Agricultural Systems xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Agricultural Systems

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

Innovation, investment and enterprise: Climate resilient entrepreneurial pathways for overcoming poverty

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ARTICLE INFO

Keywords:
4A model
Portfolio of choices
Grassroots innovations
Honey Bee Network

ABSTRACT

Harnessing innovative potential of individual and communities in high risk environments provides an entrepreneurial approach to poverty alleviation. The access to resources and the ability of communities to transform these resources technologically depends on the matrices of institutional assurances and attitude to take risks to convert ecological variability into entrepreneurial opportunities for investments. These innovations can emerge endogenously or sourced exogenously or might be a blend of both. The Honey Bee Network has evolved several instruments for scouting, documenting, validating and value-adding, financing and disseminating innovations *for, from* and *with* grassroots.

Climatic fluctuations produce four kinds of household portfolios depending upon the average income or productivity and variance around it: a) high mean-low variance, b) high mean-high variance, c) low mean-low variance and d) low mean-high variance. Category d comprises the most vulnerable community members; but the challenge before agriculture scientist is to recognize that the economically poorest people may not be intellectually or institutionally poor. The grassroots innovations often remain localized and underdeveloped. Blending and/or bundling formal and informal knowledge systems can generate viable, investible choices for individuals, communities or a combination thereof. Innovation can take place in terms of various combinations of products, processes, services and systems (PPSS). The conventional agricultural system has not focused on creating or augmenting innovation capabilities or potential by modifying the interplay between existing institutions, technologies and resources. in the age of mass customization, the standardized solutions and packages have no place. Without enhancing local capabilities to interpret climatic and other sources of fluctuations, we cannot generate dynamic household portfolios of private, common and public resource based survival strategies.

Innovations in instruments of engagement between formal and informal system are as important as technological and other innovations. The microfinance has to evolve into micro venture innovation finance so that communities and individuals can take risk to generate viable social and economic enterprises. Incentives to experiment, explore and fail may not work effectively without risk absorption mechanisms at different levels. While conventional intellectual property protection system is useful for market based economies, the concept of Technology Commons may be more apt for network based economies, promoting open sharing among communities but sharing with commercial firms through licensing.

The proposed inclusive innovation ecosystem focuses at strengthening the coping strategies of marginal farmers, particularly women by 1) harnessing social & ethical capital by pooling and sharing of resources and associated knowledge, 2) converting access to resources and knowledge into episodic and/or perennial enterprises 3) overcoming climatic or market induced fluctuations through innovations in PPSS; 4) building self-designed, self-governed institutions i.e. autopoietic institutions for continuous learning and experimentation to overcome poverty; 5) encouraging third party interventions through heteropoietic institutions only for short term so as not to dissipate long term autopoietic potential for sustainability by having permeable and fuzzy boundaries to facilitate exchange of expertise, feedback and other resources as and when needed, and 6) fostering distributed, decentralized and diversified innovation-based portfolio of enterprises contributing to social, economic and ecological resilience.

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https://doi.org/10.1016/j.agsy.2018.07.013
Received 30 September 2017; Accepted 19 July 2018

1. Introduction

Household vulnerabilities due to climatic fluctuations are amplified in high risk environments, such as flood and drought prone areas. Many of these disadvantaged regions are neglected not only by public institutions but also by market forces. Transaction costs in dealing with factor and product markets increase consequently. Small farmers and workers suffer even more when they are not able to take advantage of good weather opportunities. They suffer when the weather is bad but they do not necessarily benefit when it is good. The 'good weather code',[3] suggested by Dr. M S Swaminathan (1971) was never developed in India or elsewhere. However, we do have the famine code developed during the colonial period. Poverty alleviation does not necessarily imply dealing only with negative deviations around the mean level of income flows but also exploiting the full potential of positive deviations during good weather periods. While scientists have developed contingency cropping technologies for rain-fed regions to minimise losses during drought or floods (CRIDA, 2008), they have not yet developed opportunistic choices for either primary production or storage, processing, transportation and distribution of value added production in *good* seasons. At such times, prices come down and possible benefits of good weather are often wiped out. *Unless we harness good weather opportunities, merely by minimizing risk under adverse climatic situations, poverty cannot be eliminated.*

Vulnerability in the context of climate risks, has been defined as, "(t)he degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001). Adaptive capacity is the ability to adapt to environmental stress over time through different pathways (Brouwer et al., 2007). Different kinds of vulnerabilities do not affect all groups of farmers/livestock keepers/artisans alike. Likewise, not all vulnerable farmers adapt or just adjust with climatic risks the same way with or without access to credit (Gupta, 1981). Some of them try to transcend the constraints by exploring creative and innovative ways of converting crisis into opportunity (Gupta et al., 2000; Gupta, 2006; Dey and Gupta, 2016). In this paper, we have outlined the framework in which pathways for poverty alleviation can be explored. The role of innovations in strengthening different pathways is illustrated through specific endogenous and exogenous innovations, and practices. Adato and Meinzen Dick (2002) suggested application of the sustainable livelihoods approach to study the "multi-layered interactions between technologies and the vulnerability context of households, their asset base, intervening institutions, and livelihood strategies". They added that the "role of culture, power, and history needs to be integrated with the framework to understand the role of agricultural research in the lives of the poor".

