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

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

School of Natural and Rural Systems Management, The University of Queensland, (Gatton Campus), Gatton, Queensland, Australia

Gomathy Palaniappan is doctoral student in the school of Natural and Rural Systems Management at The University of Queensland (Gatton Campus), Australia. The research was undertaken as a holder of International Post graduate Research Scholarship. Part of the research was conducted in India as a holder of University of Queensland Graduate School Research Travel Grant.

E-mail: g.palaniappan@uq.edu.au

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

E-mail: christine.king@uq.edu.au or E-mail: dcameron@uqg.uq.edu.au

Correspondence to:

Gomathy Palaniappan, Ph.D. candidate, School of Natural and Rural Systems Management, The University of Queensland, (Gatton Campus), Gatton, Queensland, Australia 4343 Phone: 61 7 5460 1696 Fax: +61 7 54601324

The word count of the paper is:4289 (excluding references)

Affirmation statement: The authors hereby affirm that the paper entitled **Complexity of transition to alternate farming systems – more than substitution of inputs** is original based on authors' research findings and has not been published elsewhere.

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

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 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 a mere substitute of inputs may not be sufficient for making transitions to sustainable systems. Effective transition requires a fundamental change in the way soil is viewed.

Introduction

Controversies on industrialized versus alternative farming have had no apparent influence on the demand for organic produce as it is been increasing rapidly all over the world. The rate of farm conversion to alternative farming systems is relatively slow, the consequences arguably being continued risks to natural resources and lives on the planet. This has raised questions regarding the complexity involved in the process of making transition. This paper investigates the complexity in making transitions to alternative farming approaches by considering the complex nature of the system in Australia as an example of the western world practicing modern agriculture and in India as an example of the developing world with indigenous farming practices. Farmers making 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.

Background:

As suggested by Marshall (1993) 'conventional farming' describes a reductionist approach (maximizing production through removing nutrients, weeds and pests). Economic motivation played a major role in the process of transition from previous, lower input production systems towards modern industrialized agriculture. One result was a disattachment of farmers' association with nature (Jackson, 1980). Alternative farming, ranging from Low Input Biological control/Integrated Pest Management to Chemical free Biodynamic/Organic to Wild harvest (McCoy & Parlevliet, 2000), constitutes a more holistic approach (recycling nutrients, management of pest and weeds). Hence 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, and there is a need for new methods to deal with the complexity of the transition and spread the change widely (Röling, NG & Wagemakers, 1998).

Methodology:

This research was based on the premise that farmers who had made or were making the transition from conventional to alternative, more sustainable forms of production were well placed to provide guidance suitable for developing into learning tools suitable for individuals contemplating it themselves or supporting the change by others. Among the wide choice of methodology available, action research was chosen as an appropriate way for a researcher to (1) develop understanding of the complexity of transition within complex social situations in the real world, and (2) to address ambiguous situations where the solutions were unique to every individual. Action research methodology being participatory in nature helped the researcher to involve people to participate in the research cycle of plan, act, observe and reflect spiral attributed to Kurt Lewin (Lewin, 1946).

Convergent interviewing

As one part of the research convergent interviewing method was used to collect data. This is an in depth interviewing method developed by Dick in Australia (Dick, 1990) 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 arrived. The interviewing process was stopped on obtaining answers to the secondary questions or when no new themes emerged.

Results and discussion

Part One: Themes for transition

Themes that emerged from the convergent interviewing process in both the countries are discussed in this section. Themes are not independent of each other and to make a transition the themes need to be understood by both the farmers intending to make the change and the change agent supporting the farmer. The main themes that emerged are listed below and depicted in Figure 1.

1. Knowledge sharing through networking
2. Diversity through Species diversity / Genetic diversity / Integrity of organisms / Native culture / Extrinsic values
3. Learning through action, observation and reflection

4. Indigenous knowledge
5. Self sufficiency
6. Enriching soil health through perceptional change

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

1. 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. This is due to the existence of competitive market (Maria, 2007) and to peer pressure (Elfreda, 1996). Participants in India shared most of the knowledge due to lack of competitive market and for attaining ecological balances. This agrees with the statement of van de Fliert et al., (2007) that smallholder 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 (Moore, 2008) and helped farmers and consumers to directly connect with each other (King, 2008). 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. Hence to promote transitions at a larger scale, factors hindering knowledge sharing need to be addressed by practioners and policy makers.

