NEH Region, Tripura Centre to have greater power and interest in SRI innovation system being an organization of the Central Government which, they thought, automatically gives them the command over resources. The same trend has been observed in Dhalai Tripura also.

The decentralized democratic administrative units, the Panchayati Raj Institutions have taken special interest in SRI. The SRI beneficiaries in the villages are selected by the village panchayat rather than DoA. The disbursement of funds for subsidised machineries, making provision for irrigation, etc. is done through the PRIs being village level units they have better understanding of the situation and needs of the farmers and hence are in a better position to take decisions (Personal Communication, March 16, 2013). In the monthly meetings of the Gram Pradhans (village chief) with the Superintendent of Agriculture and other extension functionaries, they raise issues of farmers' interest and the Panchayats also had authority to make minor changes in the implemented policies. The suggestions of the PRIs are taken up by the Planning Section of DoA to implement them at the village level. The PRIs, being the decentralised administrative unit, have both the knowledge about the farmers' condition and interest in development of the farmers being a part of the rural society.

The SHGs are mostly considered as receiver of technology with low to moderate power but high interest as they commit all their resources to SRI. But since the Self Help Groups (SHGs) are regularly in touch with the DoA, they do have a power to influence policies to some extent. The farmers of West Tripura district perceived the SHGs to have low power but high interest in SRI innovation system because they believed the SHGs to be beneficiaries with no real power to mobilise resources or advocacy of policies but since they are committing their resources to SRI, they have a high stake and hence interest in the innovation systems.

Individual farmers are believed to be low power – high interest stakeholders as the SRI farmers generally commit all their resources to it and have made it their livelihood. Though the department closely monitors their conditions and extends supports for them as possible either by capacity building or by assisting in cash and kind, the farmers themselves are believed to have low power to voice their needs or they prefer not to do so since most of their needs are taken care by the department. Since farmer participation just to comply with administrative standards is not enough to bring about institutional changes in innovation (Sulaiman, 2009) and needs to be actively integrated in the systems.

DRR is not considered to be an important stakeholder in SRI innovation systems in the state either in terms of power or interest. Though the extension personnel get technical help from the organization as and when needed through the officials who keep personal and official contact with the personnel of DRR, but it does not play any significant role in the state. The farmers of the state had no idea about DRR and hence had no idea about the power or interest of the organization.

Media, as one of the stakeholders in SRI innovation systems undertook extensive media coverage of SRI (2-3 articles on SRI each month, publication and broadcast of interviews of successful farmers and extension personnel, success stories of farmers of the state and programs and articles about technology and economic and sustainable aspects of SRI) to create awareness among agriculture and rural development administrators (the ministers and officials of Government of Tripura), policy makers (at all the administrative levels in the state), political leaders, extension personnel and farmers and have been a part of the SRI mass movement in the state. Even though it was not recognised by farmers directly in some cases but media always had a positive impact on the farmers, extension personnel and other stakeholders in the state by repeated publishing and broadcasting of success stories which motivated the farmers and to some extent, contributed in mobilizing organizations like ICAR-RC for NEH Region, Tripura Centre towards SRI. Moreover, it has always had an effect on farmers, in mobilizing policy makers and informing the common public which can be best described by Mark S. Granovetter's (1973) theory of 'strength of weak ties' according to which individuals who share strong relationship with each other have more or less the same information but from the weak ties with individuals or other groups they get important information which was not known by the individuals. In other words, it emphasises on the cohesive force of weak ties. Thus media with its constant presence at the backdrop of SRI innovation systems has made itself one of the important stakeholders in it.

Information flow among stakeholders of AIS in SRI

Power and interest of stakeholders in the SRI innovation system influenced the communication and linkage of the stakeholders as well. Since stakeholder organizations were different in the two districts studied, the networks formed are also different.

In SRI innovation systems of West Tripura district, the reciprocity of the links is 0.50, *i.e.,* 50 per cent of the total ties in the network are reciprocated connections. Unidirectional flow of information between stakeholders like MoA, DRR and Media with DoA, and SARS, the star actors of the innovation system network, was the major reason for only 50 percent reciprocated ties. In Dhalai district, the reciprocity was higher at 0.64 or 64 percent reciprocated ties due to stronger network. Strong reciprocated toes were observed among farmers, DoA, PRIs, SHGs, and SARS in West Tripura and KVK in Dhalai.