Viability of innovation based pathways for poverty alleviation rests on four assumptions: a) reducing or eliminating the transaction costs of bringing together innovation, investment, and enterprise is necessary assuming that not all three functions may converge in one place, person or institution; b) assuring the access of poor to relevant resources, institutions and technologies through appropriate institutional frameworks, and inculcating/leveraging skills to convert access to technologies into investments; c) exploiting untapped opportunities by vulnerable households/communities dealing with formal agricultural research and extension services besides other support institutions (innovation brokers, bridge-organizations, farmer cooperatives, self-help organizations of women, retailers of agri -inputs, corporate outreach organizations, social movements); and, d) promoting do-it-yourself models of using technologies wherever possible and democratising knowledge, innovations and practices and hence, the role of innovation brokers in making these pathways to work.

The need for innovation brokers to reduce transaction costs by bridging existing gaps among different actors in the value chain has been realized in various settings (Gupta, 1987; Klerkx et al., 2009, The Rebasing Partnership, 2012, Long et al., 2013). The Network discovered such a need decades ago when it set up three institutions, i.e. SRISTI, 2013 [Society for Research and Initiatives for Sustainable Technologies and Institutions, set up in1993 (www.sristi.org)], GIAN [Gujarat Grassroots Innovations Augmentation Network, set up in 1997, (www.gian.org)] and NIF [National Innovation Foundation, set up in 2000, (www.nifindia.org)], for mediating with various stakeholders by reducing their transaction costs. Ironically, apart from the open source database of farmers' practices and innovations by SRISTI and Honey Bee Network, there are not many other open source platforms with solutions that farmers can experiment with. There is thus a need for many multi-language, multimedia databases on the subject, for people to learn even if illiterate, and in their mother tongue to overcome barriers of language, literacy and localism (Gupta et al., 2000). Such databases can reduce the search cost of communities as well as scientists. Resilience in the wake of climatic fluctuations will require such innovations and practices to be treated not only as solutions but also as frugal heuristics to develop location specific solutions by communities themselves with or without the help of scientists. One can learn from an innovation at least at four levels: artefactual, metaphorical or analogic, heuristic and gestalt level (Gupta et al., 2016). Such databases can help other farmers learn by practicing an innovative practice as such, and also by using it as a metaphor or analogy; or using the heuristics, principles or thumb rules underlying it, or by adapting or evolving an ecosystem or gestalt of technology, institutions and culture.

1.1. Organization of the paper

The paper is divided in three parts: part one deals with the conceptual framework and the review of relevant literature on climatic risk and creative strategies for resilience, resource augmentation and poverty alleviation. The conceptual framework includes discussion on different dimensions of Innovation: PPSS (Product, Process, Service, System), strategies for risk mitigation and minimization, blending endogenous and exogenous innovations, portfolio of coping strategies, and institutional pathways of risk mitigation.

Part two lays down the challenges and provides empirical illustrations and arguments for pursuing different pathways for livelihood diversification, nutrition security and poverty alleviation. Examples of resilient varieties and practices in the informal sector are included. Key lessons about platforms for sustaining entrepreneurial pathways for poverty alleviation are illustrated in part three, through Sattvik: Traditional Food Festival. Examples of how linkages among innovation, investment and enterprise are forged are also illustrated in the different cases. The role of Shodhyatras in scouting innovations and unmet social and technological needs and sharing prior solutions is explained. Lastly, key policy and institutional implications are mentioned in the concluding section.

[3] Scientists and public administrators have devised codes for famine and droughts, so as to conserve rain water to provide life-saving irrigation and drinking water for human and livestock purpose. A good weather code implies that we should be equally concerned and organized to harvest, conserve and utilise rain water during good rainfall years. In its absence much of the rainfall flows into the oceans and the tanks are not desilted in advance for in situ conservation of water.

2. Materials and methods

We used the Honey Bee Network database of innovations and traditional knowledge practices (http://www.sristi.org/hbnew/honeybee_database.php) to select and analyse grassroots innovations. Such innovations include sustainable agronomic practices, herbal pesticides, small agro-machinery, etc. A few cases are presented to illustrate how these grassroots innovations reduced transactions costs, added value, and/or improved productivity, reduced risks, generated employment and thus helped in reducing poverty.

2.1. Part one: conceptual framework

Climate resilient pathways for poverty alleviation require that various endogenous and exogenous innovations receive investments of social, ethical and natural capital besides financial capital. This enhances the capacity of communities, individual households and other social institutions in converting access to resources, assurance from institutions and ability to convert resources into enterprises (social or economic) by using technologies. Ethical and social capitals are also converted into financial capital by reducing transaction costs. To illustrate, when 950 Indian patents (nifindia.org/ipr) were filed by NIF through pro bono help of IPR attorneys at an average cost of USD 300 against market cost of 3500 to 4000 USD, one can find out the financial contribution by just one community, thanks to social and ethical capital of the Honey Bee Network. Likewise, most scientists involved in the validation and value addition of the innovations did not charge for their time and thus contributed to the institutional capacity to validate many more technologies than would have been possible otherwise. Fig. 1.