2. Diversifying through biophysical and sociocultural methods

Biodiversity is essential for human life and plays an important role in farming. Hence during the interviews, diversifying farming for both economic and ecological benefits was mentioned by the participants. As stated by Baars and Baars, the first step to enhancing biodiversity is to stop applying chemicals in the farm, the second is to follow ecological principles and the third is to respect the integrity of other living organisms (Baars & Baars, 2007). 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 extrinsic values. These are depicted in Figure 1.

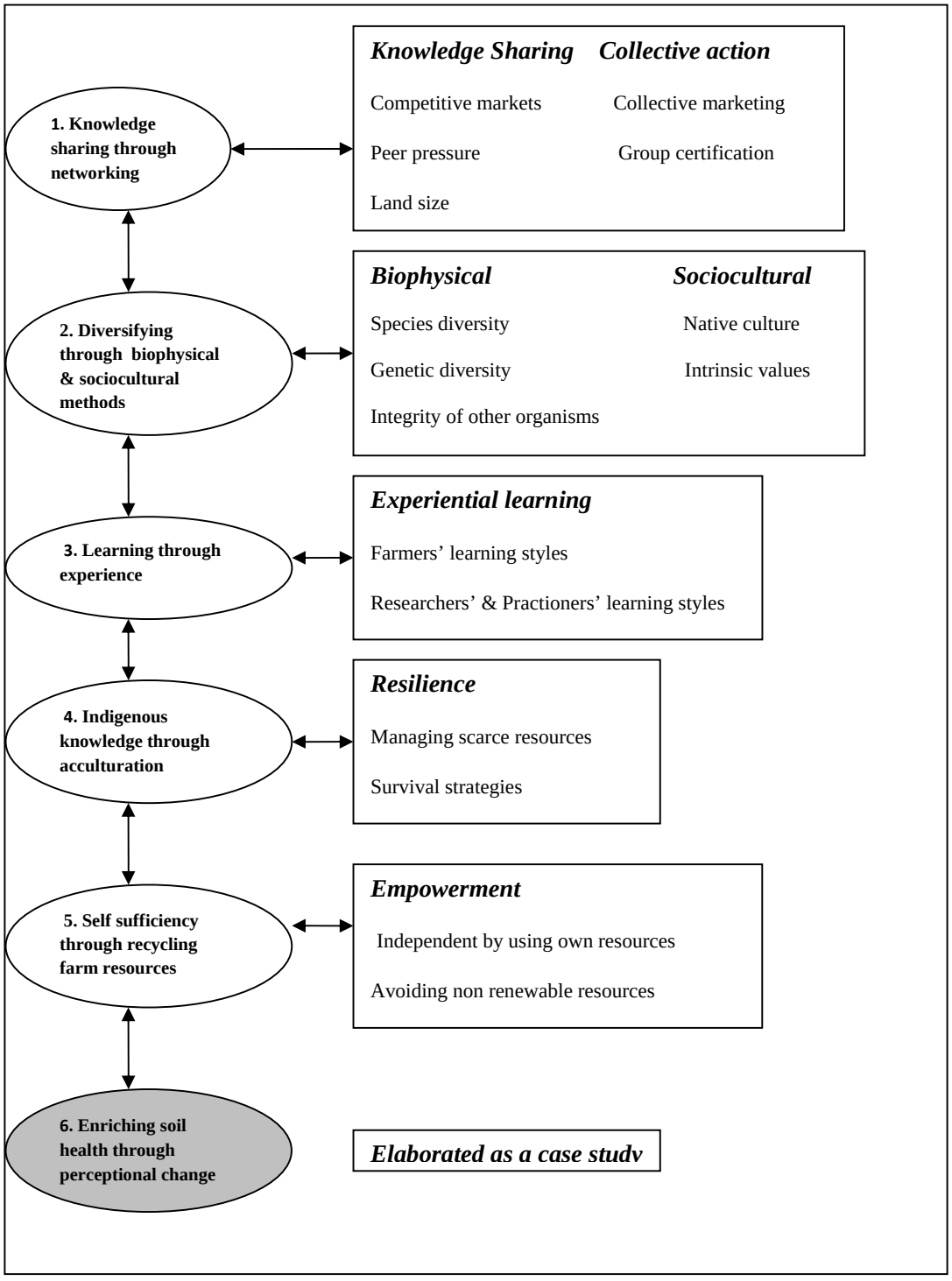

Figure 1. Themes for transition process

2.1. Bio-Physical diversity

2.1.1. 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).

