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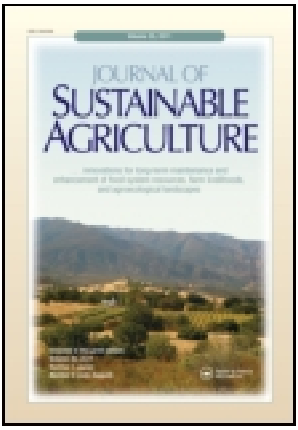

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Farmers' Participation in Knowledge Circulation and the Promotion of Agroecological Methods in South India

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In the context of widespread agrarian distress in rural India, finding ways to secure livelihood sustainability of small farmers have become urgent concerns. Agroecological methods (AEMs) are considered by some to be effective in solving structural problems with farmers' production processes engendered by the use of resource-intensive technologies. AEMs generally require extensive participation by farmers for further development through on-farm experimentation and collective learning. This article studies learning through the lens of knowledge circulation between farmers and 'experts' in a local innovation system. In particular, it analyzes farmers' participation in knowledge circulation using network data on problem-solving knowledge flows to and from an innovative south Indian village. The findings suggest that farmers' participation was restricted by formal and informal institutions governing the knowledge interactions between the development organizations that promoted AEM and the farmers. Any new ways of working (technological and institutional innovations) are argued to be filtered through the sediments of

This article has been a long time in the making and I have accrued the debt of many people on the way. Initial guidance was provided by my Ph.D. supervisor, Robin Cowan. Additional comments came from professors Arno Riedl and Alan Kirman. In India, Andy Hall and his colleagues at CRISP helped to set up the fieldwork. People at the NGOs in Hyderabad and Khammam gave their time and encouragement. Residents of Ananthadudem were the most gracious hosts and enthusiastic respondents. I will be forever indebted to them all. Interviews in Telugu were conducted by my friend Poorna Chandra and his contacts. Recent drafts of the article have benefitted from comments by Tommaso Ciarli, Koen Frenken, and two anonymous referees of this journal. Any errors of course remain mine and mine alone.

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extant techno-institutional context, leading to the profusion of hybrid forms of technology and organization. However, despite this profusion, or perhaps because of it, epistemological and socio-cultural hierarchies continue to operate in avowedly participatory projects organized to promote AEMs based on farmers' "traditional knowledge."

KEYWORDS indigenous knowledge, innovation systems, institutions, rural development, social networks

1. INTRODUCTION

Rural India is in the grips of an agrarian crisis. Agricultural indebtedness and natural resource-depletion are widespread ("On India's farms, a plague of suicide" 2006; Rao and Suri 2006; Nagaraj 2008; Posani 2009; Sainath 2009). Green revolution "successes," the provinces Maharashtra, Andhra Pradesh, and the Punjab, are the worst affected. Achieving livelihood sustainability of smallholders has thus become an urgent concern in policy and academic circles (Ghosh 2007; Government of India 2007; Mishra 2007; Chandrasekhar 2008). The focal points of achieving this sustainability are a) increased availability of affordable formal credit and insurance to resource-poor farmers, and b) ushering a new green revolution through technologies that can "increase productivity in perpetuity" (Swaminathan 2006, 4). This focus is challenged by critics, mostly from civil society organizations, who argue that the resolution of the current agrarian crisis lies beyond the ambit of cheap credit or a new green revolution. In fact, the latter is blamed for many of the structural problems afflicting farmers' production process. These problems, including the socioecological impacts of chemical pesticides and fertilizers and alarming depletion of groundwater due to the use of water-guzzling crop varieties promoted since the green revolution, are argued to lie at the root of the agrarian crisis. Thus, their preferred solution lies in the widespread adoption and development of agroecological methods (AEMs) (e.g., Sustainet 2006; Eyhorn et al. 2007; Shiva 2007; Ramanjaneyulu et al. 2009; also see International Assessment of Agricultural Knowledge, Science and Technology for Development 2009).

AEMs allow farmers to reduce costs of cultivation, for example, by substituting chemical pesticides and fertilizers with non-pesticidal and integrated nutrient management respectively, while creating avenues for the regeneration of farm ecology. AEMs are generally knowledge-based processes, often embedded in farming communities through *participatory* initiatives. They require on-farm experimentation and collective learning undergirded by two-way knowledge exchanges between different farmers on the one hand, and between farmers and any supporting organizations on the other.

Note that this collective learning for a new AEM takes place within an existing *system of production and innovation* that was put in place to develop and use a *competing* technology now under threat of substitution.

This article studies a participatory AEM development project in south India. Using network data on knowledge flows to and from farmers of an innovative village that received substantial media coverage for successfully averting the agrarian crisis by adopting an AEM, I analyze farmers' participation in local circulation of knowledge. I find that a basic condition for achieving collective learning—knowledge sharing—was rare among farmers of the village. In addition, the limited knowledge circulation between "experts" from a facilitating nongovernmental organization (NGO) and a few influential farmers was inadequate to sustain the continued use of the AEM. Using the network results as a basis, I discuss the framing of farmers' participation by formal and informal institutions. I argue that any new ways of working are filtered through the sediments of an extant techno-institutional context, leading to the profusion of hybrid forms of technology and organization. However, despite this profusion, or perhaps because of it, epistemological and sociocultural hierarchies continue to operate in avowedly participatory projects organized to promote AEMs based on farmers' 'traditional knowledge'.

This article is structured as follows. In section 2, I critically appraise some relevant facets of the vast innovation systems literature. Section 3 discusses the methodology, in particular, the identification of knowledge circuits in a network and the data collection approach. This is followed by a brief discussion of social dynamics in the village. Section 4 is divided into two parts. First, I present the patterns of AEM adoption and knowledge flows followed by an analysis of farmers' participation in knowledge circuits in the network. In section 5, institutional framing of farmer participation in agricultural knowledge creation is discussed. I conclude in section 6.

2. AGRICULTURAL INNOVATION SYSTEMS

In an innovation system, interactions between users and producers of a technology or product are considered to be the first vehicle of *knowledge circulation* and subsequent "learning by interacting" (R. R. Nelson 1993; Freeman 1995; Lundvall 1988). Additionally, (radical) innovation is considered to be a result of recombination of diverse ideas and knowledge types, as opposed to innovation simply as access to new ideas, which are unlikely to reside in a single actor (Ziman 2000; Vedres and Stark 2010). Thus, the recombinant nature of innovation necessitates that a dyadic user–producer interaction gets embedded in wider knowledge-flow networks between heterogeneous actors including upstream and downstream firms in a value-chain, producer and consumer associations, research centers, and government bodies. Such a network is governed by an institutional setting that includes formal regulations as well as the informal sociocognitive routines. Together these organizations and institutions form an *innovation system* (SI) that can be defined at various levels: the national (e.g., R. R. Nelson 1993; Lundvall, Johnson et al. 2002; Lundvall, Joseph, et al. 2009), regional or local (e.g., Cooke et al. 1998; Doloreux and Parto 2005), and sectoral/technological (e.g., Carlsson and Stankiewicz 1991; Breschi and Malerba 1997; Malerba and Mani 2009). In general, as Markard and Truffer (2008) point out, SI's promote innovative activity in existing technologies (incremental innovations) and toward novel technologies (radical innovations). Thus, both new and existing technologies may be developed, diffused, and used within a single SI.

