World Development xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

World Development

journal homepage: www.elsevier.com/locate/worlddev

Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants

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ARTICLE INFO

Article history:
Accepted 29 July 2017
Available online xxxx

Key words:
gender
climate adaptation
food availability
India

SUMMARY

Women, especially in the marginalized communities of the high-risk regions prone to flood and drought are considered most vulnerable to climate change risks. They play a very important role in household nutrition management and resource management in terms of labor, off-farm products, and small savings. In the absence of help from formal and informal R and D and technology institutions, their knowledge and resources' exchange system has to be very robust to cope with the seasonal shortages arising due to climate fluctuations. The study found that these exchanges, spilling over caste or class boundaries, serve as valuable informal safety nets and contribute to household resilience. Researchers seeking to strengthen community coping strategies should pursue such polices and institutional interventions which strengthen women's resource exchange and exploitation mechanisms. We offer in the end a 4-E model involving exchange, expertise, ethics, and environmental consciousness which describes how these empower women and help in articulation of their unique coping strength at intra- and inert-community levels. Lateral learning among community members sustains and enhances over time collective and household coping strategies with climate risks.

1. Introduction

Adjustment strategies of women at the farm and household level play an important role in coping with climate variability and food security. Some of these strategies are short term or episodic while some others are institutionalized over time in the form of traditions and culture. Several studies have observed that women are more vulnerable to climate risks due to institutional factors (Adger, 1999), socio-economic factors (Bäthge, 2010; Denton, 2002; Terry, 1999), higher dependence on natural resources (UNWomenWatch, 2009; UNDP Policy brief, 2013), etc. However, the lack of empirical studies at the household and individual level has been a major gap in understanding their role in coping with climate uncertainty (Berrang-Ford, Ford, & Paterson, 2011; Goh, 2012). The tendency to see women as homogenous group and resort to excessive generalizations has also been rightly decried (Arora-Jonsson, 2011; Kelkar & Nathan, 1991).

This exploratory study looks at women's role in ensuring availability of material like food, seeds, etc., and non-material resources like labor during climate fluctuations, through social exchange/pooling, sharing nursery, vegetables, and/or harnessing local knowledge about edible weeds. Their access and ability to convert access into availability of resource varies among different women members of the community. The asymmetry in access to different resources, institutions, and networks contributes to their vulnerability (Dankelman, 2002). In a rainfed region, a household diversifies their portfolio of livelihood options by including farming and nonfarm activities, animal husbandry, etc., to minimize risk over time and space. Some of these activities may be season, space, or skill specific [Niehof, 2004; Ellis, 1998]. They may also cope by distributing risk over different livelihood options at various times and among members of the community.

Although adaptation takes place over time, short-term concurrent adjustments to cope with stress help the household to observe, experiment, learn, and adapt. The heuristics derived from the successful experiments are often used to build an institutional arrangement around them, thus ensuring continuity. The ability to absorb, or insulate from the stress induced by climate fluctuations depends on the institutional context, agro-ecological conditions, and household endowments of individuals and dynamics of knowledge and material exchanges (Agrawal, 2010).

https://doi.org/10.1016/j.worlddev.2017.07.026
0305-750X/

2. Part 1- Conceptual framework

(a) Vulnerability and variability

Climate fluctuations and changing patterns of climate have a direct bearing on food security and the marginalized communities are likely to suffer most from altered environment (Gupta, 1984; Burke & Lobell, 2010; Chakraborty, 2001; Tompkins & Adger, 2004). The effects of climate fluctuation is different for men and women, partly due to different perceptions (Hemmati, 2005), physical and cognitive attributes (Eckel & Grossman, 2008), and their expertise due to difference in access to resources, technology, and institutions (Demetriades & Esplen, 2010; Denton, 2002; Nelson, Meadows, Cannon, Morton, & Martin, 2002; Reid et al., 2009; Yavinsky, 2012). Social sanctions and historical discrimination against women have limited their access to institutions to a varying extent (Quisumbing, Brown, Feldstein, Haddad, & Peña, 1995; Adhikari, Di Falco, & Lovett, 2004; Resurreccion & Elmhirst, 2012). Women in the marginal communities are vulnerable due to their limited access to resource support (Mearns & Norton, 2010). Gender inequalities and other socio-economic differences increase their vulnerability to climate risks and hence uniform adaptation strategies for men and women might not work (UNDP, 2011; Ahmed & Fajber, 2009; UNWomenWatch, 2009).

Within their socio-cultural limitations, women's role has been central to meet household subsistence nutrition and energy needs especially in the least developed and developing nations (James, 1995). They mobilize resources at the intra-house level through reallocation, storage (apprehending future scarcity), and modifying their consumption over the needs of other family members (Quisumbing, Brown, Feldstein, Haddad, & Ray, 2007). Women often forgo their own nutritional requirement to meet the family needs. This has also been called "maternal altruism" (Whitehead, 1988). This increases their vulnerability to food insecurity in the wake of climate change. Climatic stress affects other activities like collection of firewood and managing agriculture, especially in marginalized communities in high-risk regions (Morton, 2007). The ability of women to access Climate Smart Agricultural (CSA) practices may not improve if their constraints in dealing with imprecise weather information, increased work load due to new technologies and lack of access to validated indigenous knowledge practices of other communities facing similar risks (Jost et al., 2016).

At the inter-household level, men are involved more in financial exchanges with formal or informal financial institutions and at generally a higher scale, women take precedence in managing non-monetary exchanges and financial exchanges of much smaller order. These exchanges are important strategies of coping with market and climate risks. They can also pool or amalgamate resources to cope with the risk. In his study of Northern Cameroon, Molua (2011) observes, "Despite the economic challenges and the exposure to food insecurity risks, these households provide an interesting test of women's capability as household-level resource administrators and food security managers." They play a crucial role in household adjustment and coping by managing intra- and inter-household resources, especially in a high-risk environment (Gupta et al., 1985).

This study tries to assess the role of individual women in coping with the climatic risks, with special reference to managing agriculture, energy, and nutrition in flood- and drought-prone paddy-growing region of eastern India. The central research question is how can external agencies from public, private, and civil society help disadvantaged women in coping with climate fluctuation particularly in the context of paddy cultivation in mainly rain-fed regions?

Women's participation and involvement is much higher in the nursery than men, transplanting, weeding, harvesting, and post-harvest operations in paddy cultivation (Singh & Tiwari, 2009 in Singh & Hensel, 2012). Physical strength may have partly influenced the gender-based role division but also the different degree of tenacity in tasks involving higher degree of drudgery like transplanting paddy (Chi & Yamada, 2003; Mbiti, 2007). Technological change has been rather slow in the tasks that women do (Balakrishnan, 2000; Gupta, 2012; Gupta et al., 2003). The persistence of drudgery necessitates higher reliance on socio-cultural exchange mechanisms rather than technological innovation. The role of women in science and technology institutions has also remained under-studied (Gupta & Mashelkar, 2005) affecting the rate of innovation development targeted at reducing their constraints. Institutional factors such as negligence by both formal (and sometimes by informal R and D sectors) in developing strategies reinforce the social inertia that enhance women's capacity in different agro-climatic regions to cope with climate fluctuations. Historically, several cultural factors have also contributed to these constraints such as denial of opportunities to pursue the occupations of black smithy and carpentry in south Asian region. Therefore, even if they had ideas, they did not always have the tools to execute them or innovate new solutions (Gupta, 2012; Gupta, 2016; Stanley, 1995)[i]. The cultural norms also inhibited women to express and articulate their technological needs stifling lateral learning potential (Häusler, 1997; Singh, 2010).

3. Context changes the content

In a situation like this when not many technological alternatives are available and climate change/fluctuation risks have to be coped with, we argue that there are ingenious ways in which individual women find creative ways of coping by managing resource exchange and pooling, overcoming class and cultural boundaries.

Many women are simultaneously part of several institutions like social groups or networks that help them to draw on collective support and solidarity. This reinforces their confidence and the capability to take decisions i.e., agency. Unequal power dynamics affect their autonomy even in reciprocal relationships, shaping the terms of exchanges (Riley, 2008). The effectiveness of their decisions and coping strategies has to be assessed by examining the embeddedness of their responses (Reid et al., 2000). They might not be assertive or stand-alone and may be highly contextualized in certain cases (Johnsson-Arora, 2011). They follow different cultural traditions, and technological practices evolved through a dynamic interplay of social and economic institutions and ecological endowments. This lends to diversity of coping strategies, which may later be embedded into a portfolio of adjustment strategies. Many of the earlier studies considered women as a part of one group (Gabrielsson, 2014). Such an assumption may deny the opportunity for creating a knowledge network among different women for developing diverse coping strategies across regions.

Many adaptations are autonomous i.e., done by the local communities/social groups/individual son their own. These may complement the ex-ante strategies that government might have planned to reduce overall loss to the households due to climate fluctuations. However, these become imperative where timely governmental intervention is difficult or absent.

Earlier studies on vulnerability (Adger, 1999, 2006, 2006), sustainable livelihood (Krantz, 2001; Scoones, 2009) gender analysis (SEAGA (Socio-economic and Gender Analysis), and adaptation to risk (Oxfam and UN, 2009) have pointed toward need for augmenting assets, increasing capacities and improving policy and

[i] Autumn Stanley (1995) studied the USPTO database for 200 years and found share of women innovators to be much lesser than that of men.

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institutional environment for disadvantaged women to deal with risks suitably and sustainably. The policy recommendations generally included either improving their access to various resources individually or in groups, or improving their skills to avail of new opportunities. In this paper, we have tried to take vulnerability of women due to climate fluctuations as given. However, the empirical evidence of coping strategies reveal that in a specific socio-ecological condition, the policy and institutional interventions have to be tailored to the specific set of constraints affecting resource (including knowledge) management by women. The study focusses more on what they can do themselves by exploiting and strengthening their autonomy and agency.

4. Autonomy, agency, ability, and action

The household strategies are influenced by differential access to institutions in specific agro-ecological contexts. Institutions can be formal such as agricultural university, banks, extension systems, etc., or the informal ones dealing with exchange system of paddy nursery, and cultural institutions like devotional hymn-singing committees. The terms or rules of access may be influenced by the assurances from institutions including kinship networks. In his experiments, Raymond (2006) found that institutional assurance covered up for lack of trust among individuals and incentivized people for effective collective protection of endangered species. Access to resources and assurance from institutions are not enough, the ability to convert access into investments is also vital. However, in the absence of an attitude of overcoming barriers and inertia, the other three A, i.e., access, assurance, and ability will be of little help. Eventually, the mix of differential access, availability of assurance, abilities, and attitude influences the autonomy and agency of women to cope with the climate risks. Autonomy is defined as the freedom to act in a given set of constraints. Agency refers to the ability to use that freedom by overcoming what is often called "learned helplessness" (Peterson & Bossio, 1989).

