Complexity of transition to alternate farming systems – more than substitution of inputs

Gomathy Palaniappan[1], Christine King[2], and Don Cameron[3]

School of Integrative Systems, The University of Queensland, (Gatton Campus), Gatton, Queensland, Australia 4343

Gomathy Palaniappan (PhD) was a doctoral student in the school of Integrative Systems, at The University of Queensland (Gatton Campus), Australia. She undertook this research as a holder of a University of Queensland International Post graduate Research Scholarship. Part of the research conducted in India was supported by University of Queensland Graduate School Research Travel Grant.

Christine A. King (Ph.D.) is Senior Lecturer and **Donald Cameron** (Ph.D.) is Research Postgraduate Co-ordinator and Senior Lecturer in the School of Integrative Systems, The University of Queensland (Gatton Campus), Gatton, Queensland, Australia.

Abstract: This paper reports on aspects of doctoral research that explores ways of enhancing farmers' capacity for transition towards more sustainable farming systems. The study was conducted in Australia and India to explore the learning experiences of those who had pursued a transition to more sustainable food production. The research was conducted using action research methodology in which qualitative data were collected using convergent interviewing methods. The themes that emerged suggest that making the transition to more sustainable production systems involves more than a mere substitution of inputs. Effective transition requires a fundamental change in the way soil is viewed. We generalize some relevant learnings for the transition process through elaboration on the emergent themes.

Introduction

The rate of conversion from conventional to alternative farming systems is relatively slow. Many recent studies have acknowledged that the complexity and integrity of the living systems in alternate farming can impose further challenges for addressing the transition process (Norton *et al.* 2009). The objective of this paper is to focus on the learnings of those who have made the transition process in two contrasting contexts - Australia as an example of modern western agricultural practices and India as an example of the developing world with indigenous farming practices. Farmers making the transition in both countries were interviewed through a convergent interviewing process that sought to explore their transition journeys. The themes that emerged during the transition process are discussed in two parts in this paper. The first part highlights the themes and the second part elaborates on the complex nature of the system with a case study on soil health.

Background

Transition to alternative farming cannot be attained through simply applying a new package of practices or through mere substitution of inputs. It is a complex, multifaceted process that requires a paradigm shift through learning (Röling & Wagemakers 1998). According to Silvasti (2003), there are a number of reasons that farmers do not make the transition. First, they fear that it will affect the economic performance of their farm, and second, they still consider that modern, industrial ways of farming are harmonious with nature. Thompson (1995) states that the transition from conventional agriculture to organic farming involves a difficult period for several reasons: (1) it occurs at a time of least experience for the growers who are getting into organic farming; (2) the predator–prey links are not fully developed within the farm ecosystem; (3) farmers usually do not receive a full premium for their products until organic certification has been achieved; and (4) initial yields may be low. The four reasons discussed by Thompson (1995) reveals the complexity in the transition process. The complexity increases as transitioning from conventional to organic farming is at the very least, region-specific and frequently, farm-specific in nature (Katsvairo *et al.* 2007) implying that a package of practices may not be the solution.

Methodology

This research was based on the premise that farmers who had made or were making the transition from conventional to alternative forms of production could provide guidance suitable for developing into learning tools. These learning tools will be suitable for individuals contemplating it themselves or supporting the change by others. Among the wide choice of methodologies available, action research was chosen as the research aims to study the system and concurrently collaborate with members of the system in making the change. In this study, the information was collected during different phases of the research using different methods. In the initial phase, information was collected through immersion and field observations recorded in a field diary. Reflections on the immersion stage led to the development of the broad research question, which was addressed by collecting information through convergent interviews undertaken in Australia and India. By analyzing the information collected through the convergent interviews learning tools were developed. The application of the learning tools was assessed using case study methods.

Convergent interviewing

Convergent interviewing method was used as one part of the research to collect data. This is an in depth interviewing method developed by Dick (1990) in Australia to collect, analyze, and interpret qualitative data about people's experiences, opinions, attitudes, beliefs, and knowledge and to converge on important research issues (Driedger *et al.* 2006). The interviewing process began with a broad question and progressed with secondary questions that emerged due to the agreements and disagreements on themes. The secondary questions on themes were raised with the subsequent interviewees until agreement or an explanation for the disagreement was established. The interviewing process was stopped on obtaining answers to the secondary questions or when no new themes emerged. Recording the information was done with the use of audio tape, field notes and diaries. Audio taped interviews were converted to audio files and stored on a computer disc. These audio files were transcribed. Soft and hard copies were made for analysis. The transcripts averaged from 10 to 20 pages of single spaced 12 point font.

Analysis of the information commenced during transcription as it was not mere typing of the audio conversation into text. Analysis was also done simultaneously through highlighting the text using different colours to ease the coding process. The purpose of transcribing the interviews was to quote the participant's views in their own words. The NVivo - 7 software aided in managing the data and thereby, all the audio files, transcripts and nodes could be referred through their links to each other to develop the themes. The software was chosen as it allows the researcher to work in languages apart from English, such as Tamil, as the interviews were conducted in Tamil in India.