In the last decade, the innovation systems framework has gained rapid currency in agricultural development studies. Unlike earlier top-down and "farmer-first" models of technological development (Chambers et al. 1989; Sherwood and Larrea 2001), agricultural innovation system scholars place equal emphasis on farmers' and scientists' knowledge, highlighting the need to integrate diverse types of knowledge at all stages of the recombinant innovation process (see, e.g., A. J. Hall et al. 2003; Spielman 2005; World Bank 2006; Biggs 2007; A. J. Hall 2007). Components of an agricultural innovation system include public research institutions,[1] CGIAR (Consultative Group on International Agricultural Research) institutes, private firms, NGOs, farmers and their associations, credit providers, formal institutions such as intellectual property rights and informal ones such as cultural 'traditions' and organizational routines. These formal and informal institutions are then seen as "rules and norms that govern" the "social process of learning" (A. J. Hall et al. 2003, 215). Knowledge circulation between different actors, shaped by formal and informal institutions, is deemed critical for continuous learning and innovation.

A considerable amount of agricultural innovation systems literature focuses on "institutional learning," particularly by national agricultural research institutions and the CGIAR (see, e.g., A. J. Hall et al. 2003; Horton and Mackay 2003; Raina 2003; A. J. Hall and Yoganand 2004; Klerkx et al. 2009). It is argued that, in order to create pro-poor agricultural innovations, the innovation *process* must be made genuinely participatory. The formal research establishment must abandon top-down models of technology transfer (from laboratory to farm). They must change their routines and practices in order to learn through interactions with diverse actors in an agricultural innovation system (farmers, NGOs, private firms) and recognize that there can be 'multiple sources of innovation' (Biggs 1990). That is, they must learn institutionally in order to learn technologically, for co-creating innovations that work for the poor.[2] Here they can attempt to emulate successful innovation processes in the "civil society" domain of NGOs and participating farmers (see Clark et al. 2003). However, we know from economic theory that organizational routines and other institutions are not easily amenable to change (Parto 2005; R. R. Nelson and Winter 1982). To be transformed successfully, they require concerted efforts driven by agricultural science and technology policies and by the commitment of individual scientists and extension workers.

Thus, learning institutionally involves the gradual build-up of capacities to engage in participatory processes that involve two-way knowledge exchanges between farmers (and other non-scientists) and scientific experts. Obviously, not all technologies may require a highly participatory mode of working and joint learning with and from farmers. The degree of input from farmer-users may depend on the complexity of a new technology and the degree to which the technology requires users to change established ways of working (Douthwaite et al. 2001). In the specific case of knowledge-intensive AEMs, which often require on-farm preparation and experimentation, knowledge sharing with and among farmers may be critical (Warner 2008).

The concept of institutional learning in the agricultural innovation system literature however fails to capture the complexity of the actual practice of participatory and community-driven technology development projects. This practice is shaped not only by routines of research organizations but also by local social relations and heterogeneities (e.g., due to religion, caste, and gender-based identities) existing within poor communities. These heterogeneities may cause interests and knowledge of some community members to diverge from those of others. This divergence, and its interplay with extant expert-farmer hierarchies that continue to situate project administrators as legitimate interpreters of community conditions, may cause the needs and knowledge of locally dominant individuals and subgroups to be interpreted and projected as those of the entire community (Mosse 1995; Chhotray 2004).

In addition, these local politics of participation become enmeshed with institutions and practices associated with a competing technology that is more widely diffused. Thus, while agricultural innovation system studies highlight the institutional heterogeneity and diversity of innovation processes, they tend to neglect the fact that any new technology gets filtered through a sociotechnical substratum constructed around an older competing technology.

Dominant incumbent technologies, and technological paradigms or regimes,[3] may have an advantage over competing new ones due to a range of economic, social and cultural factors. These factors include a) innovation policies that promote the development of new technologies within the dominant paradigm (e.g., that of the green revolution); b) user perceptions formed over time; c) extant knowledge and expertise-based hierarchies; and d) other private and public sector activities and routines including lobbying by industry associations (e.g., seed, chemical pesticide, or fertilizer manufacturers) and their power to set research and policy agendas, media bias, and pressures to perform research that is publishable in high-impact journals (Vanloqueren and Baret 2009). In general, public and private research activities are embedded in stable technological regimes that provide the grammar of cognitive routines and social conventions. These routines and conventions shape technological development by affording legitimacy to only some innovations while excluding others (Geels 2004; Holtz et al. 2008). This extant institutional bias hinders radical changes to existing regimes (and paradigms).

Variants of many of these regime factors can be observed at the local level, hindering the introduction and development of agroecological innovations. These include the joint work of agricultural extension officers and seed/pesticide/fertilizer (all-in-one) dealers in promoting input-intensive agriculture (e.g., by offering expert advice that accompanies the provision of chemical inputs or through the supply of farm-inputs on credit to farmers). Other similar factors include socioeconomic proximity of some input dealers to influential farmers; farmers' perception that crop yields will reduce dramatically if they don't use chemical pesticides and fertilizers; and the association of farmers' social status and prestige in a village with higher yields.

These factors constitute the local *organization* around an existing dominant technology. In the knowledge domain, this organization can be observed in the form of networks formed to transfer and share knowledge between 'experts' and farmers. In this article, I focus on circuits of knowledge organized to support the continued use of an existing technology, which co-exist with knowledge circuits to facilitate the further development of a new competing AEM. For AEMs, these circuits of knowledge may be formed by farmers and representatives of a supporting organization, who attempt to bridge the "expert"-farmer knowledge hierarchies (cf. Nerbonne and Lentz 2003; Warner 2008). However, this knowledge sharing and learning for AEM may spur actors with vested interests in the continued use of the older substitutable technology to organize new, or bolster existing, competing circuits of knowledge. Through such knowledge-sharing, the older technology may be improved (or adapted to local socioecological conditions) to better meet the needs of the farmers. By seeking knowledge from farmers, producers or suppliers of an old technology may also successfully project that they are as "participatory" and sincere about addressing farmers' problems as the promoters of a new competing AEM.

3. VILLAGE, FIELDWORK, DATA, AND METHODS

Knowledge has long been treated as a central component of technology (see, e.g., Constant 1980; Dosi 1982; Rosenberg 1982; K. Nelson and Nelson 2002). Knowledge, here, is distinct from information, particularly in the sense that it cannot be wholly codified and transmitted. The noncodifiable component of technological knowledge is often referred to as tacit knowledge, which is considered akin to skills (Polanyi 1962; R. R. Nelson and Winter 1982; Cowan et al. 2000). Tacit knowledge is difficult to articulate verbally. But even when it is "verbally articulable," such as in the case of skilful swimming or balancing of a bicycle, it may still be difficult for a listener to emulate a skilled performer (Polanyi 1962). Thus, the transfer of tacit knowledge requires extensive face-to-face interaction, underlining the importance of interpersonal knowledge-exchange networks.

