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Where Is the Coherent Response to Climate Change and Peak Oil? An Examination of Policy and Practice Affecting Agriculture in Regional Australia

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Abstract. Climate change and peak oil will have profound impacts on food production across the world. This article uses selected documents from the agriculture policy arena to explore international, national and local scale responses and recommendations. Using two regional Australian case-studies, we describe local farming practice. We find that while seeking to be adaptive overall, farm decisions are, necessarily complex, often limited and result in both short- and long-term perverse outcomes. This includes changes previously considered as innovative or adaptive responses to climate change or energy constraint. By contrast, these responses now may appear reactive and maladaptive. We argue that the maladaptive responses are most likely to continue because of a lack of policy coherence and integration across scales. Farm experimentation and improvization requires supportive coherent policies. Good on-ground decision-making requires clear signals that support change beyond current variations within a 'business as usual' trajectory.

Introduction

There are many levels to the discourse around climate change and peak oil. In this article, we consider policy responses associated with food and agriculture in a farming area of Victoria Australia, through the critical examination of three policy documents at various levels and foci and their implications for Australian farmers. Underpinning the article is a social and ecological systems (SES) approach, which

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counters reductionist analysis and arguably encourages the possibility of adaptive capacity and resilience within a system (Harris, 2007). Therefore, we imagine the global forces of climate change and peak oil as a constellation of variables in the SES that are constantly emerging. This emergence is characteristic of system dynamics; but when policy-makers are considering how to formulate and provide useful direction to guide the continuing level of change and adaptation required to deal with so much uncertainty, we argue there appears to be conventional resistance to transformative change built into their policies. The ideal is to be able to engage the agricultural farming system as an SES, as the resilience narrative describes (Folke, 2006), wherein the shocks to a system can be absorbed for long enough to allow on-going innovation and successful adaptation.

Policy responses to issues such as climate change and energy security are complex and not automatically congruous, for example, investment in unconventional gas may augment fuel supplies, but could also have potentially significant implications for greenhouse gas emissions (Howarth et al., 2011). Responses extend across multiple levels where they are developed separately in countries, states and cities and the lack of consistency and recognition of interrelationships raises questions about the effectiveness of such initiatives. However, global scale issues require global commitment as well as local solutions. Multilevel governance literature describes this situation where the interaction of institutions exists at multiple levels. As Paavola (2007, p. 98) suggests, multi-level governance solutions may emerge because an upper level of governance is established to coordinate between lower-level solutions, or because lower-levels of governance are established to implement higher-level strategies'. Urwin and Jordan (2008), in a study focusing on policy across multilevels, argue that climate change needs to be integrated into all areas of public policy-making (i.e. both climate and non-climate sectors) if policy is to support rather than obstruct adaptive responses – a process they term 'climate proofing'. They acknowledge the tensions of multilevel policy-making between-policy makers at higher levels and the implementers at the on-ground level recognizing the need to view the issues as both top-down and bottom-up. Their research found few examples in the UK of existing policies within agriculture and the water-resources sector that actually promoted integrated climate change adaptation responses and found examples where adaptation options in effect were hindered at local levels. These and other authors (Pahl-Wostl, 2009; Daniell et al., 2011) note, however, that the task of integrating climate policy across scales is laden with both practical and political complexities particularly as climate policy intersects in some way with almost all other policies. Therefore, the risk of perverse outcomes or maladaptation associated with reverse engineering policies continues.

Recently, Barnett and O'Neill (2010, p. 211) have described maladaptation as 'action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups'. They identify five pathways through which maladaptation to climate change can occur:

1. pathways that, relative to opportunities, increase emissions of greenhouse gases, i.e. adaptation practices that themselves increase energy usage;
2. disproportionately disadvantaging the most vulnerable, i.e. by aiming to fulfill the needs of one group another more vulnerable group may be further impacted;

3. high opportunity costs whereby the social, economic and/or environmental costs of the proposed adaptation are higher than other adaptation courses of action;
4. path dependency, i.e. owing to large capital outlays it becomes difficult to steer away from a particular course of action; and
5. reduction of incentives to adapt, i.e. where there is no encouragement to change behaviour and/or the responsibility for changing the behaviour is transferred from the individual (Barnett and O'Neill, 2010, p. 212).

