

Bridging the research-practice divide in organic and low external-input agriculture

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While enhancing development impacts of the mainstream agricultural research has become a central issue of the twenty-first century, various alternative approaches to the mainstream agriculture have appeared but their impacts are also mixed. It is often ambiguous which alternative and whose reality is being sought. Non-certified organic growers and smallholder farmers are increasingly alienated from the mainstream development interventions, mainly due to the gap between research and practice, the quest for technological innovation and economic growth, and the corporate capture of alternative agricultural markets, specifically the certification of organic and fair trade produce in the global markets. Based on the empirical evidence generated through direct observation, key informant interviews, focus group interviews and document review, this paper characterizes that the community-based participatory research and development processes in conventional agriculture brings science into society, the ‘mode I research participation’ under the realm of expert-led post-normal science, while similar processes in alternative agriculture brings society into science, the ‘mode II research participation’ under the realm of farmer-led post-normal science. The findings revealed that an apparent challenge to mainstream the mode II research participation is to unlearn already learned habits and practices while learning new ones – conventional scientists and large-scale farmers have difficulty to unlearn the science and technology behind industrial agriculture, and similarly the alternative stakeholder groups have difficulty to unlearn social, cultural and spiritual embeddedness of organic and low-external input agriculture – as a preparatory step to foster broad-based learning, experimentation and innovation under the realm of post-normal science. Therefore, the role of innovation brokers would be to engage multiple stakeholders in unlearning, learning and innovation processes in their respective ‘silos’ and to facilitate wishful liberation from their ‘expert mind-sets’, the habits and practices that are entrenched within disciplinary, sectoral and organizational boundaries.

Introduction

The increasing divide between agricultural research, and local and indigenous practices has often compromised the development impacts of agricultural research. The notion that formal research systems as the source of innovation is being challenged by the innovation systems thinking where all relevant stakeholders, including researchers, development practitioners, local and indigenous people, rural farmers and urban consumers, are potentially creative and innovative in respective domains (Edquist 1997; Lundvall 1992; Nelson 1993). The innovation systems approach refers to the network of public and private stakeholders engaged in production, exchange, regulation, adaptation and application of knowledge pertaining to a particular economic activity, such as input-intensive agriculture and low external-input agriculture.

Although the innovation systems approach recognizes that research is still a major source of innovation, it challenges the *status quo* of scientific communities for their reluctance to broaden the notion of innovation beyond the practices of normal science, a paradigm-based science as it is referred in the classical literature (Kuhn 1962). This implies a need for post-normal science that is characterized by an involvement of multiple stakeholders and deliberation on extended facts to solve complex problems that the humanity is facing nowadays (Bidwell 2009; Funtowicz and Ravetz 1992). In other words, the innovation systems approach challenges the perception that science-society relationships are linear, often referred to as ‘transfer of technology’ in favour of unlearning, learning and innovation through non-linear interactions of multiple entities in biophysical, technological and social systems (Pant and Hambly Odame 2009a). This paper argues that the conventional notion of science-society relationships are problematic, particularly in alternative agriculture where scientific establishments fully dedicated to alternative practices, such as organic and low external-input agriculture, hardly exists.

While the actors of the mainstream agricultural paradigm are skeptical to the promise of alternative agriculture to feed the humanity, those who promulgate alternative agriculture argue that the mainstream agriculture have failed to address social and environmental problems, and further marginalized subsistence agriculture. A normative argument presented this paper is that a truly alternative agriculture should not only challenge the mainstream industrial model of agriculture but also embrace the every-day realities of subsistence farmers in low-income countries – *alternatives to the mainstream as well as alternatives to subsistence agriculture*. When one adapts the innovation systems approach to alternative agriculture, a new challenge would be to employ alternative forms of relationships bringing unusual partners together, such as the for-profit private and non-profit private sectors.

This paper specifically investigates whether and how the broadening of the concept of innovation beyond the notion of ‘technology transfer’ offers an alternative to the sustainable future of alternative agriculture. This investigation begins with a review of the nature and meaning of agricultural science, technology, innovation and development in the twenty-first century. Then the paper turns to empirical materials generated through direct observation, key informant interviews, focus group interviews and document review, specifically in community-based participatory research and development in mainstream and alternative agriculture in Nepal and India. Although there are various forms of alternative agriculture, the Systems of Rice Intensification (SRI) is specifically presented to illustrate how community-based participatory research and development brings society into science. Finally, the paper discusses various ways of bridging research and practice in alternative agriculture, and draws conclusions.

Nature and Meaning of Agricultural Science, Technology, Innovation and Development

The nature of global agriculture is changing and this change is often responsible for the food crises that the humanity witness time and again in spite of the unprecedented scientific and technological advancements. One of the causes of limited development impacts of agricultural science and technology are argued to be small-scale farmers’ capability failure to respond to the changing nature of global agriculture in terms of scientific research and technology development, agricultural production and processing, and food safety and quality regulations.

