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Supporting Sustainable Innovations: An examination of India farmer agro-biodiversity

Abstract

Critical to sustainable agriculture, agrobiodiversity conservation provides immediate benefits and retains options for climate change adaptation. Reframing conservation as sustainable seed innovation allows for a dynamic view of farmer contributions. Sustainable seed innovation entails in-situ conservation and the innovation of new plant varieties through traditional practices. Farmer interviews from regions throughout India form the empirical basis, while the concept intellectual property broad integrated with evolutionary economics informs theory. Sustainable seed innovation within India receive support primarily from non-profit groups favouring open-source systems. Conserving natural and financial capital motivated farmers to adopt sustainable techniques, but farmers believed attracting additional innovators required development of new markets. India's Protection of Plant Varieties and Farmers' Rights Act recognises farmers as plant-breeders, but does not provide incentive to innovate sustainably. Moreover, agricultural policies reinforced by an underlying discourse where 'progressive' farmers follow unsustainable practices incentivises formal innovations, at the expense of sustainable innovations of farmers.

The FAO (2017) called for a substantial shift towards 'holistic' ecological approaches informed by traditional knowledge, and away from high-input unsustainable agricultural production. They reasoned that only a major transformation would assure food security, while also addressing water shortages, soil depletion and greenhouse gas emissions. Sustainable transitions of this magnitude require technological, institutional, and social innovation (Rodima-Taylor, Olwig, & Chhetri, 2012). By reframing in situ agrobiodiversity conservation as sustainable seed innovation, this article situates agrobiodiversity conservation at the centre of a transition process towards sustainable agriculture. The aim of this research was to identify how to foster sustainable seed innovation amongst smallholder farmers in India, and thereby, contribute to the wider literature related to sustainable innovations.

Sustainable seed innovation involves the parallel promotion of in-situ innovation of plant varieties and agrobiodiversity conservation by farmers (Kochupillai, 2016). Acknowledging agrobiodiversity as sustainable innovation permits: (i) the creation of policies that promote sustainability rather than relying exclusively on regulating natural resource use, (ii) the inclusion of topics considered within innovation-related literature, and (iii) the opportunity to learn how to create systems that support other types of sustainable innovation. In this case, sustainable denotes sustained biodiversity, but concurrently achieves wider sustainability goals as agrobiodiversity provides insurance against crop failure, nutritional security, more optimal labour availability, and includes the experiences of small-scale farming communities (Dwivedi, 2014; FAO, 2011). Moreover, traditional knowledge of what works under specific conditions, and continued access to genetic diversity provides a vital strategy for adapting to climate change (Smith, Bragdon, & Elliott, 2015).

The varieties cultivated today exist due to the selection done by generations of farmers; yet, many do not view the process of cultivating and developing traditional varieties within farmers' fields as innovative (Vanloqueren & Baret, 2009). These locally-adapted farmer varieties have greater genetic variability providing yield stability in even the most challenging climatic conditions (Lehmann, 1981). By comparison, high-yielding formally improved varieties have a very narrow genetic base and typically perform well only with the use of chemical fertilizers and pesticides (Hasan & Abdullah, 2015). Despite these qualities, seed improvements have moved out of the fields to being set in formal lab situations and valuing genetic uniformity (Kochupillai, 2016).

Additionally, farmers' varieties require further selection to meet the uniformity standard required for intellectual property protection through plant variety registration (Salazar, Louwaars, & Visser, 2007). IPRs value individual exclusive rights; however, often communities conserve and improve upon farmers' varieties. At the same time, acknowledging smallholder farmer innovation requires recognising that their knowledge does not necessarily have an entirely 'traditional' source or a contribution from every individual in the community (Gupta, 1999). Nonetheless, agricultural policies, seed regulations, intellectual property laws and the adoption of commercial varieties that exclude the possibility of seed saving, jeopardise in-situ agrobiodiversity conservation and farmer-level innovation (Kochupillai, 2016).

The policies and regulations recently implemented in India, in addition to India's high agrobiodiversity and large population of small farmers make the country an ideal choice for this case study. For instance, India is one of the world's 12 mega-diversity centres (Dwivedi, 2014). A majority of India's population farms, with approximately 80% of India's farmers classified as either small or marginal and preferring to use saved seeds (Ravi, 2010). Finally, India's Protection of Plant Varieties and Farmers' Rights Act differs from any legislation in the world by dedicating an entire chapter to farmers' rights including: the unrestricted right to save, sow, exchange, share or sell farm produced seed; protection of TK; provisions for benefit-sharing and the right to participate in decision-making (Peschard, 2017).

India's legislation has made significant attempts to acknowledging and legally protecting the contributions of farmers. Nonetheless, research and policy pertaining to agrobiodiversity conservation and traditional knowledge tends to focus on issues related to bio-piracy and benefit-sharing (Ruiz Muller & Vernooy, 2012), while giving inadequate attention to understanding how to support and promote farmer innovations (Kochupillai, 2016). This research, therefore, builds on Kochupillai (2016) interdisciplinary examination of sustainable seed innovation.

