Open Innovation at Different Levels for Higher Climate Risk Resilience

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With the increase in climate variability, creating knowledge networks becomes important for leveraging the embedded resilience in the communities through cross-pollination of ideas, resources and institutional linkages. Communities have developed knowledge systems around climate-mediated environmental changes since time immemorial. Some social groups have capacity to cope with stress better. They have homeostatic advantage due to either accumulated surplus (Burton, 2001, Vulnerability and adaptation to climate change in the drylands, United Nations Environment Programme) or access to institutions, technology and social networks (Adger, 2003, Social capital, collective action, and adaptation to climate change. Economic Geography, 79(4), 387–404). However, these knowledge systems often remain limited as isolated islands of expertise or small local networks resulting into asymmetries of knowledge at inter- or intra-community level. Intermediary organisations/platforms become important to bridge the gap that exists among communities within the informal sector and also between the formal and informal sectors. The platforms like the Honey Bee Network (henceforth, the Network) have been able to facilitate both horizontal exchanges, people-to-people learning and sharing, and vertical exchanges, connecting the informal actors with the formal system. The variation in different components of an Open Innovation System is studied in this article through their degree of openness in sharing, self-governance and self-regulation. We explore different activities and institutions of the Network to study the degree of openness and how they contribute to make the 26-year-old ecosystem more sustainable. We draw lessons for other institutions, organisations, communities who strive towards an autopoietic system, that is, a self-designed, self-organised and self-governed system with a feedback system from within and outside. This may make the whole innovation and knowledge ecosystem resilient in dealing with changing climatic conditions and fluctuating environment.

Introduction

THE DISCOURSE on open sharing of resources or open innovation has been limited largely to formal R and D organisation in private and public sectors. The sectors

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dealing with survival of communities such as agriculture, livestock, craft, tree cultivation, etc., have been largely left out despite very early head start by the Honey Bee Network (HBN) (henceforth, the Network), 26 years ago. In the wake of increasingly erratic behaviour of the climate, natural resource based enterprises at individual or community level are likely to be hit the worst (Tompkins & Adger, 2004, p. 10). Given the concern for food and livelihood security expressed in Sustainable Development Goals (SDGs), material and non-material resource exchanges among community, corporations, state and civil society need to be studied in the socio-ecological context to understand risk, resilience and responsiveness (Gupta, 1985). In this article, we stress upon the importance of open innovation through horizontal knowledge exchange, that is people-to-people and people-to-corporate (public and private) sharing of ideas, innovations and traditional knowledge practices for their stronger resilience in food and livelihood security systems (Honey Bee Newsletter, 1990–2015)[1] (Gupta, 1992, 2009a, 2012). The main focus of this article is to study the role of intermediary organisations like Society for Research and Initiatives for Technologies and Institutions (SRISTI) and National Innovation Foundation (NIF) and new social movements like the Network in facilitating both horizontal and vertical dialogues in an open innovation framework on reforming policy, institutions and practices. This article is divided into three parts. In the first part, the conceptual framework builds upon the asymmetrical distribution of knowledge in the society and the possible ways of making it more open and symmetrical for transition towards a knowledge-intensive resilient society. In the second part, we see the roles of intermediary organisations in democratising knowledge exchanges across domains, at different levels and scales. We study the role of the Network platform and model which facilitates open innovation and knowledge exchanges. In the third part, we draw upon key lessons for increasing the resilience at community level, given the variability and fluctuations in natural resources, household endowments and institutional performance.

We define open innovation as reciprocal exchange of ideas and innovations among actors (individuals, institutions or organisations) in formal and informal sectors with different degree of respect and responsibility towards each other. It is obvious that given the experience of the HBN with open innovation over 28 years, these exchanges are also expected to be governed by ethical norms of mutual accountability. But in practice, exchanges are expected to be guided by varying degree of mutual reciprocity, responsibility and respect. The article provides a theory by which such variations can be understood, anticipated in some cases and negotiated fairly and in just manner without disadvantaging knowledge/innovation providers in the informal sector.

Several authors have looked at open innovation models mainly to deal with the knowledge and idea flow across formal organisations in dealing with disasters (Yun, Won, & Park, 2016), unravel entrepreneurial potential of economy in evolutionary perspective (Yun, 2015, p. 17; Yun et al., 2016, p. 7) and dealing with climatic risks among industrial clusters (Cooke, 2015, p. 1). Several recent reviews of literature on open innovation rightly leverage external sources of ideas and innovations (Hossain, Islam, Sayeed, & Kauranen, 2016; Randhawa, Wilden, & Hohberger, 2016; Salampasis, Mention, & Torkkeli, 2014; Santos, 2015; Torres, Ibarra, & Arenas, 2015; West & Bogers, 2013) but neglect the role of reciprocity and responsibility of knowledge seeking formal organisations, corporations and other agencies towards informal sector grassroots innovators and individual inventors (Gupta et al., 2016).