Changing nature of agriculture

While the mainstream industrial model of agriculture has repeatedly failed to feed the humanity, various alternatives to the mainstream agriculture are being promoted. This brings a philosophical question about which alternative we are contemplating and whose reality is being addressed through advancement in agricultural science, technology and innovation. Before we embark on this issue, we review four major ways the nature of global agriculture is changing in the twenty-first century. Firstly, in terms of agricultural research and technology development, two distinct paradigms, technology push and demand pull, have appeared. The trajectory of technological advancements, such as the Green Revolution and Gene Revolution, illustrates that technology push paradigm have been proved less relevant to solve intractable problems, such as environmental pollution, natural resource degradation, poverty, hunger and social exclusion. During the 1960s and 70s, the national and international public sector actors orchestrated the Green Revolution in rice, wheat and maize while in the twenty-first century multi-national life science firms steer the ongoing Gene Revolution, including the development of transgenic varieties of cotton, canola, maize and soybean (Parayil 2003).

The Green Revolution that promoted monoculture of high yielding rice, wheat and maize varieties did not work in harsh rural and remote agro-ecosystems, where the majority of subsistence farmers live. The Green Revolution technology increased food grain production in relatively more accessible areas with high agricultural production potentials, but the so called productivity enhancing technologies, such as use of agro-chemicals, farm machinery and large-scale irrigation infrastructures damaged the natural environment, including the persistent organic pollutants (POPs) (UNEP 2005). Likewise, the Gene Revolution is being culminated into transgenic agriculture promoting Bt-crop varieties often compromising investments in traditional agricultural biotechnology, such as plant tissue culture for micro-propagation and production of virus-free planting materials, molecular diagnostics of crop and livestock diseases, embryo rescue in crop and embryo transfer in livestock, and marker assisted selection in breeding downy mildew resistant millet, bacterial leaf blight resistant rice and African sleeping sickness tolerant cattle (World Bank 2008). The positive impacts of transgenic agriculture on environmental protection, poverty reduction and food security is yet controversial given the high costs of Bt-seeds and potential risks to the environment and human health. For example, in South Africa, small scale farmers could not afford seeds of Bt-maize varieties because Bt-seeds were costly to these farmers who depend on local seed saving and exchange (Gouse et al. 2005). In India, small-scale cotton farmers were indebted from cultivating Bt-cotton and thousands of them committed suicide as a tragic strategy to debt relief (BBC 2006; Prasad 2007). Contrary to this ongoing skepticism arising from monoculture of Bt-crops often repeating the mistakes of the Green Revolution agriculture, Bt-cotton and Bt-maize are claimed to reduce pesticide use and prevent yield losses from insect borers specifically in emerging economies like Indian and China (World Bank 2008). This is, indeed, controversial. Even for large-scale farmers, transgenic agriculture is heavily dependent on the use of farm machinery, large-scale irrigation infrastructure, synthetic fertilizers and agro-chemicals to suppress insect pests, diseases and weeds to which the Bt-crops do not carry resistance (Altieri 2005).

Secondly, in terms of agricultural production and processing, mainstream development interventions often focus on high-value agriculture, including the use of food grains in livestock

and poultry feeds and non-food use, such as biofuels. These are often contemplated as new market opportunities for food grains. The role of subsistence agriculture in food security is being once again overlooked. Many small-scale farmers are unable to take advantage of the new income-generating opportunities presented by high-value agriculture in the global markets due to high barriers to market entry, such as food safety and quality standards, and biosafety regulations (von Braun 2007). Attempts have been made to encourage poor farmers to grow crops for biofuel production so that elites could drive luxury cars while the poor farmers themselves keep on lighting kerosene lamps and pine chips to let their children complete school assignments, let alone chronic household food grain insecurity. While smallholder subsistence farmers struggle to secure food grains through cultivation of starchy staples, a new trend emerges using maize, sugarcane, sugar beet, sorghum and wheat in bioethanol production and sunflower, rapeseed, soybean, jatropha and oil palm in biodiesel production. Agro-energy production aims to curb greenhouse gas emission, provide new markets for agricultural produce and reduce dependency on fossil fuels (Charles et al. 2007; Hester 2007; Mol 2007), but use of food grains in biofuel production have negative implications for global food grain availability (Katz 2008; von Braun 2007). Moreover, it is ironic that burning food grains into biofuels consumes more fossil fuels although proponents of biofuel paradigm claim that agro-energy help reduce the consumption of fossil fuels. An emerging alternative to save food grains while still promoting agro-energy would be biofuel production from the cellulosic materials, including grasses, trees, crop residues and municipal wastes (Hester 2007; Mol 2007). This alternative interferes less with food availability and arguably has less negative environmental consequences, but this new generation of biofuel production requires even more fossil fuels to run the plants, larger facilities, advanced technological innovations, larger areas to grow biomass often dwindling available resources to grow food grains and requiring higher capital investments (Mol 2007).

Thirdly, the nature of global agriculture is changing in terms of food safety and quality standards, specifically in high-value and differentiated agriculture, such as organic and fair trade produces. The concerns for food safety and quality are growing with the globalization of food supply chains and subsequent disconnect between food producers and consumers – the increasing food mileage. Food safety standards are emphasized to protect plant, animal and human health while food quality standards are emphasized for enhancing private, often cosmetic, values of the produce (Berdegué et al. 2005; Henson and Reardon 2005). Neither mandatory nor voluntary public food safety regulations have inspired public confidence and thus a third party certification for food safety as well as quality emerges as a significant regulatory mechanism in the global agricultural and food markets (Hatanaka, Bain and Busch 2005). For example, a third party certification is recently announced to put in place voluntary private food safety standards in Bt-crops recognizing the ambiguities associated with public regulations in the agricultural biotechnology – illegal releases of genetically modified organizations (GMOs) that were not approved for human consumption or even for commercial planting (Clapp 2007). The third party certification not only urges for socially and environmentally responsible production and post-harvest practices but also reflects the growing power of supermarkets to regulate global agricultural and food supply chains posing challenges to small- and medium-sized suppliers, particularly non-certified small-scale growers from developing countries (Hatanaka, Bain and Busch 2005). This challenge is becoming apparent also in alternative niche specific food supply chains, such as fair trade and organic food certification processes (Campbell and Liepins 2001; Hatanaka, Bain and Busch 2005). For example, supermarkets are gradually taking over the