Results and discussion

Part One: Themes for transition

Themes that emerged from the convergent interviewing process in both the countries are highlighted in this section. Themes are not independent of each other but are interlinked. Furthermore, for successful transition the themes need to be understood not only by the farmer intending to make the change but also the change agent supporting the farmer. The main themes that emerged are: Enriching soil health; Knowledge sharing; Diversity; Learning; Indigenous knowledge/local knowledge; and Farm Sufficiency.

Each theme is highlighted below, and the theme on enriching soil health is explained in detail as a case study to understand the learning involved in transition.

Knowledge sharing through networking

Participants from both countries had informal networks for sharing knowledge enhancing the transition process. However the participants in Australia were more selective in sharing knowledge in comparison to those in India, plausibly due to the existence of competitive markets and peer pressure. Participants in India were prepared to share most of the knowledge due to lack of competitive markets and in the interests of attaining ecological balances. This agrees with the statement of van de Fliert et al., (2007) that small holder farmers need to take collective decisions as ecological processes are not restricted to artificial boundaries. Other than sharing knowledge, networking was used for collective marketing in Australia and for group certification processes in India. The majority of participants in Australia were involved in collective marketing such as farmers markets and community supported agriculture. This has definitely reduced the distance of food travel and helped farmers and consumers to directly connect with each other. Participants in India were involved in group certification processes for organics and marketing. This agrees with the argument of Faure (2004) that collective action is likely to occur to solve concrete and short term problems at the farmers' organization level with benefits limited to few farmers.

Diversifying through biophysical and sociocultural methods

Biodiversity is essential for human life and plays an important role in farming. During the interviews, diversifying farming for both economic and ecological benefits was mentioned by the participants. As stated by Baars and Baars (2007), the first step to enhancing biodiversity is to stop applying chemicals on the farm, the second is to follow ecological principles and the third is to respect the integrity of other living organisms. These principles were followed by the majority of the participants. The themes that emerged are classified as biophysical and socio-cultural. Biophysical ways of gaining diversity are through species diversity, genetic diversity and through respecting integrity of organisms. Socio-cultural ways of regaining diversity are through preserving native culture and intrinsic values.

Bio-Physical diversity

Species diversity: Participants in both countries followed diversified cropping practices such as growing different crops at the same time (intercropping) or different crops over a period of time (crop rotation). This helped in maintaining the ecological balance in different ways (Youyong *et al.* 2000).

Genetic biodiversity: The loss of genetic biodiversity was mentioned by the participants in India as the 'improved' hybrid varieties replaced the traditional varieties. The traditional gene-rich system fulfilled the needs of a diverse diet for both human and animals, and did not involve high investments or technology thereby minimizing risk (Altieri 1994).

Integrity of other organisms: Participants practicing alternate farming have begun to understand farming as a part of the ecosystem as weeds and insects are no longer eliminated but managed through multiple methods.

Socio-cultural

Preserving native culture for biodiversity: Participants in India attempt to revive their culture as traditional farming practices are embedded in the cultures of habitat. This agrees with Nabhan's views that "Preserving biodiversity requires preserving native cultures and their ideas and practices, and probably vice versa" (Nabhan, 1997). However, the rest of the farming communities, in Australia and India, were influenced by modern agricultural technologies, which had brought rapid cultural transition and destruction to the environment (Nabhan 1997).

Preserving intrinsic values for diversity: Farmers interviewed in both countries insisted that to maintain diversity, participants need to have certain values. These values included self interest to preserve the land for future generations, and the desire to produce healthy food, for both family and society. This falls under the 'conservationist' position that favours the protection of natural areas with self-interest thus, conserving land and resources for later human use (Robinson 2004).

Learning through experience

Participants had been through an experiential learning process of trial and error and observation making judgements rather than relying on external expertise alone. Participants in both countries had been through a learning process as a result of observations in the field, cross checking with fellow farmers, conducting trials, and reflecting on their results. They also gathered information through reading a wide range of material, including magazines and consulting internet sites. This agrees with the statement of Röling and van de Fliert, (1994) that the paradigm shift from dependence on external advice to empowerment may happen through experiential learning. The change in farmers' learning styles in turn demands a change in learning styles of the researchers and practioners.

Indigenous knowledge/local knowledge through acculturation

The indigenous/local knowledge theme emerged with participants from both countries emphasizing revisiting old practices. The incidence of belief and faith developed within one's culture causes conflict with new knowledge. The majority of the Australian participants had followed Western science principles and incorporated local knowledge with rationality. Indian participants, who had given up indigenous practices, perhaps because of the domination of Western science for its truth and political power relationship had returned to revisit them through their faith and values. It may be concluded that some see incorporating indigenous/local knowledge as a selective strategy to overcome certain issues in farming, whereas others use indigenous/local knowledge to address complex issues in sustainable farming. It may be concluded that neither indigenous/local knowledge nor Western science is always correct and as a result, a balance of both is required.

Self sustaining through recycling farm resources

Participants in India practiced alternative farming as a method of empowerment, reducing dependence on seeds, fertilizers and other off farm inputs. On the other hand, participants in Australia practiced alternate farming as a method for healthy living. It may be concluded that farms may be regenerated through seed, soil, ecological preparations and knowledge that may lead to empowerment and self reliance.