Kochupillai's (2016) empirical research focussed on pulse cultivation in two neighbouring states Madhya Pradesh and Chhattisgarh to understand the effect of seed replacement and new variety releases on seed-saving culture. In addition to statistical analysis, a few open-ended survey questions provided context to gaining a better understanding of the research findings. For instance, farmers often purchased some seeds from market, while also saving seeds, rather than an all or nothing approach to seed saving and replacement. Most notable for the current study, Kochupillai (2016) found ambiguity in how farmers answered the hypothetical question of whether they would prefer a one-time cash award or exclusive rights upon developing a new plant variety. Farmers often responded with a preference for exclusive rights, while at the same time stating that they would still share the seeds. In addition, farmers often noted the need to continue a tradition of sharing and the preference for fame for themselves, or the community, over exclusive use. These findings informed the research approach used here. Rather than approaching seed innovations as a market failure, and restricted to Intellectual Property Rights (or IP-narrow), this research uses an evolutionary theoretical approach with an IP-broad focus. Empirically, this study differs by employing in-depth interviews in four very different states. Rather than hypothetical questions, research participants included farmers who have registered varieties and have received Genome Saviour recognition. Finally, while Kochupillai (2016) considered seed saving a prerequisite to seed innovation, this research looked at the entire process going beyond the prerequisite of seed saving to seed selection and the ability to identify improvements of varieties in the field.

The article argues that despite recent legislative efforts, the current policy system creates barriers rather than providing incentives for seed innovation amongst farmers. Creating incentives for farmer-level seed innovation requires a system that extends the concept of intellectual property beyond just legal property rights to highlight the innovative nature of traditional knowledge. Intellectual property broad communicates the usefulness of farmer improved varieties to farming communities and consumers through community festivals, farmers' markets, and public recognition of innovative farmers and farming communities.

The next section explains the theoretical approach, followed by a description of methods, and then a two-part results section. The first subsection examines the relevant national policies and current incentives for innovation within the national context. The second subsection details farmers' experiences in the process of seed innovation: seed-saving, field observation and selection, seed exchange and finally the development of a new plant variety. Finally, the concluding section provides policy implications stemming from the analysis.

Theoretical and Conceptual Background

This article's approach to researching sustainable innovation follows evolutionary economic theory; specifically, ecological economics and innovation economics. Evolutionary theory avoids a sole focus on technology by including social, ecological, institutional systems and their interactions in creating systems of innovation (Rennings, 2000). Consequently, policy recommendations focus on enabling innovative systems to spur sustainable development instead of attempting to address the negative externalities arising from economic growth (Courvisanos & Mackenzie, 2014; Rennings, 2000; van den Bergh, 2001).

Sustainability Framework and Farmer Seed Innovation

A sustainable innovation like a sustainable livelihood maintains or enhances local and global assets, provides net benefits to other livelihoods, copes and recovers from stress and shocks, and provides for future generations (Chambers & Conway, 1991). Improvements in the relative quantity of natural, human, social, physical and financial capital (assets) within the Sustainable Livelihood Framework indicate the sustainability of innovative techniques adopted as shown in Table 1.

-TABLE 1 ABOUT HERE-

Continued access and improvements to these forms of capital determine whether innovations are sustainable; however, all types of innovation require human capital to generate and implement ideas.

Evolutionary Processes and IP-broad

Intellectual property relates directly to human capital. 'Intellectual property rights' (IPRs), however, are a product of neoclassical economic theory. Market failures in knowledge generation justify IPRs, thereby ignoring the role of non-market institutions and processes crucial to innovation within evolutionary theory (Dosi, Marengo, & Pasquali, 2006; Paul, 2015). Furthermore, IPRs typically benefit firms rather than individual or community innovator(s) and protect innovations regardless of potential for detrimental effects (Beier, 1980; Kochupillai, 2016).

According to the World Intellectual Property Organization (2017a), IP primarily functions to differentiate products and services, but IPRs as a legal instrument have a negative nature by prohibiting others from free use and access. By contrast, an expanded interpretation of IP moves away from a focus on monetary value and exclusion to inform discussions sensitive to cultural contexts (MacLeod & Radick, 2013). The concept of IP-broad emanates from considering a longer historical view of science and technology development. Specifically, IP-broad involves any type of priority or productivity claim (Charnley & Radick, 2013). IP-broad develops according to context, for example, peer-review validates scientific knowledge with reputation as the reward, payment for market use rewards technological advances, while the use of knowledge within communities validates traditional knowledge (Correa, 1999). Thus, rather than address a market failure, IP-broad depends on historical context and supports innovation in a manner consistent with evolutionary economic theory.

Ultimately, IPRs do not embrace open and collaborative processes (Strandburg, 2016), but rather focus solely on outcomes. Meanwhile, an evolutionary approach recognises that innovation happens through social interaction within the system as a process and an outcome (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). Thus, the use of traditional knowledge in seed selection, seed-saving and seed-exchange are innovations independent of outputs generated (i.e.: new plant varieties).

Moreover, the act of selecting, saving, and exchanging seeds fulfils the role of a technique. Mokyr (2000) argues that technique should be the unit of analysis for understanding innovation. In evolutionary terms, the decision to choose one technique from all other techniques available, deciding on what knowledge is useful, and choosing vehicles to transmit knowledge are three selection processes occurring simultaneously (Mokyr, 2000). The fourth selection pressure arises when markets decide on the outcomes through purchase decisions (Mokyr, 2000). IP-broad plays a role in all these selection processes by conveying the usefulness of knowledge and techniques along with the value of products to consumers.

Empirical studies of sustainable innovations have not typically focused on innovative processes, but rather researched the diffusion of sustainable technologies (Seyfang & Smith, 2007). As a result, the selection processes prior to market selection receive little research attention. This paper begins to address this gap by attending to all selection processes and by a close examination of technique adoption. In addition, a focus on technique(s) allows this research to highlight the achievement of wider sustainability goals arising from innovation.