global organic food markets imposing third party organic certification that small scale *de facto* organic growers can hardly afford to get certified. Corporate control in food certification has largely undermined a possibility for community-based participatory food safety and quality control mechanisms (Nelson et al. 2008).

Finally, while the rapidly changing global agriculture is expected to help prosper innovation and economic growth, the increasing social divides regarding wealth, ideology, knowledge and innovation capacity polarize the contemporary agricultural knowledge economy (Lundvall et al. 2002). The emerging debates on mainstream and alternative agriculture have seldom brought a discourse on subsistence agriculture in the past, particularly the status of *de facto* organic agricultural practices (Table 1). This is often a source of frustration specifically among subsistence farmers because the literature is ambiguous regarding which alternative and whose reality are being contemplating in alternative agriculture movements. It is evident that knowledge divides exist not only in terms of science, technology and innovations but also in production, processing and consumption practices, including certification of agricultural and food products. For example, the debates over transgenic agriculture, biofuel production and third party certification vis-à-vis alternative agriculture have yet to demonstrate their promise for small-scale producers in low-income countries.

Table 1. Two-fold alternatives of alternative agriculture

Parameters	Mainstream agriculture	Alternative agriculture	Subsistence agriculture
Lead actors	Government, for-profit private	Civil society, non-profit private	Rural communities
Most appropriate unit of analysis	Technology and/or commodity	Consumers preference	Individual livelihoods
Food mileage	Relatively longer	Relatively shorter	An abstract concept
Quality control	Public or third party certification	Community-based participatory certification	An abstract concept
Common examples	Export agriculture, free trade	Organic agriculture, fair trade	Subsistence agriculture, trade free

Source: Author

Broader meaning of innovation

Innovation system thinking has been in vogue in industrial countries for the last three decades. Contrary to the notion of 'the technology transfer', the innovation systems approach adds to the diversity of available set of useful tools for promoting sustainable economic growth, environmental protection, renewable natural resource management, and social well-being both in developed and developing countries, and is applicable for high technology as well as low and

medium technology sectors, including renewable natural resources and agriculture (Lundvall 1992; Lundvall et al. 2002; Nelson 1993). Innovation systems thinking refers to a new understanding of innovation as an interactive process in which stakeholders, in interaction with each other and supported by institutions and organizations, play a key role in bringing new products, new processes and new forms of organizations and institutions into economic, environmental and social use (Mytelka 2000). (1) This recognizes the current emphasis on the knowledge economy and knowledge-based comparative advantage of economic activities. Specifically in renewable natural resources and agriculture, agro-ecological advantages as the main source of comparative advantage is being replaced by the issues of knowledge management and capacity development (Pant et al. 2008). Small-scale farms can no longer remain competitive unless the conventional sources of competence, such as favourable growing conditions and technological advancements are replaced by learning-based competence development of organic and low external-input farmers.

An innovation system as it applies to renewable natural resources and agriculture of middle and low-income countries is a nascent field of study with its beginning only about a decade ago. Empirical research has been conducted to describe, analyze and compare innovation systems at national, regional and sectoral levels, but its application in ex-ante systems building have been very limited in both developed and developing countries (Lundvall et al. 2002). Specifically in agriculture, most of the empirical evidence of sectoral innovation systems comes from high value agricultural commodities, often aimed for export markets (Clark et al. 2003; Hall 2003; Hall et al. 2001; Pant and Hambly Odame 2009a; World Bank 2006). However, this is rarely happening in organic and low external-input agriculture where local and indigenous production and post-harvest practices are expected to meet the private standards of importing partners, such as EurepGAP, which particularly regulates agrochemicals use in commodities like cut flowers and cassava, and shrimp and pineapple, and vanilla and other species (Pant and Hambly Odame 2009a). Moreover, such regulations can apparently demand an additional expense for low external-input agriculture, particularly *de facto* organic farms, where farmers can hardly afford agrochemicals. This problem is further complicated by the ambiguity in naming of organic food as the term 'organic' is socially constructed and often contested among stakeholders (Campbell and Liepins 2001).

In a nutshell, without conceptual broadening of innovation in alternative agriculture – *alternatives to the mainstream as well as subsistence agriculture* – coupled with financial, technical, or educational assistance, the high costs associated with biotechnology, high-value food and agricultural products, including biofuels and third party certification, will simply be rhetoric beyond the capacity of many small-scale farmers (Gouse et al. 2005; Hatanaka, Bain and Busch 2005; Mol 2007). Moreover, the innovation systems in mainstream agriculture, although benefits large-scale farmers and often argued to generate employment to small-scale subsistence farmers and landless labourers, its focus on monocultures of high yielding crop varieties and animal breeds can be damaging to the environment and agricultural biodiversity, and thus perpetuates the vicious circle of poverty, debt and social exclusion. Therefore, government policy and international development assistance programs should be geared towards building the capacity of the stakeholders in alternative agriculture in response to the complexity associated with food and agricultural systems.