Part two: A case study on the theme soil health

Enriching soil health

Participants from both the countries emphasized improving soil health, which consequently emerged as an important theme. In Australia the term 'soil health' was mentioned by the participants following organic and biodynamic practices. These farmers have a desire to manage the soil differently to prevent ecological problems of pest, disease and weed outbreaks, and to help crops thrive during unfavourable conditions like drought. This agrees with the insurance hypothesis stated by Yachi & Loreau (1999) that biodiversity helps farmers to survive during ecosystem imbalances of stress and disturbances which applies to soil biodiversity as well (Brussaard *et al.* 2007).

In India, participants of both the conventional and the organic system believe that soil is a living system which reflects the cultural dimension of environmental stewardship (Appiah-Opoku 2007). This also agrees with the statement of Leopold (1949) that land is more than a physical landscape for the native people and it includes the living environment. Although the participants benefited from escaping the ecosystem imbalances, conservation of land for future generations was emphasized. Although participants from both countries emphasized soil health there seem to be differences in the perception of soil health.

Perceptions of soil may be classified as belonging to either hard or soft systems paradigms. As stated by Blaikie et al., (1997) there are three types of development paradigms: classic, neo-liberal and neo-populist and each of these paradigms constitutes a system of thought that influences theoretical and normative assumptions about development. Perception of soil differs in each of these paradigms. The classic paradigm in reference to agriculture development, associated with replacing local knowledge with technological solutions and thereby eliminating farmers' participation, resulted in viewing soil as matter. As a result soil is seen as a 'hard' system with principles evolved from natural science as shown in the Figure 2. The neo-liberal paradigm attempts to balance local knowledge with technological solutions and practically reinforced the technical solutions. Soil is therefore seen as a living system, a view that is not hard systems alone but that integrates principles of both the natural and social sciences. The neo-populist approach, which emerged in contrast to the classic approach, respects local knowledge and empowers the farming community. This results in respecting the indigenous views of seeing soil with dimensions of spirituality. As represented in Figures 1, 2, and 3, there are no firm boundaries for any discipline. However the integration of principles and philosophies from natural sciences and social sciences occurred consistent with the paradigm represented in Figure 2. Theories that evolved within this paradigm are discussed in detail below.

Soil is seen as matter in Classic Paradigm

The basic soil science derived from the principles of natural science focused on soil surveys to assess the world's soil resources through soil classification, for land use management (van Baren *et al.* 2000) which is referred as Pedology, as shown in Figure 1. The influence of soil components on other living organisms inclusive of crops referred to as 'edaphology' is widely referred to as soil science. The findings on soil components greatly influenced management practices which are emphasized by many international organizations. Hence the influence of soil components on crops receives greater attention in the literature as elaborated below. Soil is seen as matter, supplying nutrients for the growth of the plants through organic constituents or through mineral nutrients. The organic constituent principle was suggested by pioneers J.G. Wallerius and Albrecht Thaer, laying the fundamentals of the alternative farming through the humus theory (Manlay *et al.* 2007).

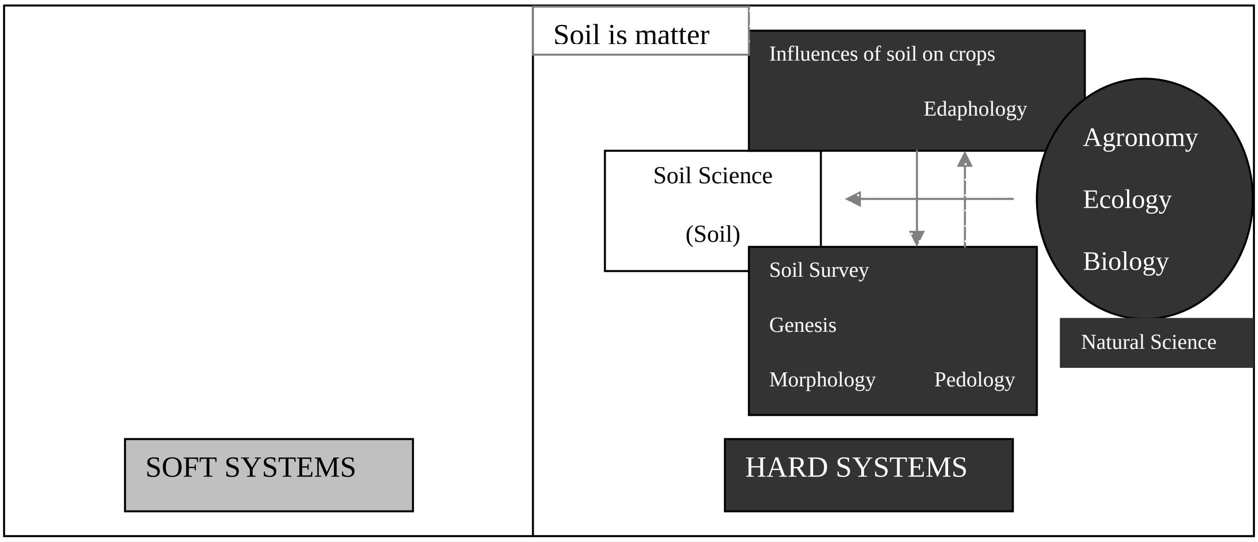

Figure 1. Perception of soil in the Classic Paradigm

The mineral nutrients principle was suggested by Justus von Liebig, Carl Sprengel, Bossingault, Lawes and Gilbert through rendering the humus theory with the Law of Minimum. This theory formed the basis for the modern High External Input Agriculture in the west and the green revolution in the east. Thus the education and research systems of the Western world mobilized to the rest of the world, through education, trainings and research projects, the theories derived from the hard systems perception of soil as matter (Mermut & Eswaran 2001). However the classic paradigm's technological solutions lead to the degradation of agricultural land through intensification in the production methods and causing environmental degradation (Houghton *et al.* 1983).