In this article, we will focus specifically on three of these pathways (increasing greenhouse gas emissions, path dependency and reduced incentives to adapt) that emerge from our case-study.

It is maladaptation or perverse outcomes associated with policy and on-ground practice that surface as a consequence of recent field research. The on-ground everyday practice of farmers needing to juggle farm inputs in response to conditions that they have little or no control over helps focus the meaning of ideas relayed through policy frameworks. We apply Barnett and O'Neill's (2010) definition of maladaptation and the pathways through which it can occur to our analysis of those aspects of climate change policy most obviously affecting food and agriculture. We extend their ideas by pointing to what Urwin and Jordan (2008) have identified as the policy interplay – or lack of it – across global, national and state government. We argue that energy and climate change policy is silo-based (or non-integrative) and inherently intended to affirm reductionist 'solutions' rather than be responsive to integrative system wide change. Therefore adaptive management is adaptive within the confines of existing structural limitations. Adaptive management has emphasized the ability of local scale practitioners to adjust, reform, innovate – rarely acknowledging the 'lock in trap' (Allison and Hobbs, 2004) that farmers encounter when trying to innovate around one issue at a time – as if changes in one part of their farm will not impact on all parts of the social and ecological reality of that system. The local response is consequently constrained engagement with policy ideas, even as there is local evidence and awareness of the need for some or any energy and climate change action on-ground.

To build this analysis we assess the current evidence for the significance of peak oil and climate change for food and agriculture in the second part of the article. We selected recent documents in the policy arena that expressly address the future of food and farming. We chose documents focusing on different scales – global, national and sub-national – and specifically highlight the discourse of climate and fuel/energy impacts on food and agriculture. At a global level, we selected the World Agriculture Outlook 2010–2019 (OECD and FAO, 2010) and briefly, its update in 2011, World Agriculture Outlook 2011–2020 (OECD and FAO, 2011). At the national level we study the guide to the Murray Darling Basin Plan – a scoping document for looking at the future of water allocation in the Murray Darling Basin (MDB), an area that contributes around 40 % of the national gross value of Australian agricultural production (ABS, 2008). At the sub-national level, we examine the State of Victoria's Future Farming Strategy. In part four we describe the on-ground narratives of farmers, with particular emphasis on farm decision-making as it relates to energy and climate. The discussion in part five draws on Barnett and O'Neill's (2010) identification of maladaptive pathways in policy and practice. We conclude by calling for urgent recognition of the interconnectivity in system dynamics, time lags in adaptive capacity and a concerted effort to overcome the strictures of the current policy silos.

The Significance of Fossil Fuels – and Oil in Particular – for Food and Agriculture

Oil supplies cater for 35% of the world's energy demand (British Petroleum, 2010). Food production and distribution systems across the world are dependent on access to affordable fossil fuel-based energy. The production of most nitrogen fertilizers uses natural gas for the hydrogen and energy. Gas and oil are used for production of pesticides and herbicides and other agricultural chemicals. Farm machinery and pumps are run with petroleum fuel and other materials and equipment used on farms are often derived from oil (for example, plastics) or are made with the energy from petroleum fuel. Petroleum is used to transport farm inputs and farm products to market. Fossil fuel-based energy plays a significant role in the process of getting food to the consumer. For example, Heller and Keoleian (2000) estimate that food related energy use beyond the farm gate was over four times that of energy used directly in agriculture. The United States Department of Agriculture estimates the food related share of total energy consumption (92% of which is derived from fossil fuels; EIA, 2010) in the US was around 16% in 2007 (Canning et al., 2010).[1]

Peak Oil

In late 2008 the International Energy Agency (IEA) shifted distinctly in tone with its declaration that 'current global trends in energy supply and consumption are patently unsustainable' (IEA, 2008, p. 3) and 'the era of cheap oil is over' (ibid, p. 15). In its 2010 *World Energy Outlook*, the IEA warns that 'the oil price needed to balance oil markets is set to rise, reflecting the growing insensitivity of both demand and supply" (IEA, 2010, p.6). This official caution has been complemented by a series of analyses from the private sector and military organizations that warn of a 'supply crunch' some time within the next few years. The UK Industry Task Force on Peak Oil and Energy Security (2010) declared that 'as early as 2012/2013 and no later than 2014/2015, oil prices are likely to spike, imperiling economic growth and causing economic dislocation'. The US Joint Forces Command (2010) makes similar predictions and a leaked German military report explores the consequences further. It states that there is 'some probability that peak oil will occur around the year 2010 and that the impact on security is expected to be felt 15 to 30 years later… shortages in the supply of vital goods could arise' (Schultz, 2010).