After performing a census of all possible triads in the West Tripura district, 64 transitive triplets were found and of all the triplets present in the network, 45.71 per cent were transitive. Again, the number of triads with two nodes transitive with any other node in the network is 61.45 per cent and triads with two nodes transitive are 76.19 per cent (Box 1) . Among the stakeholder network of Dhalai district, after performing all possible census of possible triads, 53 transitive triplets (triads) were found and 43.44 per cent of all triads were transitive, i.e., there is flow of information between all the three pairs. Again, the number of triads with two nodes transitive with any other node in the network is 63.10 per cent and triads with two nodes transitive are 79.10 per cent (Box 2). This implies that the connectivity among the actors is fairly good with two directional information flow. Partial transitivity was more frequent in both the districts because of strong connection between DoA, PRIs and farmers who again individually connected with other stakeholders.

Box 1: Transitivity in West Tripura district	**Box 2: Transitivity in Dhalai district**
Type of transitivity: ADJACENCY	Type of transitivity: ADJACENCY
Number of non-vacuous transitive ordered triples: 64	Number of non-vacuous transitive ordered triples: 53
Number of triples of all kinds: 140	Number of triples of all kinds: 122
Number of triples in which i-->j and j-->k: 84	Number of triples in which i-->j and j-->k: 67
Number of triangles with at least 2 legs: 104	Number of triangles with at least 2 legs: 84
Number of triangles with at least 3 legs: 64	Number of triangles with at least 3 legs: 53
Percentage of all ordered triples: 45.71%	Percentage of all ordered triples: 43.44%
Transitivity: % of ordered triples in which i-->j and j-->k that are transitive: 76.19%	Transitivity: % of ordered triples in which i-->j and j-->k that are transitive: 79.10%
Transitivity: % of triangles with at least 2 legs that have 3 legs: 61.54%	Transitivity: % of triangles with at least 2 legs that have 3 legs: 63.10%

The overall graph clustering (2.02) indicates a fairly high density of clustering among the stakeholders in SRI innovation systems which indicated a high flow of information among the stakeholders. Weighed overall graph clustering (1.54) is less than the overall clustering coefficient because the density of large networks are generally lesser than small ones (Table 2). Among the stakeholders, SARS has the highest number of pairs of actors in its ego neighborhood followed by DoA, SHGs and farmers. As the pioneer of SRI in Tripura, SARS looks after the implementation of the method in the farmers' field while DoA carries out the extension and funding activities. PRIs, being implementers and collaborators at the grass-root level, have a fair number of pairs in its neighborhood. While MoA and ICAR-RC for NEH Region, Tripura Centre has one pair of actors in their neighborhood each, DRR and media has none as DRR is connected only to SARS and media works independently forming formal linkage to none. In Dhalai the overall graph clustering is 2.253 which is very high and can be concluded that the actors in the SRI innovation systems are located fairly densely in the network and have high flow of information amongst them. The weighed overall graph clustering coefficient is 1.765. Since the larger graphs are generally less dense than smaller ones, the weighted average is less than the non-weighted ones. But the overall density of the network is also rather high (1.578) (Table 2). So the density of the local neighborhoods in the network is not much higher than the whole network. The size of the actor' neighborhood is reflected in the pair of actors in it. While DoA and KVK has 15 pairs of possible ties and hence densely clustered. ICAR-RC for NEH Region, Tripura Centre has only one pair and so the neighborhood is sparse. MoA, DRR and media are isolated in the network with no pair of ties around them. This is so because while KVK and DoA keeps a fairly good contact with nearly all other stakeholders in the SRI innovation systems in Dhalai

for dissemination of technology or policy advocacy, ICAR-RC for NEH Region, Tripura Centre is connected to only KVK for policy implementation and DoA as partners in dissemination of technology. MoA and DRR are connected to DoA and KVK respectively for policy advocacy and technical guidance. Media works mostly independently in the district for dissemination of technology, creation of awareness among other stakeholders.

Table 2: Clustering coefficient in West Tripura and Dhalai

Clustering coefficient in West Tripura			**Clustering coefficient in Dhalai**		
Overall graph clustering coefficient: 2.018 Weighted Overall graph clustering coefficient: 1.542 Node Clustering Coefficients			Overall graph clustering coefficient: 2.253 Weighted Overall graph clustering coefficient: 1.765 Node Clustering Coefficients		
	Clus Coef	nPairs		Clus Coef	nPairs
MoA	2.50	1.00	MoA		0.00
DRR		0.00	DRR		0.00
ICAR-RC for NEH Region, Tripura Centre	3.00	1.00	ICAR-RC for NEH Region, Tripura Centre	3.00	1.00
DoA	1.65	10.00	DoA	1.03	15.00
SARS	0.92	21.00	KVK	1.23	15.00
PRIs	2.75	6.00	PRIs	3.17	6.00
SHGs	1.85	10.00	SHGs	2.92	6.00
Farmers	1.45	10.00	Farmers	2.17	6.00
Media		0.00	Media		0.00