As environmental protection gained importance after the 1992 Earth Summit, soil came to be considered as a biological system. Thus the perceptual boundaries of soil expanded from the physical and chemical dimensions towards biological composition.

This put forth the need for integrated soil fertility management to balance inputs and output judiciously using both mineral nutrients and biological inputs. The hard system, through the integrated nutrient management approach, was challenged to optimize the mineral and biological inputs and encouraged farmers to manage nutrient flow through biological methods like nitrogen fixing crops, animal manure and applying fertilizers to complement them (Deugd *et al.* 1998). The latest development is precision farming that aims to maintain field diversity through decisions made with a combination of data inclusive of soil physical parameters (Jones & Barnes 2000).

It may be concluded that in spite of the discipline broadening from mineral constituents to biological constituents the perception of soil being matter has continued to exist in the classical paradigm.

Soil is seen as a living system – Neo liberal paradigm

The results of the classic paradigm as discussed in the previous section paved the way to the neo-liberal paradigm where the need was realized for integrated soil fertility management involving inputs and outputs being manipulated in a judicious way (Stoorvogel *et al.* 1993). Management practices maximizing local inputs and optimizing external inputs gained importance (Pretty 1995). This brought a change in management practice from High External Input Agriculture (HEIA) to a Low External Input Agriculture (LEIA) as shown in Figure 2. Soil fertility is a key component in both HEIA and LEIA with the goal of sustaining or improving yields. Soil fertility mining is compensated through fertilization with synthetic minerals in HEIA and organic nutrient sources in LEIA systems. LEIA, in spite of integrating natural resources causes adverse effects due to exploitation of natural resources (Shivakoti *et al.* 2005).

As locally available renewable resources remained the major nutrient source, LEIA also balanced the local knowledge of people with scientific solutions. Thereby the biological composition of the soil and indigenous knowledge on soils became widely recognized. Studies focused on biological composition inclusive of earth worms revealed the benefits and influences on the soil properties (Ester & van Rozen 2002). The biological components are used as an indicator for a healthy soil along with the physical and chemical factors (Pattison *et al.* 2008). The indicators are not only used as tools for assessing the favourable conditions of the soil but are also used as warnings for any serious damage. This agrees with the views of Barrios *et al.* (2006) that the indicators will be useful as the unobservable changes in the soil will be revealed before leading to visible changes, like soil degradation.

The knowledge of people interacting with the soil for a long time was recognized by some researchers (Barrios & Trejo 2003; Birmingham 2003), and began to be included to increase scientific understanding on soil. Studies showed that farmers' assessment of soil properties, although purely qualitative, yielded very similar results to those derived by scientific analysis of soil samples (Ali 2003). This suggested the need for a multidisciplinary approach (Sandor & Furbee 1996), combining both the hard and soft systems views (Payton *et al.* 2003), as it changed the perception of soil from matter to a living system.