Implications of Peak Oil on the Food System

The problem is not that oil is 'running out', the problem is one about cost and production rate. We have developed the easiest half of the world's oil reserves and are moving to the more difficult or 'tough' oil, which takes more energy to extract (see Sorrel et al., 2010). The rising price of oil will have direct implications for the food system, but there are also likely to be significant indirect implications. Gross domestic product is a rough measure of activity in the economy. Activity is related to the amount of energy in the system. In 2005, the United States Department of Energy highlighted this link between the global economy and oil prices: '[o]il prices remain a key determinant of global economic performance, and world economic growth over the past 50 years has been negatively impacted in the wake of increased oil prices' (Hirsch et al., 2005, p. 30). Not only is the current way we produce and distribute food dependent on affordable oil, the influences that an increased and volatile oil price has on the economy – for example, the amount of income households have to spend, and the amount of investment available for new infrastructure – will have very significant implications for food systems.

Thirty per cent of the world's cropland has been abandoned due to soil erosion and degradation in the last 40 years (Wood et al., 2006). Moves to more marginal land increases both fertilizer requirements and transport costs. Soil degradation also reduces water storage in soil as well as carbon sequestration potential. The United Nations Environment Programme (Nellemann et al., 2009) has estimated that up to 25% of the world's food production could decline due to environmental break-down by 2050 unless action is taken. Compounding pressures on the prices of nitrogen fertilizer associated with peak oil, Cordell et al. (2009) estimate that phosphorous could also peak by 2030.

Climate Change

In late 2009, the Intergovernmental Panel on Climate Change (IPCC) authors updated the latest climate science since the IPCC's fourth assessment report two years prior <http://www.copenhagendiagnosis.org/press.html>. They warned that if long-term global warming is to be limited to a maximum of 2ºC above pre-industrial values, average annual per capita emissions in industrialized nations will have to be reduced by 80–95 % below 1990 levels by 2050. The report concluded that global emissions must peak then decline rapidly within the next five to 10 years for the world to have a reasonable chance of avoiding the very worst impacts of climate change. The chief economist of the International Energy Agency announced in May 2011 that energy-related carbon-dioxide emissions in 2010 were the highest in history noting that this represents 'a serious setback to our hopes of limiting the global rise in temperature to no more than 2ºC' (IEA, 2011, p. 1). The (Australian) Climate Commission Secretariat (2011) points out that the 2ºC target 'often quoted as defining the boundary of "dangerous" climate change, is based on value judgments, informed by scientific understanding, and has been developed through a political process [and that] there are significant risks of serious impacts in various sectors and locations at temperature increases of less than 2°C' (Climate Commission Secretariat, 2011, p. 18). Climate change will impact on altered seasons, and changing rainfall patterns and will see a shift in production zones (for Australian examples, see Cullen et al., 2010). For farmers across the world, it will also result in greater uncertainty and production loss as a result of increases in the frequency of extreme events such as droughts and floods (OECD and FAO, 2010, p. 45).

Already with a mean of 0.8°C warming over the last century we are seeing a significant impact. In Australia, climate change has been linked to substantial increases in rainfall in northern and central parts of Australia, as well as significant decreases across much of southern and eastern Australia (Bureau of Meteorology and CSIRO, 2010). There is an increasing likelihood that we are reaching critical tipping points that will trigger abrupt, non-linear changes in the global climate system (Lenton et al., 2008). Factoring in historic emissions and the inherent inertia in the climate system, Ramanathan and Feng (2008) suggest that we may already be committed to an additional 0.6–3.5°C (on top of the 0.8°C already observed). Meinshausen et al. (2009) published estimates in *Nature* that the global constraint to achieve the required level of emissions reductions (e.g. to stay within 2°C) would only allow around 27–47%

of existing fossil-fuel reserves (reserves recoverable with existing technology and prices) to be consumed.