Why Do We Need to Adapt or Mitigate?

The biological effects of climate change affect the evolution, adaptation and survival of the agro-biodiversity system (Davies, 1997; Lessmann, Brix, Bauer, Clevering, & Comín, 2001, Milbau, Graae, Shevtsova, & Nijs, 2009; Pagter, Bragato, & Brix, 2005, etc.). These effects are coped with, or mitigated through, altered management processes. As a result, a crop may become susceptible to new pests or may not be able to physiologically cope with the risks in the same ecological niche. In such instances, communities which depend on the local agro-biodiversity for their survival might have to migrate or look for substitute resources. Similarly, many other abiotic and biotic stresses along with human preferences for taste, colour, yield, etc., drive the selection of crops and varieties (Brush, 1995). The agronomic practices are devised or explored to enhance location-specific adaptation to climate change patterns in different agro-ecological systems.

Why Community Knowledge about Climate Adaptation is Important?

Communities had to cope with climate-induced stresses all through their evolutionary history. These coping strategies or survival strategies have been interwoven into the regional culture in the form of indigenous or traditional knowledge. A community's vast knowledge helps it in dealing with stress, episodic or otherwise. For instance, in the Tesu sub-region of eastern Uganda, people build their houses in the higher lands[2] especially which were previously occupied by ant hills (Egeru, 2012). In Bangladesh and many parts of eastern and north-eastern India, the houses are built on stilts to let flood water pass through underneath. The *ngolo* or *ingolu*, an indigenous farming practice evolved amongst the Matengo in Tanzania, is considered to be very effective against soil erosion; it increases soil fertility and thus crop productivity on steep slopes (Kato, 2001). Likewise, if apple or other crops are moving up to the higher latitudes on hilly areas, where these were never cultivated in the past, then the adaptations of the local communities are indicating not just the change, but its degree, location, effects and possible consequences for pest and disease cycles (Vedwan & Rhoades, 2001). Paradoxically, Harman Sharma, a grassroots innovator from Himachal Pradesh, has developed an apple variety that can grow in the plains at much lower altitude.[3] Similarly, ecological indicators have always played an important role. Kisêdje clan in the Xingu river basin in Mato Grosso, Brazil, used to time their farming activities with the appearance of flowers of murici (*Byrsonimacrassifolia*) and the appearance of Pleiades constellation at sunset (Schwartzman et al., 2013). The innovative strategies can counteract or supplement the weakening traditional adaptive strategies.

Hence, open sharing of innovative knowledge of the communities both traditional and contemporary may help them to adjust or adapt to changing environment using resources available at low cost or no cost. For example, the bamboo windmill developed by Mehtar Hussain and Mushtaq Ahmed from Assam helped communities in a contrasting desert environment in western India. Bamboo, abundantly available in the region, provided a useful adaptive advantage to small paddy farmer who could run hand-pump through windmill at slow speed and provide slow irrigation through low volume of variable discharge. It was adapted through open exchange in Kutch district for pumping brine water for salt farming in Gujarat through Gujarat Grassroots Innovations Augmentation Network (GIAN).

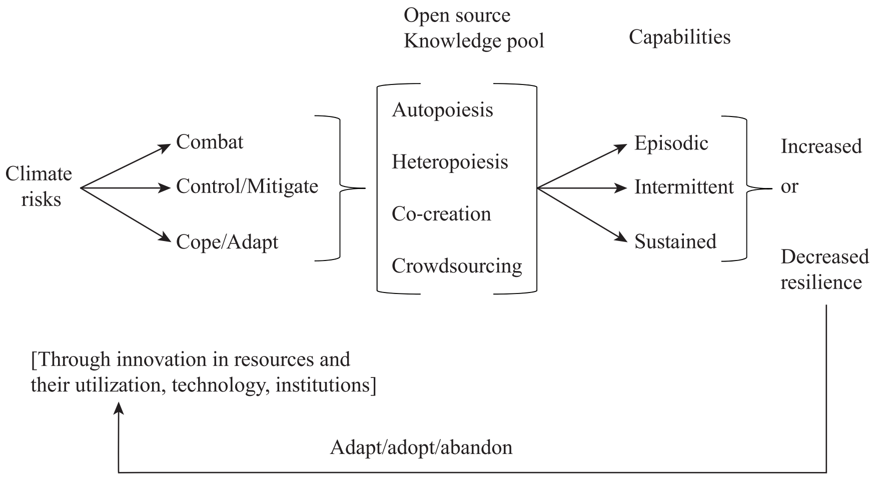
How is Knowledge Generated, Processed and Shared for Enhanced Resilience?

Knowledge in formal and informal sectors is generated when observations are made, problems are sensed and potential solutions are perceived. Local knowledge, open exploration and management system can be understood through innovation in resource use, technology and institutions (Figure 1).

