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Reciprocity among Farmers in Farming System Research: Application of Social Network Analysis

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ABSTRACT In course of agricultural activities, farmers interact among themselves to fulfill different kinds of needs, such as getting advice regarding cultivation, obtaining appropriate seeds and plants, getting tools and implements, etc. On the basis of data to whom a farmer sends requests for such help and whether the farmer receives the required help, one can build a social network of help, whether simple or weighted, in agricultural production. The paper intends to study variation in measures of reciprocity among the farmers of the two villages in respect of different activities for agricultural production. For the study, two villages Madhya-Uttar and Astabari consisting of 88 and 79 households respectively were selected from unirrigated, rainfed area in the south-eastern region of the district of East Medinipur of West Bengal. To collect the required data, open-ended check lists were employed. A standardized graph theoretic measure (s_3-measure) of reciprocity was applied to carry out social network analysis. In both the villages, values of reciprocity measures for seeds/plants and tools/implements exchange were more than that for advice giving; the measure for the network of agricultural activities as a whole was also greater than the network for social aspects. In case of all networks, values of s_3-measure for the village Madhya-Uttar were much higher than Astabari. It indicates that the farming households of a network having greater value of s_3-measure are more inter-dependent among themselves in agricultural production.

INTRODUCTION

Farmers are doubly vulnerable to risk of crisis situations of resources in life and living, not only due to scarcity in daily life and living, but in pursuing agriculture as well. Inefficiencies of formal institutions and market infrastructure constrain the flow of resources at the time of an impinging agricultural emergency. As they build a system of regular interaction among themselves in social life, they also develop a process of interaction for fulfilling their different needs in agricultural production. The latter generates, perhaps, a more stable pattern. It is usual practice for them to go to each other to obtain seeds and plants for sowing, to borrow tools and implements for preparing soil, weeding, harvesting, thrashing and so on. In course of such a process of interaction in respect of agricultural production, they build up regular ties of help among themselves, forming their social network for agricultural purposes. Using the data on mutual help/support/dependence pattern, along with added information on the purpose, quantum and frequency of help requested, one can build a social network of help, whether simple or weighted, in agricultural production. A *simple social network* is defined as one which consists of number of actors of whom any ordered pair either has a dyadic relation or not and has neither multiple arcs nor arcs from actors to themselves. A *weighted social network* is a social network consisting of number of actors such that the relationship between any ordered pair of them has a non-negative integral value, that is, number of multiple arcs (Rao and Rao 1992; Jana 2005). All the networks considered for the study are simple social networks. Considering the supply inefficiency of agricultural inputs in formal sector in the rural areas of our country as a whole, though informal, its importance cannot be denied at all.

In case of West Bengal, Goswami and Basu (2011) have studied the importance of the relation between farmer's position within their agricultural information networks and their adoption decision. Several studies on diffusion pro-

[*]Professor Suraj Bandyopadhyay expired in 2010 and the paper is dedicated to his memory — RJ & AKC

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cess of agricultural innovations have emphasized the effects of socio-structural factors; and diffusion has been explained not only on the basis of individual attributes of farmers but also according to the relationships among the farmers involved in the process (Monge et al. 2008; Jana 2011). Isaac et al. (2007) examined advice network structures by using farmer attributes, that is, kin relationships, community involvement and they also observed that farmers who lack the means to acquire farming knowledge from formal sources often rely on information within their informal social networks.

Thus there are various characteristics of a social network, of which one is reciprocity, that is helping one another. Reciprocity measure, obtained by standardizing the number of reciprocal pairs, indicates the extent of inter-dependence among the members of each pair of actors in a social network in the sense of exchange of help (Rao and Bandyopadhyay 1987; Rao et al. 1996; Bandyopadhyay et al. 2010). A pair of households is said to be a *reciprocal pair* if they go to each other for help. In the present case, it is a matter of mutual help with respect to agricultural inputs among farmers.

Continuing an earlier line of study (Jana 2005), a standardized graph theoretic measure (s_3) of reciprocity derived earlier by Rao and Bandyopadhyay (1987) is applied to carry out social network analysis (SNA) in respect of agricultural production among the farmers of two villages in order to study variation in measurers of reciprocity indicating some extent of inter-dependence among the households of the networks in the sense of mutual help in agricultural production. Incidentally, the derivation of standardized graph-theoretic measure, by Rao and Bandyopadhyay (1987), has been quoted extensively in Wasserman and Faust (1999).