The total number of ties (both in and out) in the network is 32 in West Tripura which is medium considering the number of actors in the network. Number of internal ties (10) is lower than the number of external ties (22) which gives an E-I index of 0.375. Again, given the group size and density, maximum possible internal and external ties can be 30 and 42 respectively and the expected value results -0.167 (Table 3). This difference between the actual and expected value and the higher number of external ties indicates that the group has a higher tendency towards disintegration. While ICAR, PRIs, farmers and SHGs had more propensity towards forming internal ties, SARS and DoA had high propensity for external ties, having been facilitating linkage among all other actors in the innovation system network. The network of stakeholders in SRI innovation systems in Dhalai district has 28 ties which is not much high as it regards any ties (in or out). Density of external ties (ties with nodes outside ego's neighborhood) is 16 which is higher than the internal ties (ties within an ego network within the whole network) which numbers to 12. Hence, the E-I index is -0.143 which indicates that the group has a low tendency towards disintegrating (Table 4). KVK and DoA had maximum number of ties in the network, but while KVK had more internal ties, DoA had the highest number of external ties. KVK, PRIs, SHGs and farmers have more affinity towards internal ties and are also the major stakeholders in the network, making disintegration highly unlikely. DOA, being the major promoter of SRI in the state and having stronger ties in Dhalai too, have high external links.

Table 3: E-I Index in West Tripura district

Density matrix: 32 ties. Whole Network Results				
	Frequency	Percentage	Possibility	Density
Internal	10.00	0.31	42.00	0.23
External	22.00	0.68	30.00	0.73
E-I	12.00	0.37	-12.00	-0.17
Max possible external ties: 30.000 Max possible internal ties: 42.000 E-I Index: 0.375 Expected value for E-I index is: -0.167 Max possible E-I given density & group sizes: 0.875 Min possible E-I given density & group sizes: -1.000				

Table 4: E-I Index in Dhalai district

Density matrix: 28 ties. Whole Network Results				
	Frequency	Percentage	Possibility	Density
Internal	16.00	0.57	56.00	0.28
External	12.00	0.42	16.00	0.75
E-I	-4.00	-0.14	-40.00	-0.56
Max possible external ties: 16.000 Max possible internal ties: 56.000 E-I Index: -0.143 Expected value for E-I index is: -0.556 Max possible E-I given density & group sizes: 0.143 Min possible E-I given density & group sizes: -1.000				

Only one clique is found in the network of stakeholders in SRI innovation systems in West Tripura comprising of DoA, SARS, PRIs, SHGs and farmers which indicate there is a regular flow of information among the stakeholders. Being the lead actors in the innovation systems, DoA, SARS and PRIs take active part in dissemination of technology to the farmers and keep close contact with them while SHGs and farmers, committing their resources in SRI, keep in close touch with the former players for information and material exchange and also financial assistance (Fig. 6). In the SRI innovation systems in Dhalai, there are two cliques, each comprising of four actors with very high degree of common membership as three of the four members (DoA, KVK and SHGs are common in both the groups whereas farmers, even though not a part of the first clique is very adjacent to it while PRIs is adjacent to the second clique. It indicates the high flow of information among these stakeholders in the innovation systems (Fig. 7).