Autopoiesis

When climate risks strike, the communities have several options: (a) to combat the situation, (b) to control or mitigate its ill-effects and (c) to cope by making concurrent adjustments. These strategies can be designed autonomously by the autopoietic

Figure 1
Local Knowledge Exploration and Management System



Source: Authors' own compilation.

communities, that is, self-designed, self-organised and self-governed systems. Based on their observations and experiments, communities are able to develop heuristics or rules of thumb within a particular local context (Woodley, 1991). These thumb rules help the members to deal with uncertainties at different stages of the crop. For example, indigenous communities often employ different biophysical natural indicators based on the structure of clouds, direction of wind, movement of birds, insects and wild animals, flowering of certain species, etc. These careful observations of inter-relationships among various natural phenomena have been tested and passed on over generations in the form of folklores, customs, etc. These might not have been discovered at once or as a whole together, instead individual experience might have been validated and value added by other community members. This could happen because the community has a sense of creating and managing collective goods/services through mutual consent or guidance of the elders, as the case may be (Ostrom, 1994). While Ostrom (2005) focused on external sanctions as major driver of collective choice, compliance with rules enacted for governance of commons, Urpelanien (2011) makes an important contribution towards conception of endogenous institutions, akin to what the autopoeisis process may facilitate. He argues for two conditions. First is the generation of common knowledge by a community that enacted rules or imagined that institutions may help in making decisions about solving a problem or exploiting an opportunity. Second is to have self-enforcing expectations to emerge to legitimise or facilitate collective action. Higher the uncertainty in the environment due to climate fluctuation or other reasons, greater need may emerge for cooperation through sharing of knowledge of losses that may have been incurred without cooperation, and also through divergent expectations about finding pathways ahead separately rather than collectively.

Autonomy, organisational closure, structural coupling and self-referencing have been considered important attributes of an autopoietic knowledge system (Abou-Zeid, 2007; Bednarz, 1988; Koskinen, 2013). But self-referencing does not imply that the system will always self-correct. Autopoietic systems are not closed but only self-referential. They need to have three properties: self-correcting, self-design and self-governing or else communities will be caught up in a downward spiral or 'involution'. Efficiency keeps on declining in such cases. When communities continue to refer to only their best, this might be much lower than the societal best. Geertz (1963) described the persistent poverty of the Indonesian farmers in the 1950s as an outcome of 'agricultural involution' due to the socio-ecological constraints. He says that

> *the overdriving of an established form in such a way that it becomes rigid [...] tenure systems grew more intricate; tenancy relationships more complicated; cooperative labor arrangements more complex—all in an effort to provide everyone with some niche, however small.* (p. 82)

Open organisations are open to ideas and criticism from within as well as from outside the organisation, that is, they take clues from that change in environment as well, climate being the most dynamic attribute of a natural system. In a double-loop learning system (Argyris, 1976; Argyris & Schon, 1974), viewpoints of others are invited and then decision is taken based on more complete set of available information. The community members may then become intrinsically committed to the cause. This double-loop learning in an autopoietic knowledge system can generate knowledge which is (a) conflictive or dialectic or paradoxical, (b) iterative and (c) interactive (Gupta, 1983). The institutions may not be open at all, enough or equally at all stages of learning or innovation process. The process of idea generation is often open as in crowd sourcing platforms but idea processing and progression are generally closed in the corporates. We have tried later to identify the conditions under which it might be open, autopoietic and responsive and reciprocal towards informal sector.

Heteropoeisis

In addition to or in the absence of community-led initiatives, third parties like government, non-governmental organisations, private market agents, etc., may design solutions to strengthen the existing institutions or technology. These may complement, supplement or replace and, in some cases, even constrain existing less efficient solutions. Such initiatives are called heteropoietic when the design and management is done by external actors like many of the government or non-governmental schemes. Heteropoietic knowledge systems become sustainable by the system restoring and sustaining activities pursued by the external agencies (Zeleny, 2005, p. 205). These agencies support the knowledge system by collecting and disseminating ideas, information, technology and other resources. However, when the agency is withdrawn, the system may succumb (Parra-Luna, 2009) to various exigencies. This happened about a decade ago under a joint project by Indian Institute of Management–Ahmedabad (IIM-A) and SRISTI on in situ conservation of agro-biodiversity. It was found that by 2002, the number of local paddy varieties had reduced to less than 40 per cent of the varieties reported in 1988-1989 (Gupta, 1989). In 2003, seeds of local/traditional rice varieties were collected and distributed to farmers who showed willingness to cultivate in a prior survey. For three years, when the external agency was involved in monitoring, the area under cultivation of local varieties increased. When the area was surveyed during 2013–2015, none of the traditional varieties were found. The farmers who were given seeds in 2003–2005 had also adopted modern hybrid varieties, although some of them still believe that several traditional varieties were superior in quality and taste.