2.1.2. 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 diverse diet for both human and animals (Altieri, 1999), did not involve high investments or technology thereby minimizing risk (Altieri, 1994). This agrees with the statement of Sejdo that the Southern part of the world is "gene rich and technologically poor"(Sedjo, 1992).

2.1.3. 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.

2.2. Socio-cultural

2.2.1. 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). This may be supported with the findings of Sinha and Wertz. Sinha's findings reveal that the tribal people in India preserve their culture and farm practices (Sinha, 1997) and (Wertz, 2005) states that the Native North Americans preserved biodiversity through cultural diversity.

2.2.2. Preserving intrinsic values for diversity

Participants insisted that to maintain diversity they need to have certain values such as self interest to preserve the land for future generation, to produce healthy food for both their family and their society. This falls under the 'conservationist' position that favours protection of natural areas with self-interest, conserving land and resources for later human use (Robinson, 2004). Lockwood argues, in support of the 'conservationist' position, that in order to restore and preserve biodiversity one must attempt to think and feel towards gaining

intrinsic or unconditional values (Lockwood, 1999). The Ecofeminist approach for biodiversity also puts forth a similar view stating that women farmers show connectedness which is also far from conventional values (Sachs, 1992).

3. Learning through experience

Participants have been through an experiential learning process of trial and error and observation making judgements rather than relying on external expertise alone. This agrees to the statement of Röling, N 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.

4. Indigenous knowledge through acculturation

Participants in India admitted the influence of western science and values dominating over their indigenous values. Hence interviewed farmers had been encouraged to document indigenous knowledge as very limited is passed on to the younger generation, agreeing with the statement of Osherenko (1988) that through the process of acculturation, indigenous beliefs are no longer passed on to the younger generations. The indigenous knowledge documented possessed survival strategies for resilience.

5. Self sufficiency through recycling farm resources

Participants in India practiced alternative farming as a method of empowerment preventing dependence on seeds, fertilizers and other off farm inputs. Thus alternate farming helps to achieve the goal of sustainability through empowerment (Pezzoli, 1997).

Part two: A case study on the theme soil health

6. Enriching soil health

Participants from both the countries emphasized on improving soil health which 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 environment 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 (Röling, N & van de Fliert, 1994; Yachi & Loreau, 1999) 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 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 emerged in contrast to the classic approach respecting the local knowledge and empowering the farming community. This resulted in respecting the indigenous views of seeing soil with spirituality. As represented in Figures 2, 3, and 4 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 evolved within this paradigm are discussed in detail below.

6.1. 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 and formation, for land use management (van Baren et al., 2000) which is referred as Pedology as show in Figure 2. The influence of soil components on other living organisms inclusive of crops referred as edaphology is widely referred as soil science. The findings on soil components greatly influenced management practices (Manlay et al., 2007) which is emphasized by many international organizations (Mermut & Eswaran, 2001). 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 (Russell & Russell, 1950) and Albrecht Thaer, laying the fundamentals of the alternative farming through the humus theory (Manlay et al., 2007).