Methodology

As a research strategy, choosing a case study approach allows for the consideration of many variables in the examination of a phenomenon (seed innovation) within context (India) (Yin, 2009). Agricultural, seed, and intellectual property policies formed at the national level influences innovation; and therefore, this study has a national scope. However, the act of innovation occurs at the farmer-level with the selection of knowledge and techniques.

In India, farmers do not play a direct role in policy decisions (Ramanna, 2006); therefore, attaining the views of farmers was deemed a priority. Data collection and analysis was primarily qualitative to share the experience of these often-ignored voices and to gain a detailed understanding of the process of seed innovation (Creswell, 2013). The emphasis in sample selection was to collect a range of views from different farming communities. Therefore, sample selection was not random, but purposive in both the selection of regions and research participants[1]. As a result, the sample represents farmers' technique-selection in the context of India's diverse regions.

Sample Selection

Site selection aimed for a range of geographical and socio-economic diversity. The sites included Fazikal, Bathinda, Ludhiana, and Faridkot in Punjab (north), Lakhimpur in Assam (northeast), Bilaspur in Chhattisgarh (southeast), and Pune, Latur, and Satara in Maharashtra (southwest). The sampling procedure recruited participants across the spectrum of sustainable seed innovation. This spectrum included farmers: following conventional practices, conserving traditional varieties, demonstrating knowledge in seed selection, and registering improved farmer varieties. While interviews primarily focussed on farmers in each region, staff from agricultural universities in Punjab (n=4) and Assam (n=2), and non-profit staff in Punjab, Maharashtra and Chhattisgarh[2] participated in interviews as well (n=3). These interviews helped in understanding the context of farming in each state. For instance, the farmer participants from Assam (n= 10) and Punjab (n=9) were described as the exception to the rule for farmers in those states. Punjab is one of the most agriculturally developed states; therefore, most farmers in the state follow conventional practices and cultivate high-yielding, formally-improved varieties. Meanwhile, research participants from Punjab were members of KVM, a non-profit group promoting the use of indigenous varieties and organic cultivation. The farmers interviewed in Assam either had received national recognition for their sustainable practices or the Agricultural University recommended them as participants. The University staff described these farmers as more conscientious and commercially minded compared to other farmers in the state. Again, these farmers, described as exceptions to the rule in Punjab and Assam, are key to understanding technique-selection for two very different regions. The farmers in Chhattisgarh (n=10) worked with the Art of Living cultivating traditional varieties and following zero-input techniques. Finally, participants in Maharashtra (n= 7) included farmers involved in conventional farming in addition to farmers cultivating traditional varieties organically.

Data Collection

Data collection was iterative and as participant-driven as possible to garner the diverse opinions of farmers on the topic of sustainable seed innovation. The first stage of data collection involved semi-structured interviews and a statement-sorting procedure covering the topics of intellectual property, seed saving/exchange, seed selection, seed replacement, innovation, agroecological practices, and sustainability indicators. For the sort procedure, participants sorted a collection of 10 statements[3], described in Table 2, along a quasi-normal distribution according to how strongly they agree or disagree with each statement as shown in Figure 1.

-TABLE 2 ABOUT HERE-

-FIGURE 1 ABOUT HERE-

The number of statements fit the minimum amount required for sorting into a normal distribution due to the practical challenge of translating statements from English into participants' languages. These statements were gathered from literature related to Indian agriculture; however, 10 statements would not be enough to cover the full breadth of the topic as required by Q methodology (Rogers, 1995). Therefore, this procedure was used to complement and supplement interviews by offering more nuanced, open, and non-leading questioning to elicit further discussion on each topic (Brannstrom, 2011). Moreover, the statements purposefully allow for interpretation to prompt questions and further discussion from participants. A factor analysis was performed, but only to illustrate the divergent and convergent views of farmers to the farmers themselves for feedback at the round-table event.

In total, 45 participants were interviewed in the first stage of data collection. Interviews lasted from 45 minutes to 3 hours and often involved tours of farms. Interviews with University staff and non-profit groups were in English, while farmer interviews were typically conducted with the aid of a local translator in the state languages of Punjabi, Marathi, Chhattisgarhi[4] and Assamese. Interviews were recorded and transcribed[5].

In the second stage, the range of views expressed by farmers throughout India were presented to the farmers for feedback at a round-table event. This step is useful in verifying that the researcher has interpreted the farmers' perspectives correctly. At the event, farmers were divided into discussion groups related to intellectual property, research needs, participatory plant breeding and consumer outreach and awareness. The round-table event involved stakeholders[6] and farmers from the original participating states as well as Bengal, Jharkhand, Karnataka, Rajasthan, Tamil Nadu, Uttar Pradesh, and New Delhi.

Analysis

Interviews were analysed qualitatively using a prior conceptual framework related to innovation, IP broad and sustainable livelihoods. For instance, trends in access to natural, social, human, physical and financial capital provided indicators of sustainability (Chambers & Conway, 1991; Scoones, 1998). As well, motivations, incentives and barriers to innovation, and the outcomes attained through IP-broad received focus. Concurrently, the constant comparison process of grounded theory informed analysis and maintained an openness to new ideas (Charmaz, 2006). New literature was consulted and included in the analysis as new areas emerged (Hickey, 1997). This literature included on-line documentation of non-profit groups working in other regions of India to understand the experiences shared across regions. Literature pertaining to international agreements, national policies and sustainability challenges provided the context necessary to understanding the process of sustainable seed innovation as described in the next section.