External agencies in public, private or civil society sectors may withdraw support too soon due to project compulsions, or lack of long-term resources, or lack of interest in finding a durable solution. They may also not provide timely agro-meteorological information made contingent or applicable to specific local conditions. There are very few, if any, expert systems[4] in which local community members feed external climatic forecasts, local soil and water conditions besides crop and varietal situation to generate more precise farm-level risk mitigating contingent options (Gupta, 2009b). Government rules and regulations for availing of relief and rehabilitation support in the wake of climate-induced disasters may be cumbersome, excluding the really needy and poor sometimes. However, that is not the reason to deny the role of state or external agencies for the hetereopoietic model of community engagement and empowerment for dealing with climate-induced risks.

Another factor which may facilitate sustainability of heteropoiesis is that the system should have some freedom to correct design gaps or fallacies. It is particularly relevant when theoretical knowledge or formal knowledge is transferred to the practical/informal setup. Instead, only the basic framework/tools can be provided such that the user can generate and/or customise solutions to suit their context, needs and to some degree, aspirations. Institutional rules should be able to invoke intrinsic values, morals and motivations if the system has to become self-sustainable in future.

Heteropoietic systems could also be allopoietic,[5] that is, they produce entities other than themselves; hence, if they lose their predetermined purpose, they become unsustainable (Koskinen, 2010; Zeleny, 1995, 2003). Gujarat Grassroots Innovation Augmentation Network (GIAN) set up in 1997 by the HBN and IIM-A supports green innovations through hetereopoietic and also allopoietic models. It is important that the system gives some flexibility to the local communities to be able to experiment with their own strategies and devise robust solutions by experimentation or improve upon existing solution without dissolving the overall purpose of climate change adaptation.

Co-creation Models

While formal systems like UNFCC, UNDP, etc., have started acknowledging and sharing local knowledge about adaptation and mitigation, blending or bundling these with formal knowledge systems still remains a challenge. Agrawal (2010) rightly noted that the role of partnerships between local, civil society and public institutions is crucial for empowering local communities. However, adaptation being a local phenomenon, it is highly dependent on the local and external institutional contexts. Co-creating solutions adapted to local institutions is an important strategy. These strategies are attuned to the cultural regime and norms which in turn influence the effectiveness of the adaptation interventions by the national or international agencies. These also help to translate the solutions into the local language to make them more acceptable and effective, bridging the gap between local communities and external agencies (Agrawal & Perrin, 2008). The blending of knowledge produced by/with formal scientific institutions with informal knowledge is stressed repeatedly (Gupta, 1995, 2006; Nyong, Adesina, & Elasha, 2007; Pareek & Trivedi, 2011). The Network has been doing this for several decades, but more such platforms are needed. To facilitate co-creation, it is important that leaders in both formal and informal sectors acknowledge each other's strengths and beliefs in building mutual capacities. They can bring in technologies or solutions from different domains and regions, *bundling* them to create a package of best practices or *blending* them to bring a more robust solutions (Sinha, 2008).

Crowd Sourcing

Crowd sourcing can be of ideas, technologies or support for supply chain functions, funding or any other stage of the value chain. The contributors may or may not claim novelty or innovation. Crowd sourcing will be preferred when (a) organisation does not have the ability or capacity to produce solutions from the known sources (within the organisation or in their network), (b) when uncertainty is high and too much is at stake, to depend on only one source of information or resource is risky, (c) cost of existing solutions or expertise is high, (d) the said activity does not fall under the existing domain of specialisations of organisational members, (e) problem is fuzzy and not easy to even exactly ascertain domain or domain expertise within which it specifically lies, (f) problems are wicked, or persistent, dynamic and complex like the effects of climate change and (g) when the degree of customisation or niche specificity is high and skill to answer to a problem may be widely distributed.

Crowd sourcing adaptation or mitigation measures from the distributed communities has become unavoidable as they have dealt with uncertainties for long. They have evolved in some cases very robust knowledge systems in dealing with climate fluctuations and uncertainties. Even when some of these coping measures lose their contemporary relevance due to micro-climatic or eco-physical changes in a habitat, these strategies could still be relevant in another context as a heuristic, metaphor, or even a rough template. When knowledge is crowd sourced, ascertaining its authenticity might pose some problems.