MATERIAL AND METHODS

Location and Socio-economic Composition of the Study Villages

This study is based on data regarding agricultural practices of farmers of two villages Madhya-Uttar (MU) and Astabari (AB) selected from unirrigated, rainfed area in the south-eastern region of the district of Purba Medinipur of West Bengal (Jana 2005). The two villages are of almost equal size of households, 88 and 79 respectively.

Households of MU mostly belong to the middle-rank Mahishya caste, whereas all households of AB belong to the low-rank Poundra caste which is categorized as a SC (Table 1). In MU, 80% of the Heads of households have, at least, completed primary education. On the contrary, the education of the Heads of the households in AB is, at most, at the primary level. Considering ownership of agricultural land, 51.13% of MU households own land of size greater than 3 *bighas* (that is, 1.5 acres). In AB, it is totally reverse, that is, most of the households (92.40%) have less than 3 *bighas* of agricultural land. In MU, the farmers are mostly small or middle own-account cultivators, while in AB they are mostly marginal or agricultural labours. From the point of principal source of livelihood, most of the households of MU (81.95%) live mainly on non-labour activities, like teaching, business, contractual jobs, private tution etc. while the majority of AB (55.70%) are engaged in labour activities like day labour, sawing, van pulling, *khalasi (cleaner)* in truck, etc. Thus, in short, the village AB is socially and economically backward and less resourceful than MU. A comparison of findings of SNA of two different types of farming communities will contribute to enrich interpretation.

Table 1: Socio-economic composition of two villages: Madhya-Uttar (MU) and Astabari (AB)

Socio-economic variables	*Madhya-Uttar*	*Astabari*
Total hhs	88	79
Caste	Middle-rank caste(Mahisya)	Low-rank caste (SC)(Poundra)
Head's education	Class V + (79.98%)	Class V – (70.46%)
Own agricultural land	> 3 *bigha* (51.13%)	< 3 *bigha** (92.40%)
Per household agricultural land owned (in *bigha)*	5.15 *bigha**	2.23 *bigha**
Family main source of livelihood	Non-labour (82.95%)	Labour (55.70%)
Households having contact with:		
i) GP, Block	6.8%	10.1%
ii) Market	71.6%	81.0%

1 acre = 3 *bigha*

Choice of Respondent

The data for help required by a household with respect to its agricultural practices were collected from the Head of the household. Because, it was gathered in the first stage field work that the Head was usually the most knowledgeable person in the household about the information the researchers were interested to collect. It was also observed that, in most of the families, the Head of the family owns the land and actively participates in agricultural activities. Besides, the Head is the main responsible authority for taking the final decision about any matter, whether agricultural or social. He may, of course, discuss the matter with the other adult members of the household if it seems to be a complex one or if he feels its need. Only in two cases in MU, the family members themselves suggested to interview the sons instead of the Head because the latter was too old and therefore, agriculture was looked after by the former as they were mentally more alert and physically more competent. Besides, it was also felt that it would be appropriate for a comparative analysis to collect data from the persons occupying similar position of authority within the households.

Core Data

The main thrust of this study was to collect data on articulation of help as and when required among the farmers in course of pursuing agriculture activities. As stated earlier, a farmer may visit another in order to request for some agricultural inputs – mostly to get some seeds/plants or for agricultural advice or to borrow agricultural tools/implements, and so on. Hence data on purpose of request as well as frequency and volume were also noted. Since agriculture is the economic mainstay of the two villages, the households may be somewhat forced to exchange help among themselves in respect of agricultural production. But how do they interact to provide help and support to meet various types of emergencies which often happen in their social life, will be important indicator of normative pattern of articulation of ties of help and support flowing voluntarily, in general, among them. The pattern of articulation of ties in social life provides a sort of backdrop to the pattern obtained from agricultural production. Hence, besides agricultural needs, data were also obtained regarding who has sent requests for help to whom at the time of an emergency in the family to procure material, physical or monetary help or support. Obviously, the two social networks, one based on livelihood needs and the other to mitigate socially critical situations faced by a household, present two different modes of articulation of network relations. But in a way, they complement each other to provide jointly a total picture of pattern of articulation of social relation of help and support in villagers' life and living. The network data on help relation at times of social crises of the families were also collected from each village, besides data on help for agricultural purposes in order to compare mutuality in the sphere of agricultural production with its incidence in social life.

