Mapping village social networks to analyze vulnerability to climate variability and adaptive capacity in the semi-arid tropics of India

Padmaja Ravula, MCS Bantilan, D Parthasarathy and Naveen P Singh

Abstract:
Adaptive capacity is influenced by a number of context-specific factors - socioeconomic-cultural-political-institutional- that constrain or strengthen resilience to shocks and risks. In this paper, village censuses and case studies are used to analyze the dynamics of social relationships by mapping the network architecture of rural men and women in agriculture. It captures key transactions and relationships within and outside the village. The methodology allows for innovative quantitative and qualitative analysis of social networks to capture the village dynamics in responding and adapting to climate related variability. This analysis facilitates the identification of strategies by adaptation practitioners through viable entry points for intervention, media for collective action, pathways of information flows and access to resources and services. Insights from gender-based analysis illustrate how social networks influence and shape individual and collective behaviors in this process. Understanding adaptive capacity ultimately provides a basis for identifying delivery channels for technical adaptation options.

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2 International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
3 International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
4 Indian Institute of Technology, Bombay
5 International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
1. Introduction:

It is now a greatly accepted fact that climate change is a global phenomenon, with impacts that are already being experienced on a human level. Climate changes are likely to manifest in four main ways: slow changes in mean climate conditions, increased inter-annual and seasonal variability, increased frequency of extreme events, and rapid climate changes causing catastrophic shifts in ecosystems. It is also recognised that it is those who are already the most vulnerable and marginalised who experience the greatest impacts (see IPCC 2007). These vulnerable and marginalized groups and people are in need of adaptation strategies in the face of such shifts in weather patterns and variability. At the same time, it is the vulnerable and marginalised who have the least capacity or opportunity to prepare for the impacts of a changing or a variable climate. Women, especially rural women dependent on agriculture for their livelihood and in most cases are the poorest of the poor, are most affected by these changes. Despite the lack of hard evidence it is being increasingly recognised that climate change exacerbates existing inequalities in the key dimensions that are not only the building blocks of livelihoods, but are also crucial for coping with change, including: wealth; access to and understanding of technologies; education; access to information; and access to resources (Masika 2002). Along with these, social and institutional innovations and arrangements are also becoming important in coping with climate change and variability.

Vulnerability is the susceptibility of people, a community or an individual to the harmful impacts of disturbance in climatic conditions and weather patterns. An individual’s or a group’s vulnerability to climate variability besides the obvious reasons of rainfall and temperature are influenced by a complex array of socio-economic and institutional factors operating at various levels (Brooks 2003). Rupsha et al (2010) further state that as the understanding of vulnerability goes; it is the level of risk that one is exposed to; the higher the level of risk, the higher the vulnerability. The level of risk can differ from groups of people or individuals depending on their position in society. Social and cultural factors influence and shape characterization of risks and selection of risk management strategies. Perceptions influenced by socially embedded beliefs and values. Hence decisions regarding risk are based on the way of life or world view of the individual, household or community (Douglas and Wildavsky, 1983; Parthasarathy 2009) Individuals and groups rank risks in terms of their probabilities, their own coping strategies, ability and the willingness of the state to help them adapt and survive various crisis and disasters (Parthasarathy et.al 2009).

The semi-arid tropics (SAT) with a harsh environment and exposed to the vagaries of climate variations are home to over 2 billion people globally, and 644 million of these are the poorest of the poor. Low soil productivity, rainfall variability, water shortage or scarcity, poor development in rural infrastructure, institutions and markets are major identified characteristics of the semi-arid tropics (Bantilan et al. 2007, Shiferaw et al. 2004) and the farming is primarily rainfall dependent. The SAT of India are vulnerable to climate variability and change as droughts have been frequently occurring and number of rainy days shows a decreasing trend. Climate change projections indicate that rainfall is likely to emerge even more unpredictable, erratic and concentrated in the future, and that the risk of dry spells and droughts is likely to increase (Kumar et al., 2006). Recent evidence and predictions show that climate changes are accelerating and will result in changes to the characteristics of climate
risks in terms of frequency, magnitude, timing, duration, and distribution over space, sectors, and households. As climate risks intensify, socioeconomic factors such as economic growth, demographics, nutrition, and health status are changing human exposure and sensitivity to these risks. Also, there is evidence that climate variability is triggering changes in other risks (e.g., related to pests and disease, food prices). In addition, adaptive capacity (defined as ability to manage these risks) is changing as a result of changes in household assets and livelihoods, intra-household composition and dynamics, changes in social networks, and changes in policies and institutions at community, local, national, and international levels.