Opening Up the Knowledge System

Different processes of knowledge generation mainly differ in the degree of openness, that is, extent of sharing with and learning from outsiders or strangers, and the degree of self-governance (see Figure 2). For a system to be robust, inclusive and sustainable, it has to be open to others for learning and sharing, adoption or adaptation and critical disruption when needed. The evolution of the possible derivative knowledge system may strengthen the parent knowledge system through feedback, criticism and user experiences. Hence, these feedback channels have to be carefully designed so that both the knowledge provider and the seeker are benefitted. Hamel (1991) suggested that alliances are like membranes through which exchanges of resources, skills, knowledge takes place in the form of 'collaborative exchange'. Unlike purely business, corporate or political alliances, knowledge exchanges around climate adaptation and mitigation options may have competitive advantage; even then such exchanges are not very common. The reason may be that benefits of climate change exposure, effects and efficient adaptation by design are asymmetrically distributed owing to the differences in natural and social capital endowment,

Figure 2
Openness in the Knowledge System

Degree of openness	Degree of self governance: High	Degree of self governance: Low
Low	Autopoiesis	Heteropoiesis
High	Co-creation	Crowdsourcing

Source: Authors' own compilation, 2016.

Figure 3
Eco-institutional Perspective

Ecology	Institutions	Technology	Culture
Access			
Assurances			
Ability			
Attitudes			

Source: Gupta (1987, 1989).

and socio-economic and power status of the communities (Bretschger & Valente, 2011). Gupta (1995) describes sustainability through the 4A model with resources (knowledge and natural endowments), institutions, technology and culture on one axis and access, assurance, ability and attitude on the other axis (see Figure 3). This model is adapted to overcome the forces of exclusion in five dimensions (5S), that is, space, social segment, sector, season and skills which lead to the asymmetrical distribution of knowledge.

Asymmetry in knowledge, resources, skills and access to institutions increase the transaction cost, necessitating mediation by third party agencies to bridge the gap by acting as a broker, benevolent *baniya* and/or institution builder (building self-renewing capacities) (Howells, 2006). It is not enough to have access and assurance to resources, institutions or technology or even cultural platforms, if the ability or skill to convert access into investments or opportunities is lacking. Further, positive or optimistic attitude is an important driver of efforts to overcome asymmetries in access and assurances despite having skills. The formal and informal knowledge systems have evolved differently as they focus on optimising different parameters depending upon the heuristics used by the actors in both the sectors. Collaboration between the two can fill the void in the national innovation system, particularly, in the sectors or the regions neglected or unreached by the formal sector. Intermediary organisations also become crucial when knowledge remains in isolated islands and is incomplete in itself. Trust, authenticity and reciprocity are important. Evans and Schmalensee (2007, in Han & Cho, 2015) noted that intermediaries internalise the externalities of one group on another. Hence, the role of intermediaries in making the climate change knowledge system more open can be summarised as follows.

- Maintaining a searchable database of solutions that people have tried and tested.
- As mentors, bringing in formal and informal actors together for testing and improving upon the existing function and design of institutions and technologies.
- Decrease search cost of both problems and solutions.
- Performing buffer/peacemaker/arbitrator function in the case of disagreements.
- Protect the interest of both the parties, that is, formal and informal sectors.
- Help in licensing, technology transfer and business development.
- Supporting knowledge networking and facilitating validation, value addition and new knowledge creation by users.

Though the concept of intermediary organisations and functions has been recognised in the past, they were mainly supplementary to other functions. But with the gaps recognised in the inclusive innovation landscape, full-fledged intermediary organisations like NIF, GIAN and SRISTI which are part of the HBN evolved to bridge the gap between both the knowledge systems. We shall study the role of these organisations and some of their activities to learn about the way they have made their impact in making the climate knowledge system more open.

The Brief Story of the Network

The HBN was founded in 1988–1989 (see Gupta et al. (2016) for more comprehensive story) with the realisation that knowledge was often collected from the communities or individuals in the informal sector without any reciprocity or sharing benefits back with them out of the value generated from that knowledge. Moreover, the formal sector innovations had numerous channels of disseminations; the informal sector did not have many such platforms, though word of mouth was always available to them. When information spreads through word of mouth, some of its components might be subtracted or substituted while some others may be modified. In case of diffusion of technological innovations related to disaster management, Yun, Park and Avvari (2011) found that the users (civilians) not only disseminated but also helped in knowledge production by giving feedback and sharing their experience with the experts. Hence, integration of local knowledge and social networks will enrich the innovation ecosystem to provide climate ready solutions to the communities.

The Network follows the philosophy of honeybee that collects the nectar and cross-pollinates the flowers, enriching the diversity. The flowers do not feel short-changed when their nectar is taken away, in fact they attract the bees. Similarly, the people whose knowledge is taken away should not feel short-changed. They should ideally, find exchanges with formal sector mutually rewarding. The Honey Bee Newsletter was started by the Network to give voice, visibility and velocity to the creative solutions devised by the communities and also protect their knowledge (intellectual property) rights while connecting them to formal scientific and other market institutions. As the frugal and inclusive innovation ecosystem started evolving, different partners preferred different degree of stake in the institutional platform designed for the purpose. At different stages, as and when support could be mobilised, different formal institutions were set up by the Network in addition to the existing ones to meet the needs of the innovators and knowledge holders at different levels, in various regions and sectors.