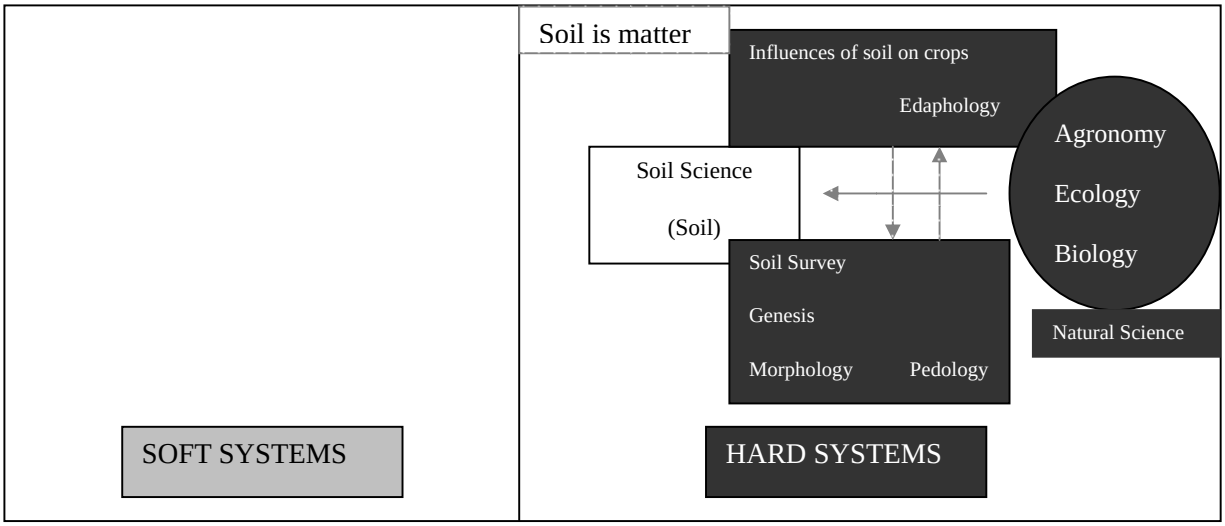

Figure 2. Perception of soil in the Classic Paradigm

The mineral nutrients principle was suggested by Justus von Liebig, Carl Sprengel, Bossingault, Lawes and Gilbert (Russell & Wild, 1988) 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 Western world mobilized the theories derived from the hard systems' perceiving soil as matter, to the rest of the world through education, trainings and research projects, which is also mentioned by Mermut & Eswaran (2001) However the classic paradigm's technological solutions lead to the degradation of agricultural land (Waldon et al. 1998) through intensification in the production methods and causing environmental degradation (Houghton et al. 1983).

As environmental protection gained importance after the 1992 Earth Summit (Talawar & Rhoades, 1998), soil came to be considered as biological system (Doran, J. W., 1994; Doran, John W. & Zeiss 2000) (Talawar & Rhoades 1998). Thus the perceptual boundaries of soil expanded from the physical and chemical dimensions towards biological composition (Hole, 1981; Sherwood & Uphoff, 2000).

This put forth the need for integrated soil fertility management to balance inputs and output judiciously (Stoorvogel et al., 1993) 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 aiming 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 continued to exist in the classical paradigm.

6.2. Soil is seen as 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 (Pretty, 1995) gained importance. This brought a change in management practice from High External Input Agriculture (HEIA) to a Low External Input Agriculture (LEIA) as shown in Figure 3. below. 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 (Liebman, 2000). LEIA, in spite of integrating natural resources causes adverse effects due to exploitation of natural resources (Kessler & Moolhuijzen, 1994; Blaikie et al., 1997; Shivakoti et al., 2005)

As locally available renewable resources remained the major nutrient source (Reijntjes et al., 1992), 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 (Syers et al., 1979) and influences on the soil properties (Ester & van Rozen, 2002). Hence biological components are used as an indicator for a healthy soil along with the physical and chemical factors (Abawi & Widmer, 2000; Mele & Crowley, 2008; 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 statement of Barrios that the indicators will be useful as the unobservable changes in the soil will be revealed before leading to visible changes like soil degradation (Barrios et al. 2006).

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 (Sandor & Furbee, 1996). 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, which created with many issues (Payton et al., 2003), as it changed the perception of soil from matter to a living system.