In the recent years a more social science oriented approach to adaptation is under way alongside impact studies with a focus on political, economic, social and institutional conditions that make human societies vulnerable to climate variability and change (Vincent 2004, Liverman 2001b, Adger 1999, Comfort et al. 1999, Cutter 1995). Vulnerability is not only a function of the physical characteristics of climate events, but also includes societal properties determined by factors such as poverty, inequality, gender patterns, access to health care and housing etc. (Brooks 2003). By analysing the historic evolution of social systems in various regions, the social approach to vulnerability tries to explain why certain groups are less able to adapt to environmental stress than others (Liverman 2001a).

This paper attempts to analyze vulnerability to climate variability by mapping the village social networks to access information, technologies and resources. We focus on the role of social networks and institutions in building resilience to climate variability. It is aimed that through the focus on mapping village social networks, it elevates our understanding of vulnerability, adaptive capacity and gender relationships.

2. What do we already know – a review of related literature

In the semi-arid tropics (SAT) regions of Asia, the agriculture sector is highly vulnerable to climate change, and with potential to exacerbate the loss of biodiversity in the region. SAT ecosystems, where most of the world’s poor live, are characterized by extreme rainfall variability, recurrent but unpredictable droughts, high temperatures and low soil fertility. The underdevelopment in the SAT region of Asia reflects the pervasiveness of poverty, as demonstrated by continuing concerns about malnutrition, migration due to frequent droughts, growing constraints of the natural resource base (water scarcity and land degradation), lack of infrastructure, poor dissemination of improved technologies and effects of government policies, and further economic liberalization (Dar et.al 2007). The semi-arid tropics of Asia as a focal point indeed present significant constraints to intensive agriculture. SAT agriculture accounts for 90% of food production and climate variability is key in defining production uncertainty and risk aversiveness with regard to investment in agriculture in both high potential and more marginal environments (Cooper et.al 2006). A synthesis of evidence and lessons learned from ICRISAT’s Village Level Studies (VLS) conducted since 1975 provide empirical evidence on the vulnerability of the poor to various climate risks and shocks, as well as
their lack of capacity to access physical, financial and social resources and networks in the risky environments of the drylands (Bantilan et al. 2006).

Jodha (1975), Bliss (1976), Barah and Binswanger (1982), Walker and Jodha (1986), Walker, Singh and Asokan (1986), Dreze (1988), Walker and Ryan (1990), ICRISAT (2006), Cooper et al. (2007), and ICRISAT (2007) have studied the ways in which farmers adapt to risks caused by climate variability. Bidinger et al. (1991a,b) studied the economic, health, and nutritional consequences of a drought in the mid-1980s in Dokur, a representative village with better local water harvesting infrastructure where tank and well irrigation was common. Although the drought was very harsh, food grain price stability and widespread availability of consumption credit allowed villagers to maintain their consumption pattern of normal years. But due to lack of public works programs, laborers, particularly women workers, endured unemployment. The scarcity of clean water, compounded by a severe shortage of electricity, led to a sizable increase in water-related morbidity symptoms such as diarrhoea, eye infections, and scabies in the second year of the drought.