Some of the exchanges among communities may go beyond local regions through various kinds of market platforms. They are not limited to household or community level. The risk mitigation and minimization strategies shaping household portfolios show that endogenous and exogenous innovations can be blended (see details later). For example, the Santi-mobyke operated plough developed endogenously by Mansukhbhai Jagani in India (for the Saurashtra region which has light soils could not work in the heavy soils of Kenya. It could be adapted after using the plough developed by the Jua Kalis and scientists of JKUAT (Jomo Kenyatta University of Agriculture and Technology) for diffusion in Kenya supported by USAID (www.sristi.org/cms/sristi-usaid, also see http://www.gian.org/innovationdetails.php?page=3&category=3).

Pathways for poverty alleviation require reducing *ex-ante* and *ex-post* transaction costs of connecting innovators, investors and entrepreneurs. The three functions of innovation, investment and enterprise may not always be performed by the same person. *Ex-ante* transaction costs include searching, finding suppliers, negotiation and drawing up the contract. *Ex-post* transaction costs include executing the contract, side payment if original terms of contract do not work anymore, conflict resolution and the cost of drawing up a new contract if the existing contract fails to connect innovators, investor and entrepreneurs (Gupta et al., 2016). The exchange of paddy nursery or seeds, weeds for fodder or human consumption, labour for collective activities like transplantation of paddy, etc., particularly among women, require mutually acceptable informal arrangements (Dey and Singh, 2015). The role of women in coping with risks and managing various opportunities of survival at different stages of risk adjustment requires reduction of transaction costs significantly. Who has extra nursery of which variety suitable for early or late transplantation is shared informally in the community knowledge network. A multi-village formal knowledge and resource exchange platform might actually help. What kind of IOUs (I owe you) are generated in these exchanges also depends upon local socio-cultural norms and history of bilateral exchanges? Community level exchanges generally are managed through informal enforcement of contracts.

However, when an innovator needs to access the situational resources, technologies or finance, these transaction costs acquire more significant importance in the entrepreneurial journey of the innovator as well as those farmers who adopt/adapt innovations. We illustrate how these costs are reduced through the Honey Bee Network activities: a) The development of new variety by farmer breeders, b) Farm machinery for pre and post-harvest operation, and c) other technologies

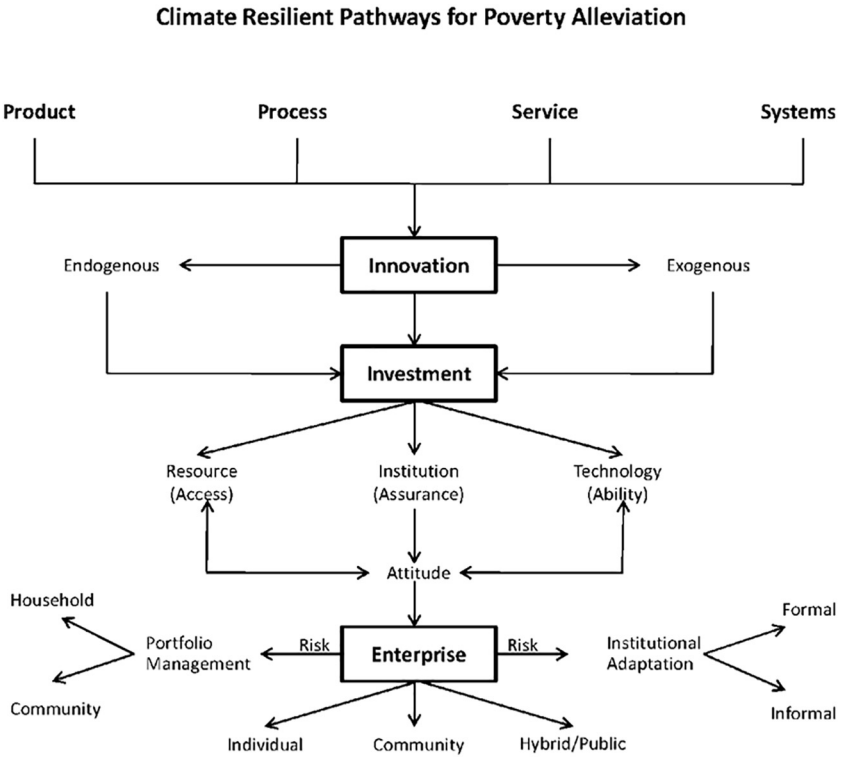

Fig. 1. Climate resilient pathways for poverty alleviation

needed for overcoming poverty.

While describing the processes that help in reducing transaction costs, particular reference is made to different platforms like Shodhyatras, Sattvik Traditional Food Festival, regional language publications, meeting of experimenting farmers, clearing house to bring innovators, investors and entrepreneurs together at regional level and also national level through Festival of Innovation and Entrepreneurship. All these processes reduce the ex-ante and ex-post transaction costs involved in building climate resilient pathways for poverty alleviation. Both macro and micro linkages get made at these levels to provide connections beyond usual boundaries.

The role of financial investors has remained subdued so far because retailing small scale risk capital involves much higher transaction costs than a few big venture capital investments. The micro finance movement focuses generally on goods and services for which a market exists. The micro venture finance fund pioneered by the Honey Bee Network through SRISTI and National Innovation Foundation [NIF] deals with innovations for which a market is yet to be created. The higher the climatic fluctuation in a given region, the lesser is the chance that market based instruments would be available for reducing these transaction costs. Policy implications are clear. If public policy interventions supplementing civil society initiatives are not undertaken, then it is unlikely that farmers would take risks and move forward on an entrepreneurial path. There is a strong case for the formal and informal sectors of science and technology to blend platforms for leveraging local knowledge, skills, resources and entrepreneurial urge to generate autopoietic (Maturana and Varela, 1991; Kay and Cecez-Kecmanovic, 2002; Reynolds, 2005; Varela et al., 1974) self-designed, self-governed systems of poverty alleviation.