In some cases, as we strengthen their autonomy and enable access to resources and institutions, many of them are able to perform at par with men and sometimes better (Nathan & Apu, 2007). Efforts are also being undertaken to increase their access, assurance and hence ability to participate (Joy & Paranjape, 2005; Morley, 2005) in programs that improve their food security. Gupta (1985, 1992) articulated vertical and horizontal assurances in the 4A (Access, Assurance, Ability, and Attitude) model of sustainability. However, these have different meanings and implications for men and women, and even among women; for instance, Ray (2007) distinguishes gaining access to water from agency to use it properly. When autonomy and agency can trigger actions or experiments, a portfolio of inter- and intra-household coping strategies emerges. Inter-household coping efforts often depend on the effectiveness of intra-household coping along with many other cultural factors. The feedback from inter- and intra-household coping efforts influence the viability of initiatives by different women in a community.

We illustrate in this paper, how some of the coping strategies are culturally coded like, in the songs sung by women at the time of transplantation or while pursuing other collective activities facilitating inter-generational transfer of knowledge. These measures strengthen the agency of women. We thus argue that by paying attention to these coping mechanisms, scholars can contribute toward multi-level institutional development which may complement the design process of technological solutions and to some extent compensate for the historical inertia.[ii] Technological inertia should be overcome but until it is done, we can strengthen the hands of women through improved access to institutional, socio-cultural, and informational knowledge base. This has been one of the thrust areas of the Honey Bee Network for the last twenty-eight years for enabling communities and individuals to cope with the risks, improving productivity and reducing drudgery.

The role of a woman as a part of household, with or without adequate autonomy and agency to take decisions affecting her ability to cope with climatic stress has not been empirically studied adequately, although her contribution as a part of social group (often assumed homogeneous) has been studied to some extent.

5. Part 2: The study

(a) Study area and methodology

This paper is a part of a larger longitudinal study on loss of agro-biodiversity from 1989–90 to 2014–15 conducted in three villages Isoulibhari, Shivnathpur, and Kharella in Faizabad district in eastern Uttar Pradesh, India. The district falls under the Hot Sub humid (moist) eco-sub region. These flood prone villages are located in the floodplains of Sarayu River. The region follows rice–wheat cropping system and is largely rain-fed. The climate data have been obtained from the Department of Agricultural Meteorology, Narendra Deva University of Agriculture and Technology.

One hundred and twenty-two detailed interviews were carried out to study the loss of agrobiodiversity and farmers' coping strategies with climate variability and fluctuations, apart from a plot-by-plot survey. Being a largely patriarchal society, opportunistic focused group interviews were conducted wherever women's participation was noticed. The case studies, thus, are not randomly selected but rather are opportunistically sampled. Fifteen focus group interviews were conducted with an average participation of 5–7 women in each group. The total number of households and number of interviews in the villages are Isoulibhari (365 households, 7 interviews), Kharella (170 households, 5 interviews), Shivnathpur (96 households, 3 interviews). Some of the examples of uncultivated or less cultivated plants or weeds used by women for making food formulations/recipes have been quoted from the Honey Bee Network database (www.http://www.sristi.org/hb-new/).

(b) Adjustments with climate variability

Rainfall and temperature data were analyzed for twenty-five years in the case study region (1990–2014). Three periods were analyzed: the monsoon season or the kharif season, the post rainy period, which coincides with the rabi season, and pre-monsoon season that coincides with the zaid/summer cropping season.

It is apparent that there is a high fluctuation in the onset, withdrawal, number of days it rained, total rainfall received, and average rainfall received per number of days, which received rainfall during the monsoon season (Table 1). Higher the fluctuation, particularly during the crop cycle, higher the resilience required. The situation becomes more difficult in the case of high fluctuation in the rainfall onset and withdrawal dates. Since primarily women perform transplantation and harvesting, they get constrained due to these fluctuations. Depending upon the respective social capital, different women try to mobilize voluntary labor from other women. However, the ability of poor women to either hire labor or mobilize voluntary labor through reciprocity may be limited.

The knowledge of women about managing extremes of water availability and the ability to seek co-operation from the farmers owning plots above and below their field for receiving drainage water or draining their field to lower lying plot makes a critical

[ii] It has been suggested earlier that institutional inadequacies can sometimes be compensated by technological innovations and vice versa, Gupta et al. (1997).

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Table 1
Descriptive statistics of rainfall and temperature data of the kharif season.

	Monsoons at Kumarganj				
	Onset	Withdrawal	Days of rain	Total rainfall (mm)	Average rain/no of rainy days mm)
Mean	137.80	282.16	52.24	917.06	17.68
Standard Error	2.96	2.23	1.26	38.96	0.61
Median	136.00	282.00	52.00	902.40	17.90
Mode	124.00	287.00	56.00	#N/A	18.40
Standard deviation	14.80	11.15	6.29	194.80	3.05
Sample variance	219.08	124.22	39.52	37945.84	9.32
Kurtosis	−0.19	0.09	1.30	2.65	0.49
Skewness	0.77	−0.50	0.51	1.19	0.06
Range	50.00	46.00	28.00	921.11	13.88
Minimum	121.00	257.00	42.00	597.60	10.86
Maximum	171.00	303.00	70.00	1518.71	24.74
Sum	3445.00	7054.00	1306.00	22926.58	441.89
Count	25.00	25.00	25.00	25.00	25.00
Confidence Level (95.0%)	6.11	4.60	2.60	80.41	1.26

Note: day of arrival is calculated at nth day of the year taking January 1 as day 01.

difference in the choice of technology and thus the survival. Limited attention to such adjustments has led to limited research on expanding the degrees of freedom during such period. If a women farmer is constrained in inviting other women because of cultural reciprocities due in such voluntary exchanges (like offering tea and snacks after pooled labor) or limited financial resources for hiring other laborers, which stage of water drainage of crop should she focus on most is one such question to ponder upon by agricultural scientists. Not all varieties may be equally vulnerable to standing water at all stages of the crop. When we look at the data of varietal choice of lowlands, uplands, and medium lands, the preponderance of Sarju 52, a traditional improved variety in the uplands and the lowlands, which are more risky domains, is evident. The hybrid varieties like PA 6444 are sown in medium lands, which require more number of irrigations in a dry spell (Dey, Singh, & Gupta, 2015).

Through a correlation analysis, we found that if rains arrived late in the kharif season, women who might have sown nursery late due to financial constraints, might actually have only a limited advantage. However, as they may also be engaged in labor at other's farm due to cash compulsiveness (Bharadwaj, 1974), they might not be able to utilize their own nursery wholly. Lower temperature in the post rainy season will result in lower evapotranspiration losses and will not pose much problem for households who do not have irrigation sources. Late withdrawal of the rains is directly related to the total number of rainy days in the kharif season, the minimum temperature in the summer season (in the pre-rainy season), and the increased minimum temperature during the rainy season. Late withdrawal of the rains will lessen the turnaround time (i.e., time interval between harvesting the last crop and sowing the next crop). This will constrain ability of women to harvest the paddy crop before full ripening, drying them in the sun for threshing and sowing of the next crop. The total amount of rainfall received is negatively correlated to the maximum temperature in the previous season i.e., the summer season. Lesser rain will affect the availability of water for both on farm and off farm use. In most rural areas, women fetch water for drinking and other household chores, often from long distances. The amount of rainfall received per number of rainy days, is inversely correlated to the maximum temperature in the summer/zaid season, suggesting the chances of flood or cloudbursts. Floods pose several problems for the women: (1) restricts their mobility and increase their dependence on stored resources (Ahmed, 2004), (2) increases labor in collecting fuel wood and meeting other needs (Alam, Bhatia, & Mawby, 2015: 21–22), and (3) induces other farm and nonfarm stresses (Crate and Nuttal, 2016). The early arrival of the rains in kharif season increases the probability of cloudy weather in the winters or the rabi season. Early rains are useful for farmers who have sown the nursery early. It creates an opportunity for selling of the nursery or bartering it with labor required for transplantation, through factor and product market linkages (Bharadwaj, 1974). As women do most of the transplantation, they can exchange their labor for the nursery that a well-off farmer might have grown owing to his access to irrigation sources.

Women have an expertise in knowledge of tasks they are exclusively engaged in (IFPRI, 1995), like paddy transplantation, weeding, seed storage, post-harvest processing, livestock health and hygiene, and marketing of certain kinds of farm produce especially in the local village markets. The expertise might not be gender specific but might be due to experience in the particular tasks (Gupta et al., 1997). Paddy is the most dominant kharif crop here and, like other rice-growing regions, transplantation involves pooling and exchange of female workforce in the community. Weeding takes a major portion of resources for farms located in uplands and medium lands or in case there is a long dry spell, even in low lands. Women tackle these risks through their network where they exchange labor, equipment, and commodities (Agarwal, 2010a,b; Muthoni & Wangui, 2013). These exchanges are seldom monetary in nature and are often reciprocal. Only if there is a large difference in labor requirements, i.e., a larger land holding will need more labor, there is a supplementary compensation generally in kind though sometimes in cash. Similarly, they stagger their activities to be able to help each other during harvesting and post-harvest activities like storage of grains and food processing.

Storability of food grains and crops pose challenges in the tropical climate. Careful storage of grains and other crops play an important cushioning strategy. The Honey Bee database[iii] has several practices provided by women, which they use to make crops pest free. Gupta (1987a), Gupta (1987b, Gupta (1987c, Gupta (2007a, Gupta (2007b) reported that women in Bangladesh not only took care of consumer preference but also the shelf life and storability of sweet potato. He reported that women in Tangail district of Bangladesh cut some of the rootlets from the nodes of sweet potato cuttings before transplanting them. This helped in the development of rounder tuber with a thicker skin. Consumers in the market preferred rounder tubers and the thick skin increased the shelf life (Gupta, 2016). He also reported that a woman farmer in Bangladesh followed the practice of planting one banana plant among four areca trees (see Sheshagiri, Narayanaswamy, & Shivanna, 2010). The

[iii] www.honeybee.org.

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banana suckers absorbed moisture in the monsoons and made it available to areca roots during winters when there is a water stress (Gupta, 1987a; Gupta, 1987b; Gupta, 1987c). This provides an interesting example of the scientific basis of knowledge of women in the unorganized sector. Jacka, 2016 (in Crate and Nuttal, 2016: 186–199) found high correspondence between climatic data and its perception and related local knowledge of communities in Papua New Guinea, akin to the findings of numerous other studies reviewed recently (Lebel, 2013).