Community-Based Participatory Research and Development

The changing nature of agriculture provides an opportunity for large-scale industrial farmers to work for global export markets, and in this context the innovation systems approach provides powerful diagnostic tools to generate learning lessons towards strengthening the competitiveness of national innovation systems. However, as the above literature review revealed, the crux of the problem is not strengthening national competitiveness but building regional and sectoral innovation systems, specifically through addressing the divides between expert knowledge systems, and local and indigenous practices. This empirical section brings evidence to broaden the meaning of innovation in mainstream and alternative ways of agricultural research and development, clearly moving beyond the realm of normal science.

Participatory research and development in mainstream agriculture

Formal participatory research and development in agriculture can be traced back to the mid-twentieth century, when the social and environmental impacts of the Green Revolution in low-income countries were becoming evident. One of such attempts was the Farming Systems Research and Extension (FSR&E), with various levels of integration of expert knowledge systems, and local and indigenous practices. The linkages between formal research and informal practices were essentially linear, meaning that technologies developed at research stations were tested through various levels of user participation throughout the ‘technology supply chain’ from scientific establishments to farming communities (Collinson 2000; Norman et al. 1995). While there were initiatives to test a product of science on farmers’ fields, the level of involvement of farmers was very different – on-farm trials planned and managed by scientists, on-farm trials planned by scientists but implemented by farmers, on-farm trials planned and managed by farmers (Table 2). On-farm trials planned by farmers and managed by scientists were, however, beyond of the scope of the FSR&E, and the local and indigenous knowledge and practices were grossly unheard in the mainstream agricultural research and development discourse. Later during the 1990s, the concept of participatory plant breeding (PPB) served as a postnormal incarnation of researcher planned and farmer implemented on-farm trials, initially for bean variety development in Rwanda and rice variety development in Nepal (Sperling, Loevinsohn and Ntabomvura 1993; Witcombe et al. 1996).

Table 2. Typology of on-farm trials in mainstream agricultural research systems

	Scientist implemented	Farmer implemented
Scientist planned	Most common	Common
Farmer planned	Uncommon	Least common

Source: Author

The contemporary practice of participatory research and development is led by experts. For example, Sperling et al. (2001) classified PPB into formal-led and farmer-led, and they criticize that the work in Nepal was persuaded by the habits and practices entrenched in mainstream research, such as use of modern varieties as parent materials, focus on official release of varieties developed and limited involvement of farmers at the selection of stable breeding lines. The

above critique has been overlooked until recently as Witcombe et al. (2005) argues that farmer involvement in selecting the segregating materials may not be an essential component of PPB. They outline a set of conditions when farmers' involvement would be desirable – in absence of market incentives to develop a variety, when it is possible to reduce cost through farmers' involvement, to handle qualities that cannot be tested in laboratory, to learn farmers' specific preference and to empower farmers (Witcombe et al. 2006).

Since one of the widely cited cases of expert-led participatory research and development is from Nepal, this paper first turns into a presentation of expert-led PPB in the country, and then to a story of a high-value horticultural crop in the South Indian state of Andhra, respectively representing subsistence and high-value agricultural practices. Nepalese farmers grow a diversity of local rice varieties in addition to the cultivation of a few modern rice varieties available through the formal rice research systems – about 200 local rice varieties against a finger countable number of modern rice varieties. Among several dozen modern rice varieties available through the formal research systems, farmers cultivate only a couple of them. For more than a decade, the non-profit private actors in collaboration with rural communities and local subsidiaries of public agencies engaged in community-based participatory research and development of various rice varieties under farmers' management practices. Lessons from such an interactive learning and innovation were instrumental to amend the crop variety registration and release procedure of the National Seed Committee thereby allowing both public and private actors, including rural communities, to propose a variety registration and release. Although corporate plant breeders were not yet active in Nepal as the domestic seed market is very small, the policy amendment has not ruled out an opportunity for corporate plant breeders to register and release a variety.

The ongoing battles for alternative rice breeding practices were sustained through the initiatives of civil society plant breeders often in collaboration with grassroots public service providers, but the public sector researchers were still influential to impose mandatory multi-location testing of plant breeders' and farmers' crop varieties on research stations before they are officially released for general cultivation. Once stakeholders, who believe in alternative agriculture, developed and tested crop varieties on farmers' fields through their hard work over a decade or so, it was ridiculous to subject a farmers' variety into on station screening as if the varieties were unsafe to release for cultivation. In an intriguing case, a creative and innovative farmer developed rice varieties of his own and tested among his fellow farmers as promising over other available varieties, but after all it was sent to disease screening and multi-location testing on research stations (Pant and Hambly Odame 2009b). Since the rice varieties were already in farmers' fields, it was not like the crop varieties developed on research stations that could potentially harm farming systems, available agro-biodiversity and human health, and thus required a government approval for cultivation. This illustrated how the *status quo* of normal scientific establishments forced the practitioners of alternative plant breeding to subscribe the norms of developing distinct, uniform and stable (DUS) crop varieties suitable for large-scale monoculture in spite of the achievements of alternative plant breeders: (a) decade-long breeding and selection of rice varieties under farmers' management practices, and (b) amendment of the crop variety registration and release procedures to accommodate varieties developed through alternative breeding practices.