SRISTI was set up in 1993, essentially to support the activities of the Network to recognise, respect and reward creativity at the grassroots. It remains partly autopoietic with farmers and innovators on the board having major say over its governance. However, its support to the innovators is heteropoietic and also allopoeitic since it is an intermediary organisation. It has been able to create knowledge systems which have acquired different degrees of openness, self-governance and engagement with the knowledge producers and users. SRISTI maintains databases of innovations and traditional/indigenous knowledge, medicinal plants, common property resource institutions, technology student projects, etc., and tries to give awards to outstanding student innovators (http://www.sristi.org/wsa/; techpedia.sristi.org. gyti.techpedia.in).

Shodhyatra

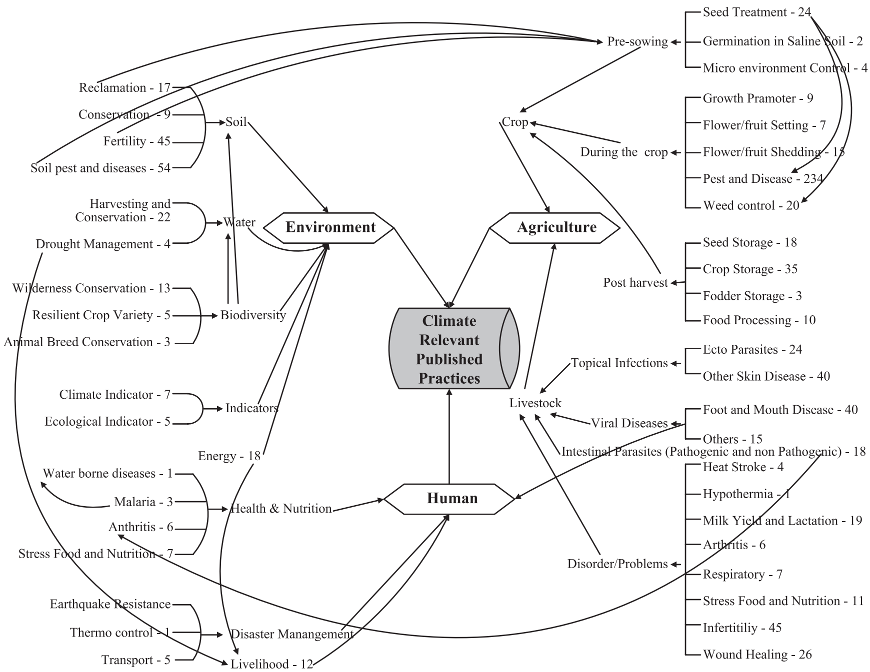
Shodhyatra (Shodh = search, yatra = journey), organised by SRISTI, is a journey to search and share the knowledge, creativity and innovations at the grassroots. The walk is organised twice a year, to the hotter places in the summers and to the colder ones in the summers. The idea is to learn from the communities' survival strategies during climatically harsher season and to felicitate knowledge holders who cope with various stresses well at their doorstep. It is one of the most open, reciprocal and responsible mass or crowd sourcing off-line platform (Gupta et al., 2016). Knowledge is shared openly from both the sides and many grassroots innovators also participate and share their innovations and knowledge. Some help the local people to co-create or design innovation-based enterprises based on their local resources. The knowledge system around Shodhyatra is partly autopoietic to a great extent since it evolves and sustains itself at its own terms though exchange with external world takes place (http://www.sristi.org/cms/shodhyatra). When we share the prior ideas, innovations and practices, it also contributes to the heteropoietic process as it helps in reproducing not only the journey partially but also in fertilising or cross-pollinating the local knowledge systems.

NIF is an autonomous institution under the Department of Science and Technology and GIAN is a non-governmental organisation supported by the Government of Gujarat. They are involved in scouting, documentation, augmentation, value addition, validation and dissemination of grassroots innovations and traditional knowledge. GIAN mainly works on ideas scouted by SRISTI as well directly. GIAN was the first incubator in India, perhaps the world, for grassroots innovations and knowledge. It reduces the ex-ante and ex-post transaction costs of innovators, entrepreneurs and investors so that three vectors converge to trigger sustainable innovation based social or economic enterprises. These institutions are run according to the rules and policies of the respective governing agencies but have some degree of freedom, or else NIF would not have been able to make new policy instruments like Micro Venture Innovation Fund (MVIF, nifindia.org/mvif) and Grassroots Technology Innovation Acquisition Fund (GTIAF, nifindia.org/gtiaf). NIF has to follow public service rules, being part of the government, but that has not come in its way of expanding openness of technologies except for patented or potentially patentable technologies. It is heteropoietic in nature but with some flexibility it has been able to innovate new policy instruments which have strengthened its service delivery system to address unmet community needs.