Therefore, agriculture, energy and climate change policies need to respond to interrelationships across systems. Without policy coherence there is a significant risk of maladaptive response – for example, where strategies to increase adaptation to climate change inadvertently increase emissions or exposure to increasing energy prices.

The Policy Arena

We selected three recent policy texts at varying scales to explore these energy security and climate policy discourses. The *World Agriculture Outlook 2010–2019* (OECD and FAO, 2010) updated in 2011 – *World Agriculture Outlook 2011–2020* (OECD and FAO, 2011) represents global food and agriculture policy. The guide to the Murray Darling Basin (MDB) Plan – a scoping document for the future of water allocation in the MDB – encompasses policy for an area that includes a significant proportion of Australia's arable land. At the sub-national level, we examine the State of Victoria's *Future Farming* strategy. The strategy sets priorities for research and government service delivery to farmers. The guide to the MDB plan is a discussion paper – the starting point for a process to set water diversion limits on the river system. The OECD/FAO document outlines current and future issues in food and agriculture at a global scale and is intended as a resource for member countries in setting agricultural policy. The common thread between these documents is the shared intention to provide policy direction for the future of food and farming.

Global Scale Assessment: World Agriculture Outlook 2010–2019, 2011–2020

This OECD and FAO (2010) report covers projections for production of commodity bio-fuels, cereals, oil-seeds, sugar, meats and dairy products out to 2010–2019. The report highlights 'severe shocks' faced by agriculture in recent years – high oil prices, commodity price spikes, food security fears and recession. Nevertheless, for the purpose of projections it assumes 'normal conditions' (OECD and FAO, 2010, p. 12) and advises that 'in the absence of unexpected shocks, growth remains on track with estimated long term requirements of a 70% increase in global food production in 2050' (ibid, p. 11). It also assumes average or normal weather conditions, the absence of weather-related supply shocks. It acknowledges that 'frequent weather disturbances associated with climate change may render global yields much more variable, leading to a greater instability in production and trade flows' (ibid, p. 43) but offers no direction. The report notes that reducing greenhouse gas emissions will be expected but does not recommend how this can be achieved or by whom or when.

Energy is discussed at some length – acknowledging that agricultural prices are underpinned by increasing energy cost structures particularly in regions where energy inputs are used intensively. The assumption of higher oil prices plays out by pushing agricultural commodity prices upward. Crop prices show significantly higher sensitivity to oil price changes compared to livestock products. This stems from a higher energy share in total crop production costs because of fertilizer, chemicals and fuel prices.

Limits on production 'as usual' are mentioned briefly, but the general assumption is that people will respond with innovation in response to market signals and so maintain production levels. Diversification is suggested as an option for individuals in managing risks but this comes with a caution that it may result in reduced production and profit (OECD and FAO, 2010, p. 59). The role of government in managing risk is highlighted, although the focus is on managing 'short-term volatility' and avoiding 'catastrophic risks that are rare but have large consequences' (ibid, p. 61). Despite recognizing the significant link between energy and food production, the general message of the report is that if the policy and institutional settings are right, farmers and consumers will respond to price signals; the global population will innovate – to achieve a 70% increase in food production by 2050. In general, these assumptions remain consistent in the update (17 June 2011). However, the more recent analysis, reflecting on the context of the fifth year of extreme price volatility in agricultural commodities, provides a much more in-depth analysis of the drivers of price volatility – including climate and weather related shocks and energy and other resource constraints. The report modelling finds that the variability of oil/fertilizer prices and yields has the greatest impact on agricultural commodity prices, well above other macro-economic variables (ibid, p. 69). Yet still the suggested policy response to these particular issues centres on raising the productivity of small-scale farmers in 'developing countries' (e.g. through public sector research and development) and reducing post-harvest losses (ibid, p. 67). This falls short of acknowledging any serious vulnerabilities inherent in energy resource intensive systems across the globe.

National Arena: The Guide to the Proposed Basin Plan – Murray Darling Basin

In October 2010, the Murray Darling Basin Authority released the *Guide to the Proposed Basin Plan* for public consultation. The focus is on the key decisions the Authority is required to make under the Australian Water Act 2007 in particular the new limits on water that can be taken from the Basin (sustainable diversion limits – SDLs). This document represents the start of an ongoing process, rather than new policy settings.