Knowledge produced by vulnerable households while coping with climatic fluctuations may not always be stored, shared or used widely. Households that have portfolios facing high fluctuations in income from enterprises which yield low (for example, local breeds of poultry, rainfed pulses, oilseeds, small sheep herds etc.) are most vulnerable.

Blending and/or bundling formal and informal knowledge systems can generate viable, investible choices for individuals, communities or a combination thereof (Sinha, 2008). While designing conventional agricultural systems, scientists do not focus enough on creating or augmenting innovation capabilities or potential of communities by modifying the interplay between existing institutions, technologies and resources. In the age of mass customization, standardized solutions and packages have no place. Without enhancing local capabilities to interpret climatic and other sources of fluctuations, we cannot generate dynamic household portfolios of private, common and public resource-based survival strategies.

Buechler and Mekala (2005) after studying farmers' innovations in wastewater utilization for irrigating crops in drought prone regions, advocated the, “need for greater recognition and dissemination of local innovations and a reversal of knowledge flows entailing improved linkages between local populations, researchers, managers, development workers, and policy makers”. Highlighting the role of timely agrometeorological information translatable into micro level adaptive responses, an institutional innovation was suggested by Stigler (2005) and Dey and Gupta (2016). Stigter pleaded that, “intermediaries are necessary, to be trained in “extension agrometeorology” at the intermediate level, between the producers of action support systems and the farming systems where the agrometeorological services are needed”. Dey and Gupta (2016) argued, on the basis of detailed analysis of coping strategies of communities in flood and drought risk at different stages of the paddy crop in eastern India, that timely information of weekly forecast can strengthen women's capacity to pool and exchange their labour to manage drainage, and manage nurseries. They can then decide which salvage strategy to use after the damage has been caused by an extreme climatic event.

In this paper, we have made a case for empowering creative communities, individual innovators to move on an entrepreneurial path by developing social, economic, and in some cases, even cultural enterprises to alleviate poverty and conserve the environment.

3. Part two: innovations for resilience and reinforcing entrepreneurial pathways: the challenges

There are unmet social needs which markets, state and civil society are not able to meet. Some of these needs are widespread, for example smokeless multi-fuel, energy efficient stove or manual paddy transplanter for a spontaneous nursery,[4] but some are location or place specific such as a particular variety of crop. Not all unmet needs get addressed through local innovations. Some remain unaddressed for decades or centuries (conventional cooking stove is one example with less than 20% combustion efficiency). Given the historical neglect of local creativity, most societies do not have strong cultural traditions of recognizing local odd balls. When outsiders recognize these achievers, local communities also pay attention. This is true even at state agencies level. Many innovators do not even realize that they have really developed an innovative solution. They often assume that they have merely solved a problem that they came across. They move on with the life without caring much about sharing or diffusion of such local solutions.

Agricultural scientists can acknowledge good practices and share them after validation and value addition if needed. For instance, nipping apical buds in chickpea promotes lateral branching, higher photosynthetic efficiency and better yield. Farmers use sheep herds to do that whereas scientists also find it useful but have not recommended it for want of a better alternative. A crop growing on residual moisture provides attractive opportunity in rainfed regions for increasing farmers' income particularly when supplemented by nipping (Baloch and Zubair, 2010).

The challenge before agriculture scientists is to recognize that the economically poorest people may not be intellectually or institutionally poor. Grassroots innovations often remain localized and underdeveloped. The higher the local fit, the lesser maybe the chances of wider diffusion. For some technologies like farmer bred crop varieties, plasticity is higher and they diffuse widely. But for agro-mechanical innovations, the closer fit to local edaphic, agro-climatic conditions requires more design flexibility. They often remain localized. Many farmer innovators solve a problem to the extent desired and then move on to solving the next problem. They may not necessarily optimize any one solution to its logical end. They are, as Simon (1959, 1974) articulates, satisficers and not optimisers. In some cases, they are solo-pathfinders rather than multiple-pathfinders, ‘My-solution, my-way’ seems to be a dominant tendency. Most grassroots innovators are also headstrong (will they innovate otherwise?) and thus scientists need to develop special negotiation skills and empathic attitudes to work with them.

3.1. Small but significant

Farm machinery such as cycle plough for weeding, a manual drainage pump for managing water in paddy fields, food processing machinery for adding value to primary production at individual or co-operative level, etc., are examples of innovations improving entrepreneurial pathways of poverty alleviation through lease financing or rental services at community level. The productivity of farm workers, men and women can improve significantly through small machinery. However, various research institutions have not yet adequately recognized that unlike farmers who know a great deal about his or her farm, a farm worker knows much more about many farms within and outside the village. Therefore, in addition to farmers, focusing on

[4] Manual paddy planters exist for mat nursery whose area is negligible in India and many other south Asian countries but not for spontaneous nursery.

'forgotten farm labourers' (Gupta, 2008) by providing risk capital to acquire small value adding or drudgery reducing machinery can help both the farmers as well as workers. By-product utilization is another area where non-farm workers can be benefited. Using high silica content of paddy straw ash for ceramics and clay pots is one such example.

