Agricultural innovation in the Swartland: investigating promising practices for larger farms

Introduction:

There is currently a growing focus within the sustainability literature towards small-scale, localised, organic forms of agriculture (Badgley *et al,* 2006; Magdoff, 2007). This is driven by a growing recognition of the need for food which is healthier and less harmful to the environmental and social systems in which it is produced (Halweil, 2004; Taylor, Madrick and Collin, 2005; Pretty, 2006).

In South Africa however, large commercial farmers are pivotal to national food security and, for better or worse, remain the stewards of the majority of the country's productive land (Mc Lachlan & Thorn, 2009). As such, it seems clear that despite the need to develop small scale farmers and localised food systems, large-scale farmers will remain important players in South Africa's socio-ecological story for many years to come. Given this fact I'd been experiencing a growing sense of apprehension at the emerging polarisation between those in favour of organic, localised food system model, and those who maintain faith in the increasingly large, high-external-input (HEI) ways of farming. The reason for this apprehension is simple: South Africa faces serious problems regarding agro-environmental stewardship and food security that require urgent attention and knowledge sharing (Vink & Van Rooyen 2009; Goldblatt, 2010). However, at the time of conceptualising my research I saw very little collaboration taking place between the two camps.

I sympathised with the principles and concerns of the pro-organic perspective, but knew that the challenge of transforming the South African agricultural sector is so great that intense collaboration is needed if meaningful progress is to be made. As such, this research sought evidence of low-external-input systems working in closer partnerships with natural systems that could serve as an example of a practical middle ground for large scale farms.

Swilling's conceptualisation of a global polycrisis provides a clear indication of the widespread need for deep changes in the way that people interface with each other and the non-human environment. Deconstructing the polycrisis into seven sub-crises of eco-system degradation, global warming, peak oil, social inequality, urbanisation, intensifying slums and food insecurity also provided a useful lens through which to analyse how large farmers perceive the problems they are facing and with which to evaluate the long-term sustainability of their responses.

According to Swilling and others it is becoming increasingly clear that the current patterns of human development are transforming the nature of the Earth in ways which will negatively affect life on it(MA, 2005; IPCC, 2007; Swilling& Annecke, Forthcoming). A growing number of diverse indicators allude to this change and suggest that fundamental changes are required across many sectors of society if greater suffering and loss of life is to be averted (MA, 2005; IPCC, 2007; UNEP, 2009; FAO, 2009). Swilling describes this situation as a global polycrisis in which seven key sub-groups exist, namely: Eco-system degradation, global warming, peak oil, social inequality, urbanisation, intensifying slums and food insecurity (Swilling and Annecke, 2012). Swilling further argues that all seven factors are interdependent and manifest themselves in all other aspects of life.

For agriculture the theoretical implications of the polycrisis are two-fold: Firstly that agriculture must be understood as a process which both effects and is affected by *all* elements of the polycrisis, despite apparent separations. And secondly, when considering adaptations and innovations within agriculture, new practices need to be evaluated on two levels simultaneously:

1. The new practice's ability to protect framers from the immediate problems they face
2. Their ability to deliver long term prosperity by addressing the fundamental issues contributing to the polycrisis

In the context of this study this meant establishing what farmers felt the drivers of agricultural change in the region were, how their responses affected their farms and lastly whether these responses addressed the underlying global drivers of change that underpin the polycrisis. Due to the multifaceted nature of this information the research design consisted of a literature review, seven innovative-farmer case studies and secondary data from agricultural industry sources. The seven case-studies of innovative farmers in the Swartland provided the core qualitative data[1] which I cross referenced with the secondary data and literature review. The use of the literature review was also vital in contextualising the findings from the Swartland within the global discourse around the polycrisis.

Table 1: Summary of interviewees and farm details

	Location	Farmer name	Farm size	Primary Crops
1	Malmesbury	Peter Steyn	1100 ha	Wheat, oats, medics (legume), sheep,

[1] It is important to note that these farmers were selected because they were considered unusual. Therefore, the seven case studies should not be considered as a benchmark for the region but rather a suggestion for what it could become.

				cattle
2	Bo Hermon	Mike Gregor	6500 ha	Wheat, clover/medics, oats, triticale, barley, canola, sheep, cattle, buffalo, grafting vines
3	Philadelphia	Junior Heroldt	1800 ha	Wheat, oats, medics, wine grapes, sheep, dairy cattle, beef cattle
4	Morreesburg	Cobus Bester	2250 ha	Wheat, medics, sheep, cattle
5	Picketberg	Francious Ekstien	2486 ha	Wheat, oats, canola, medics, lupines, sheep, cattle
6	Pools	Aubrie Rigter	1000 ha	Wheat, oats, canola, medics, lupines, sheep, cattle
7	Malmesbury	Dirk Lesch	395 ha	Wheat, oats, canola, wine grapes, sheep, cattle

Why the Swartland?