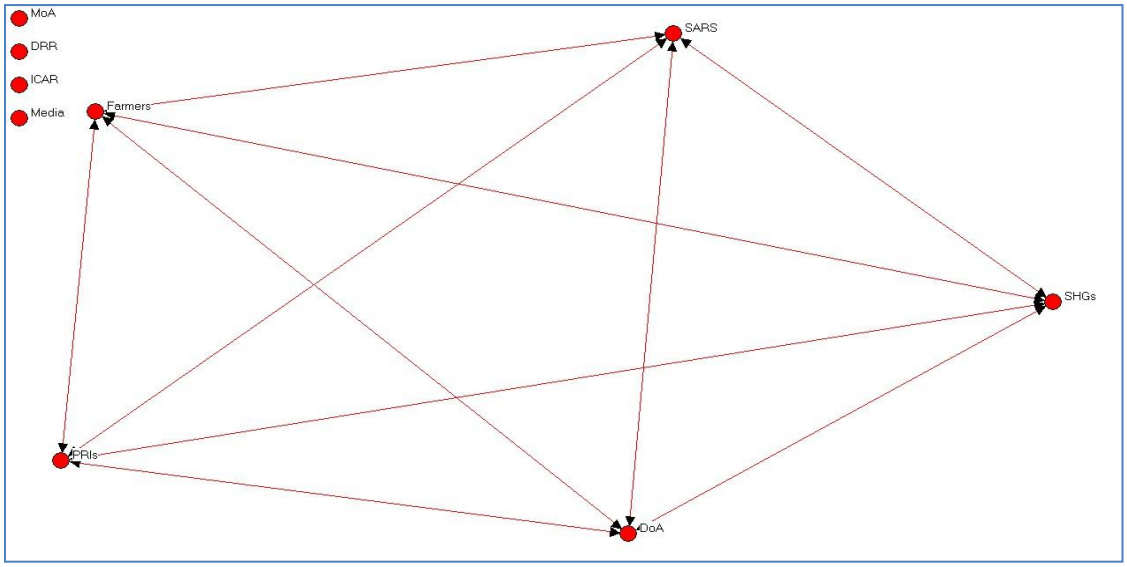

Fig. 6: Clique in West Tripura district

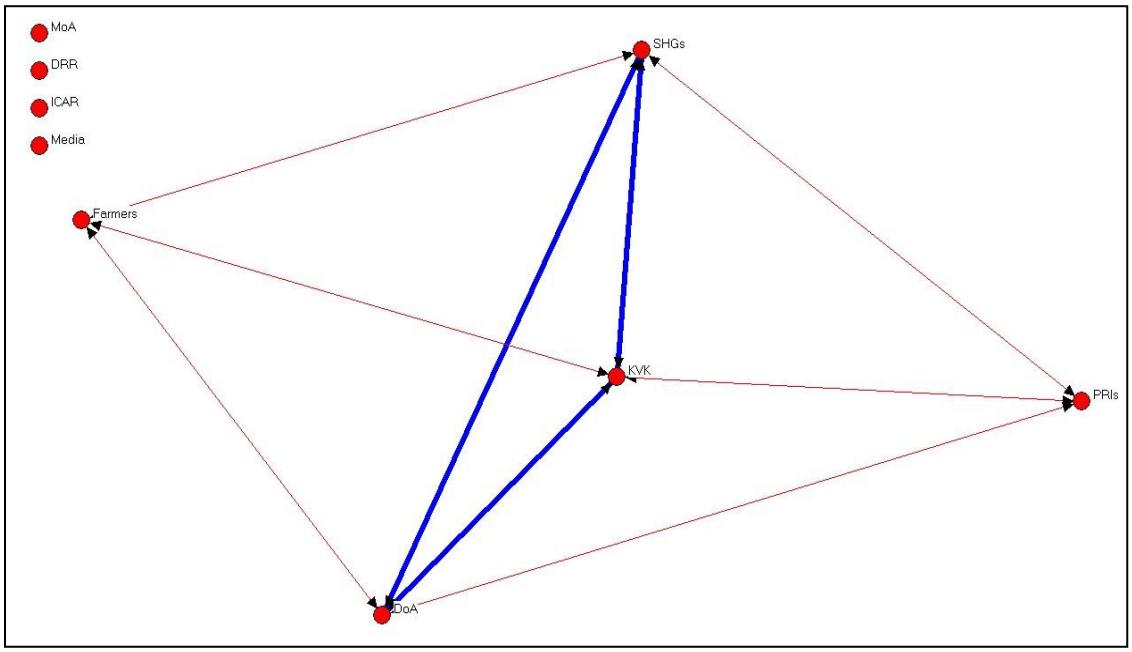

Fig. 7: Cliques in Dhalai district

There were some quite central relations in the network between the actors of the SRI innovation systems in West Tripura district. Relationship between SARS and DRR and Media has high values as they would be otherwise isolated. SARS has a high value of betweenness as it lies on many geodesic paths or between many actors whereas DoA has medium betweenness while MoA, DRR, ICAR-RC for NEH Region, Tripura Centre and media has zero betweenness (Table 6, Fig. 8). Betweenness in the network system in Dhalai district is moderate as the actors are mostly part of the network and are part of a geodesic path (length of shortest path between two actors). Again, particularly high value (5) was observed between KVK and DRR and DoA and MoA which arises because without the tie, DRR and MoA will be largely isolated from the network (Table 7, Fig. 9).