The earlier studies analyzed the vulnerability of the rural households in the low rainfall areas and documented the ways in which these households responded to shocks and income shortfalls. But some of these traditional coping mechanisms have diminished in importance in recent years (Bantilan and Anupama, 2002). Within the last 5-6 years, however, this work has received new focus and vigor as a result of the global concern about climate change and the widely accepted recognition that coping better with current climates and adapting to future climate changes should be a seamless continuum. In this context, the eloquent and emotive quotation of International Institute of Sustainable Development (2003) bears repetition; “Adaptation to climate change and variability is therefore no longer a secondary and long-term response option only to be considered as a last resort. It is now prevalent and imperative, and for those communities already vulnerable to the impacts of present day climatic hazards, an urgent imperative.” This paper attempts to understand vulnerability to climate variability and the adaptation and coping mechanisms from a sociological perspective using the tools of social network analysis.

3. Putting adaptive capacity in context:

Adaptive capacity influenced by a number of context-specific factors: socioeconomic, cultural, political, and institutional, that constrains or strengthens resilience to shocks and risks. As Jodha et al. (2010) put it, the situation in fragile and marginal regions of the SAT are likely to have increased risks and vulnerabilities due to climate variability. Furthermore, the focus here is on agriculture and the poor resource base (e.g. soil and water in particular). Agriculture not only constitutes one of the largest areas exposed to climate changes but sustains bulk of the rural

6 Households in India’s SAT have shown six major ways to compensate for shortfalls in income. They are borrowing for consumption, selling stored produce, liquidating assets, receiving help from relatives, changing jobs and / or increasing their labor market participation and migrating in search of work.

7 ICRISAT has worked in collaboration with the International Research Institute for Climate and Society (IRI), of the Earth Institute, Columbia University, USA, to evaluate the potential effectiveness, constraints and impact of seasonal climate forecasts for small-scale farmers. The results were positive. Not only did farmers see clear opportunities for benefiting from such forecasts, but also the level of reliability of such forecasts was found to meet farmers’ expectations.
population in these areas. Literature also reveals that people dependent on agriculture for their livelihood are likely to be worse off in the face of climate change and variability, due to their present marginality and vulnerability to risks as well as the limited resources and capacities to withstand these weather-related shocks and crises (ICRISAT 2009, Jodha 1996, Kates 1985).

Even in the SAT, the findings by Adger et al. (2003) hold true that climate change will have greater negative impacts on poorer farm households as they have the lowest capacity to adapt to changes in climatic conditions. Adaptation measures are therefore important to help these communities to better face extreme weather conditions and associated climatic variations. Irrespective of the help received from external sources, there is a need to build internal resilience through improved technologies that can enhance the productivity of the resources of the rural people, and new institutional arrangements including formal and informal social networks that help foster collective action and community participation to better respond and adapt to climate variability. Examples of these include changing cropping systems and practices to suit the new length of growing periods and rainfall patterns, noting that the magnitude of these changes may remain uncertain. Insights and information support from knowledge-intensive institutions including research, extension and development organizations become critical in enhancing the resilience of rural people to cope with the changing climatic patterns.

Adaptive capacity is an important concept to address when thinking about community vulnerability. Adaptive capacity is the "ability to design and implement effective adaptation strategies, or to react to evolving hazards and stresses so as to reduce the likelihood of the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards" (Brooks, Adger, and Kelly, 2005). The most critical aspects therefore would be the ability to design strategies that will address the possible shocks facing the SAT region and to implement plans based on these designs. The double nature of adaptive capacity indicates identification and availability of resources needed to design and implement strategies that reduce vulnerability - institutional capacity, financial resources, environmental resources, and social networks - for looking at vulnerabilities and adaptive capacity simultaneously.

Social networks are central to the idea of adaptive capacity because they shape and allow for crucial collective as well as individual behaviors. There have been some studies that have drawn structural analyses of social systems for the study of adaptive capacities, adaptation, and adaptive co-management. This paper focuses on social networks and its structure on some components of adaptive capacity namely innovating, diffuse of innovations, and diversify strategies for improving livelihoods in the agrarian communities of SAT India. This discussion from a networks perspective of adaptive capacity can guide framing actions to facilitate adaptation to climate change and variability.
4. **Methodology on mapping village social networks to study adaptive capacity and vulnerability to climate variability.**

This research takes place in the SAT regions of India which are exposed to frequent, recurrent droughts (3 years out of 5 years are bad years). The villages are situated in the states of Maharashtra and Andhra Pradesh, the heartland of the semi-arid tropics (see figure 1). Findings from three villages namely Kanzara, Aurepalle and Dokur are discussed in this paper. The main objective of this paper is to understand how social networks and key individual(s) contribute to rural adaptability to climate variability, in the form of droughts, irregular rainfall patterns, and prolonged dry spells which lead to crop loss, yield losses, pest and disease attacks, environmental damage and breakdown of social structure.