Agriculture in the Western Cape serves as an interesting point of entry for the examination of intersects between the polycrisis and agriculture. This is because the Western Cape is a region of extreme social, economic and ecological convergence.

Farm sizes and levels of mechanisation are comparable to those of farms in Europe, Australia or the United States, while on the other, farmers in the Western Cape receive none of the corresponding subsidies and limited trade protection (Joubert, 2010).In terms of the region's cultural history, the agricultural sector in the Western Cape was historically closely aligned with the pre-1994 government, which has left it politically tarnished and stereotyped. Even the farmers themselves - who are predominantly white Afrikaners - are unique in the convergent cultural space they occupy between North and South. Despite the Western Cape being the most literate and generally best-resourced province in South Africa (Gbetibouo, 2009), racial segregation and socioeconomic inequalities remain some of the most extreme in the world.

Environmentally the Western Cape is unparalleled. With an entire floral kingdom - one of only six in the world - within its boundaries, the level of biodiversity found in the tiny region surpasses that of most of the northern hemisphere combined and is trumped only by the vast expanses of the Amazon (Conservation International, 2007). As the biggest land user in the region, agriculture in the Western Cape has a footprint on global biodiversity which is vastly disproportionate to its size (Conservation International, 2007). This makes commercial farmers of the Western Cape very important actors in the management of global biodiversity and under greater pressure to farm in ways which are more environmentally sensitive.

However, given the diversity of production in the province and the scope of the study, a smaller study region was required. As an area which epitomised the social, economic and ecological extremities highlighted above, as well as being an important food producer for the region (and therefore relevant to regional food security) the Swartland was an ideal focal point for this study[2].

The main focus of Swartland agriculture is rain-fed winter cereals production, predominantly wheat but also some oats and barley. In addition the Swartland also produces canola, horticultural products such as wine grapes and vegetables, sheep, cattle, poultry, eggs, dairy products and wool. Farm sizes are relatively large and generally range from 300 - 2000 hectares. Annual rainfall varies across the region but is between 250 and 700mm depending on location (Morel, 1998).

Drivers of change in the Swartland

Based on the seven case studies of progressive farmers in the region, secondary data, as well as grey and white literature, there are clear indications that the primary drivers of change from the farmers' point of view in the Swartland are economic pressures, financial risk minimisation, the desire for intergenerational sustainability motivated by the tradition of the 'family farm', and the logical incentive to shift towards systems which appear more profitable and resilient. These four drivers are highly interdependent; economic viability is vital to intergenerational sustainability, as is the minimisation of risks associated with crop failure and drought.

As well as being interdependent, these drivers share a number of common causes, referred to within this chapter as secondary drivers. These secondary drivers were as, if not more, important to understand than the primary drivers. For example, most farmers cited economic pressure as the primary driver behind their changes in practice. Further questioning revealed that this economic pressure was not an event in itself, but rather the culmination of a range of other drivers such as local and international trade policies (Gregor, 2010), rising input prices (Heroldt, 2010), rising input requirements (Heroldt, 2010), soil degradation (Heroldt, 2010), rising machinery costs (Lesch, 2010), high land prices(Heroldt, 2010),, variable weather (Rigter, 2010), theft (Bester, 2010) and crop price fluctuation (Gregor, 2010).

It also became clear that there is a growing recognition of the role which complex biological soil functions plays in financial risk management, alleviating economic pressure and ensuring the intergenerational sustainability of farms. This made biological soil conditions and the management thereof a very prominent secondary driver identified by the study (all seven farmers listed soil improvement as a reason for adopting new practices).