Table 5: Betweenness of the actors in SRI innovation systems network in West Tripura

	MoA	DRR	ICAR-RC for NEH Region, Tripura centre	DoA	SARS	PRIs	SHGs	Farmers	Media
MoA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DRR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ICAR-RC for NEH Region, Tripura centre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DoA	2.50	0.00	0.00	0.00	3.00	1.00	1.50	1.50	0.00
SARS	2.50	5.00	0.00	1.00	0.00	1.00	1.50	1.50	5.00
PRIs	0.00	0.00	0.00	1.50	3.50	0.00	1.50	1.50	0.00
SHGs	0.00	0.00	2.50	1.50	3.50	1.00	0.00	1.00	0.00
Farmers	0.00	0.00	2.50	1.50	3.50	1.00	1.00	0.00	0.00
Media	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

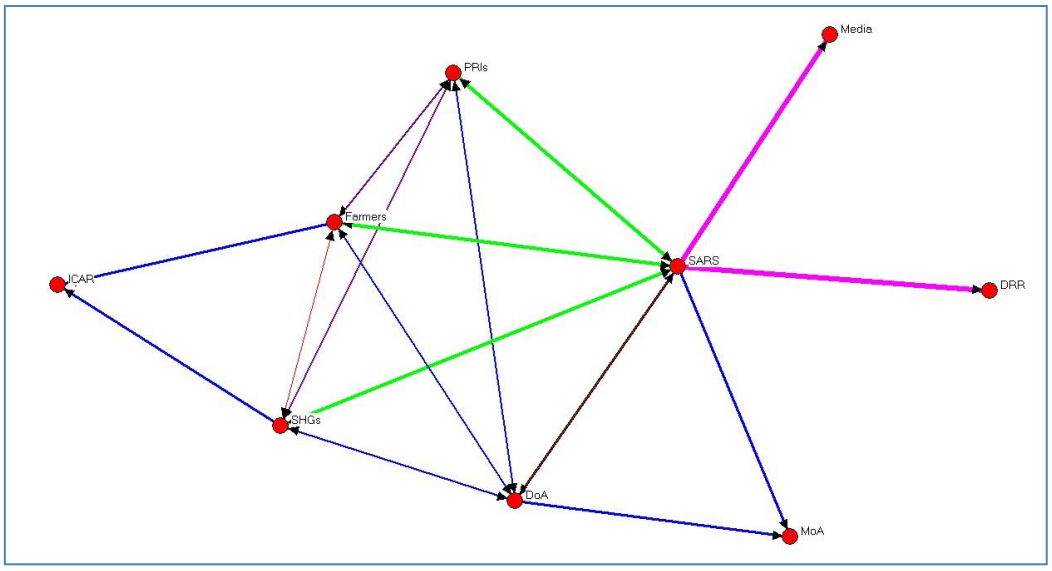

Fig. 8: Betweenness of the actors in SRI innovation systems network in West Tripura

Table 6: Betweenness in the SRI innovation systems network in Dhalai district

	MoA	DRR	ICAR-RC for NEH Region, Tripura centre	KVK	DoA	PRIs	SHGs	Farmers	Media
MoA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DRR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ICAR-RC for NEH Region, Tripura centre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KVK	0.00	5.00	2.50	0.00	2.00	1.33	1.00	1.00	0.00
DoA	5.00	0.00	2.50	2.00	0.00	1.33	1.00	1.00	0.00
PRIs	0.00	0.00	0.00	2.50	2.50	0.00	1.00	1.00	0.00
SHGs	0.00	0.00	0.00	2.50	2.50	1.33	0.00	1.00	0.00
Farmers	0.00	0.00	0.00	2.83	2.83	0.00	1.33	0.00	0.00
Media	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