Results and Discussion

National Scale

This section details factors at the national scale influencing seed innovation. First by describing sustainability challenges facing agriculture in India. Then by detailing the government of India's attempt to reconcile competing demands of international agreements through national policies. Finally, by summarising the balance of incentives for formal and informal innovation along with the current state of seed innovation in India. Considered together these contextual factors establish the opportunity for sustainable seed innovation, while also establishing a policy environment that disincentives sustainable seed innovations.

Sustainability Challenges

Agriculture is a significant driver of economic growth in India, concurrently, across 15 agroclimatic zones, smallholder farmers assure food security for hundreds of millions of people by cultivating thousands of locally-adapted plant varieties (Government of India, 2014). While smallholders cultivate 44 percent of active agricultural lands, the fragmentation of land-holdings due to an increasing population means that many of these farmers have access to less than two ha of land (Sajesh & Suresh, 2016). As a result, limited land resources challenge the economic viability of many smallholder farmers.

Current literature highlights critical issues pertaining to the socio-economic sustainability of agricultural in India. For example, the high rate of farmer suicide in India has received both media and research attention. Several researchers have found crop failures, debt and increasing costs of cultivation to be the predominant cause of farmer suicide in India (Behere & Behere, 2008; Dongre & Deshmukh, 2012; Manoranjitham et al., 2009). Moreover, an analysis of 47 years of suicide records and climate data found high temperatures and suicide rates to be correlated during the growing season; thus, indicating yield losses due to heat as a possible underlying cause (Carleton, 2017). Related to climate resilience, Carleton (2017) also found no evidence of climate change adaptation even when considering rising incomes and access to modern technologies.

In terms of natural capital, adoption of inappropriate cultivation techniques has degraded the physical and biological quality of soils on 120 million hectares in India (Chaudhari, 2016). One response to declining soil fertility and water tables has been to start a crop diversification programme in the original green revolution states (Punjab, Haryana and Western Uttar Pradesh) focussing on moving away from paddy to alternate crops including pulses, oilseeds, and agroforestry (Department of Agriculture, 2017). The government of India has also attempted to address sustainability by meeting international commitments via national policy as detailed next.

International Agreements and National Policies

Discussion of these policies commences with the government's targets for meeting agrobiodiversity conservation. In the latest report to the Convention on Biological Diversity, the targets set by the government for 2020 aligned well with sustainable seed innovation. These targets include i) enhanced use of landraces, ii) increase in local crops and varieties that are more adapted to the environment, requiring less external inputs and achieving greater household food security, iii) increases in organic farming and integrated pest management iv) improved awareness of agrobiodiversity conservation amongst farmers, extension service staff, and scientists (Government of India, 2014). Furthermore, the government reports an aim to strengthen national initiatives using communities' traditional knowledge relating to biodiversity. A measure of meeting this target includes documentation of grassroots innovations and traditional practices through the National Innovation Foundation (Government of India, 2014).

In 2000, the government's Department of Science and Technology, created the National Innovation Foundation to ensure protection of intellectual property rights and fair distribution of benefits for grassroots innovations (Gupta, 2006). The Foundation maintains a database of innovations and formally recognises innovators in an annual awards ceremony. In terms of IP, the Foundation has filed 41 applications and successfully registered 5 plant varieties developed by farmers at the Protection of Plant Varieties and Farmers' Rights Authority (National Innovation Foundation India, 2018).

The Protection of Plant Variety & Farmers' Rights Act, 2001 was necessary to be compliant with Article 27.3(b) of the Trade Related Aspects of Intellectual Property Rights Agreement. This article requires countries to provide protection of plant varieties by patent, an effective sui generis system or by a combination (WTO, 2018b). By opting for a sui generis system the Indian legislation aimed to integrate the rights of breeders, farmers and communities (Brahmi, Saxena, & Dhillon, 2004). Moreover, the 2001 Act recognises the contribution of farmers as breeders by incorporating the benefit-sharing right from Article 9 of the International Treaty on Plant Genetic Resources for Food and Agriculture (Chawla, 2014).

Specifically, the Protection of Plant Variety & Farmers' Rights Act, 2001 requires plant breeders to disclose when genetic material conserved by rural communities is used to develop a new variety (Paul, 2015). Still, the registration of farmers' varieties has yet to result in a single instance of benefit-sharing (Peschard, 2017). Indeed, under the 2001 act, farmers will receive economic benefit only if their registered variety contributes to a formal breeding program aimed at creating hybrids (Kochupillai, 2016). However, the Authority used registration fees to establish the National Gene Fund to compensate communities, disburse shares to benefit claimers, and strengthen local capabilities for maintaining conservation and sustainable use (Brahmi et al., 2004). From this fund, the Authority annually recognises communities and farmers for agrobiodiversity conservation and improvement of genetic resources by granting 5 Plant Genome Saviour Community Awards, 10 Farmer Awards, and 20 Farmer Recognitions (Peschard, 2017).

As in the case of plant variety protection, the Trade Related Aspects of Intellectual Property Rights Agreement included Geographical Indications (WTO, 2018a). Geographical Indications can potentially benefit communities as products suitable for Indication are often the result of traditional processes continued within communities for generations (World Intellectual Property Organization, 2017b). Moreover, Indications convey the character and quality of the product to consumers, while potentially contributing to rural development (World Intellectual Property Organization, 2017b). Currently just over 300 products have been registered for protection (Intellectual Property India, 2017), while an estimated 50,000 products in India could benefit from Geographical Indication protection (Joseph, 2010).