In India, mango industry provides natural comparative advantage over other mango producing countries accounting about 43 percent of the world's mango production – the land of mangoes, the centre of diversity. India recognizes mango as the national fruit – an icon of national pride. However, it is generally perceived that Indian mangoes have failed in the export market because the fruit spoils during long transport. Quality was, however, just one of a series of evolving challenges to sustainable future of the mango sector. The public sector was preoccupied with mango export through the development of technology, such as improving local varieties, experimenting sea freight and determining cobalt ray radiation dosages to sterilize mangoes for export; and infrastructure, such as construction of integrated pack house facilities; and exclusive policies, such as subsidies to export oriented commercial mango growers and other supply chain actors (Pant et al. 2008). Stakeholders, particularly in the South Indian state of Andhra, neither sufficiently explored the potential for organic mango production nor alternatives to the export markets given that the urban middle class consumers are increasing in Indian cities.

Farmers' collective effort to export mangoes failed through the excessive influence of active commission agents, and fruit and vegetable merchants (*mandiwalas*) based in mega cities of India, such Mumbai and New Delhi. In addition to the public sector preoccupation to mango export promotion, the lost battle was also due to the ever deepening social divides between small-scale mango growers, large-scale growers and commission agents. The public sector failed to involve the powerful commission agents and their merchants in broad-based learning and innovation networks. Specifically, in Krishna district of Andhra Pradesh, the Vijaya Fruit and Vegetable Growers Association went through two successive restructurings since its establishment as a federation of cooperative in 1992 – initially a federation of 16 primary cooperatives representing 500 farmers to a public limited company to finally an association of 217 individual members. A government official in charge of export promotion says, “Mango export is not going well. ...farmers' cooperative is no longer there.” The lost battle for cooperative marketing compelled mango farmers sell their produce to cunning commission agents accepting unfair pricing mechanisms. In spite of all these problems, creative and innovative farmers utilized the processing facilities, heavily subsidized to supply premium quality mangoes to export markets, to supply premium quality mangoes to Indian supermarkets.

The problems were related to social divides, such as socially exclusive learning networks of friends and families, anti-poor public policy provisions and unfair access of small-scale farmers to inputs and produce markets, further aggravating the situation. Specifically, export subsidies were only available to large-scale mango growers and exporters who specifically work for export markets clearly excluded small-scale producers who maintain multifunctional home gardens to meet dietary needs of their families as well as a sale of surplus mangoes in the local and regional markets. The public policy was also subtle about alternative approaches to mango production, such as organic and fair trade mangoes, and species-diverse home gardens. Home gardens customarily met the dietary needs of the poor families while benefiting from agro-ecological services, such as moisture conservation, organic matter recycling and biological pest control, and aesthetic and cultural values.

Participatory research and development in alternative agriculture

Among several approaches to alternative agriculture, this paper uses the Systems of Rice Intensification (SRI) as a case to illustrate how participatory research and development in alternative agriculture brings society into science in spite of the widespread skepticism among mainstream agricultural researchers. First initiated by Father Henri de Laulaníe, a French Jesuit priest, in Madagascar in 1983, the SRI concepts and techniques are now spreading around the world, not only in rice but also in the production of other crops and livestock as diverse as millet, sugar cane, wheat, cotton, and even poultry (Uphoff 1999; Uphoff 2003; Uphoff 2006). The story in this section specifically focuses on rice in Nepal, as it would provide a logical comparison with the previous discussion of expert-led PPB. Specifically in rice, the concepts and techniques include early planting, single transplanting of young seedling, wider spacing, refraining from continuous flooding conditions under which rice is conventionally grown, use of local rice varieties, mechanical weeding, and use of organic matter and non-pesticidal management of insect pests and diseases. (2)

Some public sector scientists introduced SRI in Nepal as early as 1999 but the results were disappointing at the research station (Uprety 2005; Uprety 2006). These scientists turned into strong skeptics of the SRI and also persuaded other mainstream researchers that the idea of growing rice in non-conventional ways would not be possible. In subsequent years, development practitioners, mostly from civil society organizations, tested SRI techniques, including the use of Farmers Field Schools to experiment with the techniques. Once declined by the public sector scientists, the SRI gained its roots through the exemplary work of public extension workers. Rajender Uprety (2005; 2009) shares a personal story that he was inspired to practice the SRI after reading an article written by one of the theorists of the SRI in 2002. This was the time when SRI movements took momentum in Nepal through active participation of farmers, development practitioners, some policy makers and popular media. However, there was still resistance and criticism from scientists, agriculturists and policymakers who had heard about the disappointing results of the public sector scientists.

Skeptics of the SRI are understandable because the conventional wisdom of rice cultivation supported by rational thoughts help us pursue that rice is a water-loving plant, and thus a flooded growing condition is necessary for good results (Uphoff 2006). (3) In addition to the departure from this dominant practice, there are other deviations in SRI concepts and techniques – transplanting young seedlings of 9-12 days against the conventional practice of transplanting seedlings of 25-30 days old, transplanting single seedling per hill against the practice of transplanting multiple seedlings (3-5), wider spacing of 20X20 cm or even 25X25 cm against the dominant practice of 15X15 cm or less spacing, and modifications in other cultural operations to fit these deviations. For example, since one of the key concepts of the SRI is to allow a rice plant to produce tillers of its full potential allowing wide spacing and good soil aeration, the rice plant can tolerate biotic and abiotic stresses, such as sustaining a damage of tillers by insect borers without significant yield loss under non-insecticidal management practices.