The Honey Bee Network Database

The Newsletter, a vehicle to share the HBN database practices in different languages, has published more than 2,500 articles and practices from the grassroots. We identified a sample of 820 practices which are relevant for climate risk adjustment or adaptation (Figure 4). The largest number of practices is related to pest and diseases including sucking pests like aphids, whiteflies, leaf eaters, beetles, etc., on different crops. In livestock, maximum numbers of solutions were given by communities for foot and mouth disease. These practices are generally based on extremely low-cost plant materials, and are amenable to DIY (do-it-yourself) mode of replication and are generally eco-friendly. These have been shared with prior informed consent from the knowledge holders in the cases where these were unique. Feedback from the readers helps bring strangers into the Network. The newsletter is published in six Indian languages and also in Chinese apart from English. The newsletter has contributions from the grassroots communities and scientists as well. Apart from the newsletter, the online databases have more than 10,000 practices and knowledge from the grassroots regarding medicinal plants, agriculture, livestock, forestry, soil and water conservation etc., and management of indigenous common property resource institutions in open source. It serves as one of the oldest and notable examples of an open innovation platform since the inflow and outflow of knowledge exchanges happens from both the sides—formal and informal—with acknowledgement and reciprocity. The newsletter has contributions

FIGURE 4
Climate Relevant Practices Published in the Honey Bee Newsletter



Source: Honey Bee Newsletter (1990–2015).

from around the world of contemporary and traditional wisdom. For example, an article reads, 'Fan Sheng-Chih's Chinese Encyclopedia written in the First century BC reports that melted snow helps better retention of moisture in soil and also kills insects. Treatment of seeds with melted snow gives drought tolerance to plants and yields better' (Tagare, 1998). When the need of validating these practices from the formal scientific principles was felt, Sadbhav-SRISTI Sanshodhan Laboratory was set up, solely dedicated to validate and value add in common people's knowledge. Hence, the best practices for a problem were pooled and formulations were made, tested and standardised. A non-profit Section 25 (now Section 8) company, SRISTI Innovations, was set up to market these. The names of the knowledge providers/communities are shared on the package of the products and the benefits are shared with them in every single case.

Taxonomy of coping strategies was used to create a metric to measure the fit between pest stage and coping measures. Different practices work in different time frames. Practices of soil or agro-biodiversity conservation are limited but may pay off only in the long term. The cost of losing crop due to pest or other stresses are paramount and may be realised during or after the crop season. The importance of conserving wild relatives of crop varieties such as *Oryza rufipogon* in eastern UP may not be realised in short term. But when modern varieties of crops become vulnerable to the pests or climate fluctuation induced stress, then search for new genes for stability or resistance will require accessing these wild relatives and/or local varieties. The interaction between edaphic, climatic and biological components and agro-biodiversity takes places in a co-evolutionary manner under human selection pressure. Conserving germplasm only or mainly ex situ (that is the gene banks) may not suffice. The genes for stress may not get expressed in highly fertile and controlled environment. Through successive growing of seeds periodically to maintain their viability in gene bank, the genes responsible for stress adaption may get eroded. Hence, in situ conservation is important (a) to let genes be exposed to different weather conditions and have more chances of getting expressed and identified for suitability under different kinds of climatic stresses, (b) to allow evolution through mutations occurring naturally and (c) encourage human selection in natural variations to let resilient genotypes evolve.

Water harvesting and conservation, soil conservation, etc., are practices or mitigation measures which are planned ex ante to help the communities to increase farming resilience in the wake of natural disaster.

The maximum number of practices was published in pest and disease management both in crops and animal husbandry. Different solutions are effective for different stages of the life cycle of the pest, influenced by contingent factors. Table 1 shows that the maximum number of practices was found for controlling insect pests, both in larval and adult stages. Some which could not be controlled were minimised. The number of practices for prevention of pest and disease incidences was relatively lesser. This weakness of the local knowledge system needs to be overcome to generate a more robust pest and disease management system. While many of these practices are followed independently, some need community participation or collective action. For example, one such practice in the database mentions that when Pak Oyo, a farmer in Buah Dua, West Java, found that dragonflies were natural enemies for many of the paddy pests, they convinced the community members to conserve them. The problem, however, was that the larvae of

Table 1
Characterization of Pest and disease Management Practices Published in the Honey Bee Newsletter

Pest and Disease Management	*No. of Practices Published*		
Pest type	*Prevent*	*Control*	*Minimise*
Sucking pests like aphids, thrips, etc.	6	21	2
Mature insect pests like grasshoppers, plant hoppers, beetles, etc.	11	41	27
Larval stage of insect pests	5	43	10
Termites	4	9	5
Pathogens	1	29	18
Crustacean pests	0	2	0
Total	27	145	62