![Figure 1. Map of India showing the study locations](image)
The methods employed in this study are 1) village censuses using semi structured interviews and questionnaires for mapping social networks at the individual and household level; 2) ranking of individuals identified by community members to understand the role that key individual(s) play in mobilizing community members to cooperate and cope during shocks including climatic shocks; 3) tapping the multigenerational long-term data on agricultural and economic change in these regions through the ICRISAT village-level studies (VLS)\(^8\); 4. using meso-level data to understand changes at the macro-level and 5. social analysis using qualitative tools to understand social networks as a coping mechanism to climate variability.

Village censuses and case studies are used to analyze the dynamics of social relationships by mapping the network architecture of rural men and women in agriculture. Comparison of these across space and time allows analysis of the village dynamics as farm-households respond and adapt to climate related risks (e.g. rainfall variability and increase in temperature). The social networks methodology through village censuses, ranking of individuals and social network analysis allows for innovative quantitative and qualitative analysis of social networks to examine the village dynamics of farm-households as it captures key transactions and relationships within and outside the village. The social network architecture thus developed at different levels and groups (caste, class and village) assist in analyzing vulnerability and adaptive capacity.

In summary the data generated and used for this study includes:

- Long term data on climate and weather variability
- Focus group meetings on farmers’ perceptions to climate change
- Village censuses to capture key transactions and relationships
- Household panel data from ICRISAT Village Level Studies
- Formal survey on farmers’ perceptions

Understanding of the structure and functioning of the social networks will lead to knowledge about the density of key individual relationships, the nodes and ties of the network, and the importance of bridges between the key individual(s) with other groups and institutions involved with the village. The main hypothesis of this study is that social networks and key individuals play a significant role in the ability of the community to adapt to climate variability. It will also focus on the community’s ability to adapt to climate variability; and the ability of the community to build social capital to be used in subsequent times of crisis.

### 5. Results and inferences

\(^8\) The ICRISAT VLS makes an unrivalled tool to support development in the marginalized and the less favored areas as the micro-level insights from the grassroots level provide and understanding of the farm household behaviour as well provide an illustration of village dynamics – economic, socio-cultural, political, institutional – which is a key to development of adaptation strategies for mainstreaming in government programs specifically targeting the most vulnerable groups.
The analysis, results and inferences presented in this section follow a sequence – from macro to the micro level. Hence the descriptions transcend from the country/district level to village, community and individual level focusing on the vulnerability, farmers perceptions and coping, adaptation strategies and resilience building to climate variability.

1. Understanding climate variability - complementing quantitative findings with qualitative perceptions

a. Vulnerability of Indian agriculture to climate change: In a detailed study of district-level vulnerability of Indian agriculture, O'Brien et al (2004) mapped the adaptive capacity as a composite of biophysical, socioeconomic, and technological factors, and juxtaposed against a map of sensitivity to climate change (using output from the HadRM2 downscaled general circulation model). The mapping revealed higher degrees of adaptive capacity in districts falling in the Indo-Gangetic plains (except for Bihar) and lower degrees of adaptive capacity in the interior regions of the country, including districts in Bihar, Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Karnataka). Using this information, community-level case studies were carried out in highly vulnerable districts which brought out the wide disparities in adaptive capacity across villages, across communities in villages, and specifically across individuals depending on land holding size, education, caste, etc. The findings from this study corroborate with the analysis of the ICRISAT VLS data which revealed that while larger farmers are able to benefit from government subsidies (e.g. for drip irrigation), formal bank credit, crop insurance, and access to larger markets, smaller farmers are disadvantaged due to lack of information and dependence on local people (money lenders, input suppliers etc.) for credit. Similarly other case studies by ICRISAT in Anantapur district in Andhra Pradesh, where groundnut is the principal crop revealed that farmers were facing a crisis due to the growing import competition and stagnating market prices, which coincided with a multi-year drought. Farmers are unable to shift to production of more profitable crops, due to lack of alternative, drought-tolerant, and economically viable crops. Rainfed crops which could be economically viable, either require too much capital or do not have long enough shelf lives to be marketable under current circumstances. Without irrigation, water harvesting systems, or alternatives to groundnut, dry land farmers in Anantapur are highly vulnerable to the variable climate.