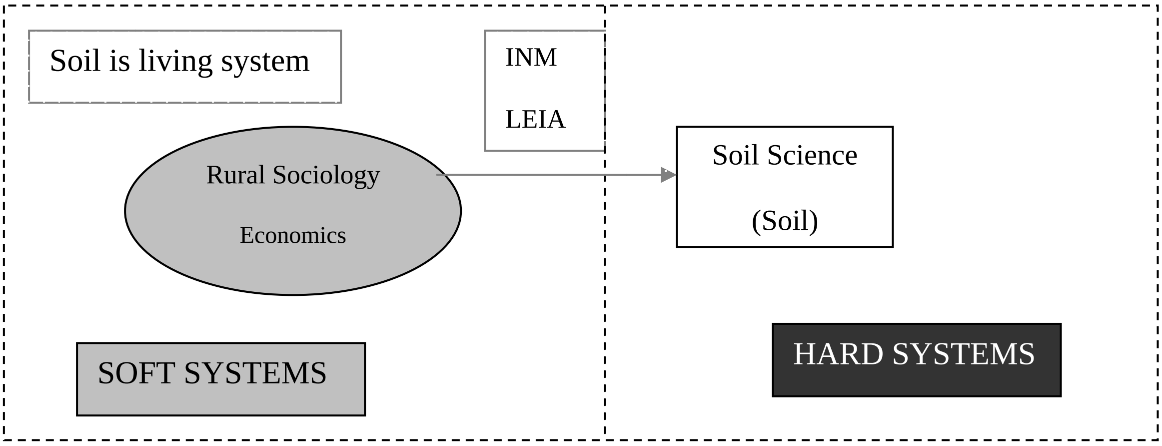

Figure 2. Perception of soil as living system – Neo-liberal Paradigm

INM – Integrated Nutrient Management LEIA – Low External Input Agriculture

Soil seen as a spiritual system – Neo-populist paradigm

The Neo-populist paradigm emerged opposing the classic paradigm demanding a change in the ways of thinking and knowing. As a result, alternative farming systems gained importance. These farming principles are strongly opposed to the mineral nutrition theory derived in the classic paradigm as the minerals are perceived to cause lethal effects on living soil organisms. Thus the biological organisms central to the philosophy of the alternative farming like natural farming, organic farming, biodynamics etc. became indicators of healthy soil (Paoletti 1999), and also served as tools to compare both the alternative and conventionally managed soils.

In this paradigm, indigenous knowledge is considered to be indispensable rather than a mere addition to scientific findings, hence disciplines like EthnoEcology, Ethnopedology etc, emerged, as shown in the Figure 3. It is accepted that farmers perceive soil more holistically than researchers do (Ingram *et al.* 2008) and that the cultural connection with the soil is spiritual rather than for its fertility utility alone. As stated by Barrera-Bassols and Zinck (2003) the assumption underlying the ethno-ecological approach is that the human use of landscape is beyond the merely materialistic, and that the techno-productive phenomenon can be better understood through exploring cultural connections.

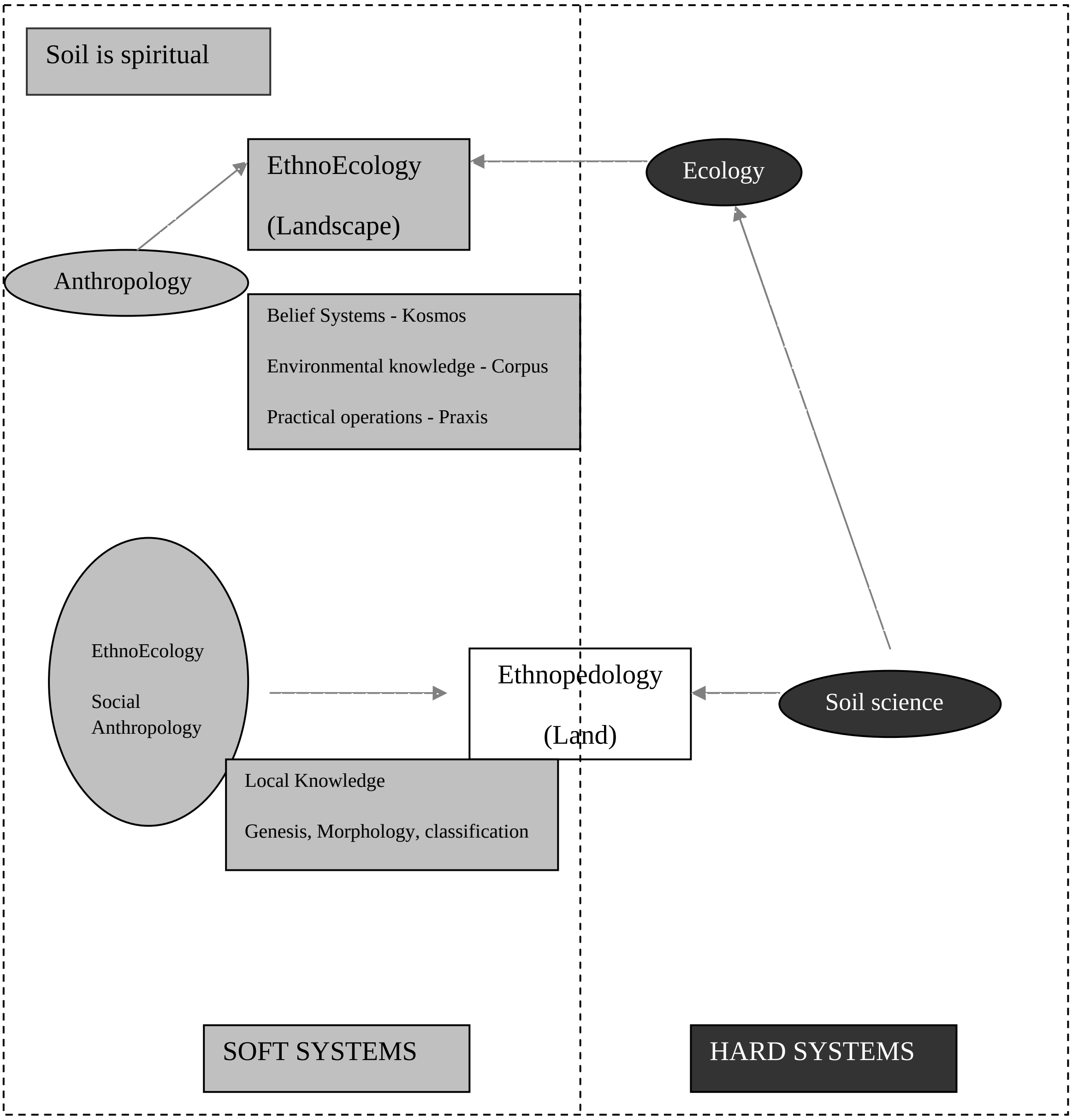

Figure 3. Perception of soil as spiritual - Neo-populist paradigm

‘Ethnopedology’-is the local knowledge and understanding of soil genesis, morphology and classification. The discipline initiated as a sub discipline of ‘EthnoEcology’ has broadened as a hybrid discipline by combining both the soft and hard systems. Ethno Ecology is an interdisciplinary study of local environmental knowledge with the K (Kosmos) - C (Corpus) – P (Praxis) frame work.