Many of these secondary drivers can in turn be linked back to deeper causes within the global polycrisis. For example, crop failure, severe weather and rising input requirements can all be linked to ecosystem degradation and climate change (Conway, 1997; Meadows, 2003; UNEP, 2009). In turn, trade policies, high land prices and theft have strong connections to social inequality and the urban migrations taking place both regionally and nationally. Figure

[2] I also had access to farmers in this region through personal relationships with a few wheat farmers, plus my research was funded by the Stellenbosch University Food Security Initiative which was interested in research of relevance to food security in Stellenbosch and the Swartland is the closest wheat producing area to Stellenbosch.

1provides an example of this by demonstrating some of the linkages between economic pressures faced by farmers in the Swartland and the polycrisis.

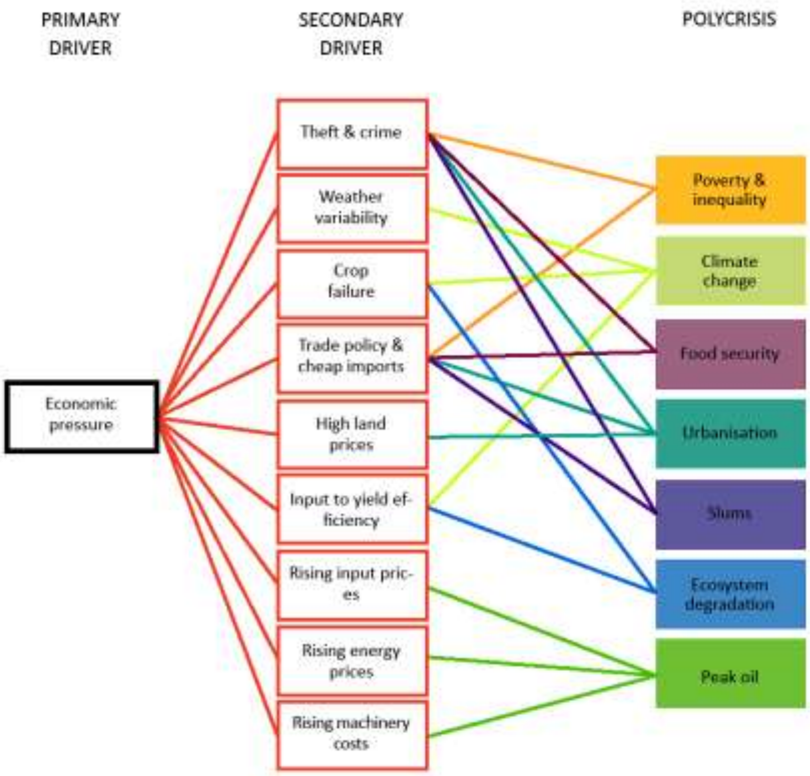

Figure 1: Indirect links between economic pressure on Swartland farms and the polycrisis

While the connections between the three columns in Figure 1 are simplistic and ignore many of the complexities and contradictions present, they serve to illustrate a diverse chain of connections between Swartland farmers and the polycrisis. Being aware of these tiered levels of causality is vital to ensuring that the responses put in place to address the primary drivers provide long term solutions rather than serving merely as a temporary bail-out. For example, lobbying for increased protection against cheap imports is unlikely to deliver a sustainable solution unless it is done in a way that simultaneously addresses food insecurity, poverty and inequality. While this may seem impossible from the point of view of the individual farmer, who very often is on the verge of personal bankruptcy, it remains a reality that needs to be confronted.

While many such linkages arose, two particularly clear linkages became apparent. The first of which is the relationship between the cost per unit of production and ecological decline within the farm system - most notably soils. While a number of complex factors affected the relationship between soils and costs of production, it is most simply summed up by Junior Heroldt who said

At the introduction of fertilisers and that high input approach to farming that came with it the results were spectacular, even small increases in synthetic nutrient application significantly increased our production. However, over time this ceased to be the case and we found that we were requiring increasing amounts of fertilisers just to maintain our production levels. The reason we later found was that when we began applying fertilisers we were applying them to relatively healthy soils, but that over time this natural capital had been eroded. It was clear to us that continuing on the path we were on was financial suicide. That's when our slow process of rebuilding the organic components of our soils began. (Heroldt 2010)

The second linkage was the relationship between increasing climatic uncertainty associated with climate change and the financial risk profile of farmers in the Swartland. High-external-input systems require farmers to invest heavily up front in inputs such as seeds, herbicides and fertilisers in order to prepare their crop. Under the dry-land conditions which these farmers operate, the return on these investments is dependent on reliable weather conditions. With weather in the Swartland forecast to become less reliable and more extreme (Midgley *et al,* 2005; Gbetibouo and Ringler, 2009)there is a higher likelihood of crop failure and farmers losing the money they invested to prepare the harvest. Whether farmers have been able to invest their own capital in the up-front costs for the season or taken on credit, increasingly severe weather and climatic uncertainty amplify financial risk in a very direct manner.