Farmers select odd plant from natural variations caused by mutations or wild crosses or otherwise. Through recurrent selection of desired plant types or sometimes just an odd plant or deliberate crossings, they develop new varieties. Most of such varieties are distributed freely, but in a few cases, the farmers become entrepreneurs through micro venture innovation investments from NIF or own funds or through the help of friends. Richa variety of pigeon pea is one such variety developed by Raj Kumar Rathor,[5] which has converted many buyers of seeds into micro entrepreneurs. It has a profuse bearing, has relatively high pest tolerance and responds well in low external input conditions as well (Hardev et al., 2016). However, Kudrat variety by Prakash Singh Raghuvanshi performed better than Richa under Gandhinagar conditions and has diffused widely as an open source variety. Rathor does charge premium price for Richa seed. Many of these farmer varieties have been licensed to private companies on a non-exclusive basis with royalty sharing arrangement besides signing fees. In some of these cases, the licensing was done by SRISTI or GIAN and facilitated by NIF (see the list http://nif.org.in/dwn_files/Technology-Licensing-List-Compiled.pdf). The upfront fees help farmers fund their other experiments and innovations. There is another instrument through which the Network and the NIF facilitates diffusion of grassroots innovations. NIF acquires the right of various small technologies under GTIAF (Grassroots Technological Innovation Acquisition Fund) by paying upfront an amount to innovators and then makes these solutions open source (http://nif.org.in/GTIAF).

Testing a farmer's variety under different agro-ecological situations poses another challenge. It helps in exploring its potential in widely different regions. Such testing also offers tremendous role-model effect besides yield improving possibilities. An apple variety by Hariman Sharma from Himachal Pradesh, developed for plains region, was tested by NIF in 17 different states at thousands of locations and apples were harvested for the first time in plains regions, and not just mountains in India.

3.2. Delink innovation and entrepreneurship

Since many grassroots innovators do not make good entrepreneurs, transaction costs of licensing or joint ventures between such innovator (s) and an entrepreneur are thus also met through intermediary organizations like Honey Bee Network institutions (SRISTI, GIAN and NIF and other collaborators like Palle surjana, Pather pathshala, Nam velan mai etc.,). Innovations that reduce risks (such as in situ or ex situ water conservation), improve resilience (relay cropping, mixed or inter cropping, diversified portfolios of household livelihood enterprises) or help in overcoming losses through salvage or rehabilitation technologies are well understood in literature. But innovations by farmers in the form of numerous crop varieties developed by farmer breeders, including salt tolerant high yielding paddy variety (Surjeet Basmati paddy variety, awarded by the President of India, http://nif.org.in/surjeet-basmati-1-aromatic-paddy-variety), herbal pesticides, low cost veterinary medicines, have not yet become part of packages and practices released by various agricultural research institutes and universities. In a Honey Bee Network editorial (Honey Bee Vol 26 (3) & 26 (4) July–December 2015), a question was asked as to why do simple ideas not diffuse? Irrigating cotton in alternate rows reduces water requirement by half and also reduces pest attacks without affecting yields adversely as per a farmer innovator Harbhajan Singh from Hisar (nif.org.in/innovation/cotton_cultivation_in_water_stress_condition/124; for scientific evidence of this practice see Ahuja et al., 1991). Yet, this is not a widely recommended practice leading to tremendous wastage of water worldwide and increasing cost of small farmers apart from decline in water table. Poor farmers are affected adversely because they often do not have resources to use submersible pumps when the water table declines steeply.

3.3. Blending endogenous and exogenous innovations

Innovations thus may emerge endogenously or exogenously. Endogenous innovations may be triggered by a persistent or a transient unmet need. They may also follow the discovery of an opportunity of transforming resource use practice or find new or underutilized resources or build upon a serendipitous idea. Sometimes, innovations emerge through a series of incremental steps taken by different community members and pooled by a few of them into a working system. For instance, several weeds occur in different fields. Women who often do weeding may have either traditional knowledge or may experimentally find out new uses of some of the weeds. While some women may feed unsorted weeds to the animals, others select out the weeds that have medicinal or nutritional properties for human as well as animal consumption. The integration of this knowledge may help in converting some of the weeds into crops (Dey and Gupta, 2016).

Exogenous technologies like hybrid crop varieties, new components (say a new gearbox) of agri-machineries, salvaged parts of old automobiles for making multipurpose motorised ploughs, or tool-bar attachments, etc., can add a lot of degrees of freedom for local innovators. More than sixty to 70% of farm machinery innovations in the Honey Bee Network database use one or more salvaged parts of old automobiles, or other machineries with or without re-conditioning. *Platforms need to be developed offering an exchange/sale of such second-hand components and salvaged parts for fertilizing imagination of farmer innovators and boosting circular economy*. Likewise, testing, calibration and certification facilities need to be provided at low or no cost to such innovators to get formal registration of blended or bundled extremely affordable and often durable solutions. Scientists need not always develop stand-alone technologies but they should try to complement local innovations and help improve them further.

3.4. Investment

In order to reduce climate change vulnerability of poor agricultural households, development interventions, such as anti-poverty programs, have to go beyond cash transfers. These programs should incorporate risk management policies that enhance synergies between generic and specific capacities of communities, corporations, civil society institutions and public research and development organizations by leveraging grassroots innovations.