The cultural connection with nature as spiritual includes soil as a component of earth. Earth is respected for its feminine qualities for bearing and protecting vital processes. For instance, Earth is denoted as Bhoomadevi in southern parts of India (Tamil name meaning goddess) and in the Andean region considered as Pachamama (Winklerprins & Barrera-Bassols 2004). Many cultures considered Agriculture as a part and parcel of nature and with the sun playing a major role. It is believed that nature is beyond human control and so is agriculture. Agriculture is made to operate successfully through offerings of ritual tributes made to the Mother Earth. Many cultures practiced patterns of offerings and sacrifices. Human sacrifices were made long back in history (eg. in Athens and India). Thanksgiving rituals are also commonly practiced in many cultures - as Zimmerer puts it 'Earth Mother needs to be constantly thanked through ritualistic tribute'(Zimmerer 1996). A thanksgiving festival called Thai Pongal is celebrated to thank Nature, the Sun and Farm Animals in providing a successful harvest in the Southern part of India.

The interviews in India revealed that some farmers, despite having implemented conventional practices for some time, continue to reflect spiritual connections with the soil. For example, one observed *'like any other living thing the soil needs to breathe, Soil needs water when it is thirsty, Soil needs to be fed with organic manures, Soil needs be covered with a blanket (soil mulch) etc'.* This is also observed by Winklerprins and Barrera-Bassols (2004, p. 146) as follows: *'Soil "strength" is balanced through periods of "weakness" and "recovery." The land "works," thus requiring "resting" when it is "tired;" it needs to be fed when "hungry" and needs to "drink" when thirsty to recuperate its strength. A fertile soil may become unfertile after "working" for several years and then needs to be left to "rest" (fallow) as any other living being'.*

The shift in paradigms clearly explains the changes in the perception of soil by the scientific disciplines, covering the entire spectrum from viewing soil as matter at one extreme, to seeing it as a living system and to be respected in a spiritual context, at the other. Farmers in both the countries are subjected to these influences through interventions. Hence it may be concluded that practitioners or farmers making transition to alternate farming systems need to be aware of the alternate perceptions of the soil, if they are to make a long term change towards sustainability. Table 1 below sets out an extension of the three paradigm view (seeing, knowing and doing) of soil with a six-part typology, with the characteristic perceptions and related approaches to management of cost and benefit.

Table I. Typology of views of soil and associate management approaches

Typology	**Characteristic**	**Management**
High Reductionist perception	People perceive that soil is a *non living entity*.	Cost: *Remedial measures* of application of inorganic inputs for increasing production and for immediate solutions Benefit: Profit on harvest and *farm residues*
Less Reductionist perception	People perceive that soil is *a non living entity encompassing living organisms*.	Cost: *Remedial measures* of application of both organic and inorganic inputs for increasing production and for immediate solutions Benefit: Profit on harvest, *reducing inorganic inputs*
Intermediary between reductionist and holistic perception	People perceive that soil is a *non living entity constituting living* organisms.	Cost: *Managing* application of on farm residues, organic inputs and using inorganic inputs where ever essential Benefit: Profit on harvest, reducing inorganic inputs and *to retain the efficiency of inorganic inputs*.
Less Holistic perception	People perceive that soil is a living entity constituting living organisms.	Cost: *Substituting* on farm residues and organic inputs for inorganic inputs as a requirement for market values Benefit: Profit on harvest and reducing inorganic inputs, preventing loss due to erosion, pest out break, biodiversity etc
Holistic perception	People perceive that soil is a living system.	Cost: Soil balance attained through combination of practices, Environmental degradation costs Benefit: Profit on harvest and avoiding non renewable inorganic inputs, recycling farm produces, protecting the land for future generations and ecosystem diversity
Spiritual perception	People perceive soil as a myth and possessing blessing of spiritual power.	Cost: Farm activities based on faith and belief Benefit: Living on harvest and keeping the land and the spirits happy with rituals

High Reductionist perception

This is the first level of perception reflecting the ethos of the reductionist paradigm or the conventional paradigm. It strongly reflected non-acceptance of transition either through ignorance or denial.

Less Reductionist perception

This is the second level of perception that reveals little acceptance of transition. This is the first stage where attempts to transition may be initiated.

Intermediary between reductionist and holistic perception

The third level of perception is caught between the conflicting ethos of the reductionist and holistic paradigms. Questioning the underlying assumptions may help the transition process.

Less Holistic perception

The fourth level of perception is favourable for transition. However, the ethos of the previous paradigm still exists unconsciously.

Holistic perception

The fifth level of perception reveals a satisfactory transition to the holistic paradigm. The ethos of the holistic paradigm is built in strongly.