While these drivers deserve more detailed discussion, the important point is that strong connections exist between the challenges being experienced by large-scale farmers in the Swartland and the polycrisis. The significance of this to the debate around the future of large-scale agriculture in South Africa is that irrespective of whether they have conceptualised it in the same manner as Swilling, some large-scale farmers are beginning to identify similar challenges. More importantly, in response to this realisation these farmers have also begun developing solutions. Due to the fact that many of these solutions focus on underlying issues which are rooted in the polycrisis, it can be argued that these solutions are indicative of a shift towards more sustainable approaches to farming in the region.

Innovations, adaptations and reactions

34 innovations or changes in practice were identified amongst the seven farmers in the region. Of the 34, 29 were considered positive steps towards LEI systems that work in closer partnership with natural systems. As with the drivers of change, high levels of interdependency existed between many of the 34 practices. Four however, were identified as keystone practices that were critical in their own right and without which many other improved practices would not be possible.

These were:

- The uptake or increased use of legume rotations
- A shift towards minimising soil disturbance during tillage
- The introduction of technologically advanced planting machinery
- Increasing farm sizes

As was suggested above the majority of these changes delivered positive effects. Legume rotations build soils by contributing organic nitrogen, reduce soil and crop born diseases, help to reduce input costs and promote income diversification. Similarly, by reducing tillage farmers cut down in diesel and labour costs while improving soil structure, soil organic carbon (SOC) and water retention.

Unfortunately the trend in increasing farm sizes seems to be a mixed blessing - primarily because land consolidation results in labour shedding. On the one hand this drives improved labour productivity, greater economic competitiveness and probably the up-skilling of the agricultural labour force (Vink & Van Rooyen, 2009). However, on the other it is contrary to the crucial efforts of the land reform programme. It also results in a loss of crucial livelihoods for some of the region's poorest families and promotes migration into urban areas that are ill equipped to accommodate new arrivals. While a degree of criticism towards certain farmers may be warranted it would appear that the main drivers of this trend have been of an external nature, as is discussed later in this chapter.

Beyond the direct costs and benefits these four practices delivered, they were vital to enabling the uptake of additional beneficial practices. For example, without the technical ability of planting machinery to plant fresh seeds through the residue of the previous year's crop, it would not be possible to attain all the benefits associated with the maintenance of organic matter on the soil surface. Equally vital to the maintenance of crop residue was the introduction of legume rotations as these rotations break wheat-specific disease cycles that had previously been controlled by burning off the crop residue under mono-crop systems. By replacing the role of fire in breaking crop-specific disease cycles, legumes not only contributed nitrogen to farm soils, they also enabled organic residue retention. In turn, below a certain farm size, many farmers can't afford the machinery, or the legume rotations[3] that are required to achieve the benefits of maintaining crop residues. This means sufficient farm size is a third factor which needs to be in place before the benefits of mulching with crop stubble and residue can be realised (Lesch, 2010; Bester, 2010).

While it could be argued that these and other factors represent a practical and technological lock-in to the existing system, there was little doubt in the minds of the farmers who were interviewed that failing to address these challenges would result in the collapse of their farms and livelihoods. In other words, maintaining a business-as-usual approach was not a sustainable option for them. This view is supported by a wide range of local and international literature which critiques the prevailing approach to large-scale HEI agriculture (as has been practiced in the Swartland) and highlights the importance of adaptation in response to this realisation (Magdoff *et al.* 1997; Sherr, 1999;Smit, 2002; Meadows, 2003; Midgley *et al.* 2005; Lal, 2006; Pretty, 2006; ARC, 2010; Lal, 2010).

Table 2 provides a summary of the keystone practices, the practices these enabled and the benefits and concerns of both.

Keystone practice	**Direct benefits/concerns**	**Enabled practices**	**Benefits/concerns**

[3]Due to cash flow constraints which arise from not achieving a wheat crop on part of the farm.