In this article, a knowledge(-flow) network of a south Indian village was constructed using new data collected by the author for purposes of this study (see below for data collection approach). The links in this network are directed, representing the flow of knowledge from a source to a recipient. Traditional network measures (e.g., centrality), focusing on transmission of *information*, are inadequate to capture the essence of interactive learning through *knowledge* circulation. This circulation, as I argued in section 2, is considered critical for innovation through recombination and participatory development of AEMs, which require knowledge sharing between two or more actors. To identify such knowledge circulation structures involving multiple nodes in a (directed) network, I use a method based on the graph-theoretic notion of a cycle (a circular process of flows). The most basic circuit of knowledge is a cycle between two individuals who receive and provide knowledge to each other. In bigger cycles involving three or more nodes, each node has an incoming link from and an outgoing link to two different nodes in the cycle (see Figure 1 for an example). Thus, every node is directly or indirectly connected to all other nodes in a cycle. Furthermore, in cycles of size 3 or more, there can be additional internal links (see Figure 2a for the same cycle as in Figure 1, but with one additional internal link). These cycles (with additional internal links) nest smaller cycles within them (for instance, in Figure 2b, a cycle between nodes 1, 2, and 3 is nested within the larger cycle of size 4). There can be a large number of such cycles in a directed (knowledge) network.[4]

3.1. The Village and the Land

The studied village, Ananthagudem (a pseudonym), of approximately 900 inhabitants is located in Khammam district of Andhra Pradesh (AP). Out of a total of 212 households, 155 are cultivating farmers. 141 of the 155 farming households own some land, and 14 exclusively cultivate land leased from others (a few farmers with small landholdings also lease land; see Table 1).

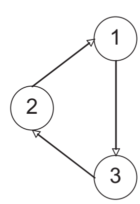

FIGURE 1 A cycle of 3 nodes.

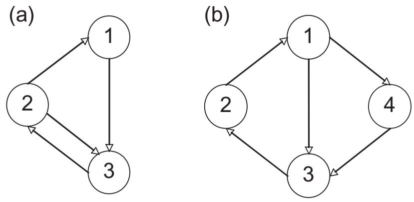

FIGURE 2 a) A cycle of size 3, with an additional internal link. A) A four-node cycle, with an internal link.

TABLE 1 Distribution of land holdings (owned and cultivated) in the village

	Number of owners (%)	Number of cultivators (%)
Number of farmers with ≤ 2.5 acres	71 (50.3)	48 (31.0)
More than 2.5 but ≤ 5 acres	50 (35.5)	51 (32.9)
> 5 but ≤ 7.5 acres	7 (5.0)	26 (16.8)
> 7.5 ≤ 10 acres	8 (5.7)	20 (12.9)
> 10 ≤ 15 acres	2 (1.4)	7 (4.5)
> 15 ≤ 20 acres	3 (2.1)	3 (1.9)
Total number of farmers	141 (100)	155 (100)

An overwhelming 86% of the farmers are smallholders who own up to 5 acres of land. In addition, the village is inhabited by 38 landless farm-laborers whose primary income is derived from agriculture.[5] Some households are engaged in non-agricultural professions such as small shop-owners in the village and construction work in a nearby town. A small number of farmers derive supplementary income by running small shops, or plying auto-rickshaw taxis. Overall, the main source of income in the village is agriculture which supports livelihoods of approximately 90% of its population.

The main crops grown in the village are cotton, paddy (rice), pigeon pea, and chilli. As in most other parts of India, there are two agricultural seasons: the rainy *Kharif* from July-August to December-January, and the dry *Rabi* from January–February to May–June. In and around Ananthagudem, cotton and paddy are by far the most popular Kharif crops, with pigeon pea mostly grown in Rabi. The focus of the present study is on the two Kharif crops, on which NPM was primarily promoted, largely because they are the most pesticide-intensive crops grown in the region. They were also grown by 80–90% of Ananthagudem farmers.

Ananthagudem has 10 caste groups. I have caste information for 210 out of 212 households (see Table 2). The two households, whose caste is not known, operate small shops in the village and do not own any land. The largest group is the Hinduized *Koya* tribe (75 households). A comparable group in size is that of the peasant caste, *Yadava* (62 households). The third and fourth largest groups are the *Lambadi* and the Dalit *Mala*

TABLE 2 Caste and land distribution in Ananthagudem

Caste	Number of households	Number of cultivators	Total land owned (acres)	Average per household (acres)	Standard deviation
Koya	75	60	154.4	2.06	1.18
Yadava	62	44	155	2.5	1.08
Lambadi	29	19	53.5	1.85	1.09
Mala (Dalit)	14	11	47.5	3.39	1.87
Mudiraj	10	6	50.5	5.05	2.24
Potter/Carpenter	7	6	12.5	1.79	0.57
Goud	5	2	3	0.6	0.28
Dudekula	4	3	8	2	0.57
Choudhary	3	3	6	2	0.35
Reddy	1	1	0	0	
Total	210		490.5	2.34	1.30

respectively. No single group dominates clearly in numbers: the difference between the two largest groups is only 13. Neither was there a domination of one group in economic power as measured by total land area: the *Koya's* collectively own 154.4 acres and the *Yadava's* own 155 (see Table 2). Although the amount of land owned per household is different for each caste, the inter-caste differences are not substantial (in many other parts of rural India, "traditional" landowning castes still control large parcels of land; Singh 2008). Therefore, we can conclude that Ananthagudem does not have a single *dominant caste,* using Srinivas' (1955) criteria.[6] This was confirmed in interviews during the fieldwork: nearly everyone maintained that there was no caste-based oppression or hierarchy in Ananthagudem. Correspondingly, the landless (and farmers with the smallest landholdings) are more or less evenly distributed among the different castes: there was no single identifiable marginalized caste group in the village. This absence of a dominant (or marginalized) caste *group* does not imply that there were no *individual* small and big farmers, as the standard deviation figures in Table 2 demonstrate. Thus, caste affiliations and status (e.g., as caste headmen) of individual farmers who are part of the knowledge circuits are taken into account in the analysis (see section 4).[7]

3.2. Mapping Knowledge Flows

The agroecological method (non-pesticidal management, NPM) was introduced by two NGO's in 2001. The first is a grassroots or local NGO that works with resource-poor farmers in tribal areas of AP's Khammam district. The second is a Hyderabad-based knowledge NGO that has been developing and promoting NPM for the last two decades. Ananthagudem gained widespread media publicity in 2004–2005 due to its success with the low-cost NPM and for restoring smallholder profitability while agrarian crisis had gripped the rest of the country. No media reports are cited here to protect the anonymity of the village (and its exact location). The aims of the present study and the fieldwork was not to evaluate the degree of NPM success in the village, but rather to analyze how such a positive case of socioenvironmental development was locally organized.

Fieldwork for collecting data was carried out between September 2005 and April 2006. Survey interviews with the farmers and others were conducted during the last three months of the fieldwork. The first five months were used to gather preliminary information about the NPM project and get familiar with the village and its inhabitants. This information and familiarity were critical for designing the survey questionnaire so that the questions asked by an interviewer were effectively communicated to the farmers, to capture the knowledge flows. To the best of my knowledge, all farmers in the village were interviewed for collecting network and NPM use data. For the latter, farmers were asked about the year they adopted NPM and if they switched back to pesticides after using NPM for one or more years (see section 4).