Sharing their knowledge, at least among women, helps in bonding and lateral diffusion of knowledge. Gangaben Yagnik, a widow at the age of 14, dedicated a chapter in her book Hunnar Mahasagar (1898), to examples of ecological and climatic indicators. The book also contains information on over two thousand eighty practices/trades/recipes for self-employment. It was a great hit among the readers. It is said that thousand copies were sold within a few days of its release (Honey Bee, 2003). However, in spite of such outstanding examples of contribution to science and society, the knowledge of women has remained under represented, especially in decision- making and policy discourses. They are often seen as sinks of resources rather than source of ideas and adaptation and coping mantras (Gupta, 2006).

(c) Food and nutrition availability: perceptions from field

When asked about their food in the lean months, Raj Kumar Singh replied, "It' sher department," pointing at his wife, Munni Devi. She replied, "I make curries of matar (pea) which I dried in the sun and preserved with chickpea." Many women plant cucurbits like bottle gourd, pumpkin, satputia (a small cultivar of ridge gourd), okra and colocasia in their homesteads in the summers catering to the vegetable needs of the family since these are costlier in summer. A few women ensure food security by processing fruits and vegetables and storing them safely for consumption later. Munni Devi and other women of her village Isoulibhari harvest the weeds and segregate them for consumption by human and/or cattle while the non-edible ones are either composted or thrown away.[iv] Women generally take care of the cattle and animal husbandry, while men take decisions on breeding and sale of dairy products. Many women know the medicinal and nutritional properties of weeds (or wild edible plants) as well (see Boedecker, Termote, Assogbadjo, Van Damme, & Lachat, 2014). During the monsoons, women collect Kermuha (also called Kalmuha, water spinach, *Ipomoea aquatic* Forssk.) from the nearby water pools and use it to make various preparations. Believed to be very nutritious, it is given especially to pregnant and nursing women. It has enough magnesium for adult women and children besides being a good source of iron, manganese, potassium (Umar, Hassan, Dangoggo, & Ladan, 2007). Its nutritional properties particularly with regard to antioxidants and essential amino acids have been confirmed (Doka, Tigani, & Yagi, 2014 and other scientific studies) (Prasad, Shivamurthy, & Aradhya, 2008). They use seeds of hurhur (*Cleome viscose* Linn.) to flavor curries. It is also known for its therapeutic effects, especially for the liver (Upadhyay, 2015). A few drops of juice of its leaves are put into the ears in the case of earache. Another widely adapted weed mostly growing in waste lands/field bunds, locally called lehsua (false amaranthus, *Digeramuricata* (L.) Mart.) is used as a vegetable. It is known to be effective against digestive disorders (Sharma & Vijayvergia, 2013). Women have developed rich knowledge systems ensuring nutrition security through both agriculture and other edible resources in the wild (Quisumbing et al., 1995). Such resources need to be popularized after verifying and testing their properties since food and nutrition insecurity is often an inevitable consequence of climate variability. In fact, the recent studies (Myers et al., 2014), have shown that several crops might have lesser nutrition due to increased level of carbon dioxide. In such cases, women's knowledge about weeds, which supplement these nutrients particularly K, Mn, and Fe such as Ipomoea aquatic Forssk, will become very useful (Umar et al., 2007).

Women in high-risk zones, especially arid and semi-arid zones choose leaves and stem of many perennials available throughout the year for food. This becomes an important coping strategy to fight food shortage or famine. Many of these plants, as said earlier, have been used in the traditional medicine systems for their therapeutic effects. Modern scientific tools and techniques have validated some of the properties. A compilation of some of the plants shared in food recipe competitions held during Shodhyatras conducted by SRISTI organization[v] is given in Table 2. Some of these are uncultivated or rarely cultivated plants or involve their rarely eaten part. A compilation of the uses of weeds that are found and used in Isoulibhari, Kharella, and Shivnathpur in Faizabad district, is given in Table 3.

(d) Women as a cultural agency of sustainability

In the study area, like other rice-growing regions of India, folksongs are passed on for generations, sung together during transplantation and other collective activities, which they believe, help to manage the physical pain. Some of the couplets we heard mentioned the importance of weeds. An old woman named Pyari Devi, interviewed in Isoulibhari village, explained the context of one of the songs she sang for us. The song tells about the conversation between a newlywed woman and her mother in law whom she asks, "What should I make for lunch as my brother is coming to visit me? Her mother-in-law replies, "Kundwa ma baateakhriKodaiya, khetwa me mausdasagwa, wahibanaojonarwa," (Take the kodo millet growing on the bunds and the leafy weeds and make a meal). It not only informs us about palatability (due to high fiber content)[vi] of kodo millet, which one may otherwise throw away as a weed but also defines the ecological niche where it may be found. It also asks people to look for other weeds that are eaten as leafy vegetables. In another song set around the story of Krishna–Sudama of Hindu Mythology, Susheela, Sudama's wife asks him to go to his friend lord Krishna for help. She sings "Kodosamajurtobharpait, to chahatnadoodhdadmethoti, yaghartekabhaunagayepiya, toototawanarahekathoti" (if I could get enough millets, I will not need even milk, curd, or butter. I would not ask my beloved to go away from home if there were any thing left in utensils). One of the interpretations told to us by Susheela meant that if the family could get enough millet to eat, that would have sufficed for their needs in the tough times. Such folksongs were probably the cues society has used, to survive in difficult times when the crops failed. It gives a clear indication of the nutritional superiority of the millets and suggests that when other crops fail, millets might still have a chance of survival since these are considered as climate smart crops (CGIAR, 2014; Bhat, 2015). This knowledge has stayed with the society for long but only recently formal institutions have recognized some of the components of Indigenous/local knowledge and innovation system (Gupta, 1989; Gupta, 2006). Awards by the National Innovation Foundation [NIF-India] for such unique knowledge/innovations

[iv] While weeding Canylondactylon, Dhruva grass, women make it a point to dig its roots at least 6–8 inches around the removed clum so that it doesn't easily grow again. It is one of the most difficult weed to control in certain cases.

[v] SRISTI, Ahmedabad, a voluntary organization pursues exploratory walks called Shodhyatras twice a year in the hinterland of India to learn from the local communities and share available information, honor local innovators and traditional knowledge holders at their door step. It has conducted such walks in all the states of India. Recipe contest is one of the important activity during such walks in which stress is placed on those dishes which have at least one ingredient as uncultivated plant.

[vi] See http://www.icrisat.org/crop-kodomillet.htm downloaded on Sept 18, 2015.

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Table 2
Some of the plants used in recipe competitions conducted during Shodhyatras.

SN	Plant Vernacular name	Scientific Name	Family	Plant part used in the recipe	Life span	Traditional uses	Pharmacology
1	Mokha	*Schrebera swietenioides*	Oleaceae	Tender branches, leaves, fruits	Perennial	Anemia, dyspepsia, colic, flatulence, skin diseases, leprosy, diarrhea, urethrorrhea, splenomegaly, helminthiasis, boils, burns, rectal disorders, digestive purgative, stomachic, anorexia, haemorrhoids, diabetes and vesical calculi (Nambiar, 1996)	Anti-oxidant (root), ant-inflammatory(root), antipyretic (root) (Manda, Rao, Yashwant, & Swarnkar, 2009), anti-anemic (root) (Pingali, Srinivas, & Reddy, 2015), antidiabetic (fruit), antioxidant (fruit) (Bagali & Jalalpure, 2010), hepatoprotective activity (fruit) (Bagali & Jalalpure, 2010)
2	Karad	*Dichanthum annulatum*	Poaceae	Grass	Perennial	Dysentery and manorrhagia (whole plant) (Nisar et al., 2014); fodder (Khan, Khan, & Qureshi, 2012)	Antiviral (Fraction), antimicrobial (Fraction) and cytotoxic activities (Fraction) (Awad, Ragab, & Atef, 2015)
4	Mahuda	*Madhuca indica*	Sapotaceae	Leaves, fruits, rind	Perennial	Leave: chronic bronchitis, Cushing's disease (Prajapati et al., 2003); verminosis, gastropathy, dipsia, bronchitis, consumption, derma topathy, rheumatism, cephalgia and Haemorrhoids (Sunita & Sarojini, 2013) Flower: cooling agent, tonic, aphrodisiac, astringent, demulcent, helminths, acute and chronic tonsillitis Seed: skin disease, rheumatism, headache, laxative, piles and sometimes as galactogogue (Umadevi et al., 2011)	Leave: Wound healing activity (Sharma, Sharma, & Kohli, 2010); Expectorant, chronic bronchitis and Cushing's disease, Cytotoxic activity (Saluja et al., 2011); Antioxidant activity, Nephro and hepato protective activity (Palani, Raja, Karthi, Archana, & Kumar, 2010); Antioxidant activity, Astringent, Stimulant, Emollient, Demulcent, Rheumatism, Piles and Nutritive, Antimicrobial activity (Khond et al., 2009); Verminosis, gastropathy, Dipsia, bronchitis, consumption, dermatopathy, rheumatism, cephalgia and hemorrhoids (Vaghasiya & Chanda, 2009), Antihyperglycemic activity (Ghosh et al., 2009) Aerial part: Anti inflammatory, analgesic and antipyretic activity (Shekhawat & Vijayvergia, 2010) Flower: Skin diseases (Prashanth et al., 2010); Analgesic activity (Chandra, 2001); Hepatoprotective activity (Umadevi et al., 2011) Seed: Anti inflammatory (Gaikwad, Ahmed, Khalid, & Swamy, 2009)
5	Doli	*Leptadena reticulata*	Asclepiadaceae		perennial	Leave: skin infections, ear disorders, asthma (Patel & Dantwala, 1958); cough, asthma, tuberculosis; (Schmelzer & Gurib-Fakim, 2013) Flower: eyesight (Shortt, 1878) Seed: gangrene (Schmelzer & Gurib-Fakim, 2008), Aerial parts: oviposition deterrence of storage pests, stimulant and a tonic (Baheti & Awati, 2013); Whole plant: anti-abortifacient, tonic, restorative, bactericidal, antifabrifuge, prostitutes wound healer; snake bite (Dandiya & Chopra, 1970) (Bhatt, Jain, Jayathirtha, Banerjee, & Mishra, 2002); hematopoiesis, dysentery, emaciation, dyspnea, burning sensation, and night blindness (Sivarajan & Balachandran, 1994)	Stem: Antianaphylactc activity (Padmalatha, Venkataraman, & Roopa, 2002), Vasodilation (Agarwal, Deshmankar, Verma, & Saxena, 1960), Hepatoprotective activity (Nema, Agarwal, & Kashaw, 2011) Aerial parts: Antifungal activity (Mishra et al., 2010), (Kaou et al., 2008), Antimalarial activity (Kaou et al., 2008) Leave: Antiasthmatic Activity (Baheti & Awati, 2013), Anticencerous (Sathiyanarayanan et al., 2008), Antiulcer Activity (Bodhanapu & Sreedhar, 2011) Whole plant: Antidepressant (Hakim, 1964), Cardiovascular activity (Mehrotra, Ojha, & Tandon, 2007), Oligospermic treatment (Madaan & Madaan, 1985)
6	Mankachu	*Alocaceaodora*	Araceae	Leaves and stem	Annual	Leaves: digestive, laxative, diuretic, astringent, rheumatic arthritis (Mulla, Salunkhe, & Bhise, 2009); styptic, abdominal tumors (The Wealth of India, 2004)	Leave: Antidiarrheal activity, antiprotozoal activity (Mulla, Chopade, Bhise, Burade, & Khanwelkar, 2011); antioxidant, antinociceptive, anti-inflammatory (Mulla, Kuchekar, Thorat, Chopade, & Kuchekar, 2010); antidiabetic, and hypolipidemic properties (Patil et al., 2012); antifungal (Bhatt & Saxena, 1980); hepatoprotective properties (Mulla et al., 2009)
7	Tindodi	*Coccinia grandis*	Cucurbitaceae	Leaves	Perennial	Leaves: skin diseases (Muthul, Muniappan, Nagappan, & Savarimuthu, 2006); jaundice, leprosy, psoriasis (Silja, Varma, & Mohanan, 2008); asthma (Natarajan, Leelavinodh, Jayavelu, Devi, & Kumar, 2013), ulcer (Alagesaboopathi, 2011) (Vaidyanathan, Senthilkumar, & Basha, 2013); piles, body cool (Jeyaprakash, Ayyanar, Geetha, & Sekar, 2011); rheumatism (Manjula, Rao, & Reddi, 2013); dysentery (Hasan et al., 2010)	Antioxidant activities (Umamaheswari & Chatterjee, 2008); glucose tolerance (Attanayake, Jayatilaka, Pathirana, & Mudduwa, 2013); analgesic, antipyretic activity (Madhu & Ramanjaneyulu, 2013); anti-inflammatory, analgesic (Pari & Kumar, 2002); antipyretic (Pari & Kumar, 2002; Niazi, Singh, Bansal, & Goel, 2009); hepatoprotective activity (Kundu, Mazumder, & Kushwaha, 2012); antibacterial activity (Sivaraj et al., 2011); Anticancer