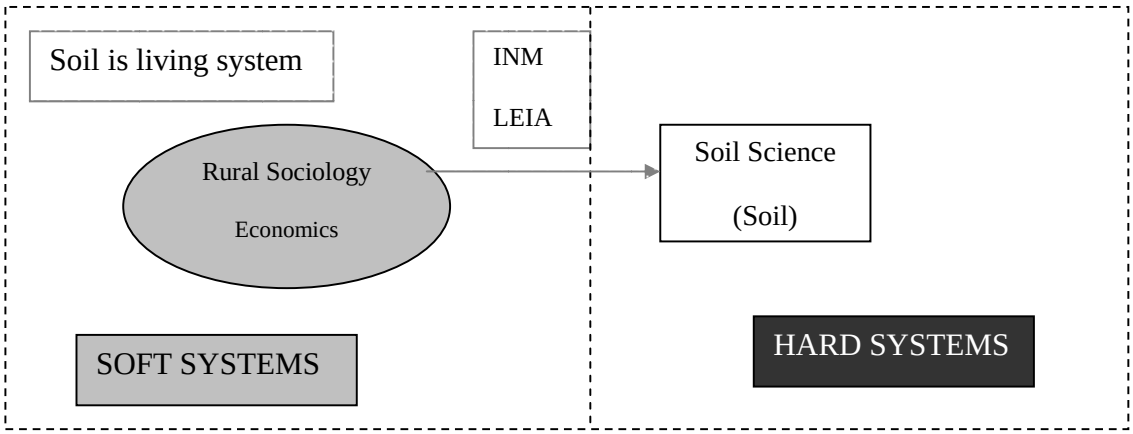

Figure 3. Perception of soil as living system – Neo-liberal Paradigm

INM – Integrated Nutrient Management LEIA – Low External Input Agriculture

6.3. Soil seen as a spiritual system – Neo-populist paradigm

The Neo-populist paradigm emerged opposing the classic paradigm (Blaikie et al., 1997) demanding a change in the ways of thinking and knowing (Sriskandarajah & Dignam, 1992). 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 (Lobry de Bruyn, 1999; Paoletti, 1999) and also served as tools to compare both the alternative and conventionally managed soils (Andrews et al., 2003).

In this paradigm, indigenous knowledge is considered to be indispensable (Blaikie et al., 1997) rather than a mere addition to scientific findings, hence disciplines like agroecology (Dalgaard et al., 2003), ethnobiology, ethnopedology (Siderius & de Bakker, 2003)etc, emerged, as shown in the Figure 4. below. It is accepted that farmers perceive soil more holistically than researchers do (Desbiez et al., 2004; 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 & 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.