Legume rotation	Soil improvement	Increased stocking of sheep and cattle	Ecological diversification
			Provides manure & microbial stimulation
	Input reduction		Financial risk reduction
	Improved farm health	Stop burning off crop residue	Provides fodder for soil based fauna and flora
	Drought resistance		Builds SOC
	Financial risk reduction	Reduced pesticide and fungicide usage	Environmental benefits
			Cost saving
			Health benefits
Reduced tillage	Mimics natural soil cycles	Maintaining post harvest crop stubble and residue (mulching)	Provides food for soil ecology
	Improves soil structure		Builds SOC
	Helps build SOC		Protects soil from sun and wind exposure
	Encourages soil biodiversity		Improves water absorption
	Improves moisture retention and drought resilience		Controls erosion
	Controls erosion		Improves soil moisture retention thereby boosting yields and drought resilience
	Reduces diesel consumption		
	Chemical weed control required	More herbicide	Increased weed resilience
			Environmental health costs
			Human health costs
New planting machinery	Improved input use efficiency	Maintaining post harvest crop stubble and residue (mulching)	*See above*
	Saved labour time	GPS precision soil and yield mapping	Improved input use efficiency
	Diesel reduction		Improved input use efficiency
	Reduced tractor maintenance	Enables reduced/minimum till	*See above*
	Higher machinery investments	Requires bigger farms to finance investments	*See below*
Larger farms	Increased economies of scale	Larger machinery investments	Replacing the need to rent equipment can result in cost and risk reductions
			See New planting machinery above
	Higher labour productivity	Legume rotations become affordable	*See Legume rotations above*
	Less employees per hectare	Unemployment & urbanisation increases	Various social issues resulting from unemployment

			Various social issues resulting from urban migration

Table 2: Summary of new practices and their effects (Negative factors in red)

In addition to the practices listed above, a number of others were taking place or undergoing experimentation. One noteworthy trend was the replacement of synthetic fertilisers with carbon-rich animal based ones such as pelletised chicken manure as a substitute for synthetic nitrogen. Another was the use of the Albrecht system of soil balancing (soil Ph. optimisation and regulation) which seemed to be yielding good results and reducing the need for lime application.

A number of farmers showed a significant willingness to consider or test organic approaches and two expressed a desire to ultimately become organic. Indicative of this was that four of the seven had used or experimented with various forms of compost tea and microbial stimulants. One had also begun making their own compost and four said they paid close attention to earth worm populations on their farms.

Knock on effects of these changes/related changes in practice

These changes are encouraging, particularly their implications in relation to the future of the region's soils. Soils in good condition also deliver higher yields and are more resistant to pests and disease (Lal, 2006; Rosenberg, 2006). Resilience to pests and disease means that farmers require fewer external inputs to protect their crops from these problems which saves farmers money while improved yields also help to boost incomes.

Healthy soils, particularly those with a higher organic matter content, are also more resilient to extreme weather since they are better at absorbing and storing water (Scialabba and Muller-Lindenlauf, 2010). This additional property is particularly important for the rain-fed farmers of the Swartland, where rainfall varies and cyclical droughts pose a very real risk to farmers (Rigter, 2010). The ability of soils to absorb water also helps farmers in times of heavy rain as it reduces the amount of water flowing across the soil surface, thereby reducing erosion and storing water for when it is needed (Sherr, 2000; Lal 2010). This improved climatic resilience under both wet and dry extremes presents clear benefits given the future risks posed by climate change.

Due to the importance of healthy soils it is unsurprising that 21 of the 34 aforementioned innovations or changes in practice as well as all four of the keystone practices related to soil management in some way. This is an important point in the thrust of the argument for an emerging middle ground between HEI and LEI agricultural philosophies. The reason being that, according to LEI philosophies around soil management, restoring and improving agricultural soil cannot simply consist of nutrient replacement (as has been the tradition); farmers have to work towards improving the soil's fertility by restoring organic matter, improving soil structure and water-holding capacity, controlling the flow of water across fields, restoring soil flora and fauna, buffering acidity, and establishing vegetative cover (Scherr, 2000; Lal, 2010). The findings of this study clearly indicate that widespread examples of all these practices exist within the studied farms. One illustration of this point can be seen from preliminary investigations into the SOC levels on five of the studied farms. As Table 3 suggests, farmers seem to have reversed the trend in declining SOC in their soils to a point which may be well above pre-agricultural levels.