NPM, according to the NGO representatives, was largely derived from 'traditional knowledge' of farmers from central and south India. Seven NPM practices were commonly used by the farmers: neem seed kernel extract; cow dung and urine solution; chilli and garlic extract; pheromone traps; trapper plants such as sunflower, maize, marigold etc.; delayed planting; and crop rotation. The NPM package brought in by the NGO's was however not limited to these seven practices, farmers could use others out of an overall list of 12–14 available methods. Both the local and Hyderabad-based NGOs consider the future development of NPM as heavily contingent on experimentation and learning by farmers, which in turn depends on knowledge sharing among farmers and with NGO representatives. For wider participatory development of NPM, results of farmers' knowledge creation efforts must find their way to NGO representatives. This makes reciprocal knowledge flows between NGO representatives and farmers, and among farmers, central to understanding the NPM experience.

Disentangling knowledge interactions from other everyday interactions of farmers was a difficult task. Pre-survey discussions with farmers revealed that they could most easily recollect their knowledge interactions that were useful for solving any serious problems encountered on the fields in the previous few years. Thus, I decided to focus on flows of problem-solving knowledge. That is, knowledge sought, and provided by, farmers and others when confronted with an acute problem—in this case, a severe pest attack (cf. Udry and Conley 2004, 4–5). On cotton, such pest attacks occurred approximately once in two to three seasons. Farmers considered a pest attack severe when they could not control it using their regular practices and had to approach others (farmers, NGO representatives, pesticide dealers, government extension officers) for problem-solving advice. Thus, farmers were asked when they faced a severe pest attack in the last three years (note that the survey interviews were conducted at the beginning of 2006 when the Kharif cultivating season was just ending). About half the farmers responded that they faced a severe pest attack in that Kharif season. The rest were roughly equally divided between the previous two years (2003 and 2004 Kharif seasons). Subsequently, farmers were asked to name the people who they approached for advice to solve the pest attack problem, and those approached them for related advice.

In order to effectively map knowledge flows to and from farmers to a heterogeneous group of other actors, farmers were asked to provide names of people in different categories including other farmers (from Ananthagudem or neighboring villages), NGO representatives, and pesticide dealers (such categories are commonly employed as name generators in network data collection; see Marsden 1990 for a review). For each question, farmers were urged by the interviewer to provide as many names as possible. Note that by including pesticide dealers, I was able to map pesticide-related knowledge flows in addition to those pertaining to NPM.

Questions about NPM were also asked to farm-laborers to map if and how they took part in NPM activities. Representatives of both NGOs, who had direct knowledge contact with farmers, were interviewed. Similarly, four pesticide dealers from whom farmers sourced knowledge and farm-inputs were also interviewed. These outside "experts" were asked to name farmers they regularly consulted and received feedback from and farmers who often took advice from them.

The knowledge network was then constructed using responses of the village residents and the outsiders. If a farmer reported to have received knowledge from another person, a directed link from the latter to the former was made. Similarly, if a farmer reported to have provided knowledge to another, a link was drawn from the former to the latter. When asked to name the farmers who received advice from them, NGO representatives and pesticide dealers generally claimed that all (or most) Ananthagudem farmers came to them for advice. Thus, precise link data about the knowledge received by the farmers is based on their own self-reports, with the NGO representatives' and pesticide dealers' providing a general confirmation. The experts did, however, name individual farmers who acted as their sources of knowledge.

Finally, in most cases, the data capture knowledge ties of male "heads" of households in the village. So, the data and this study more generally are susceptible to a gender-bias critique for omitting the central role of women's knowledge in the local agrarian economy. By taking the "mythical" unitary household as a unit of analysis (Razavi 2009),[8] and removing women from knowledge circulations, I have uncritically embraced the overtly male-dominated organization of the NPM project in which 9 out of 10 resource persons (farmers who facilitated NGO activities in Ananthagudem) were male. And as I discuss in section 5, such male-biases of participatory projects may buttress, rather than subvert, existing relations of power which subordinate women's agricultural knowledge to that of men.

4. ANALYSIS

In 2001, when NPM was introduced to the village, nine farmers adopted the technology and set the stage for interactive learning in the local innovation system. In this section, I first chart NPM adoption in Ananthagudem within the context of continued pesticide use. This is followed by an analysis of farmers' participation in knowledge circuits in the network.

4.1. Contours of NPM and Pesticide Use

A total of 72 farmers (about half of the total 155) tried out NPM in at least one season between 2001 and 2005–2006. However, many of the 72 adopters abandoned NPM after using it for one or more seasons. Farmers' reasons for stopping NPM ranged from the labor-intensive nature of some NPM methods to simply the ineffectiveness of NPM in controlling pests. Other farmers restarted pesticide use alongside NPM (some reported that using pesticides early in the season was more effective than NPM methods). Patterns of NPM and pesticide use on cotton and paddy (the two main crops cultivated in the village) since 2000 are shown in Figure 3. Before 2001, I assumed that

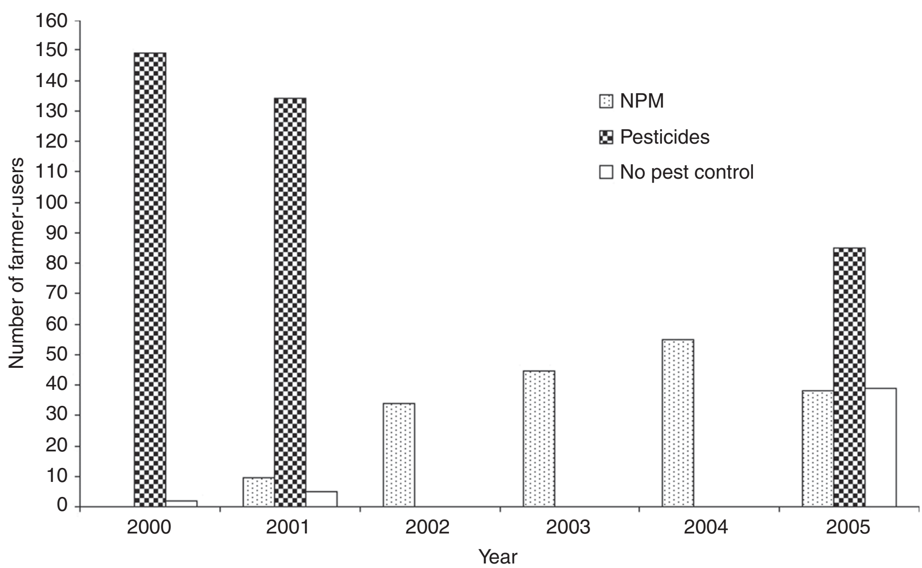

FIGURE 3 Number of users of NPM and pesticides (between 2002 and 2004, data only available for NPM users).

all farmers in the village were using pesticides except those who reported to have stopped pesticide use earlier (without the option of switching to NPM). A few additional farmers reported to have stopped using pesticide use in 2001 without trying out NPM. Between 2002 and 2004, the number of NPM users steadily increased. In 2005, however, the number of NPM users was lower than in 2004. Only 38 farmers used NPM in 2005, while the number of pesticide users stood at 85 (these numbers include eleven farmers who used both pesticides and NPM methods). Interestingly, by 2005, 39 farmers were using no pest control on cotton or paddy. However, only 9 of these farmers came to "no pest control" after using NPM first. Others simply stopped using chemical pesticides without trying out NPM after finding that the pesticides were not effective in controlling pest attacks and their high costs were landing farmers in debt.