Most grassroots innovators did not have access to institutions providing risk capital till 2003, when Honey Bee Network created Micro Venture Innovation Fund (MVIF) with the assistance of SIDBI at National Innovation Foundation. This fund extends risk capital to grassroots innovators under single signature, without any co-obligator or guarantor (see nifindia.org/mvif), to provide entrepreneurial opportunities to them.

3.5. Institutional pathways of risk mitigation

Collective risk adjustment strategies underline the importance of commons both in terms of resource management but also through collective decision making. For controlling *Striga* weed in sorghum, CRIDA (Central Research Institute for Dryland Agriculture) and ICAR (Indian Council of Agricultural Research) scientists suggested preponing the sowing time of sorghum by fifteen days. If this decision were

[5] See the citation of his recognition by National Innovation Foundation, Ahmedabad, nif.org.in/innovation/richa_2000_perennial_pigeon_pea_variety/360

to be taken collectively by the community, then everybody's problem of loss of sorghum yield due to *Striga* would be resolved. Earlier sowing led to enough sorghum leaf cover on *Striga* creeper thus preventing it from flowering and setting seeds. The next season, infestation of *Striga* went down (Sanghi, 1987). Agricultural policy has underplayed the need for collective decision making for reducing individual risks and improving collective welfare. Community based IPM (Integrated Pest Management) programs have often been discounted in preference to individual based pest control strategies, less sustainable and profitable as these are (Pretty et al., 2015).

The role of commons such as pastures, forests, water bodies, drainage channels, manure piling ground, etc., is vital in improving productivity of private lands and/or livestock (Jodha, 1986, 1991; Perez et al., 2015). Rarely, agricultural research strategies focus on improving the quality and productivity of common property assets. The poorer the family, the higher may be the reliance on common and public access land and water bodies. The need for exploring new institutional forms including hybridizing various collective and individual change strategies are being considered as vital for small farmer development (Shiferaw et al., 2009).

3.6. Evolution and diffusion of farm machinery innovations

Some researchers like Sole´ R. (2016), Kell and Lurie-Luke (2015) have compared evolutionary biology with the ecology and evolution of technological evolution. Sinha (2008, 2016) and Patel (2016) have traced the evolutionary history of Santi, farm machinery with a multipurpose tool bar attached to a motorcycle for ploughing, weeding and spraying, etc., invented in 1992 by Mansukhbhai Jagani. His was one of the first few patents filed by GIAN and SRISTI and granted at USPTO (United States Patent and Trademark Office) in 2003. It evolved along multiple trajectories to become a small tractor, or high traction legstructure (Handio), which could move over a standing five-six feet cotton crop as well as chasis based ploughs with seed cum fertilizer drills (*sanedo*). Numerous modifications by over 200 fabricators in different parts of Gujarat provided the adaptation required by small farmers unable to afford tractors or keep bullocks due to shortage of fodder. It has also been transferred to Kenya by SRISTI as an open source small tractor through a USAID supported project (www.sristi.org/cms/sristi-usaid).

4. Part three: platforms for sustaining entrepreneurial pathways for poverty alleviation

4.1. Sattvik: traditions, diversity and market

One of the platforms created by SRISTI, an institution providing back up support to the Honey Bee Network is Sattvik, a Traditional Food Festival. This provides a market-based opportunity for creating consumer demand for agro-biodiversity from all over the country besides organic and/or traditional nutritious food. Last year, the Ministry of Women and Child Development, Government of India, sponsored 50 women groups from all over the country to come and set up their stalls for selling herbal teas, creative handlooms, organic products etc. With 70,000 footfalls in three days, these groups learnt about assessing consumer needs, marketing their products and in the process made huge earnings. Some of them earned more in three days than they would have probably in a year (Honey Bee Newsletter, 2010). For poverty alleviation, scientists can characterize unique, nutritional, health and other functional properties of low value crops, weeds and other plants/animal products and generate high income opportunities through market linkages. Exogenous innovations are therefore not only for products, processes, services and systems (PPSS), but also for *platforms* (PPSS) and can add value to endogenous innovations and knowledge systems. Bringing consumers face to face with producers improved the capacity of both to invest in a collaborative market driven process of income generation and poverty alleviation. An exhibition of grassroots innovations was also put up for the visitors to create a market for innovations by GIAN (Gujarat Grassroots Innovation Augmentation Network) and NIF (National Innovation Foundation).

4.2. GIAN: convergence of innovation, investment and enterprise

These innovations need investment through access to resources, assurances from institutions and the ability or skill to transform technological conditions of production, processing and/or building other elements of the supply chain. Reduction of ex ante and ex post transaction costs of innovators, investors and entrepreneurs was realized as fundamental to building viable value chains for poverty alleviation and resilience while setting up the Gujarat Grassroots Innovations Augmentation Network (GIAN) in 1997. The culture of entrepreneurship also gets reinforced when intermediary organizations like these try to reduce transaction costs of innovators, investors and entrepreneurs by providing hand holding support. Whenever communities have a positive experience, their ability to take risks and become entrepreneurial increases. We have studied a few cases where an intermediary organization like GIAN, spawned by the Honey Bee Network, has helped in bringing Innovation, Investment and Enterprise together. Three of the most successful grassroots innovations that were supported by GIAN are Mansukh Patel's Cotton stripper, Mansukh Prajapati's *mitticool* products and Paresh Panchal's bamboo splint and incense making machines. The food processing machine of Dharambir Kambhoj was supported by National Innovation Foundation.