Decisions made through the plan process have potentially significant implications for food production in the region (particularly irrigated agriculture) – 39% of national agricultural production (including 42% of Australia's total fruit and nut production, and 32% of Australia's total dairy production) is located in the area covered by the proposed plan.

The development of the plan involved detailed hydrological modelling and consideration of the impacts of climate change. It looked at scientific evidence regarding the MDBs environmental condition and commissioned social and economic impact studies to inform the guide. When assessing the potential impact of reduction of water allocations in line with climate change predictions, the Authority extrapolates from observed trends in social and economic conditions. It doesn't explore potential future scenarios for food and agriculture inclusive of more expensive energy inputs to agriculture.

To illustrate, one of the few pieces of supporting analysis that recognized the importance of 'non-water' related structural adjustment as important context for decision-making was a report commissioned from Frontier Economics (2010) This report still only included analysis that extrapolated past trends rather than entertaining the possibility of non-linear change. In it and the guide itself, there is no mention of potential energy resource constraints or cost increases associated with either climate mitigation activities or rise in price of liquid fuels.

The climate change projections were developed by CSIRO (the government funded scientific advisory service) based on data current at the 2007 IPCC report. Despite the scientific evidence, this 2010 guide to the Basin Plan doesn't discuss a range of potential climate scenarios or the new scientific evidence since 2007, which indicates a much greater sensitivity of climate to emissions (see above). Although the guide deals with policy development that will potentially have a significant impact on the future of food and agriculture in Australia (forming the basis of water allocation decisions and strategic regional planning and infrastructure investment in the MDB), it considers a very narrow set of future possibilities and scenarios and fails to acknowledge potentially important interrelationships between resource sectors.

Sub-national Arena: The Future Farming Strategy

Service delivery through the Victorian Department of Primary Industries is guided by the *Future Farming* strategy 'to improve the productivity, competitiveness and sustainability of farm businesses' (State of Victoria, 2008, p. 1). The strategy identifies adaptation to climate change, reducing emissions and 'intensifying competition for world markets and resources' (ibid, p. 11) as central to its policy direction. It raises competition for resources as an issue, but does not acknowledge peak oil or the likelihood of absolute energy limitations affecting production or distribution of food. Change in general and the unknown qualities of food production in the future is described as positive 'opportunities': Government's role is 'providing the sector with the information and tools it needs to anticipate and manage the impact of the changes ahead' (ibid, p. 23) and setting the right conditions for resource markets. However, the future is described in terms of the inevitability of ever increasing production and competition where only the strong and innovative survive. The change trajectory is seen as inescapable, where: 'the new era in farming is being driven by economic, climate and market forces largely outside our control' (ibid, p. 6). There are limited possibilities for diversity of scale or structure in the vision for agriculture as:

> 'successful, competitive farm businesses of the future will also be larger in scale and scope. They will use more off-farm capital, specialised technical and financial advice, and non-family labour. They will plan strategically, and trade more actively in land, water, capital and their products to respond flexibly to fluctuating prices and climatic conditions' (ibid, p.6).

Across the policy arena that we have documented above, it is as Brooks et al. (2009) indicate – that policy actions are conforming to a very narrow range of mitigation and adaptive responses. These responses do not of themselves or associated with their previous policies, identify the need for reconceptualisation of approaches or strategies. Instead, their incrementalist nature is intended by government and agencies to spread risk even as it grows more unlikely that risk can be deferred in this manner. Incrementalism reinforces ideas of modernization: the continuing association with global production regimes as they have been conceived in the twentieth century (McMichael, 2009).

Methodology

Field data for this article were drawn from two separate social science research projects based in the Northern Victoria agricultural region from 2009 until the present. The projects, although different in approach, research questions and aims, both investigate how farmers are adapting to climate change by examining how farming practices have been changing over time within the case-studies.

In case-study 1, 20 farmers were interviewed from two sites chosen through both snowballing techniques and cold calling. Farmers were from both dry land and irrigated areas and from a range of industries (dairy, beef, sheep, tomato and mixed) and family farm generations (first, second, third and fourth). The interviews lasted for approximately one hour where a range of issues were discussed, especially around drought, including how and why farming practices have changed over time.