In Kharif 2005 (the season of my fieldwork), the number of farmers who used *only* pesticides was 74 whereas the number of NPM-only users was 36 (this includes 9 farmers who used nothing *after using NPM* for a few years, but not the 11 farmers who used pesticides and NPM both). Collectively, the pesticide users controlled a significantly larger amount of resources in the village than NPM users. Access to *resources accessed per farmer* for the two groups is shown in Table 3. Pesticide users have, on average, better access to land and labor than NPM users. Access to number of credit sources is roughly the same for farmers in the two groups.[9] However, the difference between the two groups in access to any of the resources per farmer was not found to be statistically significant (the null hypothesis of the *t* test was not rejected at a confidence interval of 0.05). The latter may be due to the fact that the two samples come from the same population of farmers belonging to one village.

4.2. Knowledge Flows and Circuits

Knowledge interactions in a local innovation system may include farmer-to-farmer knowledge flows, exchange between farmers and other agricultural actors, and interactions between diverse off-farm actors. Such a map of the knowledge-flow network for pest control, in and around Ananthagudem, is

TABLE 3 Access to resources by pesticide and NPM users in the village

	Pesticide users	NPM users
Number of cultivators	74	36
Average land owned, acres per farmer	3.58	3.13
Average land area cultivated, acres	5.71	4.57
Availability of laborers, average per farmer	0.22	0.14
Average number of credit sources	1.35	1.36

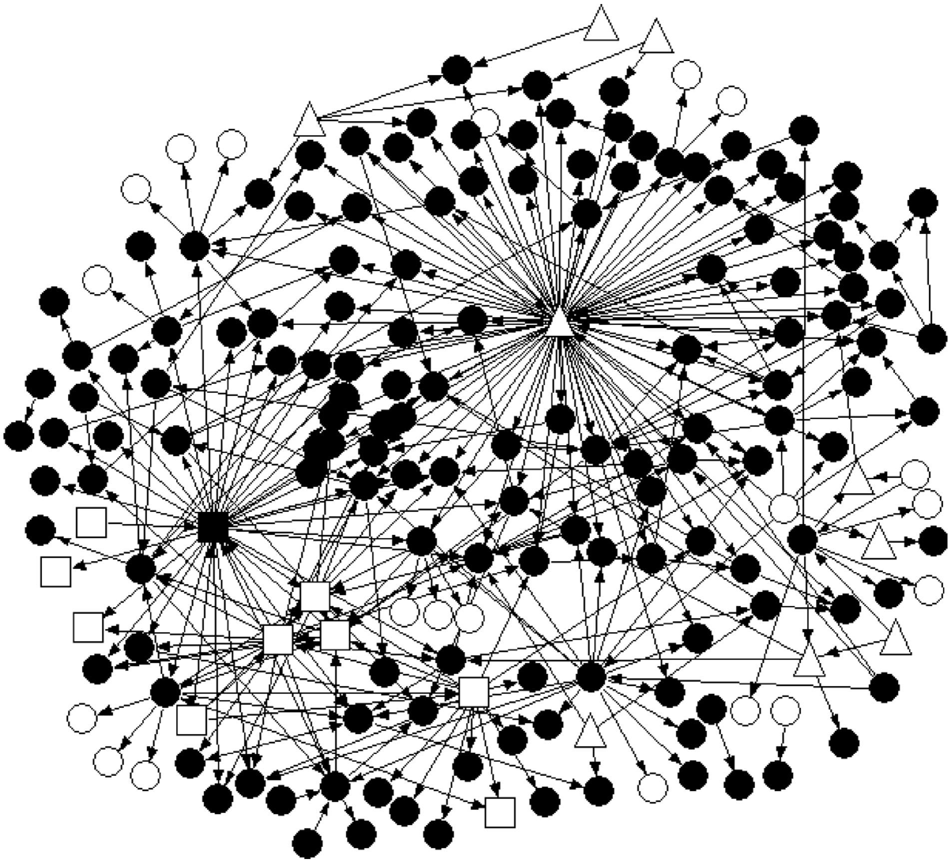

FIGURE 4 Ananthagudem's knowledge network: village residents depicted as black nodes and nonresidents as unfilled nodes (isolates, people not connected in the network, are not shown in this picture). Arrows represent the direction of knowledge flows.

shown in Figure 4. Arrows in Figure 4 represent the direction of knowledge flows. Residents of the village are represented as filled nodes whereas outside actors are shown as unfilled nodes. All farmers in the network from Ananthagudem and other neighboring villages are represented using circles;[10] NGO representatives are drawn as squares; and pesticide dealers as triangles. Some basic statistics about the network are shown in Table 4.

It is clear from Figure 4 that NGO employees and pesticide dealers are central sources of knowledge in the network: indeed, they possess the highest out-degree centrality. Actors with high degree centrality are listed in Table 5 (all names used in this article are pseudonyms, values calculated using Pajek: Batagelj and Mrvar 2007). The most popular source of knowledge is the main pesticide supplier to the village, M. Raj. Through his (direct and indirect) outgoing links, or paths in the network, he can reach 119 out of a total of 155 Ananthagudem farmers. M. Raj derives his popularity in

TABLE 4 Basic statistics of the knowledge network

Network property	Value
Number of connected nodes	188
Number of links	330
Density (ratio of the number of actual links to the total number of possible links)	0.0094
Number of nodes with an outgoing link	76
Mean out-degree (average number of outgoing links)	4.34
Number of nodes with an incoming link	161
Mean in-degree (average number of incoming links)	2.05

TABLE 5 Knowledge network members with high degree centrality (all names are pseudonyms)

Name	Out-degree centrality	Name	In-degree centrality
Raj, M., farm-input dealer	0.2801	Payal, D., NGO representative	0.0248
Meka, B., NGO representative	0.1206	Perumal, E, NGO representative	0.0248
Neha, C., NGO representative	0.0638	Selvi, F.F.	0.0248
Yarla, F.Q.	0.0567	Naidu, C.Y.	0.0213
Addala, A., NGO representative	0.0497	Koli, E.D.	0.0213
Pillai, G.B.	0.0319	Meka, B., NGO representative	0.0177
Gowda, C.L.	0.0248	Seri, A.T.	0.0177
Perumal, E., NGO representative	0.0213	Datla, B.T.	0.0177
Raman, L., Extension officer	0.0213	Moti, C.Q.	0.0177
Gorinta, E.G.	0.0177	Sapna, E.W.	0.0177

Ananthagudem from a) his local roots (son of the biggest landlord in the area, residing in the village immediately neighboring Ananthagudem); b) he belongs to the largest peasant caste, Yadava; c) unlike most other dealers, he offers farm-inputs on credit to Ananthagudem farmers; and d) he is a close friend of many Ananthagudem elites including the president of the village council (*gram panchayat*) and some headmen of caste groups. Four of the ten actors with highest out-degree centrality values are representatives of the local NGO. The most connected NGO representative, B. Meka, is able to reach 67 farmers through her direct and indirect outgoing links. B. Meka is the only NGO representative residing in Ananthagudem and is a member of the largest caste group, Koya, in the village. She is also closely related (sister-in-law) to the president of the village council. Note that among the top ten knowledge sources, there are only four farmers.

In contrast, seven farmers are among the ten people with the highest in-degree centrality, that is, the people who seek advice from the largest number of other people in the network. Three local NGO representatives are also members of this set with the highest in-degree centrality. But more than half (10 out of 19) their incoming links come from other NGO actors.