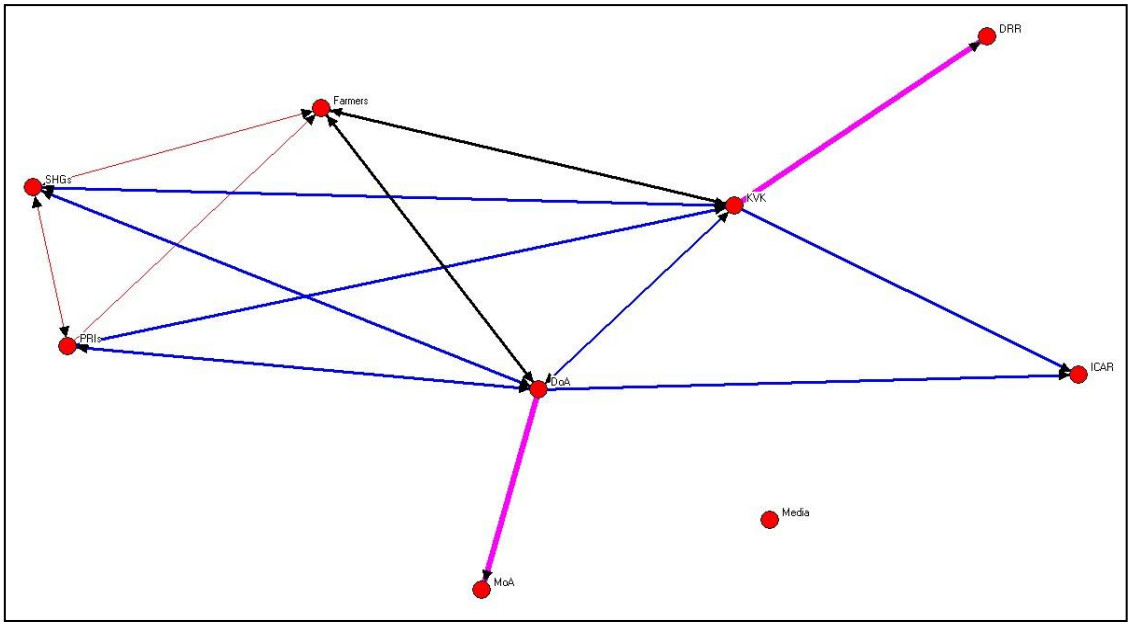

Fig. 6: Betweenness in the SRI innovation systems network in Dhalai district

Overall, Department of Agriculture (DoA) emerged as the lead link between the stakeholders and also the star of the networks in both the districts. The stakeholders of SRI innovation systems in the state mostly were partners and alliances that worked hand in hand to foster the innovation system and gave it a conductive atmosphere for growth. Stakeholders like farmers and SHGs shared a paternalistic linkage which supported technology transfer mainly by formal means of trainings, *etc*. whereas, it was an alliance between the policy making stakeholders and policy implementers. Mostly interactive type of learning was observed among the stakeholders because of the linkages existing, leading to successful innovation systems (Suchiradipta and Saravanan, 2014).

A follow up of the SRI innovation systems in the state during 2017 revealed that the linkages have been more or less static and in some cases, weakened as stakeholders like ICAR and SARS have more or less moved out the systems with the self-sustaining nature of the innovation. But on the other hand, the linkage between the producers has become stronger with increased dissemination of technology through peer contact. Also, new players are seeking entry n the system to address the issues like market linkage and processing of rice based products. While the linkage with and entry of private players are still in a negotiation stage, with changing demands in the system, the dynamics of the stakeholders are also found to have been changing (Suchiradipta and Saravanan, 2017).

Conclusions and implications for future efforts

The key players of the SRI innovation system in the state are DoA, MoA, PRIs and KVK. ICAR-RC for NEH Region, Tripura Centre was perceived to be of moderate power and interest. The SHGs and farmers had high interest and low power in the innovation system. DRR and media were thought to have low power and interest in the SRI innovation system. While SARS was the star of the information network in West, DoA and KVK were the stars in Dhalai. They played the main role in information exchange among different actors and also maintaining the connection among them. The information flow in West was mostly with external actors while in Dhalai, the connection between the actors' ego was predominant making it a denser and stronger network. Farmers were considered

just as beneficiaries but they are to be integrated in advocacy and dissemination of SRI by making them a part of decision making. Efforts should be put to make farmers' relationship with other lead actors like DoA, SARS and KVK an interactive relationship beyond obtaining inputs and transferring technology which will encourage an innovative environment among the stakeholders by increased information transfer. Farmers are considered as actors who need to be kept informed but as active adopters of SRI, they need to be made the key players with more decisive power on policy implementation by regular consultation on policy changes. The central component of SRI Innovation Systems in Tripura has been extension complemented by right attitude and relationships among stakeholders. Knowledge management, sharing and learning in SRI has been effective because of the integration of stakeholders in the state and this can be applied for other crops/technologies to enhance innovation and promote development.

References

Adger, W. N. (2003). Social capital, collective action and adaptation to climate change. Economic Geography, 79(4): 387–404.

Allen, W. and Kilvington, M. (2010). Stakeholder Analysis. In Frame, B., Gordon, R. and Mortimer, C. (Eds.). Hatched: The capacity for sustainable development. Publications (SD). Paper 1.

Allen, W. and Kilvington, M. (2010). Stakeholder Analysis. In Frame, B., Gordon, R. and Mortimer, C. (Eds.). Hatched: The capacity for sustainable development. Publications (SD). Paper 1.

Bodin, Ö. and Crona, B.I. (2009) The role of social networks in natural resource governance: What relational patterns make a difference? Global Environmental Change, 19(3): 366–374.