Table 3: Comparison of SOC levels on five of the case study farms

	First farm estimate or measurement	Lanz estimate of natural SOC[4]	Lanz sampling Sept. 2009	Farmer estimate in 2010	Farmer estimate for 2020
Average SOC	**0.52%**	**0.95%**	**1.3%**	**1.35%**	**1.9%**

Source: Adapted from Lanz (2009) and own figures

Given the indications regarding soil carbon and the wide range of practices which have been put in place on the seven farms, it seems reasonable to suggest that significant restoration and improvement of soil health is taking place.

By rebuilding their soils these farmers feel they are achieving greater economic resilience. They are also directly addressing some forms of ecological degradation in the region and potentially mitigating the effects of climate change by sequestering carbon and reducing their fossil fuel dependence.

In relation to food security the trends and practices taking place on the seven farms suggest a trend towards an increasingly diverse[5] and stable food supply. The rationale for this is as follows: even this limited diversification into legume rotations has helped farmers reduce their input costs significantly. When combined with the resource efficiency benefits afforded by new planters and improving soil vitality, farmers under these systems appear to be able to produce food at significantly lower cost per unit than their counterparts in the region. Farmers in the Swartland using a wheat-to-legume rotation cut costs by 15 percent per ton and farmers on a no-till system cut costs by 12 percent per ton (Grain SA, 2010). However, the fact that most farmers had adopted both rotational and reduced tillage practices, as well as a range of other cost cutting strategies suggest realistic cost savings well in excess of 15 percent.

If broadly adopted this reduction in the cost per unit could theoretically assist in keeping food prices low and stable in an environment prone to extreme input price fluctuations and the prospect of steady input price increases as the oil price rises. Given that in the majority of cases food insecurity is driven by high food prices and low incomes blocking access to food (FAO, 2012), this ability to shield food prices from input price volatility is a significant positive. Furthermore, regional production stability could also benefit from diversified farm systems, operating on healthier soils that are more resilient to weather and pest shocks.

Less promising however, are the side effects of these increases of efficiency on rural livelihoods and agricultural employees; particularly the effects of the somewhat forced consolidation of

[4] This figure is for the top 150mm of soil from four of the five sites. Samples were not taken to be statistically analysed, but merely to give an idea of natural levels (Lanz, 2009).
[5]Unfortunately crop diversity in comparison to many model LEI systems is still very low.

land ownership into the hands of an increasingly small group of farmers and the shedding of labour that takes place when collapsed enterprises are bought out by bigger farmers.

These increases in farm size and lower labour components do raise questions around the social equality of the current trends. Potential improvements in food price stability are unlikely to be any comfort to those who have lost jobs and homes in the process. While I think a degree of criticism towards certain farmers who are only too happy to be able to get rid of excess labour is justified, it is important to bear in mind that the stereotypical image of the rich white farmer needs to be revisited. Heavy cutbacks in agricultural subsidisation and trade-protection have taken place in the South Africa over the past 20 years (Vink & Van Rooyen, 2009). This forced dramatic and often rapid restructuring onto farmers in the region and has been the ruin of many long standing farmers who were then left with no choice but to retrench families of workers who had served them for generations as they sold their land.

Summary

The seven farmers were shown to be moving towards lower-external-input systems largely by building the biological health and water-absorption capacity of their soils. In order to do this they were diversifying their crops, increasing the number of animals they stocked, including legume rotations in their crop rotations, reducing soil tillage, feeding the soil with organic matter (in the form of crop residue, manure and compost), applying microbial stimulants, buffering soil acidity, and where possible cutting down on chemical applications which adversely affect the biological soil functions. These changes have led to reductions in a number of different inputs, these included pesticides, nitrogen, lime and diesel.

The farmers in the case studies also capitalised on modern technological developments to assist in the reduction of external inputs and improve yields. Of primary importance was the development of new planters and the associated technologies which followed them, such as GPS soil and yield mapping, larger tractors and chemical herbicides. These technological advances have enabled precision planting, band application of fertilisers, one-pass planting and reduced tillage; all of which have assisted in reducing external inputs.

The effect of these changes on the farms' food production has generally been to lower the total volume of grain produced because of less land being planted to wheat. On a per hectare basis however, wheat yields were reported to be as high as, if not higher than, the average for the region. Additionally there has been an increase in other food outputs – most notably sheep, but also cattle, canola, dairy products and potentially oats.