In case-study 2, in dry-land farming districts around a small town in North-east Victoria, 32 farmers were selected through a quota sampling technique to initially complete a questionnaire about practice change (changes on their farm and observed in the local area in recent years). Twenty of these were then selected randomly to participate in an in-depth interview. Farmers were from a range of ages and industries including beef, sheep, cropping, mixed and horticulture. In-depth interviews averaged one hour in length and focused on the life-histories of farmers, characteristics of their farming practice, how and why they became interested in farming (and continue to farm), and plans for the future.

Both series of interviews were recorded, transcribed verbatim and thematically coded. Several common themes emerged from the two cases' interviews around farming practice change particularly in relation to three of the maladaptation types as defined by Barnett and O'Neil (2010) – increasing greenhouse gas emissions, path dependency and reduced incentive to adapt.

The Local Reality

The Northern Victoria region is agriculturally diverse consisting of large areas of dry-land farming where production is dominated by sheep, beef and cropping and irrigation-based industries including dairy, horticulture and viticulture. It is estimated that in 2005–2006 the gross value of agricultural and horticultural production was over AU$ 2.2 billion accounting for approximately a quarter of Victoria's agricultural production (ABS, 2006). In responding to a changing climate with lower water availability due to both reduced rainfall and uncertain water allocations, farmers in the region have been adapting their farming practices in various ways.

The Irrigated Landscape

After eight years of drought, the majority of dairy farmers moved fully or partially away from a perennial pasture feeding regime to a semi-feed-lot system of growing crops and annual pastures. Many are sowing autumn cereals and ryes and annual pastures to cut for hay and silage, conserving as much as possible for other times throughout the year. Autumn crops are often supplemented with a summer crop if rainfall and/or water allocations permit. Particularly for the dairying industry, the competitive advantage for many years was the farmers' ability to grow their own pasture throughout the year. Now the feed needs to be handled numerous times from growing, cutting, baling and carting it in, before eventually getting fed out to the animals. Each of these steps requires additional energy, adding to the carbon footprint of the farm system. More equipment and machinery is required for a feed-lot system of farming – feed pads, silos for storage, bigger tractors and graders and wagons to mix the feed – as well as the extra travel required to source food from other areas.

With the modified feeding regimes, the amount of land needed to be irrigated has reduced substantially and there is a more strategic approach to watering to get maximum growth out of everything. Many farmers are seeing this as a more efficient method of farming – efficiency being evaluated in terms of milk production and water use efficiency – and plan to continue farming in this way even if water allocations become more secure. Although in the face of drought and water availability this appears a rational decision in the short term, on closer examination it suggests that some farmers are moving to more resource-intense regimes despite, or without considering the implications of long-term higher emissions and the potential future rises of input costs and scarcer resources.

Installing new infrastructure, particularly for more efficient watering and irrigation, has been a priority for many through the drought. The Victorian Government, through a modernization project, is updating the irrigation infrastructure in the area with the aim of making water delivery more 'efficient'. The original system relied on gravity to feed the water – the new system will require a substantial number of pumps, both on and off farms, to even water pressure and for water to be available on demand. There are savings in the amount of water used and hence the cost for this water for farmers, but this then needs to be balanced against the cost of the extra energy required to run these more 'efficient' water systems.

The Dry-land Landscape

Over the last 20 years in the dry-land region, there has been a move away from wool production to sheep meat production. There has been an increase in cropping, with new techniques (like mounding) and the dryer climate opening up areas for cropping that were previously too wet. Although mixed farming is dominant, some farmers have moved entirely into cropping. There are examples where a move to pure cropping has been prompted by the drought as farmers no longer had reliable water for stock. Some farmers that kept their livestock were forced to cart in both feed and water – a significant investment in time and resources. In very recent years, as the relative price for grain has decreased in comparison to meat, some farmers have observed a 'swing back' to livestock.

There has been a major shift to supplementary feeding and feeding out rather than grass-fed over a longer period in the year as a result of the drought. In most cases, this has meant devoting more of the farm to growing crops. Many have employed strategies like planting 'grazing wheat' and keeping most of the grain for their own animals and selling what is left. There are examples of producers moving to more intensive production systems for both beef and lamb, that is, farm feed-lots. A husband and wife who run sheep in a relatively high input system explain how supplementary and intensive feeding systems have become commonplace and what it means for them.