Borgatti, S.P. and Foster, P.C. (2003). The network paradigm in organizational research: A review and typology. Journal of Management, 29: 991–1013.

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002). Ucinet 6 for Windows: Software for Social Network Analysis. Analytic Technologies, Harvard, MA.

Bourne, L. and Walker, D.H.T. (2005). Visualizing and mapping stakeholder influence, Management Decision, 43(5): 649-660.

Calow, R.C., Morris, B.L., Macdonald, D.M.J., Talbot, J.C. and Lawrence, A.R. (1999). Tools for assessing and managing groundwater pollution threats in urban areas. BGS Technical Report WC/99/18, Keyworth UK, Chapter 5, pp. 41-47.

Coleman J (1988) Social capital in the creation of human capital. American Journal of Sociology, 94: 95–120.

Conley, T.G and Udry, C.R. (2004). Learning about a new technology: Pineapple in Ghana. http://www.econ.yale.edu/growth_pdf/cdp817revised.pdf. Accessed on 7th December, 2012.

Crona, B. and Bodin, O. (2006). What you know is who you know? Communication patterns among resource users as a prerequisite for co-management. Ecology and Society 11(2):7.

Darr, D. and Pretzsch, J. (2006). The spread of innovations within formal and informal farmers groups: Evidence from rural communities of semi-arid Eastern Africa. Paper presented on Conference on International Agricultural Research for Development, October 11-13, 2006, University of Bonn.

DoA (Department of Agriculture, Government of Tripura). (2012). Krishi Krishak o Tripura: 1972- 2012 (Bengali). Report. Branch of Agricultural Extension, Department of Agriculture, Govt. of Tripura.

DoA (Department of Agriculture, Government of Tripura). (2013). Perspective Plan. Retrieved on April 28, 2013 from http://agri.tripura.gov.in/prespective.html

Ekboir, J. and Rajalahti, R. (2012). Coordination and collective action for agricultural innovation. In: Agricultural Innovation Systems: An Investment Sourcebook (pp. 15-33). World Bank, Washington DC.

Ernstson, H., Barthel, S., Andersson, E., and Borgström, S.T. (2010). Scale-crossing brokers and network governance of urban ecosystem services: the case of Stockholm. Ecology and Society, 15(4):28. http://www.ecologyandsociety.org/vol15/iss4/art28/

Freeman, C. (1987). Technology policy and economic performance: Lessons from Japan. Frances Pinter, London.

Freeman, R.E. (1984). Strategic management: A stakeholder approach. Ballinger, Cambridge, Mass.

García-Amado, L.R., Pérez, M.R., Iniesta-Arandia, I., Dahringer, G., Reyes, F., and Barrasa, S. (2012). Building ties: social capital network analysis of a forest community in a biosphere reserve in Chiapas, Mexico. Ecology and Society, 17(3):3. http://dx.doi.org/10.5751/ES-04855–170303

Gibson, K. (2000). The moral basis of stakeholder theory. Journal of Business Ethics, 26: 245-257.

Giuliani, E. and M, Bell. (2005). The micro-determinants of meso-level learning and innovation: Evidence from a Chilean wine cluster. Research Policy, 34: 47–68

Given, L.M. (2008). The sage encyclopaedia of qualitative research methods (Volume 2). pp-697-698. Sage, Thousand Oaks, CA.

Granovetter, M.S. (1973). The strength of weak ties. American Journal of Sociology, 78(6): 1360-1380.

Grimble, R. and Wellard, K. (1997). Stakeholder methodologies in natural resource management: A review of concepts, contexts, experiences and opportunities. Agricultural Systems, 55: 173–193.

Hanneman, R. A. and Riddle, M. (2005). Introduction to social network methods. University of California, Riverside, CA. http://faculty.ucr.edu/~hanneman

Johnson, G. and Scholes, K. (1999). Exploring corporate strategy. Prentice Hall, London.

Kennon, N., Howden, P. and Hartley, M. (2009). Who really matters? A stakeholder analysis tool. Extension Farming Systems Journal, 5(2): 9-17.

Krackhardt, D. and Stern, R. N. (1988). Informal networks and organizational crisis: An experimental simulation. Social Psychology Quarterly, 51(2): 123-140.

Lienert, J., Schnetzer, F., and Ingold, K. (2013). Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure planning processes. Journal of Environmental Management, 125:134–148.

Mandelow, A. (1981). Environmental scanning: The impact of stakeholder concept. Proceedings of the Second International Conference on Information Systems, Cambridge, Mass, December 1981.