In spite of the widespread doubts about the deviant practices, the SRI concepts and practices are spreading worldwide. As of 2007, over 28 countries have adapted the SRI concepts and practices (Prasad 2007). In spite of the policy environments not being enabling for such a radical innovation, the SRI movements have been facilitated by individual agencies, such as ingenuity of Rajendra Uprety in Morong district of Nepal who own a prestigious grant from the World Bank for his work (Uprety 2005), and T. M. Thiyagarajan in the Tamil Nadu (Thiyagarajan 2006) and Alapati Satyanarayna in Andhra Pradesh of India (Prasad 2006; Prasad 2007). Satyanarayan was initially a strong skeptic of the SRI but he turned into a proponent after an accidental injury of his fingers in an official visit to Sri Lanka when he was experimenting with the sturdiness of rice plants grown under the SRI concepts and practices.

Bridging the Research-Practice Divide in Alternative Agriculture

The stories from the field demonstrated that diagnosis of maladies and prescribing quick fixes does not work in complex adaptive systems. Until one arrives with a first aid kit, the system changes its face and a new set of challenges emerge. In such a context the best practice approach of an expert 'mind-set' does not work (Snowden and Bonne 2007). A best practice is a past practice and it can be obsolete very quickly in a complex adaptive system. An effective way to address complexity would be building dynamic learning and innovation systems through continuous engagement in hindsight and foresight exercises, recognizing ingenuity and epistemological backgrounds of all relevant, traditional and non-traditional, stakeholders including more socially excluded women, youth, small-scale producers and resource-poor farmers (Shiva 1997; Stamp 1989). Such concerns of learning and innovation in response to rapidly changing contexts specifically relate to the question of power (Foucault 1982; Lundvall et al. 2002). For example, alternative plant breeders and SRI practitioners in Nepal are emerging as influential actors empowering farmers to challenge the mainstream agricultural research and development that fail to provide enough choice of rice varieties and production technologies suitable for diverse farming conditions over the last several decades.

In spite of this shifting of power from the mainstream scientists and practitioners to alternative actors, crop varieties developed through decade-long testing in farmers' fields under farmers' management practices had been subjected to testing in research stations as if those varieties provide a risk to release for general cultivation. Similarly, skeptics of the SRI are testing the concepts and practices against the scientific orthodoxy, and thus stereotyped the SRI stories as unconfirmed field observations (UFOs) not suitable for publication in scientific journals (Sheehy et al. 2004; Sinclair and Cassman 2004; Stoop and Kassam 2005). Likewise, in India smallholder mango growers are exploited by the unfair price negotiations through powerful commission agents. Smallholder mango growers were mere price takers than rightful suppliers of mangoes to domestic, regional and international markets. The ritualistic investment in infrastructure and subsidies are specially designed for export promotion seriously overlooking alternative possibilities to exploit niche markets for organic and fair trade mangoes in the thrust for innovation and economic growth through promotion of conventional mango markets. The emerging domestic markets as a result of the rise of middle income groups in Indian cities provided an opportunity to flourish supermarket culture within India but organized effort to seize

these new market opportunities were lacking, except unlearning initiatives of individual farmers who deconstructed export-led promotion of mango industry in the state.

Postnormal science, technology and innovation in agriculture

Neither formal scientific research nor state education and extension systems engage in creation and exchange of knowledge about alternative agricultural practices. These stakeholders in Nepal and India are not ready to push their comfort zones. Niche specific initiatives of individual agents of positive social change are often resisted by the organizational structures and institutional set-ups that reinforce the expert mind-sets of dominant research and development actors. Knowledge about organic and low external-input agriculture comes from practice through unlearning learned habits and practices, learning know knowledge and skills, and initiating new ways of doing things, and thus these processes of unlearning, learning and innovation appear doubtful among dominant actors. The doubt is typical of the community-based participatory research although this mode of research participation is recognized as a process able to bridge the divides between research and practice.

While the normal scientific research is based on the linear model of science-society relationships, either focusing on science-push or demand-pull mode of research practice, postnormal scientific research is embedded in innovation systems approach, the research systems being a major but only one of the sources of innovation among others. (4) This is exactly what Gibbons et al. (1994) discuss about two modes of knowledge production: Mode I disciplinary knowledge production and Mode II interdisciplinary, intersectoral and interorganizational knowledge production. As the case study illustrates, mango production and post-harvest management in India still strive to move beyond the Mode I knowledge production entrenched under the domain of normal paradigm-based science.

A closer look at the mode II knowledge production in the context of the case studies presented above clearly shows that there are two modes of agricultural research and development participation (Table 2). Firstly, mode I research participation, which can be characterized as science-led postnormal agricultural science, brings science into society, such as the participatory plant breeding presented in the empirical section. This is an expert-lead research process and experts invite farmers' intellectual input whenever they feel necessary (Witcombe et al. 2006). This approach of participatory research and development is preoccupied by expert mind-sets and believe on best practices or best bets. Nevertheless, this approach of research and development meets the two characteristics of postnormal science because there is every possibility to engage diverse stakeholder groups in deliberation of extended facts, mainly the experiments being moved to farmers' fields. Secondly, mode II research participation, which can be characterized as society-led postnormal agricultural science, brings society into science and this may be a reason why skeptics often stereotype this mode of research enough to commit agronomic UFOs. Nevertheless, the SRI is a type of postnormal science of postmodern agriculture that brings society into science (Uphoff 2006).