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Table 2 (*continued*)

SN	Plant Vernacular name	Scientific Name	Family	Plant part used in the recipe	Life span	Traditional uses	Pharmacology
							(Nanasombat & Teckchuen, 2009) (Bhattacharya, 2011); antidyslipidemic activity (Mishra, Mishra, & Ahmad, 2012); antifungal activity (Bolay et al., 2010)
8	Sejan	*Moringa oleifera*	Moringaceae	Leaves	Perennial	Asthenia, Cough, Gonorrhea, oligospermi, Hemorrhoids, High blood pressure, Immune deficiency caused by the HIV, Infertility, Intestinal worms, Fever, Malaria, Anemia, Sexual weakness, Diabetes, Dysmenorrhea, Icterus, Eyesight problems, Varicella (Agoyi, Assogbadjo, Gouwakinnou, Okou, & Sinsin, 2014)	Cholesterol lowering action (Mehta, Balaraman, Amin, Bafna, & Gulati, 2003); hepatoprotective activity (Pari & Kumar, 2002); Cardiovascular Activity (Faizi et al., 1994); anti-cancer activity (Murakami, Kitazono, Jiwajinda, Koshimizu, & Ohigashi, 1998); Wound Healing activity (Hukkeri, Nagathan, Karadi, & Patil, 2006);Antibacterial Activity (Rahman et al., 2009); Anti-inflammatory Activity (Kumar, Arora, & Yadav, 2012); Antiulcer Activity (Devaraj, Asad, & Prasad, 2007)
9	Bad phal	*Ficus benghalensis*	Moraceae	Leaves	Perennial	Diarrhoea, dysentery, abscesses (Baquar, 1989)	Antioxidant activity (Bhaskara Rao, Ojha, Preeti, Kumar, & Karthik, 2014), antitumor activity (El Hawary, Wassel, & EI-Menshawi, 2012)
10	Arbi	*Colocasia esculenta*	Araceae	Leaves	Annual	hepatic ailments (Tuse, Harle, & Bore, 2009), snake bite, constipation, stomatitis, alopecia, hemorrhoids, general weakness (Awasthi & Singh, 2000) (Devarkar, Marathe, & Chavan, 2011)	Hepatoprotecitvity (Patil & Ageely, 2011a), Antidiabetic activity (Kumawat, Chaudhari, Wani, Deshmukh, & Patil, 2010), antimicrobial activity (Nair, Kalariya, & Chanda, 2005), Antimicrobial, antioxidant, anticancer (Lee, Wee, Yong, & Syamsumir, 2011), anti-lipid peroxidative (Patil & Ageely, 2011b)
11	Kela	*Musa paradisiaca*	Musaceae	Leaves	Perennial	dysentery, ulcers, bronchitis, diabetics, menstruation (Kumar et al., 2012)	Hypoglycemic activity (Pari & Maheshwari, 2000), analgesics activity (Gupta, Garg, Sharma, & Singh, 2011), hair growth promotion activity (Savali, Bhinge, & Chitapurkar, 2011)
12	Gular	*Ficus glomerata*	Moraceae	Leaves	Perennial	glandular swelling, abscess (Paarakh, 2009), ulcers, wounds, bilious infection, dysentery (Bheemachari, Ashok, Joshi, Suresh, & Gupta, 2007)	Anti-inflammatory (Li et al., 2004), Antidiarrheal (Patil et al., 2012), Antibacterial (Shaikh, Rub, & Bhise, 2010) Hepatoprotective (Mandal, Maity, Das, Pal, & Saha, 1999) (Channabasavaraj, Badami, & Bhojraj, 2008)
13	Brahmi	*Bacopa monnieri*	Plantaginaceae	Leaves	Perennial	speech disorders (Chopra & Nayar, 2002), in premature ejaculation (Anuradha, Vartak, & Kumbhojkar, 1994), flatulence (Mohan & Singh, 1996), abdominal pain (Chetty, Chetty, Sudhakar, & Ramesh, 1998), Aging, Antioxidant, Stress, cough, cold (Pareek, 1994), (Malhotra & Moorthy, 1973), (Singh & Aswal, 1992), rheumatism (Singh, 1993), (Bedi, 1978)	Antioxidant activity (Meena, Pandey, Pandey, Arya, & Ahmed, 2012), anti-inflammation (Hossain et al., 2014b) (Mistry et al., 2014)
14	Kolu	*Cucurbita pepo*	Cucurbitaceae	Flower	Annual	Anemic, healing wounds (Colagar & Souraki, 2011),	Antioxidant activity (Tarhan, Kayali, & Raziye, 2007)
15	Karela	*Momordica charantia*	Cucurbitaceae	Leaves	Annual	Piles (Kumar & Bhowmik, 2010), diabetes (Leatherdale et al., 1981), (Duke, 2002), (Raman & Lau, 1996), Respiratory Problems (Ganesan, Natesan, Vellayutham, Manickam, & Ramasamy, 2008), Cholera (Ahmad, Hassan, Halder, & Bennoor, 1999), (Jayasooriya et al., 2000)	Antimicrobial activity (Leelaprakash, Rose, Gowtham, Javvaji, & Prasad, 2011), Antifertility effects (Prakash & Mathur, 1976), Antifeedant activity (Bing, Wang, Ji, Zhang, & Liang, 2008) Anti HIV agents (Bourinbaiar & Leehuang, 1995), Anxiolytic, Antidepressant, Anti-Inflammatory Activities (Ganesan et al., 2008)
16	Bel	*Aegle marmelos*	Rutaceae	Leaves and Fruit	Perennial	Astringent, diarrhea, gastric troubles, constipation, laxative, tonic, digestive, stomachic, dysentery, brain & heart tonic, ulcer, antiviral, intestinal parasites, gonorrhoea, epilepsy (Anonymous, 1989), (Jain, 1991), (Grieve & Leyel, 1992), (Gaur, 1999)	Antioxidant activity (Rajan, Gokila, Jency, Brindha, & Sujatha, 2011), antifungal (Gheisari, Amiri, & Zolghadri, 2011), antibacterial activity (Poonkothai & Saravanan, 2008), Anti-inflammatory activity (Rao, Ojha, Amresh, Mehrotra, & Pushpangadan, 2003), antidiarrheal activity (Joshi, Patil, & Maheshwari, 2009), anti stress, adaptogenic activity (Duraisami, Mohite, & Kasbe, 2010), Antihyperlipidemic activity (Kamalakkannan & Prince, 2003; Rajarajeswari & Pari, 2003) (Krushna, Kareem, & Devi, 2009) (Narayanasamy & Leelavinothan, 2011)

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Table 2 (*continued*)