b. Rainfall related variability: Having identified and mapped the vulnerable regions in the SAT, the next step then was to study the climate variability at the next level of aggregation – i.e. at the district and village level. The annual rainfall patterns (Figures 2a and 2b) in districts Mahabubnagar (where Aurepalle and Dokur villages are situated) and Akola (for Kanzara village) show clearly rainfall variability in both the regions. However, it is noted that in Mahabubnagar there is a continuous period of drought starting 1992 to 2005 whereas in Akola the variability is spread across the 39 year horizon. Hence the coping mechanisms and adaptation strategies vary in both the regions.
Moving from the district to the village level variability to climate, as an example the case of Akola district in Maharashtra state where village Kanzara is situated is discussed here. Monthly rainfall data of Akola District was used to determine the district annual rainfall for year 1971-2009. Using this data, the 39-year mean annual rainfall was calculated from which deviation of annual rainfall from the mean was arrived at. It can be concluded that the number of negative deviations (in percentage) has increased from 40.0% in the 1st 10-year (1971-1980) to 77.8% in the last 10-year (2001-2010). Additionally, the magnitude of negative deviations has also increased from a maximum of 24.3% in the 1st 10-year (1971-1980) to a maximum of 54.5% in the last 10-year (2001-2010). The focus group discussions with farmers to identify years with climatic shocks confirmed this analysis. With the exception of 1973 and 1986, the years (1972, 1981, 1982, 1988, 1991, 2003, 2004) as observed by farmers coincide with the sign of deviation observed in the analysis (figure 3).

Figure 3. Farmer’s perception on periodic droughts in Kanzara, Murtizapur Taluq, Maharashtra, India

Source: Byjesh et.al, 2010
c. **Farmer’s perception of climate change and variability**: In all the study villages farmers perceived climate variability rather than climate change. Farmers felt that there had been an increase in temperatures. Farmers also perceived that there have been significant variations in the quantum and distribution of rainfall over the years. They believed that the rainfall was more intense, with fewer rainy days, and an extremely erratic distribution.
2. Analysis of social networks to capture the village dynamics in responding and adapting to climate related variability.

Coping is revealed as a reactive response over a short-time frame, with different types of coping performed simultaneously by different members of a household to interacting shocks (see box 1). Social networks and community based systems play a major role for coping with climate stresses, especially given the paucity of formal credit or insurance services in rural areas. The critical institutions that facilitate these processes are (1) informal networks of dependence developed to facilitate daily livelihood activities, including those associated with generating economic income and support (e.g. kinship relationships and close neighbours) and (2) informal networks outside the village that generate new networks and opportunities. These social structures bind individuals together and are especially important in the marginalized regions of south Asia.

Box 1. Adaptation Measures/Coping Mechanisms: The case of Dokur in Andhra Pradesh

Agricultural activities are dependent on seasonal rainfall. Failure of rainfall often causes droughts and destruction to agriculture and leads to economic hardships. Despite recurrence of drought events, people try to adjust with the aftermath of the hazards by applying adaptation and coping mechanisms. Focus group meetings and discussions with the farm communities in selected villages in Andhra Pradesh, India reveal the measures that are being practiced at the micro-levels. The common measures practiced in the drought regions were as follows:

- Borrow money from formal and informal sources (banks, money lenders and relatives)
- Large scale migration in search of alternative livelihoods (both temporary and permanent)
- Changes in eating habits (two meals instead of three meals a day; women most affected as they are sacrificing their share for children and adult men)
- Sale of livestock and belongings
- Cultivate less water intensive crop
- Sell or mortgage property
- Work in government sponsored food/cash for work programs

Source: Bantilan and Anupama, 2002

The discussion presented below is based on the analysis of the social networks data from village Kanzara focusing on some components of adaptive capacity through mapping of social networks. Through this analysis it is aimed to understand viable entry points for intervention, media for collective action, pathways of information flows, and access to resources and services.

a. Mapping economic transactions: The figure 4 below illustrates the network architecture of village Kanzara in terms of economic/financial transactions during a shock esp. climate/rainfall related shock. The network architecture reveals a dense network with a number of interactions between different households in the village. It is also noted from the map that there are some reciprocal ties whereas a majority of the links are unidirectional. If the picture is cut into two circular parts – a core and a periphery it is observed that those in the core who have more links and ties are those who own land, are actively engaged in agriculture and more importantly belong either to the upper caste (Eg Deshmukhs) or to the other backward castes. The ones in the periphery had little land which is of poor quality,
had large families and belonged either to the scheduled castes, and other back ward communities. This is also confirmed through the three decades of VLS data. Focus group meetings with some of these focal nodes revealed that these people help the vulnerable and those more affected by climate variability (those in the periphery) through lending money, offering employment to both men and women and also sharing water with them in times of acute shortage of water for consumption. There is also lot of reciprocal sharing of resources, information and opportunities among the focal nodes (the links in bold red lines). For the others it is a one way linkage and also indicating the strength of the relationship.

b. Mapping the socio-cultural-political-information transactions: How does rainfall variability affect the social, cultural, political and institutional fabric in the village?

To get insights on these dimensions, the network map is mapped using the detailed village registries developed as part of the social networks data. As seen in the economic transaction network, this network is also dense with many ties (figure 5). However, unlike the previous network, it is observed that there is very good linkages among different households in these aspects. There are more reciprocal ties in these kinds of transactions and people can fall back for help in times of drought and other shocks. The core like in the previous network is not necessarily from the upper caste or class and includes individuals from all class and caste categories. Based on
these maps, some of the households (both in the core and periphery) were further studied using the VLS data and it can be concluded that people who take leadership roles in the community, those who have links with other individuals and groups in power, and those who have a social status in the village (e.g., village priest, some elderly people) belong to the core of the network. It is through these people that information, access to resources and services from the various groups (formal as well as informal), development programs by the government reaches the other households and individuals who are both in the core as well as the vulnerable who are not so well connected. On the whole it is also observed that majority of the households are involved in more socio-cultural-political transactions within the village as compared to the economic transactions. Hence it is observed that these ties are helpful for the poor, the vulnerable and especially the women to cope with climate variability and improve their adaptive capacity. The adaptive capacity is improved through i. kinship networks for sharing of food and other consumables during shocks, gifts and remittances, ii. access to information regarding development programs and thereby benefitting from them, iii. Access to services during health emergencies, again more so for women, and iv. advise and help with respect to education and nutrition of family members especially for children and women.

Figure 5. Network architecture for socio-cultural-political transactions, Kanzara