India Seed Policy

As a complement to the Protection of Plant Variety & Farmers' Rights Act, the 2004 Seeds Bill aimed to promote the seed industry, boost exports, and protect seed quality (Paul, 2015). National Seed Policy emphasises that achieving future food security requires a major effort in enhancing seed replacement rates for many crops (NSAI, 2012). The National Seed Association of India (2012) acknowledges that farmers prefer saved seeds due to unavailability of good quality seeds; and therefore, proposes the creation of incentives for the domestic seed industry to produce seeds of high yielding varieties and hybrid seeds at a faster pace. They argue the necessary seed replacement rates for achieving higher productivity are 25% for self-pollinated crops, 35% for cross-pollinated crops and 100% for hybrids (NSAI, 2012). Importantly, in the context of seed policy, seed replacement does not include acquiring seeds from farmers in exchange.

India has an established tradition of agricultural extension used to transfer relevant technology and information from research institutions to farmers and to apply policy directives (Sajesh & Suresh, 2016). From interviewing farmers and agricultural extension officers, Kochupillai (2016) found that the primary focus of extension was to promote the adoption of new seeds, increase seed replacement rates, and ensure farmers receive information about government subsidies. Thus, while farmers have the right to save seed, current seed policy actively promotes frequent seed replacement.

Balance of Incentives and Status of Seed Innovation

Currently some farmers in India practice sustainable seed innovation as evident by those farmers receiving national recognition and registering varieties with the Authority. However, the incentives for farmers to innovate do not balance the current incentives for farmers to adopt formal innovations or for the private sector to innovate. In contrast with plant breeders' rights within the 2001 Act, farmers' rights have yet to create any economic benefit for farmers registering varieties. As a one-time recognition, genome awards do not amount to benefit-sharing, but might provide incentive to innovate (Peschard, 2017). Moreover, breeders and seed producers have additional strategies to protect their innovations including: biological protections, hybridization, secrecy, seed laws, contracts, brands and trademarks (Louwaars et al., 2005). Indeed, hybridization provides one of the oldest and most commonly used mechanisms for plant variety protection and discourages farmers from seed saving due to declines in productivity over time (Louwaars et al., 2005). As evident by applications to the Authority the private sector opts to create hybrid varieties that offer additional protection as shown in Figure 2.

-FIGURE 2 ABOUT HERE-

The number of applications made to the Authority demonstrates a successful farmer education campaign conducted by research institutions, farming groups, and extension services. However, currently seed policy and the resources of extension services focus on increasing seed replacement rates thereby conflicting with the targets set-out in the latest report to the Convention on Biological Diversity and creating a disincentive for farmer innovation.

Moreover, the two systems of innovation can complement each other. For instance, the informal sector (individual farmers and community groups) along with the public sector are registering varieties for legumes, oilseeds and wheat crops, while the private sector has little activity in these crops as shown in Figure 3[7]. Innovation in these crops could support the government's crop diversification plans for conserving water and soil resources.

-FIGURE 3 ABOUT HERE-

Farmer Experiences of Sustainable Seed Innovation

This section details the selection pressures working for and against sustainable seed innovation, while also highlighting changes to the five types of capital within the sustainable livelihood framework. The following subsections first detail discursive barriers that emerged during interviews, next describe how the motivations and incentives revealed by farmers relate to natural and financial capital conservation, and then illustrate the losses and attempts to restore traditional practices associated with sustainable innovations. The final subsection discusses farmers' view of IP, their use of IP-broad, the challenges faced in farmer variety dissemination and the inability of farmers to benefit from IP.

Discursive Barriers

Farmers were often described as either 'traditional' or 'progressive' both by the farmers themselves and stakeholders. Interestingly, even proponents of traditional agriculture used the positive term of progressive to describe conventional farmers. Yet, many farmers follow a mix of practices. Furthermore, the use of the term 'progressive' to describe conventional high-input agriculture does a disservice to farmers innovating sustainably. Farmers cultivating traditional varieties explicitly stated during interviews that they were not against technology. In some cases, the contributions of 'traditional' farmers are completely lost because of a focus on 'progressive' farmers. For instance, researchers in

Punjab said that farmers in the state did not cultivate landraces. However, Punjab has 104 local indigenous varieties documented as still being cultivated in the state (BAIF, personal communication). Moreover, the farmers in the research discussion group demonstrated their 'progressiveness' when developing a comprehensive list of research needs. Hence, many farmers 'progressively' implement traditional practices and have a desire to be more innovative. The idea of farmers fulfilling the role of scientist became a theme at the round-table event. Broadening the role of farmers can contribute to confidence building and hence human capital. By contrast, a case study of farmers' rights in India stated that seed industry representatives believed that a farmer should be defined solely as a cultivator (Ramanna, 2006).

A narrow description of food security creates another discursive barrier. Current seed replacement policy is due to a focus on increasing yields. Meanwhile, India has considerable challenges with meeting the nutritional needs of citizens (Nandakumar, Ganguly, Sharma, & Gulati, 2010; Narayanan, 2015). One participant argued for attention to shift from yields to 'nutrition per hectare'. He reasoned that traditional varieties of iron-rich millet and anti-oxidant rice would be in demand only when language changed[8]. Again, the achievement of traditional farmers disappears with a narrow narrative about food security. For example, the non-profit KVM's resurrection of traditional varieties cultivated in 'kitchen gardens' provides additional income for poorer families and ensures nutritional security through a more diverse diet[9].