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17	Jambu	*Syzygium cumini*	Myrtaceae	Leaves	Perennial	Diarrhoea, dysentery (Nadkarni, 1976), strengthening the teeth (Kirtikar & Basu, 1999)	Antihyperglycemic effect (Teixeira, Knijnik, Pereira, & Fuchs, 1989), Antioxidant activity (Eshwarappa, Iyer, Subbaramaiah, Richard, & Dhananjaya, 2014), Antimicrobial, Antioxidant, Anticancer Activity (Kiruthiga, Saranya, Eganathan, Sujanapal, & Parida, 2011), Anti-inflammatory (Roy, Bhattacharya, Pandey, & Biswas, 2011), anti-allergic activity (Brito et al., 2007)
18	Pui	*Basella rubra*	Basellaceae	Leaves	Annual	Dysentery (Kumar, 2010), boils (Ramu et al., 2011), Anemia in women, coughs, cold (Rahmatullah et al., 2010), constipation, poultice for sores, urticaria, gonorrhea (Yasmin, Kaisar, Sarker, Rahman, & Rashid, 2009), headaches (Jadhav, Mahadkar, & Valvi, 2012)	Anti-Inflammatory, Anti-Bacterial Activity (Abdul Kalam, Sulaiman, Azizi, Labu, & Zabin, 2013), antidiabetic activity (Bamidele, Arokoyo, Akinnuga, & Oluwarole, 2014), Antimicrobial, Antioxidant Activity (Suguna et al., 2015), Wound healing activity (Mohammed, Anu, Saraswathi, Guru, & Chandini, 2012)
19	Cholae	*Dolichos lablab*	Fabaceae	Leaves	Annual	Wound (Balangcod & Balangcod, 2011), skin diseases (Rahmatullah et al., 2010), tonsillitis (Rahmatullah et al., 2009)	Anti-diabetic activity (Singh & Sankar, 2012), hypoglycemic activity, Antibacterial (Priya & Jenifer, 2014), Antilithiatic Activity (Deoda et al., 2012)
20	Dharo	*Cynodon dactylon*	Poaceae	Grass	perennial	Piles, vomiting, irritation of urinary tract, wounds (Khan, Khan, & Qureshi, 2013); leucorrhoea (Rahman, 2014); Epitasis, hematuria, inflamed tumors, cuts, wounds, bleeding piles, cystitis, nephritis, scabies, diarrhea (Sivasankari, Anandharaj, & Gunasekaran, 2014)	Antidiarrheal activity (Ravindra Babu, Neeharika, Pallavi, & Reddy, 2009); antibacterial activity (Chaudhari, Mody, & Acharya, 2011) (Garg & Paliwal, 2011); Angiogenic effect (Soraya et al., 2015); anticancer activity (Kowsalya, Kaliaperumal, Vaishnavi, & Namasivayam, 2015); Antidiabetic activity (Jarald, Joshi, & Jain, 2008); Diuretic Activity (Aruna, Chakarvarthy, & SarathBabu, 2013); Antiarthritic activity (Bhangale & Acharya, 2014); anticonvulsive property (Odenigbo & Awachie, 1993) (Shen et al., 1988) (Subramanian et al., 1986) (Najafi, Nazemieh, Ghavimi, Gharahkhani, & Garjani, 2009) (Najafi, Nazemiyeh, Garjani, Ghavimi, & Gharekhani, 2007), Antiulcer activity (Patil, Jalalpure, Prakash, & Kokate, 2003a)
21	Koliyar	*Bauhinia purpurea*	Leguminosae	Leaves	Perennial	Wounds (Chopda & Mahajan, 2009); infections, pain, diabetes, jaundice, leprosy, cough (Morais, Dantas, Silva, & Magalhães, 2005)	Antinociceptive, anti-Inflammatory, analgesic, antipyretic (Zakaria et al., 2007); Wound Healing (Ananth et al., 2010); antiulcer activity (Zakaria et al., 2011); Anti-inflammatory activity (Bhatia, Bishnoi, Chauhan, Kinja, & Shailesh, 2011), Antimicrobial Activity (Negi, Dave, & Agarwal, 2012), antioxidant (Krishnaveni, 2014)
22	Puvad	*Cassia tora*	Fabaceae	Leaves	Perennial	Acrid, anthelmintic, antiperiodic, cardio tonic, laxative, liver tonic (The Wealth of India, 1992) (The Ayurvedic Pharmacopoeia of India, n.d.)	Anti-Inflammatory Activity (Maity et al., 1998) (Jain & Patil, 2010), Anti-Proliferative Activity (Rejiya, Cibin, & Abraham, 2009), Anti-Microbial Activity (Bhattacharya et al., 2010), Antinociceptive and Spasmogenic Activity (Chidume, Kwanashie, Adekeye, Wambebe, & Gamaniel, 2002; Prabhu, Krishnamoorthy, Prasad, & Naik, 2013)

including plant varieties developed by farmer breeders and women herbalists at the hands of The President of India constitute may be one of the most distinctive global initiatives in this regard. Not all of this local knowledge might be true to its claim but it must be blended with formal scientific knowledge systems for societal empowering local communities and the dichotomy between so-called indigenous and formal knowledge systems must be overcome (Agrawal, 1993, 1994, 1995). There is an urgent need to document, validate, value add, and disseminate it for a more climate resilient future (Gupta, 1987a, 1987b, 1987c, 1988, 1989, 2007a, 2017b; Hiwasaki, Luna, & Shaw, 2014).

(e) Conservation of traditional varieties, wild relatives, and minor millets

Women in this region consume only uncultivated plants as food while celebrating the festival of teej. Of these plants, *Oryza rufipogon* Griff., a wild rice variety is most important. They believe that the fast will be incomplete without eating this rice. Such institutions have evolved in society probably for conservation of these otherwise less appreciated crops and varieties. Interestingly, scientists have characterized the wild rice variety for many desirable genetic characteristics (Xiao et al., 1998). It was also

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Table 3
Existing knowledge system around weeds found in three villages of eastern Uttar Pradesh.

	Botanical name	Use(s) reported in field	Traditional uses	Pharmacology
1	*Ecilpta alba/ Eclipta prostrata*	Indigestion, hair problems	Acidity, Asthma, Constipation, Diarrhea and dysentery, Fever, Gingivitis, Hemorrhoids, Hair fall, Burns, Alopecia, Bronchitis and pneumonia, Loss of appetite, Pimple, Wrinkles (Khan & Khan, 2008)	Anti-hepatotoxic property (Kim et al., 2008), Anaphylaxis activity, Immunomodulatory activity (Ghosh, 1984), (Roitt, Grostoff, & Male, 1998), (Hudson & Frank, 1991), Antidiabetic activity (Giordano et al., 1989), (Nahar, 1993), Anticancer activity (Ruddon, 2007), (St. Luke, 2007), Analgesic and Anti-inflammatory activity (Singh, Malhotra, & Subban, 2008) (Sawant, Isaac, & Narayanan, 2004)
2	*Parthenium hysterophorus*	Fever	Fever, Diarrhoea, Neurologic disorders, urinary tract infections, dysentery, malaria, inflammation, eczema, skin rashes, herpes, rheumatic pain, cold, heart trouble (Marwat, & Khan, 2015)	Antioxidant, Anti-HIV Agents, Anticancer (Kumar, Chashoo, Saxena, & Pandey, 2013), Thrombolytic activity (Prasad et al., 2006), Antitumor Screening (Al-Mamun, Hamid, Islam, & Chowdhury, 2010), Antibacterial (Madan, Gogia, & Sharma, 2011) (Fazal et al., 2011), Antifungal (Shazia & Sobiya, 2012) (Zaheer, Shafique, Shafique, & Mehmood, 2012)
3	*Ipomoea aquatica*	Anemia, given to nursing mothers	Itching, Antidote (Shukla, Srivastava, & Rawat, 2010), piles, sleeplessness, head-ache (Burkill, 1966) (J. L. C. H. Van Valkenburg, 2001), Diabetes (Iwu, 1993) (Malalavidhane, Wickramasinghe, & Jansz, 2000), high blood pressure, nose bleeds (Duke & Ayensu, 1985) (Perry & Metzger, 1980), constipations (Samuelsson et al., 1992),	Anti-diabetic activity (Villasenor, Cabrera, Meneses, Rivera, & Villasenor, 1998) (Malalavidhane et al., 2000), Anti-microbial activity, Anti-inflammatory activity (Sivaraman, Muralidaran, & Kumar, 2010), Anti-arthritic activity (Saturnino et al., 2000), Anti-ulcer activity (Sivaraman & Muralidaran, 2008), Nootropic activity (Sivaraman & Muralidaran, 2010), Anxiolytic activity (Mohd, Vipin, Varun, Manvendra, & Sanjay, 2011)
4	*Malvastrum coromandelianum*	Pain	Fever, dysentery, wounds (Shah et al., 2013), pain, diaphoretic (Amjad, Arshad, & Qureshi, 2015)	wound healing activity (Gangrade, Sheorey, Rawal, & Chouhan, 2012), Antimicrobial, Anti irritant activities (Islam et al., 2007), Anti-inflammatory, Analgesic Activity (Khonsung, Nantsupawat, Jesadanont, Chantharateptawan, & Panthong, 2006)
5	*Cleome viscosa*	Ear ache, indigestion	neuralgia, rheumatism, pains, head ache, epileptic fits, ear ache (Sankaranarayanan et al., 2010), ringworm, flatulence, colic, dyspepsia, constipation, cough, bronchitis, cardiac, disorders (Kirtikar & Basu, 1975) (Saxena, Koli, & Saxena, 2000)	Antinociceptive, cytotoxic, Antibacterial activity (Bose, Bala, Ghosh, Gunasekaran, & Rahman, 2011), Anthelmintic, Antimicrobial, Analgesic, anti-inflammatory, Immunomodulatory, Antipyretic, psychopharmacological, Antidiarrheal, Hepatoprotective activity (Mali, 2010)
6	*Commelina benghalensis*	Fever	headache, constipation, leprosy, fever, snake bite, jaundice (Hasan et al., 2008) (Yusuf, Chowdhury, Wahab, & Begum, 1994) (Yoganarasimhan, 1996), epilepsy (Okello & Ssegawa, 2007)	Analgesic, Anti-Inflammatory Activity (Hossain et al., 2014a), Acute hepatotoxicity (Sambrekar Sudhir, 2013), antitumor, anticancer, antioxidant activity (Hasan et al., 2008) (Mbazima, Mokgotho, February, Rees, & Mampuru, 2008) (Rahman, Haque, & Rashid, 1990)
7	*Digera muricata*	Kidney stones, Urinary infection	blood purifier, pulmonary congestion (Shah et al., 2013), diabetic (Jagatha & Senthilkumar, 2011), urinary discharges (Rajasab & Isaq, 2004), kidney stone (Aggarwal, Gupta, & Narayan, 2012) (Sharma, Tanwer, & Vijayvergia, 2011)	Hepatoprotective activity (Paulsson, Granath, Grawe, Ehrenberg, & Törnqvist, 2001), (Friedman, 2003), Antimicrobial activity (Mathad & Mety, 2010), Anti-diabetic activity (Jagatha & Senthilkumar, 2011), Anthelmintic activity (Hussain, 2008), Anti-testicular toxicity (Weber, Boll, & Stampfl, 2003) (Lin et al., 2008), Allelopathic effect (Bindu & Jain, 2011)
8	*Achyranthes aspera*	Dysentery	asthma, bleeding, in facilitating delivery, boils, bronchitis, cold, cough, colic, debility, dropsy, dog bite, dysentery, ear complications, headache, leukoderma, pneumonia, renal complications, scorpion bite, snake bite, skin diseases (Jain, 1991)	Spermicidal Activity (Paul et al., 2010), Antiparasitic Activity (Zahir et al., 2009), Hypoglycemic and Cancer Chemo preventive Activity (Akhtar & Iqbal, 1991) (Chakraborty et al., 2002), Hepatoprotective Activity (Bafna & Mishra, 2004), Anti-inflammatory, anti-arthritic and Anti-oxidant activity (Vijaya Kumar, Sankar, & Varatharajan, 2009) (Devi et al., 2009), Nephroprotective Activity (Jayakumar et al., 2009), Anti-depressant Activity (Barua et al., 2009), Broncho protective Activity (Goyal, Mahajan, Mali, Goyal, & Mehta, 2007), Anti-allergic and Wound Healing Activity (Datir et al., 2009)
9	*Oldenlandia corymbosa*	Skin infections	skin sores, ulcers, sore throat, bronchitis, gynecological infections, pelvic inflammatory diseases Chang Chang & But (1986) (Bensky, Gamble, & Kaptchuk, 1993) (Chang, 1992) (Qu, Xu, Li, & Luo, 1990), jaundice, liver, heat eruptions, vitiated conditions of pitta, hyperdypsia, giddiness, dyspepsia, flatulence, colic, constipation, helminthiasis, leprosy, skin diseases, cough, bronchitis, necrosis, nervous depression, bile, hepatopathy (Kirtikar & Basu, 1994)	Acute oral toxicity test (Awobajo, Omorodion-Osagie, Olatunji-Bello, Adegoke, & Adeleke, 2009), Cytotoxic Activity (Haryanti, Junedi, & Meiyanto, 2013), Anti-malarial activity (Mishra, Dash, Swain, & Dey, 2009), Antioxidant activity (Sasikumar, Maheshu, Aseervatham, & Darsini, 2010), Abortifacient activity (Nikolajsen et al., 2011)
10	*Phyllanthus niruri*	Stones	kidney stones, gallbladder stones, liver related diseases, Jaundice (Bagalkotkar, Sagineedu, Saad, & Stanslas, 2006)	Anti-spasmodic, pain relieving & anti-inflammatory (Shanbhag, Amuthan, & Shenoy, 2010), Anti fertility activity (Ezeonwu, 2011), Anti-microbial activity (Lopez, Nitisinprasert, Wanchaitanawong, & Poovarodom, 2003), Anti-viral action (Hepatitis B) (Unander, Webster, & Blumberg, 1995), Anti-ulcer activity (Cipriani et al., 2008), Antinociceptive activity (Santos, Valdir Filho, Yunes, & Calixto, 1995)