The findings regarding the cost of food production within the sample suggested that food can be produced at a lower cost using the methods employed by these farmers. This finding was supported by secondary data from Grain SA. Findings also suggested that food supply under these systems is more stable and better equipped to mitigate the effects of food price shocks akin to those of 2007/2008 for three reasons: firstly, healthy soils with higher water absorption and storage capacity are better at delivering decent yields in times of drought; secondly, land planted to legumes can be converted to wheat production to provide short-term production boosts in times of scarcity; and thirdly, farmers are far less effected by input price spikes driven by sudden demand peaks common in times of high food prices. All three of these points could help to ensure that adequate volumes of food are available at lower prices during times of need.

Conclusion

These findings indicate that although commercial farmers in the Swartland may not have conceptualised the challenges of sustainable development in the same terms as Swilling and Annecke, the pressures of the polycrisis are reflected in many of the challenges these farmers are facing. In response to these challenges the seven case study farmers demonstrated that a growing body of new knowledge and practices is developing within the commercial agricultural sector in the Swartland. This body of knowledge addresses some of the key sustainability issues raised by Swilling and Annecke, including peak oil, ecosystem degradation, climate change and food insecurity. This knowledge of how more sustainable and restorative agricultural practices can be applied to larger-scale farm systems in the Global South is likely to become increasingly valuable asset in addressing these four elements of the polycrisis. The weakness of the new systems and the challenge which remains for Swartland farmers is how they respond to the threats posed by growing poverty and inequality, rapid urbanisation and slums.

Given the mounting socio-political pressures in South Africa it seems likely that farmers in the Swartland will also have to grapple with major socio-political challenges in the not too distant future. In many ways these socio-political challenges should be interpreted as an embodiment of the unresolved components of the polycrisis within their systems (namely poverty and inequality, urbanisation and slums) emerging as direct challenges to agriculture in the region.

As such, research into social innovation and restoration within the commercial agriculture sector will be of equal if not greater importance than the LEI/NS technologies that were the focus of this research and should be granted due attention.

List of references:

1. Agricultural Research Council (ARC). 2010. *Guidelines: Production of small grains in the winter rainfall region*. Bethlehem Agricultural Research Council: Small Grain Institute
2. Badgley, C., Moghtader, J., Quintero, E., Zakem, E., Chappell, J.M., Avile´s-Va´zquez, K., Samulon, A., Perfecto, I. 2006. Organic agriculture and the global food supply. *Renewable Agriculture and Food Systems*, Vol 22(2); 86–108. Elsevier
3. Bester, C. 2010. Personal interview. 12 May. Moorreesburg, South Africa
4. Conservation International. 2007. *Cape Floristic Region*. [Online]. Conservation International Downloaded from: http://www.biodiversityhotspots.org/xp/hotspots/cape_floristic/Pages/default.aspx (23 May 2010)
5. Conway, G. 1997. The Doubly Green Revolution. In: Pretty, J. 2005. *Sustainable Agriculture*. London: Earthscan
6. FAO, 2012, State of Food Insecurity. FAO, Rome.
7. Gbetibouo, G.A., Ringler, C. 2009. M*apping South African Farming Sector Vulnerability to Climate Change and Variability*. International Food Policy Research Institute, Discussion Paper 00885. Pretoria: International Food Policy Research Institute
8. Genis, A. 2008. Minimumbewerking en wisselbou is wenresep. South Africa. *LandbouWeekblad*, 5 September: 46 – 48
9. Goldblatt, A. 2010. *Agriculture: Facts and trends. South Africa*. Cape Town: Worldwide Fund for Nature
10. Gregor, M. 2010. Personal interview. 04 May, Hermon, South Africa
11. Grobbler, P. 2010. Personal interview. 13 May, Tulbach, South Africa
12. Halweil. B. 2004. *Eat Here.* New York: W.W. Norton & Company
13. Hardy, M. 1998. *Towards sustainable crop production in the Swartland: A short review*. Elsenberg Journal. Vol 2: 42-45
14. Heroldt, J. Personal interview. 05 May, Philladelphia, South Africa
15. Intergovernmental Panel on Climate Change (IPCC) 2007. *Climate Change 2007*. Geneva: United Nations Environment Programme
16. Joubert, R. 2010. Wheat farmers sweat it out. South Africa. *Farmers Weekly*, 12 May: 14
17. Lal, R. 2010. Managing soils for a warming earth in a food-insecure and energy-starved world. *Journal of Plant Nutrition and Soil Science*, Vol173: 4–15
18. Lal, R. 2006. Perspective Managing soils for feeding a global population of 10 billion.*Journal of the Science of Food and Agriculture*, Vol86: 2273–2284
19. Lanz, J. 2009. *Report of the Soil Carbon Research Project: Final Report*. Elsenberg: Department of Agriculture LandCare.
20. Lesch, D. 2010. Personal interview. 14 May, Malmesbury, South Africa
21. McLachlan, M. & Thorne, J. 2009. *Seeding change: A proposal for renewal in the South African food system.* Development Planning Division Working Paper Series No. 16, DBSA Midrand