These discursive barriers act on knowledge-selection processes by determining the usefulness and worthiness of knowledge. In other words, discursive barriers have significant implications because they prevent the innovation process from even starting. Nonetheless, discursive barriers and a misbalance of incentives do not completely prevent sustainable seed innovation. As described in the next section, farmers' motivations to innovate relate to sustainability considerations.

Motivating Factors

> *"We do it to protect nature, god has given us good water, nice air and fertile land. By following chemical farming, we lost fertility and are destroying everything." – Chhattisgarhi farmer*

In terms of assets, protection of natural capital was the primary motivating factor for adopting the techniques associated with sustainable seed innovation. As indicated in the above quote, the corresponding practices motivated change instead of solely being motivated to conserve traditional varieties. For example, Punjabi farmers mentioned an increase in cancer rates following the adoption of Green Revolution technologies as a reason for changing cultivation practices. Farmers cited both the positive view of self-dependence gained by saving seeds instead of purchasing inputs, and the more pessimistic perspective of 'not being able to depend on government', as secondary reasons for changing to more sustainable practices. However, the tribal women farmers and one independent farmer in Chhattisgarh made the switch primarily due to the saving of financial capital from not needing to purchase inputs and mentioned environmental stewardship as a secondary factor.

> *"But it is climate resilient, if you get nothing from others (varieties) this Bao rice will give something to the farmers. At least they can harvest something for their granary, so it gives some relief. That is why it is very important."*

– Plant breeder and researcher in Assam

By contrast, farmers in Assam were following the practices of previous generations, as the extreme variability of precipitation makes traditional practices and crops an advantageous strategy. Growing traditional varieties was necessary to balance risk as described in the above quote. Farmers often cultivate high-yielding varieties as well, but in high-flood conditions 'high-yielding' varieties produce zero yields. Natural capital, in the form of climate-resilience, motivates Assamese farmers to continue cultivating traditional varieties.

Currently farmers who see the value in conserving natural capital and the potential to preserve financial capital have an incentive to adopt a sustainable seed innovation model[10]. On field visits, these farmers would often highlight the improved quality of their soil. However, as explained in the next section, many traditional practices have been virtually lost and attempts to restore practices require awareness raising on the potential benefits of these techniques through social networks.

Seed Exchange, Networks, Selection and Saving Techniques

"If the same minded people come together then it is good, but it is not happening here. That is impossible." Maharashtrian farmer

Trust is an important element of social capital necessary to maintain seed and knowledge exchange networks. The sort-statement 'community ties bind the population together' had the highest level of disagreement. Farmers involved with groups such as KVM in Punjab and with The Art of Living in Chhattisgarh agreed strongly with the statement. As indicated in the above quote, farmers working independently in Maharashtra and Assam agreed less or even disagreed with the statement. They often expressed the sentiment that it was that way in the past and it should be that way, but it was no longer true. Thus, in this study, farmers exchanging seeds within established groups exhibited greater social capital.

> *"E*veryone in this village of a 1,000 people exchanges seeds. We exchange with the surrounding villages also… within an area of 10-12 km."
>
> - Female tribal farmer in Chhattisgarh

The tribal farmer quoted above provides an exception when compared to responses from other participants. For the most part, seed-saving and exchange was a practice almost lost and then restored with the help of non-profit groups. While traditional practices have continued in Assam, the farmers interviewed did not trust the quality of other farmers' seeds. They said that they will give seeds when requested, but they do not accept seeds from other farmers due to the perception that others farmers are not as conscientious. In Punjab, a few cultivators produce seed for the KVM group and then the group distributes seeds to farmers. In some instances, farmers within the group exchanged seeds with each other as within group trading assured a high quality, organic standard of seed. In addition, a few Punjabi farmers exchanged seeds with farmers in neighbouring states in an experimental manner. While Kochupillai (2016) found that farmers freely exchanged seeds with each other, farmer participants in this study generally acquired seeds from only a few trusted sources. Conceivably a reasonable decision, as only a few participants per each state visited, indicated that they performed germination tests or used special methods when selecting seeds to save[11].

The methods used for storing seeds varied across regions and depended on crop type. In Chhattisgarh, seeds were treated with neem and cow dung smoke prior to storage.

Seeds were often dried and hung from rafters to keep away from pests. In Punjab, several farmers maintained small seed banks by storing seeds in jars. Larger stocks of seed were often stored under cow manure. The variety of techniques to protect seeds from pests shows promise in the continuation of traditional practices. However, a researcher in Maharashtra found that the traditional knowledge and technology of seed storage systems had been lost as evident in decreased germination viability after a year. Therefore, they are currently experimenting with new solar technologies to preserve seeds. In Punjab, simple solar instruments were being used to dry seeds prior to storage.

Raising the profile of these techniques largely depends on the use of IP-broad as both a tool to communicate to customers, and to convey the usefulness of techniques to other farmers. The next section highlights the challenges farmers currently face in using IP to disseminate knowledge and innovation.