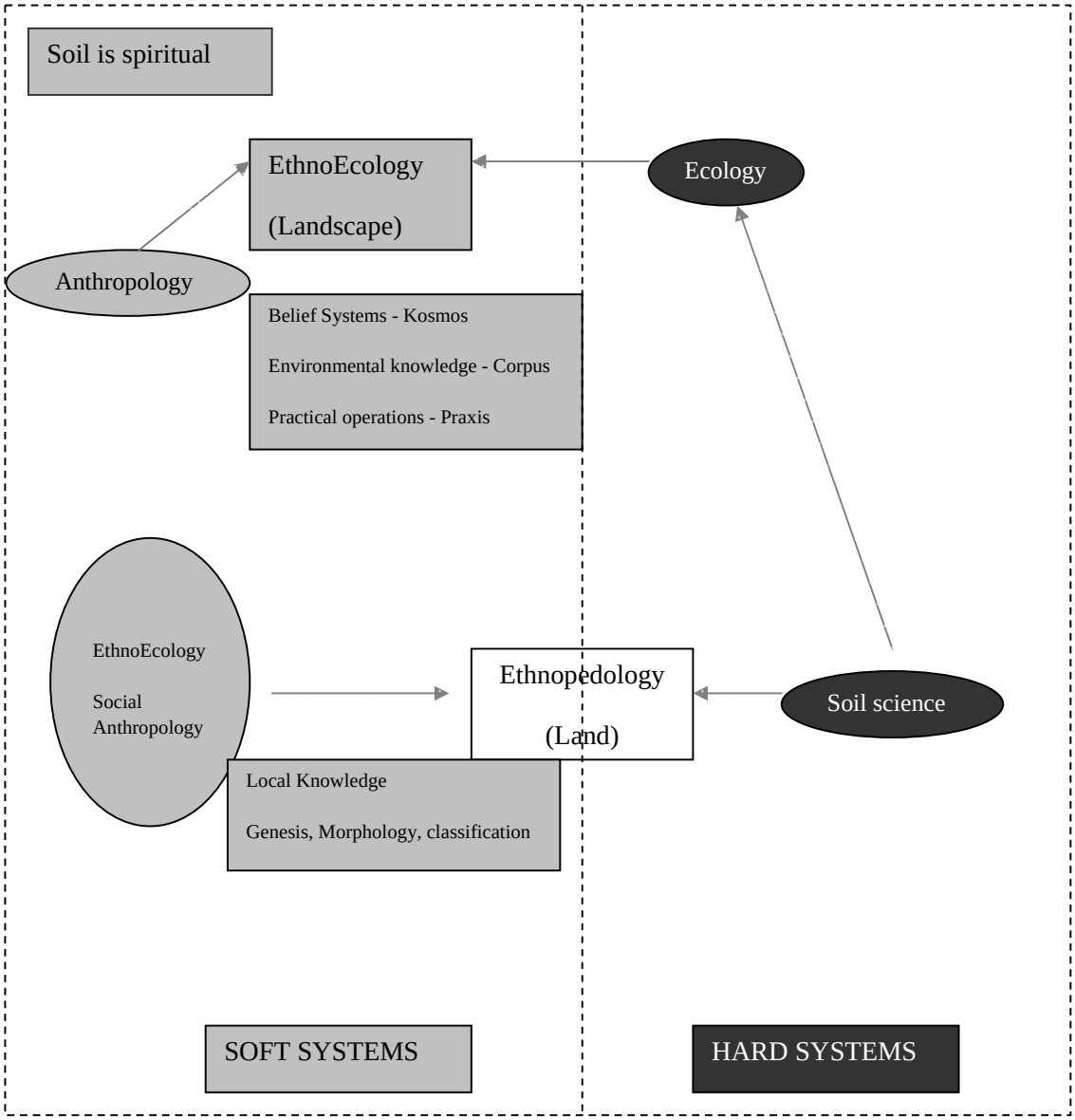

Figure 4. Perception of soil as spiritual - Neo-populist paradigm

Ethnopedology is the local knowledge and understanding of soil genesis, morphology and classification. The discipline initiated as a sub discipline of Ethno Ecology 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 (Sampietro Vattuone et al., 2008). 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. Hence agriculture is made to operate successfully through offerings of ritual tributes made to the Mother Earth. Many cultures practiced patterns of offerings and sacrifices. As stated by (Nikola Patzel, 2000) 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 thanks giving festival called Thai Pongal is celebrated to thank Nature, the Sun and Farm Animals in providing a successful harvest in 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 & Barrera-Bassols, 2004) *'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'.*

However in spite of spiritual values held by many farmers, the exploitation of natural resources, particularly in developing countries, continues. As stated by Hitzhusen, the exploitation is because these resources are not priced at the marginal social values of localities (Hitzhusen, 1993).

Hence 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 the alternate farming system 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 of soil with a six-part typology, with the characteristic perceptions and related approaches to management of cost and benefit. This table provides insights on the various assumptions behind following certain management practices based on which changes may be made.

Table 1. 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

Conclusion

Several common themes 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. The case study on the theme enriching soil health reveals the complexity of transition extends to deep perceptions of and beliefs about the nature of soil and how one should relate to it.

References

Abawi, GS & Widmer, TL 2000, 'Impact of soil health management practices on soilborne pathogens, nematodes and root diseases of vegetable crops', *Applied Soil Ecology*, vol. 15, no. 1, pp. 37-47.

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.

Altieri, MA 1999, 'The ecological role of biodiversity in agroecosystems', *Agriculture, Ecosystems & Environment*, vol. 74, no. 1-3, pp. 19-31.

Andrews, SS, Flora, CB, Mitchell, JP & Karlen, DL 2003, 'Growers' perceptions and acceptance of soil quality indices', *Geoderma*, vol. 114, no. 3-4, pp. 187-213.

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

Baars, E & Baars, T 2007, 'Towards a philosophical underpinning of the holistic concept of integrity of organisms', *NJAS wageningen journal of life sciences*, 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, no. 1/4, 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.

Dalgaard, T, Hutchings, NJ & Porter, JR 2003, 'Agroecology, scaling and interdisciplinarity', *Agriculture, Ecosystems & Environment*, vol. 100, no. 1, pp. 39-51.