As discussed in section 3, for a subnetwork (with two or more nodes) to qualify as a "circuit of knowledge" in the network, it must possess a cyclic structure. A large number of such cycles (>50) can be identified in Ananthagudem's knowledge network. Just one of these cycles (of size 2) is constituted by farmers only. All other cycles included at least one NGO representative or a pesticide dealer. Therefore, with the exception of a two-node cycle, knowledge circuits in the local innovation system are constituted by

1. NGO representatives and farmers, or
2. only NGO representatives, or
3. farmers and the main pesticide/fertilizer supplier.

The lack of cycles between farmers does not imply that farmers do not provide knowledge, or problem-solving advice, to other farmers: 142 out of a total of 330 links in the network originate from farmers but only 16 of these links provide knowledge to NGO representatives. Thus, while expertise-based hierarchies may be hindering knowledge transfer from farmers to NGO representatives, farmers themselves regularly approach other farmers for problem-solving advice: A substantial 38% of the links in the network (126) are farmer-to-farmer unidirectional flows of knowledge.[11] Yet, barring the one exception of a two-farmer circuit, these knowledge flows do not lead to the formation of knowledge circuit among the farmers alone. Many of the farmers who act as knowledge sources are influential people who are either close to the NGO representatives or the pesticide dealer and often approach these experts for advice instead of another Ananthagudem farmer. These influential farmers are also often caste headmen who may be reluctant to ask other farmers who are "lower" in status than them for problem-solving advice.

4.3. Farmers in Knowledge Circuits

Examples of two circuits in Ananthagudem's knowledge network are shown in Figure 5 (a link with arrows on both sides represents two directed flows of knowledge). The first circuit is constituted by four NGO representatives and two farmers, and may therefore be treated as an NPM knowledge circuit. The second circuit is made up of three other farmers and the main pesticide supplier to the village. There are many knowledge circuits in the network but only eighteen farmers participated in them. The pesticide knowledge circuits, always structured around the main pesticide supplier to the village, include 8 farmers as members. The NPM knowledge circuits are home to 10 farmers.

Most of the 10 NPM farmers in the knowledge circuits were early adopters: 3 adopted NPM already in 2001, 4 in 2002 and 1 in 2004 (the

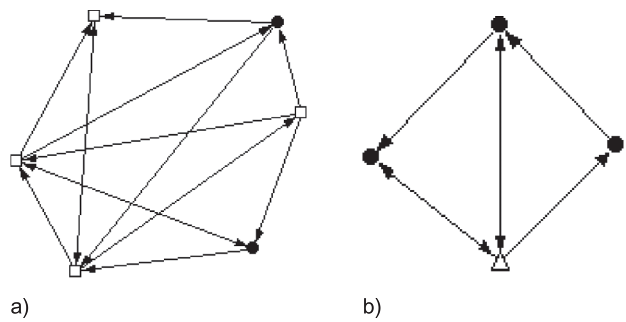

FIGURE 5 Examples of two circuits in the knowledge network. The unfilled node in (b) represents the pesticide dealer, and the unfilled nodes in (a) represent the local NGO representatives. All arrows represent knowledge flows.

year of adoption data are only available for 8 out of the 10 farmers). Thus, the average number of years these farmers used NPM (3.63) is substantially greater than the overall average among NPM adopters in the village (2.4). The village-wide average of the number of NPM methods used by an adopting farmer was found to be 3.2, while the 10 farmers in knowledge circuits used an average of 4.3 methods. Furthermore, only two of the latter farmers (20%) switched back to pesticide use after using NPM in one or more seasons, whereas the village-wide rate of switching back to pesticides was 50%. These data are shown in Table 6.

In addition to being experienced users of NPM, the 10 farmers in the knowledge circuits are influential people in the village. Two are caste headmen (including one who heads the largest cultivator-caste, Yadava, in the village). A third is the eldest son of a retired farmer who is also the headman

TABLE 6 Farmers in NPM knowledge circuits (all names are pseudonyms)

Name	Caste	Year of adoption	No. of years NPM used	No. of NPM methods used	Pest control in 2005–2006
Gowda, CP	Yadava	2001	5	6	NPM
Moti, CQ	Yadava	2001	5	4	NPM
Pillai, GB	Yadava	2001	4	5	None
Koli, EA	Mala	2002	3	3	None
Koli, ED	Mala	2002	4	4	NPM
Naidu, CY	Mudiraj	2002	4	5	NPM
Yarla, FX	Lambadi	2002	3	2	Pesticides
Kota, DN	Mala	2004	1	3	Pesticides
Sapna, EW	Koya	N.A.		6	NPM
Selvi, FF	Mala	N.A.		5	NPM
Average			3.63	4.3	20% reverted to pesticides
Overall village average			2.4	3.2	50% reverted to pesticides

of the third largest caste. A fourth cultivated the largest amount of land (20 acres of which he owns 18, making him the second largest landowner in Ananthagudem). He also owned the only tractor in the village. Two others are heads of 11-household and 7-household clans. These two, and another young circuit farmer, are widely regarded as "progressive" farmers by local NGO representatives and NPM farmers.[12] Six of the 10 farmers were resource persons of the local NGO which channels development resources through them. They help to mobilize other villagers to join NGO-led development programmes such as NPM and micro-credit groups.

In terms of caste affiliations, four NPM circuit farmers belong to the Dalit Mala caste. Two of these are brothers who exchanged knowledge with each other, forming the only knowledge circuit constituted by farmers alone. Three other NPM circuit farmers belong to the largest peasant caste, Yadava. They also acted as resource persons for the local NGO.

Some of the eight members in the pesticide knowledge circuits are also influential people in Ananthagudem. One of them is the headman of a small group of upper caste farmers. He cultivates 13 acres of land and runs a profitable dairy farming business. A second farmer owns the largest amount of land (20 acres) and is the president of the village governing council. Both these farmers are close friends of the main pesticide supplier, M. Raj. A third farmer-member of the pesticide knowledge circuits is a widely respected opinion leader who never stopped using pesticides.

Now an important question arises: what relational and cognitive factors underpin the formation of knowledge circuits that involve farmers? First, as the foregoing discussion shows, farmers in knowledge circuits are often respected as opinion leaders, or considered 'progressive', by other farmers and NGO representatives. Relatedly, the knowledge-circuit farmers are those who have gained considerable experience with the technology (early adopters or more extensive users in terms of number of NPM methods used), which afforded them with ample opportunities of learning by doing and using. They then act as sources of knowledge and potentially constitute circuits if they also access knowledge from others (often from NGO representatives).

Secondly, NPM knowledge circuits are predominantly built on institutionalized relations between the local NGO and village farmers. As discussed above, 6 out of the 10 farmers in the NPM circuits are NGO resource persons who may be considered as rural development brokers, bridging the development agency-beneficiary divide (cf. Rossi 2006). Development NGOs often approach "traditional" caste headmen and other influential people (e.g., the larger farmers) as entry points into a village to gain necessary local legitimacy for their development projects. In contrast, the pesticide knowledge circuits are undergirded by informal relations of friendship. These friendships connect two local elites (important farmers in pesticide knowledge circuits) with a nonlocal elite (the main pesticide supplier). In turn, one of these two important farmers is either a close friend, or a friend of a friend, with most other farmers in the pesticide knowledge circuits.