4.2.1. Cotton stripper by Mansukh Patel

When Mansukh Patel made the first prototype of the cotton stripper (to extract cotton from partly opened balls in rainfed varieties like 797), it had to be withdrawn from the market due to several technical problems. GIAN mobilized technical support from the National Institute of Design (NID) & Indian Institute of Technology, Bombay and financial support from Technopreneur Promotion Program (TePP) Scheme of DSIR, Government of India. The innovator developed seven different models in ten years to reach a level of a highly successful commercial product. Now, he has a turnover of INR 20 Cr (three million USD approx) through six companies. Earlier, famers bought different models of cotton stripper but now, it has been integrated with ginning factories. Farmers now bring raw cotton balls, and the entire process of stripping, tripping, seed cotton extraction, separation for cotton and seed etc., is completed in the factory. Women and children were employed in the task of stripping leading to drudgery and use of child labour. The widespread diffusion of this innovation in Gujarat has helped in eliminating child labour almost completely, at least in this task. This case was presented to ILO in a book on Childhood Unchained, by SRISTI (2013). Children are, however, still employed in the picking of cotton balls. Another innovation by Natu bhai Vadher supported by GIAN and NIF involving a tractor driven ball plucker might contribute to solving that problem too. It has been noticed that whenever productivity in agriculture is low, use of child labour is often high.[6]

4.2.2. Multipurpose food processing machine

When Dharambir Kambhoj first made the food processing machine, it had many flaws. With the help of The Honey Bee Network volunteers, and support by a commercial designer hired by NIF, the current model was made after several iterations. Inputs from the design organizations helped to make the product more compact, transportable and user friendly. He employs 30 women to process jams, jellies, herbal shampoos, soaps, etc. And men are mostly employed in his workshop where

[6] ILO, 2012, Eliminating child labour in rural areas through decent work http://www.ilo.org/wcmsp5/groups/public/—ed_emp/documents/publication/wcms_165305.pdf

he makes the machines. He received financial assistance from The National Innovation Foundation, a Honey Bee Network institution to set up his enterprise. This machine was exported to Kenya through a project supported by USAID and in partnership with JK university of Agriculture (JKUAT), Nairobi. Its design was made open source and development of standards is still in the process. As mentioned earlier, another technology for a small tractor has also been transferred, based on the initial design by Mansukh Bhai Jagani, for which standards were approved in a stakeholder meeting organized by the Kenya Bureau of Standards recently. To keep the cost of such innovations low, creation of standards is critical to facilitate regulatory approval and bank finance. Open source nature may help many small-scale producers to develop this and through fair competition, keep the designs affordable and flexible in the wake of variable agro-climatic conditions (see sristi.org/usaid).

The success of these enterprises indicates that farm and non-farm activities have to be fused, blended and complemented for poverty alleviation. In the tribal areas of Udaipur and Rajasthan, we found using the bamboo splint and incense stick making machines, the daily wages of tribal communities were quadrupled. The innovations ecosystem needs risk capital in the form of micro-venture funds, only micro finance may not be the model in most cases. The need for supply chain financing is being increasingly felt, i.e. financing at all the stages of value chain; standalone or discrete financing may not work that effectively.

4.3. Shodhyatras: sharing and seeking innovations

Shodhyatras/walks are pursued twice a year in low income regions to share and seek innovations and practices that reduce risks, increase resilience and improve productivity (now increased to four times). These walks are organized by SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions). Shodhyatra is a typical example of autopoietic (self-designed, self-organizing, self-correcting) institution where many of the activities are self-organized in the prevailing field conditions.

Shodhyatras not only help in diffusing and scouting innovations, but also in celebrating local distinctions in crafts, education, traditional nutritious foods, etc. Further, an important goal is to identify unmet social needs. One such need which has frequently come up is the proper use of crop by-products such as rice straw. Rice straw has been used for low end purposes such as baskets, bags, mats, etc. But it has also been used by a couple in Andhra Pradesh for weaving sarees, a traditional women's dress. A ceramic company leased some ponds in paddy growing regions to make tiles. The silica content in the paddy fields released into the water bodies can be very useful for high value ceramics. Rahman (1987) showed bricks with higher rice husk ash were much stronger than ordinary clay for constructing load-bearing walls. Guzman et al. (2015) found that 12.5% rice straw ash (RSA), as a replacement for feldspar and feldspathic sand, helped in making porcelain tiles of very high quality. Burning of rice and paddy straw in the fields causes huge environmental and health hazards. Nallis (2009) studied rice straw along with other materials to examine its use for composites for different industrial purposes. Such applications will synergize agricultural and industrial economies in a manner that pathways for poverty alleviation through exogenous and endogenous innovations will become more viable and sustainable.

5. Conclusion

A few lessons that the Honey Bee Network has learnt during the last three decades are summarized below, to help appreciate the contribution of reduction of transaction costs of innovators, investors and entrepreneurs can play in poverty alleviation Fig. 2.