Desbiez, A, Matthews, R, Tripathi, B & Ellis-Jones, J 2004, 'Perceptions and assessment of soil fertility by farmers in the mid-hills of Nepal', *Agriculture, Ecosystems & Environment*, vol. 103, no. 1, pp. 191-206.

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 resource document., Interchange, Chapel Hill, Qld.

Doran, JW 1994, *Defining soil quality for a sustainable environment : proceedings of a symposium sponsored by Divisions S-3, S-6, and S-2 of the Soil Science Society of America, Division A-5 of the American Society of Agronomy, and the North Central Region Committee on Soil Organic Matter (NCR-59) in Minneapolis, MN, 4-5 November 1992*, SSSA special publication, Soil Science Society of America, Madison, Wis.

Doran, JW & Zeiss, MR 2000, 'Soil health and sustainability: managing the biotic component of soil quality', *Applied Soil Ecology*, vol. 15, no. 1, pp. 3-11.

Driedger, SM, Gallois, C, Sanders, CB & Santesso, N 2006, 'Finding Common Ground in Team-Based Qualitative Research Using the Convergent Interviewing Method', *Qualitative Health Research*, vol. 16, no. 8, pp. 1145-57.

Elfreda, AC 1996, 'The impoverished life-world of outsiders', *Journal of the American Society for Information Science*, vol. 47, no. 3, pp. 193-206.

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.

Hitzhusen, FJ 1993, 'Land degradation and sustainability of agricultural growth: some economic concepts and evidence from selected developing countries', *Agriculture, Ecosystems & Environment*, vol. 46, no. 1-4, pp. 69-79.

Hole, FD 1981, 'Effects of animals on soil', *Geoderma*, vol. 25, no. 1-2, pp. 75-112.

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.

Jackson, W 1980, *New roots for agriculture*, Friends of the Earth ; Salina Land Institute, San Francisco.

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.

Kessler, J & Moolhuijzen, M 1994, 'Low external input sustainable agriculture: Expectations and realities', *Netherlands Journal of Agricultural Science*, vol. 42, no. 3, pp. 181-94.

King, CA 2008, 'Community resilience and contemporary agri-ecological systems: Reconnecting people and food, and people with people', *Systems Research and Behavioral Science*, vol. 25, no. 1, pp. 111-24.

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

Lewin, K 1946, 'Action research and minority problems', *Journal of Social Issues*, vol. 2, pp. 34-46.

Liebman, D 2000, 'Integration of soil, crop and weed management in low-external-input farming systems', *Weed Research*, vol. 40, no. 1, pp. 27-47.

Lobry de Bruyn, LA 1999, 'Ants as bioindicators of soil function in rural environments', *Agriculture, Ecosystems & Environment*, vol. 74, no. 1-3, pp. 425-41.

Lockwood, JA 1999, 'Agriculture and biodiversity: Finding our place in this world', *Agriculture and Human Values*, vol. 16, no. 4, pp. 365-79.