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Table 3 (*continued*)

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11	*Phyllanthus amarus*	Jaundice	Jaundice, gastropathy, diarrhoea, dysentery, fevers, menorrhagia, scabies, genital infections, ulcers, wounds (Patel, Tripathi, Sharma, Chauhan, & Dixit, 2011) migraine, jaundice (Kala, Dhyani, & Sajwan, 2006) (Udayan, Tushar, George, & Balachandran, 2007), gonorrhoea, skin disease, malaria (Chenniappan & Kadarkarai, 2010)	Anticancer activity (Lee et al., 2011) (Abhyankar et al., 2010), Anti-diarrheal, gastro protective and antiulcer activity (Shokunbi & Odetola, 2008), Antifungal activity (Sahni et al., 2005) (Agrawal, Srivastava, Srivastava, & Srivasava, 2004), Analgesic, anti-inflammatory, anti-allodynic and anti-oedematogenic activity (Iranloye, Owoyele, Kelani, & Olaleye, 2011), Antiplasmodial activity (Ajala, Igwilo, Oreagba, & Odeku, 2011)
12	*Cyperus rotundus Linn.*	Menstruation	Dysmenorrheal, menstrual irregularities (Bhattarai, 1993), pain, fever, diarrhoea, dysentery, an emmenagogue, intestinal problems (Uddin, Mondal, Shilpi, & Rahman, 2006) (Vidal, 1963) (Umerie & Ezeuzo, 2000), analgesic, sedative, antispasmodic (Zhu, Luk, Fung, & Luk, 1997)	Anti-mutagens and radical scavengers (Kilani et al., 2005), Antimalarial (Thebtaranonth, Thebtaranonth, Wanauppathamkul, & Yuthavong, 1995), Antidiarrheal (Uddin et al., 2006), Antibacterial activity (Nima, Jabier, Wagi, & Hussain, 2008), Antioxidant activity (Nagulendran, Velavan, Mahesh, & Begum, 2007), wound healing activity (Puratchikody, Devi, & Nagalakshmi, 2006)
13	*Physalis minima*	Urinary tract infection	Earache, stomach pain, pain (Islam et al., 2014), urinary track, diuretic, joint inflammation, blood purifier, skin disease, pimples, liver tonic (Parul, 2015)	Analgesic activity (Anand et al., 2014), Diuretic activity Antiulcer Activity (Tammu, Ramana, & Thalla, 2013), CNS depressant activity (Dharamveer et al., 2009), Antibacterial Potential (Patel et al., 2011), Antioxidant Activity (Gupta, Gowda, Umashankar, Nandeesh, & Sreedhar, 2010), Antifertility (Sudhakaran, Ramanathan, & Ganapathi, 1999)
14	*Echinochloa crusgalli*	Wound healing	carbuncles, hemorrhage, sores, spleen trouble, cancer, wounds (Duke & Wain, 1981)	antioxidant activity, antibacterial activity (Mehta & Vadia, 2014), Cytotoxic activity (El Molla, Motaal, El Hefnawy, & El Fishawy, 2015), Anti hypercholesterolemic (Sathis Kumar et al., 2013), Antidiabetic activity (Devi, Vrushabendra Swamy, Vishwanath Swamy, & Ramu, 2012)
15	*Cynodon dactylon*	Menstruation, milk yield enhancer	Scanty, irregular periods (Yadav, Kumar, & Siwach, 2006), piles, irritation of urinary tract, vomiting, wounds (Khan et al., 2013)	Antioxidant activity (Sies, 1997), Anticancer activity (Albert-Baskar & Ignacimuthu, 2010), Anticonvulsant activity (Pal, 2009), Hypoglycemic activity (Singh et al., 2008), Immunomodulatory activity (Mangathayaru, Umadevi, & Reddy, 2009), Hepatoprotective activity (Surendra et al., 2008), Antiulcer activity (Patil et al., 2003)
16	*Dactyloctenium aegyptium*	Fodder	fodder (Chaudhari et al., 2013), astringent, bitter tonic, anti-anthelmintic, gastrointestinal, biliary, urinary ailments, polyurea (Janbaz & Saqib, 2015), fevers (Choudhury, Bawari, & Singha, 2010), urinary lithiasis, spasm of maternity, renal infections (Malhotra, Dutta, Gupta, & Gaur, 1966)	Antibacterial activity (Jebastella & Reginald Appavoo, 2015), Antimicrobial activity, Antioxidant activity (Rekha & Shivanna, 2014), Anti-diabetic Activity (Nagarjuna, Murthy, & Rao, 2015)
17	*Echinochloa colonum/ Echinochloa crusgalli*	Anti-diabetic	Ingestion (Arifa, Tasveer, & Zaheer-Ud-Din, 2013),	http://www.knowledgebank.irri.org/training/fact-sheets/item/echinochloa-colona
18	*Eragrostis amabilis*	Fodder	Fodder (Dangol, 2008), Menorrhagia (Ghildiyal, Juyal, & Sadana, 2014)	—————

found to be rich in Fe, Zn, and antioxidants (Anuradha et al., 2012; Fasahat, Muhammad, Abdullah, & Ratnam, 2012). Mrs. Om Prakash Pandey, Kasari village, Faizabad District insisted on planting samai (Echinochloacolona (L.) Link) in the kharif season. She got the seeds from her brother who lives in Isoulibhari. Her husband is the village Pujari (priest). The sama grown in the kharif season called Bhadelasamai is considered very auspicious for offering to the deities during funeral. Echinochloacolona, a weed in rice fields, is reported as an alternate host for several paddy pests and pathogens (Bharati, Om, & Kushwaha, 1990; Tanwar et al., 2010). It shows resistance to feeding activity of brown planthopper due to its anti-feedant property (Kim et al., 2011). Its nutritional value is at par with the cereals and more in terms of Iron and Zinc (Salih, Nour, & Harper, 1992). It has higher Ca than its domesticated counterpart (Mandelbaum, Barbeau, & Hilu, 1995). It is widely adaptive, growing in a wide change of climatic and ecological conditions and more so in drought conditions (Padulosi et al., 2009). Some of the cultural institutions had taken care of sustainability through such institutions and knowledge systems long back, though science may find their utility now.

(f) Role in energy conservation and optimum utilization

With climate change and destruction of forests, women have to walk up to greater distances to collect fuel wood (Oxfam, 2006; Joto Afrika, 2011). Women, especially from the marginal communities, learn to be frugal and efficient in resource utilization. For example, in tribal areas of Manipur, Meghalaya, Andhra Pradesh women use shelves at multiple levels above the cooking stove to cure wood, dry fuel wood, dry different vegetables, cheese, and meat; and fumigate stored seeds to keep pests away. In this way, they are able to harvest the waste heat through a heat gradient at different heights, thereby reducing the energy wastage. In the 21st Shodhyatra in the Arku valley of Andhra Pradesh, Jyoti informed that she kept the paddy panicles on the shelf so that panicles get sustained low heat. This makes the husk and the seed expand at different rates and makes threshing easier thus reducing drudgery involved in the task otherwise. Some of these indigenous practices have been developed after generations of experimentation and testing while some have been developed recently. These strategies need to be tapped in the policy discourse on Indigenous/local Knowledge or climate change adaptation, though

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current usage is not adequate (Honey Bee database, United Nations University's Traditional Knowledge Initiative (UNU-TKI).[vii]

(g) Small savings, sharing, and reciprocity

Women sustain themselves through small savings in the rainy days. They lend to each other, often without charging an interest but with generalized reciprocity (that is, they can create equivalence between say, someone weeding their field and in turn, they taking care of her infant when she goes for work on another occasion). Generally, their husbands are not involved in such transactions. Another interesting practice in these villages is that they prefer to share the surplus production from the homestead gardens with other women rather than selling it in the market. Explaining this exchange of vegetable surplus, a middle-aged woman community member told that it helped them to keep their horizontal communication channels open. In view of the general assurance of reciprocity, they protect such plants from being eaten by cattle. Women often bond beyond their social class or status. They can share their emotions and knowledge with other women much more freely and hence they can serve as an important link in participatory research and execution of adaptation policies.