Matsaert, H., Ahmed, Z., Islam, N. and Hussain, F. (2005). Using actor-oriented tools to analyse innovation systems in Bangladesh. www.planotes.org/documents/plan_05115.pdf. Accessed on 25th December, 2013.

McElroy, B. and Mills, C. (2000). Managing stakeholders. In: Turner R.J. and Simister, S.J. (Eds.). Gower handbook of project management (3rd ed.). Gower Publishing Limited.

Mushove, P. and Vogel, C. (2005). Heads or tails? Stakeholder analysis as a tool for conservation area management. Global Environmental Change, 15: 184–198.

Newig, J., Günther, D., Pahl-Wostl, C. (2010). Synapses in the network: Learning in governance networks in the context of environmental management. Ecology and Society. 15(4):24. http://www.ecologyandsociety.org/vol15/iss4/art24/

Personal communication. (2013). Sima Rabidas, Gram Pradhan, Chotosurma Gram Panchayat, Salema Agricultural Sucdivision. Contacted on 16th March, 2013.

Pretty, J. and Ward, H. (2001). Social capital and the environment. World Development, 29(2): 209–227.

Pryke, S.D. (2004). Analysing construction project coalitions: Exploring the application of social network analysis. Construction Management and Economics, 22: 787-797.

Rivera, W.M and Sulaiman, V.R. (2009). Extension: Object of reform, engine for innovation. Outlook on Agriculture, 38(3): 267-273.

Sandström, A. (2011). Social networks, joint image building, and adaptability: The case of local fishery management, In: Bodin, Ö., and Prell, C. (eds) Social networks and natural resource management: Uncovering the social fabric of environmental governance, Cambridge University Press, Cambridge, pp 288–321.

Schmeer, K. (1999). Stakeholder analysis guidelines. Policy rootkit for transforming health sector reforms. Section 2.

Spielman, D.J. (2005). Innovations systems perspective on developing-country agriculture: A critical review. International Service for National Agricultural Research (ISNAR) Discussion Paper 2. International Food Policy Research Institute. Retrieved on February 15, 2013 from http://www.cgiarilac.org/files/Spielman_ISNAR_DP2_Innovation.pdf.

SRI-India. (2013). SRI factsheet – Tripura. http://www.sri-india.net/html/aboutsri_tripura.html (Retrieved January 23, 2013)

Sulaiman, R.V. (2009) Farmer first or still last? Uneven institutional development in the Indian agricultural innovation system. In: Scoones, I. and Thompson, J. (eds), Farmer First Revisited: Innovation for Agricultural Research and Development. http://www.crispindia.org/docs/farmerfirst.pdf

Suchiradipta, B. and Saravanan, R. (2014). Agricultural Innovation Systems (AIS): A Study of Stakeholders and their Relations in System of Rice Intensification (SRI), The Journal of Agricultural Education and Extension, DOI: 10.1080/1389224X.2014.939200

Suchiradipta, B. and Saravanan, R. (2017). Agricultural Extension Systems in Tripura. MANAGE Working Paper 1. National Institute of Agricultural Extension Management, Hyderanad, India (under publication).

Swanson, B.E. (2006). The changing role of agricultural extension in global economy. Journal of International Agricultural Education and Extension, 13(3): 5-18.

The Assam Tribune. (2013, July 26). 31.98% people in state below poverty line. http://www.assamtribune.com/scripts/detailsnew.asp?id=jul2713/at07 (Retrieved July 29, 2013).

Uphoff, N. (2008). The System of Rice Intensification (SRI) as a System of Agricultural Innovation. http://repository.ipb.ac.id/handle/123456789/43778 (Retrieved January 2, 2013).

World Bank. (2001). Stakeholder Analysis. Retrieved on January 27, 2013 from http://www.worldbank.org/StakeholderAnalysis_files/worldbanktopcorner.gif.

World Bank. (2007a). World Development Report 2008. Agriculture and Rural Development, World Bank. Washington DC. Retrieved on February 14, 2013 from http://siteresources.worldbank.org/INTWDRS/Resources/477365132759904633 4/WDR_00_book.pdf.

World Bank. (2007b). The Innovation Systems concept: a framework. In Enhancing Agricultural Innovation: How to go Beyond the Strengthening of Research Systems. World Bank, Washington DC.

Yamaki, K. (2017). Applying Social Network Analysis to Stakeholder Analysis in Japan's Natural Resource Governance: Two Endangered Species Conservation Activity Cases. Journal of Forest Research, DOI: 10.1080/13416979.2017.1279706.