Spiritual perception

The ethos of the sixth level of perception reflects neither the reductionist nor the holistic paradigm. Studies still need to be conducted to understand if it favours the transition process.

The typology of the perception of soil tool will help people to understand where they fit in within the typology and will be useful to explore different options to improve practices.

Conclusion

Several common themes including Enriching soil health, Knowledge sharing, Diversity, Learning, Indigenous knowledge/local knowledge and Farm Sufficiency emerged through interviews with farmers in Australia and India who had experience in transition from conventional to alternate farming approaches. These themes suggest that the transition process is more complex than merely changing approaches to manipulation of inputs and outputs as the themes are interrelated and thus, contribute to the complexity. The case study on the theme enriching soil health reveals the complexity of transition as the interrelations of the themes are discussed during different stages. For instance the perception of soil reflects on the biophysical and socio-cultural principles of soil discussed in the theme – ‘Diversifying through biophysical and sociocultural methods'. Also, the existence of the indigenous knowledge/local knowledge built on faith and values also plays a vital role in influencing the perception. It may be concluded that the typology of soil will extend to deep perceptions and beliefs about the nature of soil and how one should relate to it.

References

Ali, AMS 2003, 'Farmers' knowledge of soils and the sustainability of agriculture in a saline water ecosystem in Southwestern Bangladesh', *Geoderma*, vol. 111, no. 3-4, pp. 333-53.

Altieri, MA 1994, *Biodiversity and pest management in agroecosystems*, Food Products Press, New York.

Appiah-Opoku, S 2007, 'Indigenous beliefs and environmental stewardship: a rural Ghana experience', *Journal of Cultural Geography*, vol. 24, no. 2, pp. 79-98.

Baars, E & Baars, T 2007, 'Towards a philosophical underpinning of the holistic concept of integrity of organisms', *Netherlands Journal of Agricultural Science*, vol. 54, no. 4, pp. 463-77.

Barrera-Bassols, N & Zinck, JA 2003, 'Ethnopedology: a worldwide view on the soil knowledge of local people', *Geoderma*, vol. 111, no. 3-4, pp. 171-95.

Barrios, E, Delve, RJ, Bekunda, M, Mowo, J, Agunda, J, Ramisch, J, Trejo, MT & Thomas, RJ 2006, 'Indicators of soil quality: A South-South development of a methodological guide for linking local and technical knowledge', *Geoderma*, vol. 135, pp. 248-59.

Barrios, E & Trejo, MT 2003, 'Implications of local soil knowledge for integrated soil management in Latin America', *Geoderma*, vol. 111, no. 3-4, pp. 217-31.

Birmingham, DM 2003, 'Local knowledge of soils: the case of contrast in Côte d'Ivoire', *Geoderma*, vol. 111, no. 3-4, pp. 481-502.

Blaikie, P, Brown, K, Stocking, M, Tang, L, Dixon, P & Sillitoe, P 1997, 'Knowledge in action: Local knowledge as a development resource and barriers to its incorporation in natural resource research and development', *Agricultural Systems*, vol. 55, no. 2, pp. 217-37.

Brussaard, L, de Ruiter, PC & Brown, GG 2007, 'Soil biodiversity for agricultural sustainability', *Agriculture, Ecosystems & Environment*, vol. 121, no. 3, pp. 233-44.

Deugd, M, Röling, N & Smaling, EMA 1998, 'A new praxeology for integrated nutrient management, facilitating innovation with and by farmers', *Agriculture, Ecosystems & Environment*, vol. 71, no. 1-3, pp. 269-83.

Dick, B 1990, *Convergent interviewing*, 3. edn, Interchange, Chapel Hill, Qld.

Driedger, SM, Gallois, C, Sanders, CB, Santesso, N & Effective Consumer Investigator, G 2006, 'Finding common ground in team-based qualitative research using the convergent interviewing method', *Qualitative Health Research*, vol. 16, no. 8, pp. 1145-57.

Ester, A & van Rozen, K 2002, 'Earthworms (Aporrectodea spp.; Lumbricidae) cause soil structure problems in young Dutch polders', *European Journal of Soil Biology*, vol. 38, no. 2, pp. 181-5.

Faure, G 2004, 'Characterization of a collective action between farmers' organizations and institutions in an innovative process to face liberalization in Costa Rica', *The Journal of Agricultural Education and Extension*, vol. 10, no. 3, pp. 121 - 31.

Houghton, RA, Hobbie, JE, Melillo, JM, Moore, B, Peterson, BJ, Shaver, GR & Woodwell, GM 1983, 'Changes in the carbon content of terrestrial biota and soils between 1860 and 1980 - a net release of co2 to the atmosphere', *Ecological Monographs*, vol. 53, no. 3, pp. 235-62.

Ingram, J, Fry, P & Mathieu, A 2008, 'Revealing different understandings of soil held by scientists and farmers in the context of soil protection and management', *Land Use Policy*, vol. In Press, Corrected Proof.

Jones, D & Barnes, EM 2000, 'Fuzzy composite programming to combine remote sensing and crop models for decision support in precision crop management', *Agricultural Systems*, vol. 65, no. 3, pp. 137-58.