6. Part 3: Policy recommendations and conclusion

(a) Recommendations

1. Women need platforms where their can share their knowledge, get feedback and rewards.
   We discussed a few cases from The Honey Bee Network institutions like SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions). Such institutions provide a repository of women's knowledge. This knowledge needs to be disseminated at a large scale in multi-media and multi-lingual formats, given the demographic and cultural diversity of India and disparity in literacy levels. A recent publication by SRISTI viz., Shatayu: a book based on the life of majority of women centenarians shows how much one can learn from those who struggle and still sustain their spirit for a century. The knowledge transfer across generations, particularly among women is vital for maintaining sustainability quest of vulnerable communities.
   Agency of women needs strengthening because many elements of their knowledge system may exist as concatenated, fragmented, or embedded in induced institutional innovations. Their knowledge may not seem stand-alone as most of them share it with other women generally without caste or class barriers. Hence, this knowledge becomes a community or public domain knowledge owing to the culture of open sharing. However, in the absence of low transaction cost platform of lateral learning, the adequate churning of their knowledge system may not take place contributing sufficiently to climate change resilience.
2. The informal networks of women can be the channels for targeting climate adaptation policies dealing with horizontal knowledge management systems.
   In the study area, we could see that there is a culture of open sharing, beyond caste, class, or creed. This open sharing helps the knowledge system become more robust. As it gives everyone the access to the resource pool and the value-added knowledge. If women groups become the loci of the knowledge and resource dissemination at least in the cases of a disaster like crop failure due to flood or drought, there are fair chances that they will share these more openly.
   Most of the collective understanding needs negotiations, but public extension functionaries are seldom trained in institution building or induced autopoiesis (Dey et al., 2015). Community-managed portfolios of resource management choices such as for drainage, nursery cultivation, and exchange, using non-chemical pesticides play a crucial role in collective decision making or managing CPRI (common property resource institutions, see sristi.org/cpri for many examples of indigenous/local CPR institutions from around the world). The moral control rather than formal or legal contracts plays a crucial role in survival through such institutions. The informal exchanges of women also help in building community solidarity and a sense of belonging, especially in the regions where men folks out migrate.
3. Government subsidies, reliefs, and resources can be routed through prior groups like SHGs, mahilamandalis, bhajanmandalis,[viii] wherever they exist.
   Sometimes government provides subsidies or relief on individual basis and not group basis, thereby possibly weakening the collective institutions. But if they are routed through collective institutions, the cost of resolving the conflicts or disputes may go down given there better transparency, higher trust, greater accountability, and some third-party sanction against the violators in these informal institutions. There are some institutions where community representatives could censure the undesirable behavior. Moreover, it is evident that women are part of many social groups or networks simultaneously. Hence, it might be difficult to accept the idea of mediating support through any one institution. They have dealt with restrictions and stringent social sanctions for generations. Instead, an iterative model of institutional engagement and disengagement may appeal to them more. This may help them design their package of practices/incentives/solutions better and prevent rapid obsolescence of emergent solutions.
4. Weather information needs to be provided according to local calendars, which are different from the Gregorian calendars.
   The onset and withdrawal of monsoon rains have a great bearing on the farming activities in which women are involved. These operations are timed according to the local/traditional calendars. If we can develop easily manageable and comprehensible expert systems, then women can feed their local field parameters and generate operational choices to deal with various kinds of impending risks.
5. Gender-specific policies need to build upon their strength rather than their weakness (more often in terms of physical attributes). We need to reinterpret "Skill" among the so-called "unskilled laborers".
   To illustrate, a woman farm laborer who does weeding might have vast knowledge about the uses of different weeds. She can be hired to make a database and herbarium of such useful/harmful weeds and paid wages for that instead of being asked to break stones or dig earth under employment programs.
   Their expertise and knowledge about non-agricultural food sources help in dealing with food and nutrition availability for coping with fluctuating climate. Many of them were either weeds or wild perennial plants used round the year. Several weeds had therapeutic and nutritional properties identified by local communities. Gangaben's book of over 2080 recipes for self-employment compiled 117 years ago is an excellent proof

[vii] http://www.unutki.org/.

[viii] Small informal groups who carry out certain activities together like singing devotional songs, cleaning a locality, harvesting, or investing.

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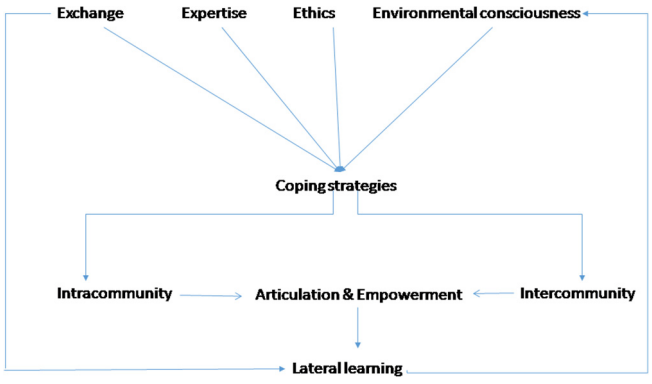

Figure 1. 4-E model of coping and adaptation by women with climate-induced risk.

of knowledge sharing. Hence, policies for women should be based upon the strength of theirs rather than their obvious physical and social weaknesses. This knowledge remains like distributed islands generally untapped in the formal knowledge discourse. It needs to be collected and disseminated to other areas where this knowledge can be used as such, or with some modifications. The knowledge and ideas of one place may lead to many other derivative innovations locally or elsewhere. However, it is also important that knowledge can flow among the knowledge holders and the users so that the users provide a feedback, strengthening thereby the knowledge and innovation system as a whole (see Figure 1).

6. Venture Fund ear marked for start-ups for and from women's knowledge.
   We saw how small savings help women during the rainy days. Several models have come up in the past like the Grameen Bank of Bangladesh, SHGs, micro credit, rotating saving and credit associations, risk funds, etc. Innovation-based enterprises have been supported by the Micro Venture Innovation Fund (MVIF) created by the National Innovation Foundation with the help of SIDBI. Some funds have also been invested to build social businesses through these innovations or knowledge. Women's knowledge about palatable weeds and perennials sustains their families through the lean months. It is however, necessary to pool and maintain this knowledge through developing small enterprises around them. These enterprises are different from the microenterprises by catering to the uncertain future needs rather than catering to the products whose market already exists. These enterprises will become very important resources in the wake of extreme climatic events and consequent food insecurity. Hence, it pays off to build and maintain them through a Climate Resilience Community Fund. This fund will enable communities or women groups to build enterprises around their knowledge, not only currently relevant ones but also those, which may deliver products in the wake of extreme climatic events and natural disasters. Thus, these may help community to overcome food and nutrition insecurity (see Figure A1).

(b) Exchange, expertise, ethics, and environmental consciousness

In this paper, we have tried to share the resources (knowledge, skills, and experimental ethic) that women are rich in the way they try to cope with seasonal irregularities in food and animal feed supply. We can perhaps better understand these coping strategies through the 4E model (Figure A2) i.e., expertise, exchange, environmental consciousness, and the ethics [4Es] of open sharing.

We could see how they cope by exchange or pooling labor, knowledge, and other biological resources. Women who have some autonomy or a say in household decision-making processes are able to cope better as they can share resources with others. The capability or agency along with autonomy increases women's ability to cope. The access to informal institutions acts as safety nets in times of need and they rely heavily on them. The assurance that knowledge and resources will be shared, influences the attitude toward even consumable goods like the homestead gardens. When women do not have autonomy, they try to utilize endogenous resources sub-optimally or may succumb to malnutrition due to prolonged episodes of self-sacrifice. We have argued that women would need both, the autonomy and agency to allow them to exchange of knowledge, and other resources including labor and skills. These exchanges take into account the asymmetry in knowledge systems because of the expertise developed by some women over time. These exchanges may be reciprocal but at times these lead to creation to public goods because of the communal ethics. Although mostly non-monetary, importance of these exchanges may not always be obvious to outsiders. When one sees the number of households involved in these transactions, one can appreciate their contribution better. Some of the cases discussed indicate that women's knowledge networks contribute immensely to tide over the adverse effect of the risk episodes. But these informal channels of dissemination of the knowledge are often not recorded in the formal scientific discourses. Even the discourse on traditional knowledge does not seem to represent as much of the knowledge of women traditional knowledge holders, midwives, or female herbal healers as may be needed (Reyes-García, 2010).

The paper also highlights the role of women as cultural agents of sustainability in maintaining biodiversity. On one hand, the cultural institutions ensured that intergenerational transfer of women's knowledge takes place but on the other, some other institutions governing resources, technology, finance, etc., led to their exclusion from several community institutions. When institutions failed to provide access, some assurance of restoring health was developed through festivals and rituals (as in the case of teej). They have tried to overcome these through their ethos and social network that help them to seek and nurture non-monetary exchanges to cope with seasonal variability. In the patriarchal societies where a woman generally goes to live with her husband's family, they also help in spatial distribution of local/indigenous knowledge in a process making the Indigenous knowledge system more robust. Here comes the significance of ethics. Ethics shapes the type of network created by women for sharing risk, resource, and skills. The conservation ethics (the fourth E) through biodiversity conservation and optimal utilization of energy resources could be seen in the case of wild rice and the multi-tier heat-harvesting systems. The conservation ethics manifests through enhanced environmental consciousness.

These coping strategies operate at intra- and inter-community level leading to their empowerment and articulation through lateral learning processes. This reinforces the coping strategies through 4Es in a dynamic manner. Women have a created a social capital which can be drawn upon at critical times. Although quantum of exchange and time of assurances both play an important role, criticality of time often supersedes the rest in the case of uncertainty.[ix] These informal safety nets so formed among women need to be supported and strengthened to achieve a more inclusive resilience (Harvey et al., 2014). We notice that lateral learning is an important strategy and platforms where

[ix] If a guest comes suddenly, women would help each other to manage the situation by helping in terms of food, delicacies, labor, etc.

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women can exchange their views, ideas, and knowledge should be encouraged and emulated. Given enormous socio-economic and cultural diversity, they need to share these in their own language and in different media formats. We need to create platforms, which enable women farm workers and farmers to learn from other farm workers. These platforms need to be essentially open, facilitating multidirectional knowledge flows so that knowledge disseminated reaches far but is deep as well. The women groups or individual knowledge providers in turn become foci of new knowledge generation and transmit the value-added/validated/modified knowledge to other men and women. Further research can map women's role more exhaustively in temporal and spacial scales. Focus on the economically poor but nutritionally healthy families can bring out many frugal practices of weed- and minor millet-based nutrition that women employ to ensure the family wellbeing despite climatic fluctuation-induced stresses.