Intellectual Property and Dissemination of Knowledge and Sustainable Innovations

> *"The community has to take the responsibility of the innovator."*
>
> *– Sanjay Patil, BAIF Development Research Foundation (BAIF)*

Participants shared a similar level of agreement regarding sort-statements related to who 'owns' genetic resources believing them to be both national property and belonging to the farmers of the world[12]. However, the farmers in Punjab pointedly noted that resources should be regional not national property. Nonetheless, participants held the view that these resources were shared 'property'. A few participants supported the statement 'individuals need to benefit from their innovations' more strongly by stressing that 'farmers are competitive'. However, relevant to the concept of IP-broad, participants also said that the farmer benefits from publicity alone. Moreover, as indicated in the above quote, participants felt that individuals could receive recognition while also benefiting communities.

Additionally, round-table participants favoured a more open and sharing model. In this model of IP, individuals and communities receive recognition through publication in websites and in the media. The non-profit BAIF uses a system where farmers provide seeds of the varieties they have developed to the seedbank and receive royalties in return. They advocated for 'opening up the knowledge' by publishing information about the variety and the farmer responsible for the development of the variety in research papers and on websites. This rules out registering varieties with the Authority and they are not alone in taking this stance. In 2014 the India Seed Sovereignty Alliance announced that it would not encourage variety registration with the Plant Variety Protection Authority (Peschard, 2017).

Evidence suggests that the Genome Saviour Award does not provide incentive to innovate sustainably, particularly since it does not reach all deserving recipients. In Assam, University staff nominated a dozen farmers for recognition, but only three received awards. They were referred to as the 'lucky ones' indicating that the other nominated farmers were as deserving of recognition. According to Dr. Debal Deb,[13] the criteria for selection of farmers for receiving the award is questionable (Sood, 2012). Moreover, in some instances, individuals received awards when entire communities were involved in conservation; thereby, causing resentment in the community (Sood, 2012).

Genome award recipients stated that nothing had changed since receiving the award, except for one recipient mentioning a boost of confidence from the recognition. These same farmers had begun the process of registering plant varieties with the Authority but were awaiting certification. In addition, these farmers had additional ideas and desires to be innovative, but expressed a lack of means to implement their ideas.

> *"Whether it be the paddy seed or Muga seed, everywhere, we must conserve seed and we must commercialize the seed. Then proper development can be expected." Assamese Farmer*

The award recipient, quoted above, was planning to reach consumers through festivals celebrating indigenous varieties. The most common challenge for farmers was consumer awareness and reaching customers with the use of IP-broad. In some regions of India, this challenge has been left to non-profit organisations such as KVM and BAIF. KVM uses a logo and has farmers' markets established in cities in Punjab, thus establishing the IP of the group with a customer base.

Farmers in Assam did not have the same type of support. However, staff at the local university would suggest farmers purchase seeds from the more conscientious farmers in the area when seeds were no longer available from the university. Thus, they generated some revenue through seed sales. Nonetheless, the Genome Saviour Award winners did not receive any sort of follow-up to assist them with marketing or benefiting from their innovations. Farmers in Assam were the only farmers to agree with the statement 'Research and development will increase when farmers pay higher prices for seeds'. They reasoned that farmers would be more conscientious if they paid more for their seeds. Since these farmers sold their seeds to other farmers, this would be a way for them to earn a better financial return for their investment in sustainable innovation.

Many of the farmers interviewed focussed solely on the cost savings from not needing to purchase inputs, and did not attend to any strategies related to generating new revenue streams. Indeed, the importance of getting a higher price for a better-quality product or generating new revenue streams was an area of disagreement. For example, one farmer in a Golden Silk (Muga) cooperative believed that by adopting technologies they could keep the price for silk low and increase income in that manner. However, the other farmers in the cooperative wished to acquire a better price for their product. Even though Muga has Geographical protection, the cooperative farmers mentioned not getting the proper price at market due to competition from product imitations. Interestingly, not a single farmer interviewed mentioned protection from Geographical Indications even when asked if the state or region was known for any specific agricultural products. Meanwhile, Maharashtra has over twenty agricultural products with protection, Assam has a few agricultural products and product related logos registered, and Punjab, in conjunction with several other states, has Geographical Indication protection for Basmati rice (Intellectual Property India, 2017).

Access to information about cultivating local varieties, sustainable practices, and farmer innovations presents one barrier to sustainable innovation. In Chhattisgarh, farmers expressed that they always wanted to follow zero-input traditional practices, but they did not have the necessary knowledge until they received training from the Art of Living agricultural programme three years earlier. In selecting vehicles of knowledge for sustainable seed innovation, farmers do not have many options available. Recognising this gap, farmers interviewed in both Assam and Maharashtra planned to establish farming colleges for their respective communities.

In relation to the dissemination of varieties, Ramanna (2006), quoting a farmer from Maharashtra, explained the difficulty in getting information when a farmer develops a new variety because unlike companies, a farmer does not have strong networks. Seedbanks and farming groups are a way to create networks to spread information and innovations. For instance, within KVM, one farmer established a reputation as having seeds for good-tasting cluster beans, while another farmer was the source of a cucumber variety. A development worker said that interactions during field visits and community centres instilled farmers with a drive to innovate. In his experience, field community centres were an excellent approach to spreading diversity and knowledge. For example, over a period of 5 years, he worked with thousands of farmers to select and eventually develop a new variety. As well, 6 years after he provided farmers with a small sample of both a rice and millet variety, farmers in the area were growing those varieties on 300 hectares and 115 hectares respectively.