Katsvairo, TW, Wright, DL, Marois, JJ & Rich, JR 2007, 'Transition from conventional farming to organic farming using bahiagrass', *Journal of the Science of Food and Agriculture*, vol. 87, no. 15, pp. 2751-6.

Leopold, A 1949, *A Sand County almanac*, Oxford University Press, Oxford.

Manlay, RJ, Feller, C & Swift, MJ 2007, 'Historical evolution of soil organic matter concepts and their relationships with the fertility and sustainability of cropping systems', *Agriculture, Ecosystems & Environment*, vol. 119, no. 3-4, pp. 217-33.

Mermut, AR & Eswaran, H 2001, 'Some major developments in soil science since the mid-1960s', *Geoderma*, vol. 100, no. 3-4, pp. 403-26.

Nabhan, GP 1997, *Cultures of Habitat: On Nature, Culture, and Story*, DC: Counterpoint., Washington.

Norton, L, Johnson, P, Joys, A, Stuart, R, Chamberlain, D, Feber, R, Firbank, L, Manley, W, Wolfe, M, Hart, B, Mathews, F, Macdonald, D & Fuller, RJ 2009, 'Consequences of organic and non-organic farming practices for field, farm and landscape complexity', *Agriculture, Ecosystems & Environment*, vol. 129, no. 1/3, pp. 221-7.

Paoletti, MG 1999, 'The role of earthworms for assessment of sustainability and as bioindicators', *Agriculture, Ecosystems & Environment*, vol. 74, no. 1-3, pp. 137-55.

Pattison, AB, Moody, PW, Badcock, KA, Smith, LJ, Armour, JA, Rasiah, V, Cobon, JA, Gulino, LM & Mayer, R 2008, 'Development of key soil health indicators for the Australian banana industry', *Applied Soil Ecology*, vol. 40, no. 1, pp. 155-64.

Payton, RW, Barr, JJF, Martin, A, Sillitoe, P, Deckers, JF, Gowing, JW, Hatibu, N, Naseem, SB, Tenywa, M & Zuberi, MI 2003, 'Contrasting approaches to integrating indigenous knowledge about soils and scientific soil survey in East Africa and Bangladesh', *Geoderma*, vol. 111, no. 3-4, pp. 355-86.

Pretty, JN 1995, *Regenerating agriculture : policies and practice for sustainability and self-reliance*, Earthscan Publications, London.

Robinson, J 2004, 'Squaring the circle? Some thoughts on the idea of sustainable development', *Ecological Economics*, vol. 48, no. 4, pp. 369-84.

Röling, N & van de Fliert, E 1994, 'Transforming extension for sustainable agriculture: The case of integrated pest management in rice in Indonesia', *Agriculture and Human Values*, vol. 11, no. 2, pp. 96-108.

Röling, NG & Wagemakers, MAE 1998, *Facilitating sustainable agriculture : participatory learning and adaptive management in times of environmental uncertainty*, Cambridge University Press, Cambridge.

Sandor, JA & Furbee, L 1996, 'Indigenous Knowledge and Classification of Soils in the Andes of Southern Peru', *Soil Science Society of America Journal*, vol. 60, no. 5, pp. 1502-12.

Shivakoti, G, Ghale, Y & Upreti, B 2005, 'The ecological dynamics of low external input agriculture: A case study of hill farming in a developing country', *The International Journal of Sustainable Development and World Ecology*, vol. 12, pp. 385-97.

Silvasti, T 2003, 'The cultural model of "the good farmer" and the environmental question in Finland', *Agriculture and Human Values*, vol. 20, no. 2, pp. 143-50.

Stoorvogel, JJ, Smaling, EMA & Janssen, BH 1993, 'Calculating soil nutrient balances in Africa at different scales', *Nutrient Cycling in Agroecosystems*, vol. 35, no. 3, pp. 227-35.

Thompson, PB 1995, *The spirit of the soil : agriculture and environmental ethics*, Routledge, London.

van Baren, H, Hartemink, AE & Tinker, PB 2000, '75 years The International Society of Soil Science', *Geoderma*, vol. 96, no. 1-2, pp. 1-18.

van de Fliert, E, Dung, NT, Henriksen, O & Dalsgaard, JPT 2007, 'From Collectives to Collective Decision-making and Action: Farmer Field Schools in Vietnam', *The Journal of Agricultural Education and Extension*, vol. 13, no. 3, pp. 245-56.

Winklerprins, AMGA & Barrera-Bassols, N 2004, 'Latin American ethnopedology: A vision of its past, present, and future', *Agriculture and Human Values*, vol. 21, no. 2, pp. 139-56.

Yachi, S & Loreau, M 1999, 'Biodiversity and ecosystem productivity in a fluctuating environment: The insurance hypothesis', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 96, no. 4, pp. 1463-8.

Youyong, Z, Hairu, C, Jinghua, F, Yunyue, W & et al. 2000, 'Genetic diversity and disease control in rice', *Nature*, vol. 406, no. 6797, pp. 718-22.

Zimmerer, KS 1996, *Changing Fortunes: Biodiversity and Peasant Livelihood in the Peruvian Andes*, University of California Press., Berkeley.