In summary, the foregoing analysis shows that farmers' participation in knowledge circuits was framed by local social institutions. These institutions include the routines of development agencies, such as epistemological hierarchies that curtail knowledge flows from farmers to NGO experts (more on this in section 5) and the practice of approaching influential people as entry points into rural communities. The development agency routines get entangled with other local (informal and formal) institutions such as caste headmanship and its continued relevance in south Indian rural communities (Ananth Pur and Moore 2010). The foregoing analysis also points to the importance of an institutional innovation at the village-level: the so-called NGO resource person who acts as a bridge or broker between the development agency and its beneficiaries (while being a beneficiary him- or herself). Note, however, that this new institution is not independent of older institutions such as caste-based status and development agency routines: as already noted, many NGO resource persons were either caste headmen or large (and/or "progressive") farmers.

5. DISCUSSION: FRAMING FARMER PARTICIPATION

A large majority of Ananthagudem farmers (137 out of a total of 155) were found to have played no direct role in the circulation of knowledge. In general, farmers acted either as knowledge recipients or as knowledge sources in mostly linear flows of knowledge. Both these roles created little room for the formation of knowledge circuits in which knowledge was shared among a small collective of farmers. Furthermore, in terms of the participatory (requiring knowledge interactions between farmers and experts) NPM project, I observed that very few farmers acted as sources of knowledge. Only 11 out of a total of 330 links transfer knowledge from farmers to NGO representatives, underlining the lack of direct involvement of farmers (and their knowledge) in participatory development of the AEM beyond their role as recipients of problem-solving advice. As discussed in section 2, two-way knowledge flows are critical for joint problem-solving and co-development of knowledge-based agroecological methods such as NPM in a local innovation system.

Knowledge exchange between farmers and NPM (and pesticide) suppliers may be restricted due to barriers of expertise-based hierarchy, lack of effective knowledge brokering (by scientists, agricultural extension officers, NGO representatives, farmers or other "neutral" actors), and the widespread belief that farmers' knowledge is essentially local or "indigenous" as opposed to "scientific" knowledge. Through this classification, experts relegate farmers' knowledge and skills to the realm of the nonscientific, that is, practical knowledge about everyday life which is inapplicable beyond its local context (Kothari 2002). It is also assumed to be scattered, akin to common sense (devoid of intellectual content and deductive logic), closed and nonsystematic (Agrawal 1995). However, as Agrawal has argued, there may be no substantive, epistemological, and contextual differences between scientific knowledge and so-called indigenous knowledge. Instead the differences are political: the politics of classifying knowledge into categories, where global and local asymmetries of authority are mirrored in the knowledge arena, privileging expert knowledge over farmers' knowledge of agricultural practices (Agrawal 2002).

Knowledge hierarchies continue to operate in projects such as those for AEM development, where indigenous knowledge is heralded as essential to harness for meeting the needs of the poor and achieving environmental sustainability (e.g., Blaikie et al. 1997; Warren 1991). However, proponents of indigenous knowledge often fail to recognize that indigenous knowledge, like all knowledge, is produced and interpreted within a set of unequal social relations. Honoring local practices and peoples' knowledge is not going to succeed without challenging the cultural power structures with which these practices and knowledge are deeply entangled (Gururani 2002). Within the context of a participatory project, development workers may discredit farmers' practices and knowledge through their "superior models of knowing and rational decision making" (Mosse 2005, 96).

Conversely, it may be erroneous to consider dominant science-based technologies such as pesticides or GM seeds, and the top-down green revolution models that sustain them, as operating outside the purview of farmers' innovation and participation. Farmers, particularly the large ones, are not just recipients of the research and development performed in corporate or government laboratories, acting as off-the-shelf buyers of farm-inputs, but may play an active role through local appropriation of "global science" (Shah 2005). Privileging a top-down imposition perspective obscures the agency of the farmers in actively transforming their knowledge and practices through the acquisition and integration of outside knowledge (Mosse 2005). Over time, farmers may incorporate such outside knowledge into everyday practice to such an extent that it becomes difficult to distinguish between global and local, indigenous and scientific (Gupta 1998 [see ch. 3]; Brodt 1999). This points to the existence and profusion of hybrid knowledges where the local or 'traditional' becomes hard to distinguish from the global or "scientific."

Similarly, in terms of organization of development projects, it is often difficult to distinguish between the democratic knowledge-sharing model of an avowedly participatory project and a top-down model of technology dissemination, as observed in the case of knowledge sharing between pesticide dealer and farmers discussed in section 4. For instance, the classic case of top-down technology dissemination—the green revolution—has been argued to be explicitly participatory, in terms of extension workers learning together with farmers (Ramanjaneyulu et al. 2005; Biggs 2007). Here again, organizational hybrids that combine top-down and bottom-up ways of working, participatory or not, seem to be a common feature.

The existence of technological and organizational hybrids points to a shared culture of agricultural development within which competing technologies are used and developed. In Ananthagudem, many pesticide users incorporated elements of NPM into their pest control strategies and vice versa. Thus, some Ananthagudem farmers used NPM and pesticides simultaneously. This hybridization was not restricted to farmers alone: one farm-input dealer sold alternatives (such as neem oil, a critical ingredient of NPM) alongside chemical pesticides for some time. Similarly, many NGO representatives working for NPM initiatives earlier worked as government extension officers who routinely argue for the efficacy of pesticides and fertilizers and promote their use, and work within top-down government-sponsored projects. Employment as an extension officer was also the most sought-after career development track for many NGO representatives I interviewed. In fact, during the duration of my fieldwork, two local NGO representatives quit their jobs to take up positions as government extension officers.

However, this amalgamation or hybridization in a shared culture of development does not imply that power relations in the local arena are concurrently remapped toward greater equality. The shared culture is composed of heterogeneous elements, and relations of power and difference persist "between different 'speakers' within the same cultural circuit" (S. Hall 1997, 11). Hybridization, thus, takes place within the context of asymmetric relations, providing greater legitimacy to some combinations while marginalizing others. Therefore, all organization for knowledge-sharing in a local innovation system, despite its hybridity, is produced within and shaped by cultural-relational (values, power) contexts and in turn carries the potential to reproduce the latter (cf. Bijker 2007; Gururani 2002).

6. CONCLUSIONS

In this article, by analyzing a south Indian village's knowledge network, I attempted to illustrate structures of knowledge circulation which undergird collective learning a local innovation system to promote the development and use of agroecological methods. First, *knowledge circulation* between different farmer–users was rarely observed, despite the fact that farmer-to-farmer unidirectional transfers of knowledge were common in the village. Farmers are central members of this local innovation system, and their knowledge creation efforts are important in adapting the AEM to village conditions and contributing to the wider development of the AEM. Thus, the lack of knowledge circulation can undermine a) capacity building among farmers to further develop and use the AEM; b) the embedding of AEM in the local agrarian community as a social practice; and c) the possibility of the AEM warding off competition posed by a pre-existing dominant technology (as documented for pesticides in section 4).