To collect data, open-ended check-lists were canvassed with respect to three broad dimensions of interaction: (i) choice of seeds and/or plants to be sown (SP); (ii) use of tools or implements which a farmer needs for cultivation (TI); and, advice (AV) or suggestion regarding cultivation, as and when required, beginning from the time of planning "for the next season" through the subsequent year of farming. Also it is common for a family to face a situation (excluding agricultural), or make a critical decision , or, take an action urgently which requires consultation or help of others. Thus, the researchers have the information on:

- To whom does the Head normally go to procure help for agricultural activities like SP, TI, and AV as stated above;
- To whom does the Head normally go for help at the time of an emergency in the family other than that of agriculture (SL).

Besides the above mentioned core data for SNA, socio-economic data were also collected regarding household characteristics.

Incidentally, one may be curious to know why SNA for help and support to pursue cultivation has been desegregated by different means for help and support, namely SP, TI and AV, in addition to doing SNA for agricultural practices as a whole. This is because, in course of life and living, people build different types of networks in different fields (Knoke and Kuklinski 1982). Farmers form social networks among themselves to fulfill different kinds of needs which vary from one to another. Hence, in order to study the pattern of reciprocity, we have first done SNA separately for SP, TI, AV and SL. Then the former

three were combined to obtain that for AG. Lastly, the two networks (one for agriculture and another for social crisis) were combined.

Data Processing to Obtain the Social Networks

Here the researchers explain how a simple social network is obtained from the relevant data using only a dichotomous relationship, that is, whether one goes or requests another (1) or not (0). Let A and B be a pair of households. With respect to a request for any type of help, data may show four types of relations between them. These are as follows: A goes to B for help but not B to A; B goes to A but not A to B; A and B go to each other; and, none of A and B goes to the other (see Fig.1 i –iv):

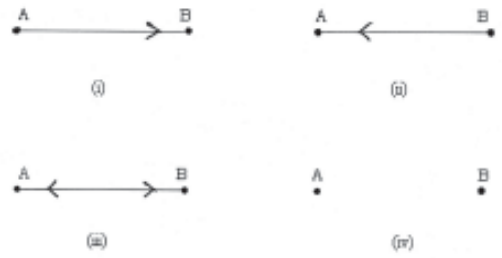

Fig. 1. Possible dyadic relations between A & B

The data on the relation between the households in each pair, constituting the simple social network, can be summarized by the NxN matrix (where N is the number of households) with 0-diagonals, where (i,j)-th entry as 1 if the i-th household goes to the j-th household for help and as 0 otherwise.

At the time of studying the combined network, the researchers have simply followed the additive rule of set theory. Let X_i be the set of households to whom a reference household goes for the i-th purpose, i = 1, 2, …, k. Then the union of $X_1, X_2, \ldots, X_k$ (i.e., $X_1 U X_2 U \ldots U X_k$) will give the combined set of households for k purposes to whom the reference household goes combining all the k purposes and thus a combined network on k purposes is obtained.

Application of s_3-measure of Reciprocity

At the beginning, it is good to mention that collection of data on both 'who goes to whom' and 'who comes to whom', from each household is time-taking but not difficult to collect. Both the sets of data considered together provide a way to cross-check field data properly and carefully. However, the researchers' field experience shows that the respondent household can recall or identify more reliably the households to whom he goes normally for help than those who come to him (Rao and Bandyopadhyay 1987). Rao and Bandyopadhyay (1987) have also discussed, in details, the significance of using the reciprocity measure s_3 compared with the different graph-theoretic and probabilistic measures of reciprocity. That's why, in case of the present study, the network data on 'who goes to whom', that is, out-degrees of the households have been considered for analysis of reciprocity by SNA of a network. The *out-degree* and *in-degree* of a household are defined as the number of Heads of the households to whom the reference goes and the number of Heads of the households who come to the reference household for getting help respectively. Thus only the out-degrees of the households have been taken as given and hence fixed for the present study, instead of their in-degree.