Source: Honey Bee Newsletter (1990–2015).

the dragon flies were collected and consumed by the women folks who considered it a delicacy and were reluctant to give it up. So, to convince them, Pak Oyo took them to field schools and taught them about the effect of this insect on pest control, and hence enhanced food production. In this way, he could bring out a change in community behaviour towards pest management. Local knowledge systems may be autopoietic and generally sustainable. But when new varieties are introduced, these systems and associated practices as was the case in dragonfly may not be sustainable. The pest load on such varieties is much higher than local varieties which are relatively more resistant. But as the pests become resistant or evolve or predators of the predators become populous, the accumulated knowledge of the community may not be sufficient to combat. In such cases, heteropoietic agents such as formal R and D centres, KrishiVigyan Kendras (KVKs), agricultural extension services may intervene and enrich or obsolete the existing knowledge system, thus in turn helping autopoiesis through a robust feedback. But the advantage of Open Innovation Platforms like HBN is that it enables communities in sharing their adjustment and adaptation strategies, so that other communities may learn, adopt or adapt them for their needs.

Key Lessons

The HBN, through its partners and activities, has been able to open up and broaden the knowledge canvas of climate change coping strategies. It has been able to bring in the best of formal institutions to work on, and validate the grassroots technologies on one hand and has given the grassroots innovators a common platform to share their ideas as such for triggering experimentation elsewhere. The communities help each other in designing or solving problems and in certain cases, improvising the derivative innovations or solutions. The network has been able to connect the rural, the urban, the young children, youth and the old, besides formal national and international institutes. With the pioneering contributions on the concept of frugal innovations for over 28 years, the Network has made a statement on the legitimacy of grassroots innovation in the climate resilience dialogue. However, the dynamics within the Network need a little more attention from the members. The feedback system can be strengthened if the products can be sold through app or incorporated in the current online retail platform. Criticism from within and outside the organisations needs to be tolerated and encouraged. Only the resilient and outstanding strategies by communities and the external partners need to be celebrated, only then can the system become more open and robust.

When the herbal pest control practices are being tested, validated or value added, consultation with experts from both informal and formal sectors is facilitated by the Network. A problem that surfaced during the interview with some of the innovators was that the cost of transporting the raw material is higher for the commercial organisations and cannot be compared to the farmer's cost in sourcing material locally. There can be two possible ways so that farmers can take advantage of the solution. (a) Distributed manufacturing: geographies with particular problems of pest and diseases will be identified and the herbal pest control formulation once standardised will be manufactured there, cutting the cost of transportation. (b) The ingredients and method of preparation can be made available to the people free of cost to make their own formulation. In case they would want to still buy, they can (Pastakia, 2002).

The Network need to renew its ties with old partners and learn about the ways in which people in their region coped with the rising variability of climate. Solutions which did not give optimal result should also be shared with the knowledge providers and others so that they are aware of the problem and consider modifying or abandoning the said practice. So far, a small group has been able to deliver so much to the society but it would need expansion in terms of human resource and other resources. Hence, partnerships with SHGs, *mahilamandalis*, farmer's co-operatives, rural schools etc., will be important along with partnerships with KVKs (agriculture science centre), extension divisions of agricultural institutions, etc., and with communication channels like post offices and railways, national and internal research and funding agencies. To facilitate co-creation and the collaborative spirit, engaging the students meaningfully with the community and industries in an open, reciprocal and responsible innovation framework has to become a regular part of the curriculum. Oganisjana (2015) observed that 'University students' collaborative skills could be promoted effectively if multi-channel collaboration in open innovation environment becomes a habitual feature and culture of the University study process across a broad range of contexts versus discrete campaigns of cultivating openness within a separate study discipline.' The idea is to increase the knowledge canvas by absorbing the strengths of the systems of autopoiesis, heteropoiesis, co-creation or crowd funding so that the knowledge system around climate adaptation becomes more robust and inclusive. Hence, intermediary organisations will need the flexibility to change from one way of working to other or might have to discontinue its own existing processes to make room for better solutions, that is, inculcate a culture of disruptive open inclusive innovation to provide better service in connecting the formal and informal climate scientists.

NOTES

1. The flagship publication of the Honey Bee Network, India, accessed at http://www.sristi.org/hbnew/magazine-all.php?lang=1
2. So also in flood plains of Bangladesh, and many north-eastern states of India.
3. NIF, 2015. Accessed at http://nif.org.in/Innovationofday/hrmn-99-apple-variety-for-low-altitude/25
4. Climate Impact Expert System, Generating climate relevant information for multiple impacted sectors and present them in an online tool, Climate KIC, accessed at http://www.climate-kic.org/projects/climate-impact-expert-system/ (accessed on 8 January 2017).
5. Allopoeitic refers to intermediary organisations which act as throughput, for instance, a school does not reproduce itself but produces students.

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