Second, the few farmers involved in knowledge circuits (both for NPM and pesticides) are "elite" farmers in the village, who derive their influence from a number of relational and experiential factors that are hinged on formal and informal institutions. These institutions include routines of development agencies and local (formal and informal) institutions of caste status and village council leadership. Routines of the development agency led to the selection of a few elite farmers, including caste headmen and other large farmers, as the first beneficiaries of the participatory NPM project. This selection also shaped learning by farmers to some extent: the earliest adopters of NPM, and those supported by the NGO to use a substantially larger number of NPM methods than other adopters, turned out to be the farmers who became members of the NPM knowledge circuits. Perhaps due to their successful learning about NPM, the rate of switching back to pesticides (after using NPM in a season) was lower among members of the knowledge circuits. This extensive use of NPM (long duration of use, large number of methods used), coupled with their elite status, allowed the circuit farmers to act as knowledge sources for other farmers *and* NGO field representatives. Therefore, the formation of knowledge circuits in the network was underpinned by institutionalized social relations put in place by rural development activities of the local NGO (more than half the farmers in NPM knowledge circuits were resource persons of the development NGO in the village) while being rooted in local caste "traditions."

More generally, little knowledge was observed to flow from Ananthagudem farmers to the experts. Farmers were largely recipients of problem-solving advice from NGO representatives (and pesticide dealers). This lack of wider farmer participation in "learning by interacting" may be restricted due to knowledge hierarchies between experts and farmers which continue to operate in avowedly participatory projects. All knowledge is produced and interpreted within a set of unequal power relations. Achieving genuine participation by farmers is more likely to succeed when these relations of power are carefully confronted rather than negated in participatory rural development projects (cf. Chhotray 2004).

However, the operation of knowledge hierarchies biased against small farmers does not completely foreclose their ability to exercise agency. These farmers attempt to mix and match technologies in their (often desperate) search for a new "miracle" solution to their problems. Such mix and match can produce hybrids or amalgams that defy a neat distinction between AEMs and chemicals, or between participatory organization and top-down models of agricultural development. Thus, efforts to promote sustainable agriculture can perhaps do better by recognizing that new AEMs may lose their "purity" as they get filtered through a sociotechnical substratum put in place by the green revolution. Moreover, ways to circumvent the amalgams, for example through certification and standardization of organic and non-pesticidal production, can lead to the exclusion of small farmers due to high costs incurred to achieve compliance. In addition, monitored standardization can be detrimental for smallholders' own knowledge, and lead to a reduction in the variety of agricultural practices and technologies actually used by farmers, thereby further diminishing their capacity to contribute to further development of sustainable practices (Vogl et al. 2005). Therefore, probably the most feasible route to sustainability of smallholder agriculture may be through the profusion of on-farm hybrids, while bearing in mind that wider development and poverty reduction goals cannot be realized through an agroecological technology fix alone: unequal power relations that are embedded in social institutions at local and global levels need to be challenged concurrently, and gradually remapped toward greater equality.

Consequently, implications for policies and strategies to promote pro-poor AEMs, stemming out of the analysis presented in this article, go against the popular wisdom (in development circles) according to which working with, rather than against, local institutions is necessary for widespread adoption of new agricultural technologies and practices. Extant institutions, and the technologies they sustain, in unequal societies generally work in favor of more powerful members in rural communities. These powerful members then may work against the widespread adoption of pro-poor AEMs due to their preference for a resource-intensive competing technology. Alternately, when they may support an AEM (as in the village studied here), the local elites are likely to become the locus of knowledge sharing and learning by successfully attracting the attention of agri-development organizations that are promoting the AEM's adoption and further development. Such an elite-centerd organization of participatory AEM adoption and development projects ends up diverting scarce (knowledge) resources away from the less powerful and marginalized, thereby diminishing any possible contribution of such projects to poverty alleviation. Perhaps, the latter is more likely in AEM projects that work against extant institutions by nurturing the capacity of the marginalized to subvert the dominant rules of the game, with full cognizance of the fact that such subversion often takes the form of a protracted social struggle against inequality and domination. This subversive struggle may be necessary for making AEMs genuinely pro-poor.

NOTES

1. In India, these include the Indian Council for Agricultural Research (ICAR) and various state agricultural universities.

2. Note here that it is the *process* of (participatory) learning that makes an innovation pro-poor, that is, helps to sustain livelihoods of smallholders and the landless. Perhaps due to their process focus,

agricultural innovation system studies have rarely defined the traits of an innovation (product, technological artefact) itself that make it work in favor of the poor. Older studies on the "benefits" of the green revolution argued that labor-intensive, cost- and risk-reducing technologies are likely to have greater poverty-reducing impact. However, the actual impact of any technologies depends on a number of other local institutional factors (see De Janvry and Sadoulet 2002 for an overview). In the present article, I follow agricultural innovation system scholars in retaining the process focus.

3. Agroecological methods and chemical input-intensive farming can be considered as embedded in two different competing technological paradigms or regimes. A technological paradigm defines the sociocognitive space (design heuristics, mental models) for further technological development in certain directions while excluding others (Dosi 1982). A broader related concept is a technological regime which includes social conventions, economic interests and knowledge infrastructures in addition to the cognitive routines (Malerba and Orsenigo 1997; Geels 2004).

4. I wrote a computer program in C++ to identify cycles in Ananthagudem's knowledge network. The program is in two parts. The first part reduces the knowledge network to nodes that have at least one incoming and one outgoing link (as a node can only be part of a cycle if it has these two links). The second part takes the reduced network as input and does a depth first search on it to find paths (http://www.ics.uci.edu/~eppstein/161/960215.html). All paths that start and end in the same node are cycles. The list and composition of the cycles and the computer program used to find them are available from the author on request.

5. The preponderance of small and marginal landholdings underlines the importance of a pro-poor approach to agricultural sustainability in the village. In villages with larger diversity in landholdings, a niche-based approach may be more appropriate. In such a niche-based approach, for instance, different types of agroecological projects may be designed and implemented for small, mid-sized and large farmers.

6. I used the amount of land owned and numerical strength in the village as measures of economic power to identify the dominant caste in Ananthagudem, as defined by Srinivas (1955). Using other more ambiguous measures such as the level of education, availability of irrigation (most land in Ananthagudem is either rain-fed or bore-well irrigated) and type of house (concrete-slab roof house versus a thatched hut) did not lead to the identification of a dominant caste in Ananthagudem.

7. As the focus of this article is on individual farmers who joined knowledge circuits, I do not perform an in-depth examination of the influence of inter-caste difference on knowledge network structure at the group level. A quick examination of the knowledge network between Ananthagudem residents revealed that, for each caste group, the number of intra-caste knowledge flows is smaller than inter-caste flows. Thus, at the group level, inter-caste difference does not appear to curtail knowledge transfers in the village.

8. It has however been observed that women's interests are not completely independent of those of their households (Razavi 2009, 209). This interdependence may be treated as a rather weak antidote to the gender-bias of the present article.

9. Note that I do not have data on the actual amounts of credit taken by the farmers. These amounts are likely to be higher for pesticide users, simply because of the higher costs of chemical pesticides.

10. Farmers from neighboring villages were sometimes reported as recipients of knowledge from Ananthagudem farmers. I was unable to interview the non-Ananthagudem farmers directly and, thus, they are not the focus of the present study.

11. Of these, 109 links transfer knowledge among Ananthagudem residents. The remaining 17 links transfer knowledge from Ananthagudem farmers to farmers residing in neighboring villages.

12. NGO representatives generally considered farmers who were enthusiastic about the NGO's development projects (and expressed it for instance through the early adoption of and experimentation with sustainable agriculture techniques) as "progressive."

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