22. Magdoff, F., Lanyon, L. and Liebhardt, B. 1997. Soil Organic Management Stratagies. In: Magdoff, F and Weil, R.R. (*eds*.). *Soil organic matter in sustainable agriculture*. New York: CRC Press
23. Magdoff, F. 2007a. Balancing food, environmental and resource needs. *Renewable Agriculture and Food Systems,*Vol 22 (2): 77-79
24. Meadows, M.E. 2003. Soil erosion in the Swartland, Western Cape Province, South Africa: implications of past and present policy and practice. *Environmental Science & Policy*, Vol 6: 17–28
25. Midgley, G.F., Chapman, R.A., Hewitson, B., Johnston, P., de Wit., M., Ziervogel, G., Mukheibir, P., van Niekerk, L., Tadross, M., van Wilgen, B.W., Kgope, B., Morant, P.D., Theron, A., Scholes, R.J. and Forsyth, G.G. 2005. *A Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape. Report to the Western Cape Government, Cape Town, South Africa*. Report No. ENV-S-C 2005-073. Stellenbosch: Council for Scientific and Industrial Research
26. Millennium Ecosystem Assessment (MA). 2005. *Ecosystems and Human Wellbeing: Synthesis*. Washington DC: Island Press
27. Morel, A. 1998. *Soil Erosion and Land Degradation in the Swartland and Sandveld, Western Cape Province, South Africa: A re-evaluation*. Masters Thesis. Dept. of Environmental and Geograpical Science. University Of Cape Town
28. Phillips, L. 2010. Tiger Brands concerned about wheat plantings. South Africa. *Farmers Weekly*, 21 May: 22
29. Pretty, J. 2006. *Regenerating Agriculture*. London: Earthscan
30. Rigter, A. 2010. Personal interview. 14 May, Pools, South Africa
31. Rosenberg, A. 2006. *Global health in crisis: the answer lies in the soil*. Place of publication unknown: Lindros
32. Scialabba, N.E. and Muller-Lindenlauf, M. 2010. Organic agriculture and climate change. *Renewable Agriculture and Food Systems,*Vol 25 (2): 158–169
33. Scherr, S.J. 1999. *Soil Degradation A Threat to Developing-Country Food Security by 2020?* Washington: International Food Policy Research Institute
34. Sherr, S.J. 2000. A downward spiral? Research evidence on the relationship between poverty and natural resource degradation. *Food Policy*, Vol 25 (4): 479-498
35. Smit, M.L. 2004. *The effect of cropping systems and tillage practise on some soil fertility indicators of a Swartland Soil near Malmesbury*. MSc Thesis. Dept. of Soil and Crop Sciences. University of the Freestate
36. Statistics South Africa (Stats SA). 2007. *Census of Commercial Agriculture 2007 (Preliminary)*. Pretoria: Statistics South Africa
37. Swilling, M. and Annecke, E. 2012. *Just Transitions: Explorations of Sustainability in an Unfair World.* Cape Town: Juta
38. Taylor, J., Madrick, M. and Collin, S. 2005. *Trading Places: The local economic impact of street produce and farmers' markets*. London: New Economics Foundation
39. United Nations Environmental Programme (UNEP). 2009. *The environmental food crisis – The environment's role in averting future food crises.* Norway: Birkel and Trykkeri AS
40. United Nations Food and Agriculture Organisation (FAO). 2009. *The State of Food Insecurity in the World: 2009*. Rome: United Nations Food and Agriculture Organisation

41. Vink, N. and Van Rooyen, J. 2009. *The economic performance of agriculture in South Africa since 1994: Implications for food security.* Development Planning Division Working Paper Series No.17. Midrand: Development Bank of South Africa