The researchers now briefly recapitulate the mathematical formula of s_3 from Rao and Bandyopadhyay (1987). Let s be the number of reciprocal pairs in a network of N households having out-degrees $d_1, d_2, \ldots, d_N$. Then

$s_3 = 100 \times (s_o - s_{min})/(s_{max} - s_{min})$

where s_o = value of s in observed network; s_{min} = graph-theoretic minimum value of s; and s_{max} = graph-theoretic maximum value of s.

Let us now denote the maximum of the out-degrees of the households and number of non-zero out-degrees by d_{max} and n respectively. Then, as determined by Achutan et al. (1982), $s_{min} = 0$ when $d_{max} \leq (N-1)/2$, and $s_{max} = [\Sigma_i/2]$ when $d_{max} \leq 2\sqrt{n-2}$.

In this study, the researchers have considered 6 networks based on SP, TI, AV, AG (= SPÈTIÈAV), SL, and AL (=AGUSL) for each village and obtained out-degrees of the households for each of four networks SP, TI, AV and SL. Thereafter the researchers have obtained their combinations for the remaining two networks (Appendix). It has also been noted that the two conditions $d_{max} \leq (N-1)/2$ and $d_{max} \leq 2\sqrt{n-2}$ are satisfied for each network in case of each of the two villages (Table 2). Hence the approximate form of the formula, given below, has been used for the present study.

$s_3 \approx 200 \times s_o/(\Sigma d_i - \delta)$,

where δ is 0 or 1 according as Σd_i is even or odd.

Table 2: Verifying the two conditions $d_{max} \leq (N-1)/2$ and $d_{max} \leq 2\sqrt{n}-2$

Village	*Network*	*N*	*n*	d_{max}	*(N-1)/2*	$2\sqrt{n}-2$
MU	SP	88	73	5	43.5	15.09
	TI	88	72	5	43.5	14.97
	AV	88	56	4	43.5	12.97
	AG*	88	79	7	43.5	15.78
	SL	88	87	9	43.5	16.65
	AL**	88	88	13	43.5	16.76
AB	SP	79	55	6	38	12.83
	IP	79	63	6	38	13.87
	AV	79	41	6	38	10.81
	AG*	79	68	11	38	14.49
	SL	79	74	8	38	15.20
	AL**	79	78	15	38	15.60

* AG = SPUTIUAV ; ** AL =AGUSL

RESULTS AND DISCUSSION

In each village, the households of a social network can be classified into four categories: (i) those who do not go to anybody else and no one else comes to them for help, (ii) those who go to others for help but none comes to them, (iii) those who do not go to anybody else but others come to them for help, and (iv) the remaining those, who go to others as well as others come to them. Following this logic, the farmers can also be distributed in four categories. The farmers in category (i) indicate their lack of interaction with all other farmers; those in category (ii) are at the bottom of the network and those in category (iii) at the top. Farmers in category (iv) are usually most numerous, and act as medium of flow of the chain of help and support in the network. They include all those who are reciprocally tied up with at least one other, and possibly some more. In the present study, the researchers were interested in studying the incidence of the latter among the farmers in category (iv) who are reciprocally tied. The s_3 measure of reciprocity calculated for all the networks in the two villages are given in Table 3.

Table 3: s_3 measures in different networks of two villages

Network	*s_3 measure (in %) in villages*	
	Madhya-Uttar	*Astabari*
SP	44.30	22.39
TI	67.42	47.19
AV	28.26	9.76
AG (SPUTIUAV)	56.69	36.96
SL	51.78	30.25
AL (AGUSL)	55.88	38.00

What do we Find from Table3 ?

As the values of s_3 in Table 3 indicate, mutual exchange is most pronounced in case of exchange of agricultural tools and implements (TI), whether in MU or AB. This may be due to the fact that the exchange works within a somewhat a priori conditioned sphere where one knows the nature of transaction and he is involved with in the process of selection of other households. On the other hand, in case of seeds and plants for cultivation, it is somewhat undefined situation where a farmer does not know what he can expect to receive at that period of time against what he has usually given in the past. Providing advice is a matter of expertise and hence, scope of its exchange becomes very much limited. It has also been observed that reciprocity for advice network is low due to the fact that number of knowledgeable farmers regarding modern agricultural practices is limited (Jana 2005). Similar observations are carried out by Goswami and Basu (2011). Hence, value of s_3 becomes the lowest in case of advice with that of SP coming in-between TI and AV.