1) Many of the grassroots innovators solve problems, reduce risks or widen their decision making options sub optimally-a la satisficing model (Simon, 1955, 1956, 1957, Barros, 2010) rather than the optimizing model; the scientists and designers can help in adding value and improving productivity and profitability of such innovations; 2) some of the innovations, evolved individually or through community level interactions (such as exchange of weeds found useful for medicinal or nutritional purposes), play an important role in improving resilience. Muti-language, multimedia databases and online and offline exchanges of such information/resources can help reduce search costs of the communities but also other stakeholders. Use of social media can also be attractive to young farmers; 3) a large number of new ideas evolve incrementally through trial and error, informal community interactions and blending or combining local ideas with inputs from market actors. Organizing clearing houses, shodhyatras, Sattvik kind of farmer and urban consumer fairs etc., can help bring innovators, investors and social, economic, cultural and ecological entrepreneurs together; 4) there is an urgent need for an exchange of knowledge, resources and ideas among community members as well as with institutional scientists working with them in reciprocal and responsible open innovation platforms. This may create an inclusive innovation ecosystem helping poor people overcome poverty, connect communities and corporations where needed, and move on to a sustainable path and invigorate the DIY open source movement in agricultural research and extension (Gupta et al., 2016, Gupta et al., 2016); 5) while diffusing endogenously or exogenously developed or blended/bundled innovations, provision of risk capital like MVIF could be very helpful in encouraging poor communities to take an entrepreneurial path of poverty alleviation; 6) the use of the concept Technology Commons (Sinha, 2008) is very critical while protecting the intellectual property rights of grassroots innovators. People to people copying of ideas is not only allowed but also encouraged. But firms are encouraged to license such technologies. In view of Presidential recognition, all the licensing has been non-exclusive because entrepreneurs/small companies can use the awards and connection with HBN institutions for branding the offerings. The farmer innovator gets license fee and royalty for otherwise open source technologies; 7) the role of women is key in exchange of non-monetary resources and knowledge to cope with risk and explore resilient strategies. For newer pathways of poverty alleviation to emerge both autonomy and agency of the local communities, particularly women, needs to be strengthened. By *autonomy* we mean the freedom to make informed decisions. It is one of the most important ingredients for building and sustaining a culture of experimentation and emergence and evolution of innovations. While *agency* is the ability to take

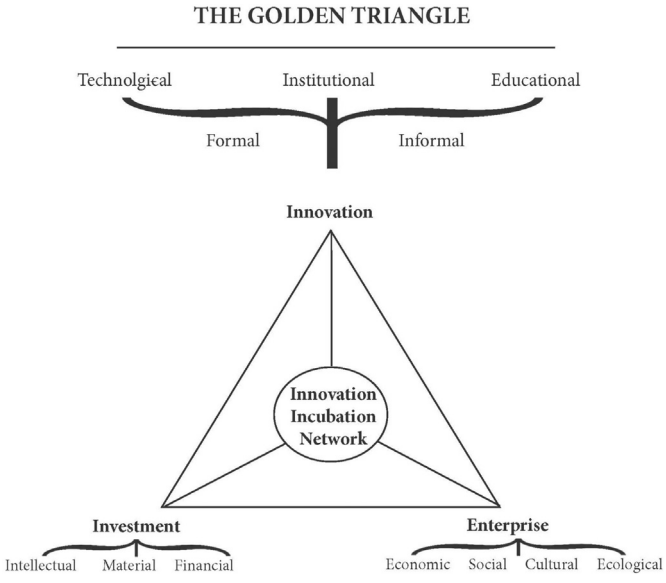

Fig. 2. Source: adapted from GIAN, 1997.

decisions or use the freedom. This entails the need to build capacities of the entrepreneurs to take risks and also make existing solutions (or innovations) available to them so that small enterprises can be set up around them. Strengthening their individual and collective agency needs new initiatives including sharing of decentralized agro-metrological information in a locally useful manner, nursery or seed banks, small tools specially designed for them on lease or rental basis, access to micro venture finance and not just micro finance, etc.; 8) food processing machinery on lease-financing basis for in situ value addition is critical to avoid farmers suffering in good weather and high crop production years (and also other years). Good weather manuals or helplines for leveraging favourable climatic conditions also need to be developed; 9) the household's portfolio to deal with risks requires drawing upon private, common and resources and institutions. Neglect of common property or pool resource based innovations needs to be overcome to generate sustainable outcomes; and, 10) distributed community food and nutrition labs need to be organized to enable poor people to get maximum nutrition from minimum investment through small enterprises adding value in weeds, minor millets and other sources. Else persistent and widespread infant malnutrition and anaemia among women may not be removed by merely increasing incomes.

A global program on developing such DIY open source technologies by combining endogenous and exogenous technologies may help to alleviate poverty and reduce drudgery. Honey Bee Network has already started such exploration through Biotechnological Innovation Ignition Schools (biis.sristi.org) by bringing 45 students for 21 days in a wet lab and fab lab environment to develop open source solutions with the help of BIRAC, Department of Biotechnology, Government of India and summer school of students on inclusive innovations (ss.sristi.org) in collaboration with GIAN and NIF and UNICEF.

Agricultural research has to move beyond primary production and enable grassroots innovators and entrepreneurs to improve productivity, reduce risks, enhance resilience and augment in situ value addition. The Golden Triangle of linking innovation, investment and enterprise developed by Honey Bee Network and GIAN provides a pathway to alleviate poverty, improve nutrition, reinforce experimentation and innovation all along the supply chains through a mix of empowering platforms.

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