Conclusions

By acknowledging agrobiodiversity conservation as a dynamic innovative process, the sustainable seed innovation model provides a means to transition towards sustainable agriculture. Locating this case within the sustainable innovation and transition literature begins to fill some notable gaps. Rather than focus solely on the success or failure of the scaling-up of a technology, the entire process of innovation was analysed from knowledge and technique selection to the challenges posed by markets.

In this case, broad policy decisions unintentionally established disincentives for sustainable innovations with further barriers created through narratives that maintain unsustainable practices. Specifically, agriculture extension services and policy actively promote seed-replacement despite the added expense to small-holders who have limited land resources. A national policy based on the targets reported to the Convention on Biological Diversity, and backed with the resources of extension services, would create a system of incentives closer to balancing informal and formal seed innovations. Such a policy might involve using public resources to support farmers and non-profit groups in creating regional seed supply systems that ensure high quality, locally-adapted, and farmer-improved cultivars. This broad approach would also address the discursive barriers to sustainable seed innovation by validating farmers' traditional knowledge as useful and innovative. Furthermore, as revealed by variety registration applications, farmers' innovation can contribute to crop diversification goals.

Current motivations for sustainable innovation require taking a longer view to value the preservation of natural and financial capital. While the farmers interviewed in this study debated the necessity of generating additional revenue by getting a better price at market, they believed improved incomes necessary for attracting other farmers to sustainable seed innovation. Furthermore, both early and late adopters to sustainable innovation needed better access to knowledge and training i.e. vehicle-selection processes. Again, policy created to meet the latest Convention on Biological Diversity targets would require training farmers.

By differentiating products and techniques, IP-broad has a role to play in both knowledge transmission and market creation. The farmers and non-profit groups interviewed expressed an interest in developing a different system of IP recognition where the community cares for the innovator and the innovator opens knowledge to all. For instance, seed and variety festivals celebrate community IP, while also raising consumer awareness. These locally generated recognitions fill a void as plant variety registration has yet to provide benefits to farmers.

Currently, smallholder farmers innovate as evident from farmer variety registration. Farmers receive some support from public universities and non-profit community groups. However, a single award does not provide follow-up to foster recognised innovators, to develop them as community leaders, or to assist them in marketing their products. Programs that develop recognised community groups and innovative farmers provide an opportunity to support sustainable seed innovation.

1 NOTES

[1] Participants in this study practiced multiple cropping as per traditional/organic standards with rice typically as the main crop or wheat/rice in the case of Punjab. The exception being conventional farmers in Maharashtra who cultivated primarily sugar cane. Farmers cultivated land plots of 5 ha or less. In Punjab, a few organic farmers cultivated larger plots of land. Concurrently, almost half of the respondents in Punjab were women working in kitchen gardens and therefore cultivating 1-2 ha of land. All participants from Assam and Maharashtra were male. Female participants from Chhattisgarh were a group of tribal farmers with three members of the group actively participating in the discussion (n=3).

[2] Some of the non-profit staff also farm and identify themselves as farmers.

[3] The sorting procedure was typically conducted with groups of participants and involved discussions; therefore, the number of 'sorts' collected was fewer than the number of interview participants. Number of sorts: Assam = 6, Maharashtra = 4, Punjab = 3 and Chhattisgarh = 6.

[4] Interviews with tribal farmers in Chhattisgarh were conducted in the tribal language and had to be translated through two translators.

[5] In a few cases, notes were taken when participants indicated a reluctance to being recorded.

[6] Stakeholders included plant-breeders, government, researchers, civil society, and media.

[7] Rice has not been included in this graph due to space constraints. Almost 3000 applications have been received from the informal sector and approximately 3500 applications in total for rice varieties.

[8] Research has documented the exceptional nutritional qualities and health benefits of traditional varieties. For example, see Bergamini, N., Padulosi, S., Ravi, S. B., & Yenagi, N. (2013). Minor millets in India: a neglected crop goes mainstream. In J. Fanzo, D. Hunter, T. Borelli & F. Matei (Eds.), *Diversifying food and diets: using agricultural biodiversity to improve nutrition and health* (pp. 313-325). London and New York: Routledge. Das, A., Raychaudhuri, U., Chakraborty, R. J. J. o. F. S., & Technology. (2012). Cereal based functional food of Indian subcontinent: a review. *49*(6), 665-672, Hegde, P. S., Rajasekaran, N. S., & Chandra, T. S. (2005). Effects of the antioxidant properties of millet species on oxidative stress and glycemic status in alloxan-induced rats. *Nutrition Research, 25*(12), 1109-1120.

[9] This also effectively marginalises the role women play in achieving food security, since women predominantly manage kitchen gardens. Moreover, participants at the round-table event stressed the importance of women in seed management because of their role in the nutritional security of the family.

[10] A farmer in Maharashtra provides one exception as he cited a return to traditional varieties arising from local taste preferences. The region stopped growing a hybrid variety and returned to cultivating Jowar (sorghum) due to taste preferences. He saved seeds from year to year for Jowar because he found the market to have inferior quality. The locals prefer Jowar, but in the city, most people use wheat flour. Thus, taste-preferences motivated a small change towards traditional varieties, but market preferences function as a barrier.

[11] Nonetheless, this 'eye' for selection, and hence potential for innovation, included farmers who had not received formal recognition and awards.

[12] Farmers believe that both the residents of the country with the resources and the farmers caring for the resources should receive benefits.

[13] Dr.Debal Deb is a scientist and farmer known for conserving over a thousand varieties of rice on his farm in Odisha (south-eastern India).

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