Source: Author’s own analysis using the VLS enhanced census surveys, 2008-09
c. Technological transactions and adaptation during climate variability: The network maps of the Kanzara village with respect to technological transactions especially those related to in-kind transactions regarding agricultural technology (eg. seeds, sharing equipment); Information/advice regarding new agricultural technology, practices, pest & disease, fertilizer use; uptake/spread of new technology; labor sharing for agricultural work; and others like household transactions in consumer and producer durables, financial assets, market transactions, etc present an interesting illustration. As can be seen from the map below (figure 6 and 7), the architecture in this case is simple and clear. Access to technology, new knowledge and links to markets is reaching almost all households in the village. This spread is mostly through sharing of information one from household to the other either through kinship networks and or other associations. There are no reciprocal ties indicating that the focal nodes who are the early adopters and innovators (confirmed from the VLS data) share this new knowledge and technology with everybody who approaches them. The adaptive capacity is shaped by whom you know and who the other person knows. This has been observed by other researchers as well who examined the various channels through which social interaction effects operate namely social learning, social pressures and imitation. The role of social networks in the process of adoption of a new intervention is documented. The findings from this study as well as the network architecture demonstrate the importance of knowledge about the new technology in adoption as well as adaptation decisions. The focal points in this process are the early adopters and innovators, neighboring farmers and input dealers. There is also evidence of social pressures inhibiting/ and adopting/adapting to a new technology and imitation without observing the outcomes. Some examples of coping with climate variability and improving the adaptive capacity through technological innovations – especially agricultural technology – by farmers of Kanzara include i. spread of a wilt resistant resistance technology through kinship networks, ii. changing the cropping pattern monopolized by cotton and sorghum in the early 70s to include crops that are drought resistant, short duration, that improve the soil health as well as fetch more incomes due to higher price in the market, iii. enhanced linkages to product and output markets for improving profitability even during shocks. These examples are discussed from a social networks perspective in Chopde et.al (2011, in press) and highlight the role of formal and informal networks in these processes.
Figure 6. Network architecture technological transactions, Kanzara

Source: Author’s own analysis using the VLS enhanced census surveys, 2008-09

Figure 7. The network architecture of an innovator, a leader as well as social status, Kanzara
The above analysis and discussion facilitates the identification of strategies by development practitioners who are interested in identifying strategies to help vulnerable groups to adapt and increase their levels of resilience. The network perspective helps in:

- identification and importance of viable entry points for interventions,
- media for collective action,
- pathways of information flows, and
- access to resources and services.

The insights derived through the study of social networks in understanding and improving the adaptive capacity illustrate that the architecture of rural communities in terms of the social, technological and institutional arrangement can be the voices of the poor that will lead us to understand their vulnerability to climatic risk or variability; how they can facilitate the strengthening of smallholder’s resilience and ability to adapt to climate variability. It also illustrates how social networks influence and shape individual and collective behaviors of women and men in this process.

6. Conclusions, recommendations and way forward

It is well known that by adversely impacting sectors like agriculture, water resources, and health, climate variability and change presents a formidable challenge for efforts to reduce poverty and achieve the Millennium Development Goals in South Asia. The fundamental dilemma for the countries of South Asia is that prolonged or extreme climate stress can drive processes of impoverishment by affecting the livelihoods of poor people, while poverty increases vulnerability to climate change by further limiting options. Understanding adaptive capacity ultimately provides a basis for identifying delivery channels for technical adaptation options. Understanding climate change, climate variability and extreme events and their impacts at the micro level is critical, as it can lead to the development of appropriate methods, institutions and technology, the use and integration of traditional knowledge and the communication of science in ways that can be understood and used by policymakers for effective policy formulation.

Literature also states that as impacts of climate change threaten to undo decades of development efforts, the best way to address these impacts is by integrating adaptation measures into sustainable development strategies. Appealing to the concept of social capital as social networks and relationships, this paper illustrates that formal as well as informal social networks help in reducing vulnerability to climate variability and thereby lead to sustainable and equitable development of the poor in the marginalized regions of the semi-arid tropics.

From the study of Kanzara it has been observed that social capital can be enhanced through increases in income levels, education and technical skills, and improvements in public food...
distribution, disaster preparedness and management, and health care systems through sustainable and equitable development could substantially enhance social capital and reduce the vulnerability of developing countries of Asia to climate change. Building new networks or strengthening existing formal and informal networks at the local, national and regional levels to enhance the adaptive capacity and reduce vulnerability of the poor is one strategy to make the communities more resilient to such changes and shocks.

There is a further need to focus on the continued improvement of both technical studies and policy development as science-based understanding increases, and their inter-relationships and complexities become clearer. Study of social networks and social network analysis is one such methodological tool which will improve our understanding of the impacts of climate change and variability on the livelihoods of the poor.

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