Acknowledgment

The authors thank CMA, IIM-Ahmedabad. We are also thankful to late Parshottam Patel who helped us in conducting the field work.

Annexure 1

Correlation table of Max and Min. temperature and rainfall in pre rainy season, rainy, and post rainy season

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
A	1													
B	−0.11	1.00												
C	0.04	0.88	1.00											
D	0.06	0.50	0.57	1.00										
E	0.03	−0.37	−0.39	0.54	1.00									
F	0.16	0.27	0.18	−0.65	−0.93	1.00								
G	0.53	0.65	0.79	0.76	0.04	−0.09	1.00							
H	−0.44	0.56	0.14	0.30	0.15	−0.06	0.04	1.00						
I	0.44	−0.53	−0.54	−0.87	−0.42	0.63	−0.45	−0.46	1.00					
J	0.33	0.76	0.78	0.86	0.16	−0.19	0.95	0.33	−0.62	1.00				
K	0.15	0.51	0.58	1.00	0.52	−0.60	0.81	0.28	−0.82	0.90	1.00			
L	−0.90	−0.03	−0.32	−0.09	0.20	−0.24	−0.63	0.64	−0.33	−0.37	−0.17	1.00		
M	−0.03	−0.55	−0.54	0.37	0.97	−0.91	−0.15	0.02	−0.29	−0.06	0.34	0.25	1.00	
N	0.81	−0.28	0.09	0.27	0.25	−0.24	0.52	−0.73	0.14	0.29	0.33	−0.87	0.23	1.00

A = Arrival
B = Withdrawal
C = No. of days of rain
D = Total rainfall
E = Average rain per no. of rainy days
F = Max. temperature in the Pre rainy season
G = Min. temperature in the Pre rainy season
H = Rainfall in the Pre rainy season
I = Max. temperature in the rainy season
J = Min. temperature in the rainy season
K = Rainfall in the rainy season
L = Max. temperature in the Post rainy season
M = Min. temperature in the Post rainy season
N = Rainfall in the Post rainy season

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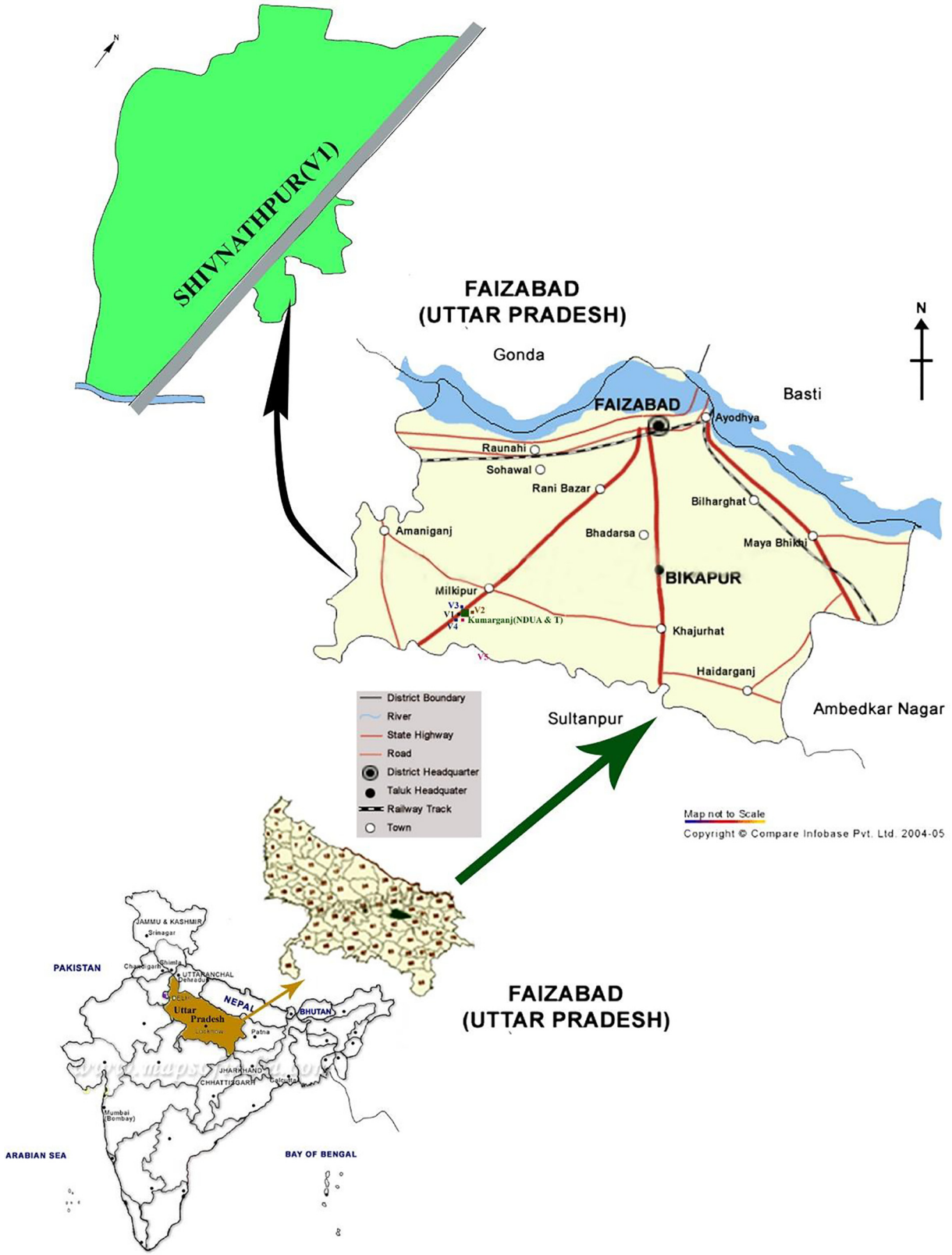

Figure A1. Location map of villages Shivnathpur. Village: Shivnathpur Block: Milkipur Tehsil: Bikapur District: Faizabad (U.P.).

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Annexure 2

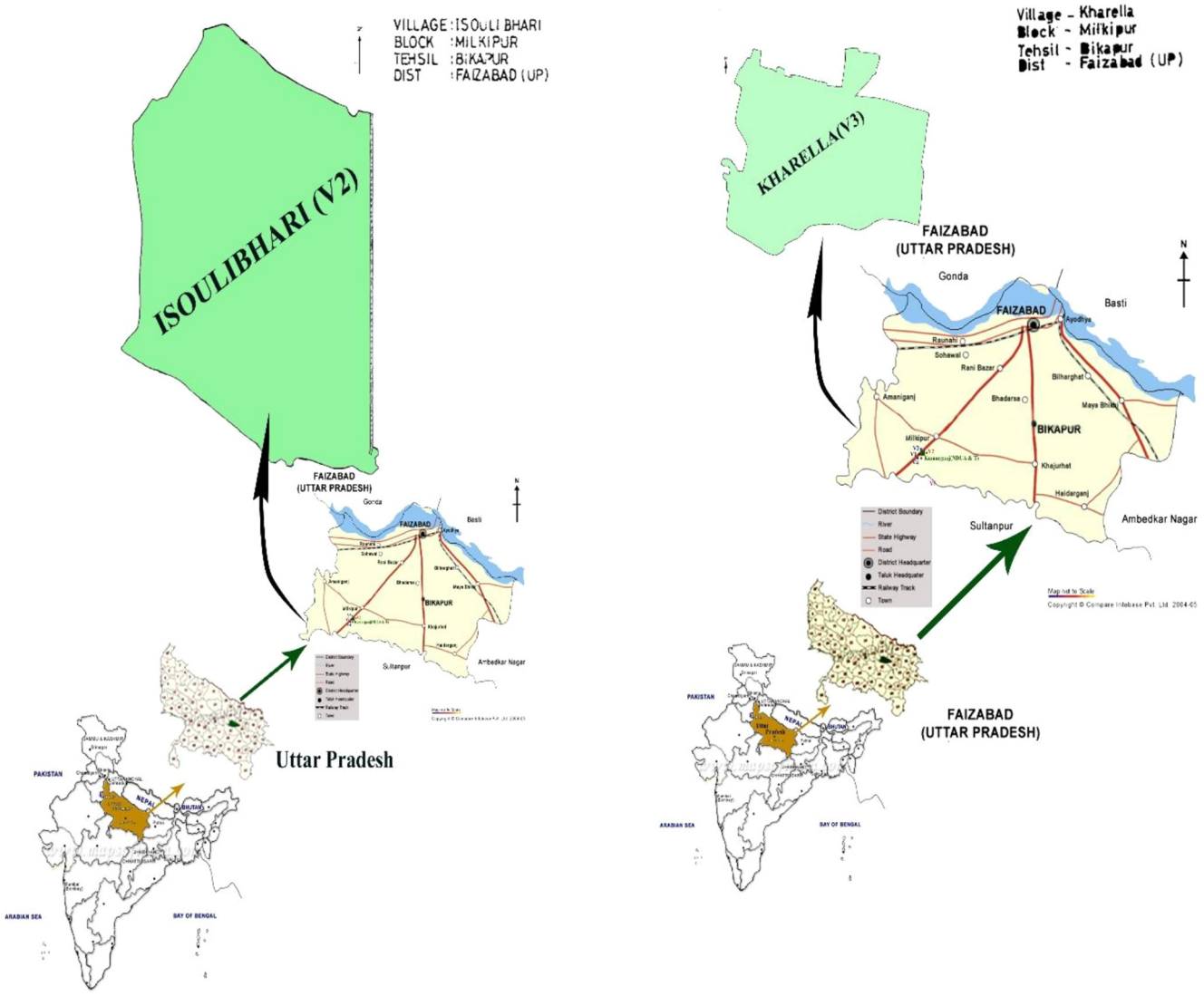

Figure A2. Location map of villages Isoulibhari And Kharella.

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Please cite this article in press as: Dey, A., et al. Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants. *World Development* (2017), https://doi.org/10.1016/j.worlddev.2017.07.026

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Please cite this article in press as: Dey, A., et al. Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants. *World Development* (2017), https://doi.org/10.1016/j.worlddev.2017.07.026

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Please cite this article in press as: Dey, A., et al. Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants. *World Development* (2017), https://doi.org/10.1016/j.worlddev.2017.07.026

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Please cite this article in press as: Dey, A., et al. Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants. *World Development* (2017), https://doi.org/10.1016/j.worlddev.2017.07.026

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Please cite this article in press as: Dey, A., et al. Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants. *World Development* (2017), https://doi.org/10.1016/j.worlddev.2017.07.026