Table 3. Typology of the modes of research and development participation

	Science into society	Society into science
Normal science	Science push research practice Science-led normal science, e.g., Expert-led normal on farm research	Demand pull research practice Society-led normal science, e.g., Farmer-led normal on farm research
Postnormal science	Mode I research participation Science-led postnormal science, e.g., Expert-led postnormal on farm research	Mode II research participation Society-led postnormal science, e.g., Farmer-led postnormal on farm research

Source: Author

The discussion moves beyond Bidwell (2009)'s argument that community-based participatory research (CBPR) can be classified into normal and postnormal science. A deeper investigation revealed that postnormal CBPR itself operates under two modes, based on who initiated the research participation and with what goal. While mode I research participation is the initiative of experts to bring science into society, mode II research participation is the initiative of local and indigenous people to bring society into science. Both modes of research and development participation involve broader groups of stakeholders, and there is every opportunity to deliberate on dialectical divides among the stakeholders (Pant and Hambly Odame 2006).

Society-led postnormal agricultural science is particularly relevant for alternative agricultural movements. Contrary to the participatory plant breeding for conventional agriculture, participatory plant breeding for organic agriculture is required to produce crop varieties that are adaptable to diverse growing conditions possible under all possible organic management practices. In other words, plant breeding that aims for organic farming systems requires developing crops varieties that are responsive to diverse growing conditions so that modifying growing conditions, such as in the SRI, can increase the productivity of the overall biomass. For example, crop varieties bred in and adapted to the unique conditions inherent in organic systems would give higher yields in organic growing conditions than in conventional agriculture (Murphy et al. 2007). Crop varieties for organic agriculture need adaptation to low-input conditions, efficient nutrient uptake and use, disease resistance, insect resistance, improved rooting systems, and stronger interspecific competition ability for weed suppression so that positive interactions between genotype and environmental conditions can be achieved (van Bueren et al. 2008; Wolfe et al. 2008). The SRI concepts and techniques focus on changing the environment to achieve positive genotype by environmental interactions for a given crop variety. The SRI aims to provide a highly favourable growing condition so that a given rice variety develops stronger root systems, achieves its full potential to give tillers, tolerates biotic and abiotic stress; all of these are basically achieved through the practice of improved soil aeration, wider spacing, planting of single seedling and mechanical control of insect pests, diseases and weeds (Uphoff 2006). This is a radical departure from the conventional practice of developing DUS crop varieties that are responsive to standardized growing conditions under high levels of fertilizer, pesticides and irrigation water use.

Unlearning for learning and innovation in alternative agriculture

The process of generating novelty begins with unlearning followed by subsequent learning and innovation. Before new ideas are generated old ideas must be unlearned, which is largely determined by our willingness to unlearn established habits and practices (Sherwood 2000). It is important to accept that learning, knowledge and past experience – ‘the dominant logic’ - can and should be challenged as a necessary initiative to learning and innovation (Bettis and Prahalad 1995; Prahalad and Bettis 1986). For example, learning in the SRI involved the processes of unlearning whereby the agents of positive social change challenged their own frame of reference that rice is not necessarily a water-loving plant and dominant nursery practices, transplanting methods and intercultural operations are indeed just an agronomic orthodoxy. Similarly other alternative agricultural practices, such as organic farming, permaculture, biodynamic agriculture and no-tillage agriculture, challenge the well established industrial model of agriculture. The concept of unlearning is valid for individual as well as organizational, network and system level learning and innovation (Becker 2005; Sherwood 2000). Innovation systems ideas represent all levels of unlearning, learning and innovation.

The findings of the empirical section revealed that an apparent challenge to mainstream the mode II research participation, which brings society into science rather than the other way round, requires unlearning already learned habits and practices while learning new ones. For example, scientists who are trained under the industrial model of agricultural research and development and large-scale industrial farmers who benefit from the established expert knowledge systems would have difficulty to unlearn the science and technology behind industrial agriculture, or even they think it is unnecessary to change the learned practices. Similarly development practitioners, civil society actors and small-scale farmers who are engaged in alternative agricultural research and development practices may have difficulty to unlearn social, cultural and spiritual embeddedness of organic and low-external input agriculture as a preparatory step to foster broad-based learning, experimentation and innovation bringing local and indigenous practices into expert knowledge systems. Although the above discussion basically focuses on the learners’ perspective, it would be equally effective for today’s educators to unlearn pedagogies and andragogies developed through expert mind-sets (McWilliam 2005). As it applies to alternative agricultural research and development, scientists and educators can no longer be considered experts because the practices of alternative agricultural movements are based on local and indigenous knowledge and innovation.