In general, however, reciprocity in the sphere of activities related to agricultural production is observed to be somewhat higher than in case of social life and living. Exchanges in agriculture which are made by a farmer to supplement his needs are focused more egoistically unlike exchanges which occur in social sphere. The reciprocal pairs in agriculture are formed by farmers with purpose-specific orientation. In social life networks, on the other hand, reciprocal relationship is formed by a more open choice of the household from a potential group of “givers”

(Rao and Bandyopadhyay 1987; Choudhuri et al. 2006; Bandyopadhyay et al. 2010).

Again, lastly, in case of all networks, reciprocal exchanges in MU are notably higher than in AB. That may be because the farmers in the former village being mostly "middle farmers" are more resourceful than those in the latter village which enables a relatively larger number of them to make more direct exchanges possible among themselves. These outcomes do not conform to other studies in the related fields (Faust 1997; Borgatti 2005) but are in similar line with study carried out by some other researchers (Goswami 2007; Goswami and Basu 2011). Incidentally, it is interesting to note that the process of "middle peasantisation" , if we may use the concept, has started among the farmers of AB quite recently after implementation of rights to land and sharecropping, minimum wages, opening of labour market and facilitation of transport communication (Bandyopadhyay 1993; Dasgupta 1995).

CONCLUSION

Higher the value of s_3-measure of a network indicates more extent of inter-dependence among the actors of the network and hence the farming households of a network having greater value of s_3-measure are more inter-dependence among themselves in the sense of mutual help in agricultural production. Farming system reciprocity, hence, comes out to be a middle peasant phenomenon. Upper layer occupants among the agriculture –based households do not need exchange in any meaningful sense while those at the bottom lack surplus resources to exchange.

There are several implications for management in agricultural practices, specifically within rural farming communities with limited formal resources. Studying of such network may not only facilitate the transfer of relevant knowledge, but also to promote social exchange and interaction, strengthen pre-existing informal networks, and increase social proximity among farmers. Besides, such social networks may be used to support broader livelihood related information like health, education, labour migration, information on developmental programmes etc. needed by the farming community, which is a challenge for the developing countries.

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APPENDIX

Data on out-degrees of the households in different networks

Network	*Village*	
	Madhya-Uttar (N=88)	*Astabari (N=79)*
SP	0^{15}, 1^{21}, 2^{28}, 3^{17}, 4^{4}, 5^{3}	0^{24}, 1^{10}, 2^{22}, 3^{17}, 4^{2}, 5^{2}, 6^{2}
TI	0^{16}, 1^{10}, 2^{32}, 3^{18}, 4^{9}, 5^{3}	0^{16}, 1^{7}, 2^{16}, 3^{29}, 4^{5}, 5^{4}, 6^{2}
AV	0^{31}, 1^{31}, 2^{18}, 3^{6}, 4^{2}	0^{38}, 1^{14}, 2^{16}, 3^{9}, 4^{1}, 6^{1}
AG (SPUTIUAV)	0^{9}, 1^{11}, 2^{13}, 3^{27}, 4^{13}, 5^{7}, 6^{6}, 7^{2}	0^{11}, 1^{8}, 2^{8}, 3^{16}, 4^{9}, 5^{13}, 6^{5}, 7^{3}, 8^{4}, 10^{1}, 11^{1}
SL	0^{1}, 1^{10}, 2^{37}, 3^{27}, 4^{10}, 5^{2}, 9^{1}	0^{5}, 1^{9}, 2^{14}, 3^{24}, 4^{16}, 5^{6}, 6^{1}, 7^{3}, 8^{1}
AL (AGUSL)	1^{6}, 2^{16}, 3^{20}, 4^{19}, 5^{12}, 6^{10}, 7^{2}, 8^{1}, 11^{1}, 13^{1}	0^{1}, 1^{7}, 2^{8}, 3^{9}, 4^{12}, 5^{7}, 6^{15}, 7^{7}, 8^{5}, 9^{3}, 10^{1}, 11^{1}, 12^{1}, 13^{1}, 15^{1}

x^{y} = out-degree x occurring for y households