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.
Maria, J 2007, 'Exploring the knowledge landscape: four emerging views of knowledge', *Journal of Knowledge Management*, vol. 11, no. 4, p. 6.
Marshall, G 1993, 'Organic farming in Australia: an economist's perspective', paper presented to AIAS Organic Agriculture Conference, The River Golf Club, Moama, <http://ageconsearch.umn.edu/bitstream/9676/1/cp93ma01.pdf>.
McCoy, S & Parlevliet, GJ 2000, *Export market potential for clean and organic agricultural products*, RIRDC publication, Rural Industries Research & Development Corporation, Barton, A.C.T.
Mele, PM & Crowley, DE 2008, 'Application of self-organizing maps for assessing soil biological quality', *Agriculture, Ecosystems & Environment*, vol. 126, no. 3-4, pp. 139-52.
Mermut, AR & Eswaran, H 2001, 'Some major developments in soil science since the mid-1960s', *Geoderma*, vol. 100, no. 3-4, pp. 403-26.
Moore, O 2008, 'How embedded are organic fresh fruit and vegetables at Irish farmers' markets and what does the answer say about the organic movement? An exploration, using three models', *International Journal of Agricultural Resources, Governance and Ecology*, vol. 7, no. 1/2, pp. 144-57.
Nabhan, GP 1997, *Cultures of Habitat: On Nature, Culture, and Story*, DC: Counterpoint., Washington.
Nikola Patzel, HSDLK 2000, 'Soil Fertility - Phenomenon and Concept', *Journal of Plant Nutrition and Soil Science*, vol. 163, no. 2, pp. 129-42.
Osherenko, G 1988, *Sharing Power with Native Users: Co-management Regimes for Native Wildlife*, Canadian Arctic Resources, Ottawa.
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.
Pezzoli, K 1997, 'Sustainable Development: A Transdisciplinary Overview of the Literature', *Journal of Environmental Planning and Management*, vol. 40, no. 5, pp. 549 - 74.
Pretty, JN 1995, *Regenerating agriculture : policies and practice for sustainability and self-reliance*, Earthscan Publications, London.
Reijntjes, C, Haverkort, B & Waters-Bayer, A 1992, *Farming for the future : an introduction to low-external-input and sustainable agriculture*, MacMillan ; Leusden ILEIA, 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, U.K ; New York.
Russell, EW & Russell, EJ 1950, *Soil conditions & plant growth*, 8th edn, Longmans, Green, London.
Russell, EW & Wild, A 1988, *Russell's soil conditions and plant growth*, 11th edn, Longman Scientific & Technical ; New York : Wiley, Burnt Mill, England.

Sachs, C 1992, 'Reconsidering diversity in agriculture and food systems: An ecofeminist approach', *Agriculture and Human Values*, vol. 9, no. 3, pp. 4-10.
Sampietro Vattuone, MM, Neder, L, Roldán, J & Vattuone, MA 2008, 'Mother Earth: soil and people relationships during the prehispanic period (Northwest Argentina)', *World Archaeology*, vol. 40, no. 2, pp. 190-205.
Sandor, JA & Furbee, L 1996, 'Indigenous Knowledge and Classification of Soils in the Andes of Southern Peru', *Soil Sci Soc Am J*, vol. 60, no. 5, pp. 1502-12.
Sedjo, RA 1992, 'Property Rights, Genetic Resources, and Biotechnological Change', *Journal of Law and Economics*, vol. 35, no. 1, pp. 199-213.
Sherwood, S & Uphoff, N 2000, 'Soil health: research, practice and policy for a more regenerative agriculture', *Applied Soil Ecology*, vol. 15, no. 1, pp. 85-97.
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.
Siderius, W & de Bakker, H 2003, 'Toponymy and soil nomenclature in the Netherlands', *Geoderma*, vol. 111, no. 3-4, pp. 521-36.
Sinha, R 1997, 'Embarking on the Second Green Revolution for Sustainable Agriculture in India: A Judicious Mix of Traditional Wisdom and Modern Knowledge in Ecological Farming', *Journal of Agricultural and Environmental Ethics*, vol. 10, no. 2, pp. 183-97.
Sriskandarajah, N & Dignam, D 1992, 'The quest for sustainable agriculture: the current position in Australia', *Agriculture, Ecosystems & Environment*, vol. 39, no. 1-2, pp. 85-100.
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.
Syers, JK, Sharpley, AN & Keeney, DR 1979, 'Cycling of nitrogen by surface-casting earthworms in a pasture ecosystem', *Soil Biology and Biochemistry*, vol. 11, no. 2, pp. 181-5.
Talawar, S & Rhoades, RE 1998, 'Scientific and local classification and management of soils', *Agriculture and Human Values*, vol. 15, no. 1, pp. 3-14.
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.
Waldon, H, Gliessman, S & Buchanan, M 1998, 'Agroecosystem responses to organic and conventional management practices', *Agricultural Systems*, vol. 57, no. 1, pp. 65-75.
Wertz, SK 2005, 'Maize: The Native North American's Legacy of Cultural Diversity and Biodiversity', *Journal of Agricultural and Environmental Ethics*, vol. 18, no. 2, pp. 131-56.
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, p. 718.
Zimmerer, KS 1996, *Changing Fortunes: Biodiversity and Peasant Livelihood in the Peruvian Andes*, University of California Press., Berkeley.