Bringing an agrarian society into agricultural science involves relatively more power struggles, value incongruence, differential predisposition, and mistrust among scientists, policy people, practitioners and farmers than bringing science into a society. In order to address these differences and subsequently facilitate learning and innovation, boundary work is important (Pant 2009). A boundary work involves two or more groups that work to different standards and objectives, such as basic scientists versus practitioners, using boundary objects (Kristjanson et al. 2008). Examples of boundary objects in bridging research-practice divide in organic and low external-input agriculture would include mind maps, models, experimental trials, concept notes, agreements and promotional flyers. Boundary actors can be an organization or an individual

within an organization, and they demonstrate behaviour as diverse as radicalists, rule breakers, positive deviants, entrepreneurs, innovators, leaders, and network managers; most effective boundary workers are jointly accountable to two or more stakeholders that are entrenched in their respective 'silos' (Hoe 2006; Williams 2002). In innovation systems literature, boundary workers are often referred to as innovation brokers (Klerkx and Leeuwis 2009), and they challenge the dominant logic behind an established regime using their diverse strategies – direct confrontation, strategic bypassing and even guerrilla tactics (Klerkx, Aarts and Leeuwis forthcoming). These boundary workers in one way or another show a behaviour of positive deviancy, clearly deviating from what mainstream actors believe to be logical and rational (Pant and Hambly Odame 2009b; Sternin and Choo 2000).

Therefore, the new role of boundary workers would be to engage multiple stakeholders in unlearning and learning processes in their respective 'silos' and to facilitate interactive learning and innovation beyond conventional disciplinary, sectoral and organizational boundaries. In confirmation to the empirical material presented in this paper, one such example in organic agriculture comes from the boundary work of Kenyan non-governmental organizations (NGOs) at national and local levels that facilitated negotiation among socially, politically, culturally and geographically different actors, such as NGOs, foreign donors, agricultural researchers, and small-scale farmers, to promote non-certified organic agriculture in the country (Goldberger 2008). This particular work to promote organic agriculture help 'scientize' and legitimize organic agriculture among the mainstream agricultural research and development practitioners; this is an example of a successful boundary work to bring society into science and to bridge research-practice divide in organic agriculture.

Conclusion

Clearly global agriculture has been polarized in terms of technology use, production practices and quality regulations and there are no signs of convergence in the near future. Alternative agriculture relies on affordable technologies generated through user participation, low external-input agriculture for local and regional consumption, and food safety and quality regulations based on moral values than government or corporate sector enforcement. In the time of crises like famine and fuel shortages, organic and low-external-input agriculture, including the subsistence modes of production, are resilient to shocks, and are under the control of smallholder farmers. However, in recent decades corporate control of alternative food supply chains, such as organic agriculture and fair trade, is pushing smallholder non-certified producers out of the lucrative differentiated produce markets, once again marginalizing farmers in subsistence economy. For example, certification cost of organic produce is unaffordable to small-scale producers. Therefore, the future of agriculture in general and alternative agriculture in particular lies on how public and private actors interact as a system in response to the changing nature of global agriculture exploring *alternatives to both the mainstream as well as subsistence agriculture*.

Polarization and dichotomies, such as research and practice, often compromising the development impacts of agricultural research and development, would be detrimental to the future of agriculture, specifically subsistence agriculture, to meet the food and fiber needs of ever

growing human populations. This paper clearly demonstrated that the conventional notion of linear science-society relationships which assume research and practice as distinctly separate entities is problematic with serious implication for the promotion of organic and low external-input agriculture. Broadening of the concept of innovation deliberately challenging the transfer of technology approach, and addressing technological as well as organizational, social and institutional innovation offers a promising alternative to the sustainable future of alternative agriculture.

Stakeholders of alternative agricultural movements have every right and responsibility to find alternatives to the industrial model of agriculture in the global North as well as subsistence agriculture in the global South recognizing that many farmers in low-income countries still operate organically or with limited use of external inputs as cost of such inputs are unaffordable or even unjustifiable for subsistence oriented production systems. For these *de facto* organic and low external input farms, development of organic value chains for both domestic as well as export markets would contribute to their livelihoods through the sale small surplus at a premium price. However, niche specific grassroots movements, such as organic agriculture, biodynamic agriculture, permaculture, biosecure agriculture, systems of rice intensification, and slow food movements, often face resistance from the dominant regime with a weak rationale that such alternatives are low in productivity. Further research would require exploring various ways of promoting postnormal science, bringing local and indigenous practices into formal research systems through the initiative of innovation brokers.

Notes

1. Organizational structures refer to sector coordinating bodies, R&D, innovation and productivity centers, standard setting bodies, universities and vocational training centers, information gathering and analysis service providers, and banking and other financing mechanisms while institutions refer to habits and practices entrenched within such structures.
2. For a review of SRI movements in Madagascar, please see Stoop *et al.* (2002). It is understandable that SRI sustained strong criticism because the concepts and practices differ from what have been understood to be the optimum conditions and techniques for rice cultivation and the success depends on neither of the two pillars of the crop-improvement paradigm of the Green Revolution: varietal improvement, and external inputs. Rather the success of SRI depends of knowledge intensive modification of the environment under which a rice plant grows rather than the modification of genotypes of a plant.
3. The SRI controversy reached its height during the beginning of 2000s. To learn more about the arguments against SRI, please see Dobermann (2004), McDonald *et al.* (2006), Sheehy *et al.* (2004), and Sinclair and Cassman (2004). The literature in favour of the controversy includes Prasad (2006; 2007), Stoop *et al.* (2002), Uphoff (1999; 2003; 2006) and Stoop and Kassam (2005) for a specific response to strong critics.

4. Postnormal science is mainly characterized by two process indicators 1) the involvement of an extended peer community; and 2) the deliberation of extended facts (Funtowicz and Ravetz 1992).

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