> ''82 was pretty dry and you know, we sold off sheep in early December for $ 7 a head or something only to find that in February/March it rained and ewe prices had tripled and with a little bit of feed we could have kept them and that has been our attitude ever since – keep our sheep and buy feed into feed them… We've had so many years of drought therefore feeding of sheep has been a huge issue. I mean you keep buying grain or outside fodder all the time… we've thought of silage bunkers and things like that so that we could store. Because we haven't got enough silos to store enough grain for the numbers, we're feeding so we've looked at cutting silage instead and storing that as a drought measure (wife)' (Sheep farmers A).

Although this is a common scenario for many of the farmers, there are others who fall at either side of this spectrum. There are those farmers that see adaptation as a short-term strategy and plan to return to old farming practices. There are those that take a more holistic approach to their on-farm management and the other variables that may come into play in the future. Examples of this spectrum of approaches are cited below.

Maintaining the Status Quo

A third generation dairy farmer we spoke to has been working on the farm for the last 30 years. This farmer has adopted other strategies in addition to changing feeding regimes to cope through the last drought, such as amalgamating three dairies with relatives and experimenting with beef and pigs as sidelines for additional income. Even though he feels the way he has been farming in recent years is more water-use efficient he doesn't get the same fulfilment from it, and wants to return as soon as possible to the way he used to farm.

> '[W]e're not believers in climate change or anything like that – our idea is that this is normal – and I'm not sure what normal is. There might be 20 year droughts. But certainly drought is normal and I guess probably the thing that has made it so much more difficult has been the government policies on environmental water… I want things to return – not back to the way they were completely – but back to growing grass – but whether or not that's going to happen I don't know. If it didn't happen I don't know if I'd stick it out. I don't want to buy feed and feed it out to cows and milk cows. It takes all the enjoyment and satisfaction out' (Dairy farmer A).

Managing for Change

On the other end of the spectrum was a first generation dairy farming couple who recognize that in planning for the longer term they need to start considering now what climate change and energy constraint may mean to them. As much of the irrigation system in their area is being upgraded, this couple has been in negotiation with the project managers for the last two years as they cannot see the logic in changing from a gravity-fed system to a system run largely by pumps:

> 'We are wedded to gravity. We think gravity's time has come. Why in an environment where we've got man-made climate change would we want to put pumps in?… That's what I said to you before about optimizing not

maximizing. There is no point in saying we have got fantastic water use efficiency when our carbon footprint has increased. What is the point? It's a negative change' (Dairy farmer B).

These same farmers are also looking at different strategies they can employ around the whole farm in an effort to become carbon neutral in the future, such as installing solar panels and experimenting with capturing methane on their effluent dams.

There was also one small-scale horticulturalist expressly planning the farm operation in response to risks around oil and climate change.

> 'If people keep learning there are positive signs that we could….ride the wave of energy descent, stay in front of it, get there, and manage to creatively adapt to ride that wave and ride it down the slope rather than have it crash down on top of us, and find ourselves with farms that are energy dependent and without the fuel to run them and collapsing agricultural production' (Horticulturalist A).

While several had planned for variable weather, only a few farmers in these cases overtly listed climate change as a consideration in farm planning.

> '[It's] hard to predict what will happen if we are looking at climate change… maybe that will have a bigger impact than anything else in determining what flows and maybe that will have an impact on capital values' (Sheep farmer B).

Another farmer discussed explicitly the risk of high fuel costs in the future as a consideration in their farm planning. It was seen as a potential risk but one that would affect everyone so in relative terms, their district less so than other localities.

> 'Fuel prices are going to dictate the future of things too I would think don't you? It's not too bad at the moment but if it goes to $ 2 litre or something like that it will make things difficult. But those things are going to affect the country as a whole – we're all in the same boat. I reckon the outback will probably suffer more than we will round here – distance, cartage, freight all those things are not going to get any cheaper… every district is going to be different because of its locality I think' (Mixed farmer A).

Managing for Increased Production

We spoke to a very large family cropping business that is meeting the expectations of 'success' as envisioned in the *Future Farming* strategy. The vision for the future incorporates further intensification and reliance on inputs, albeit with some recognition of the need to reduce transport and fertilizer costs.

> 'We've expanded the machinery manufacturing and modification elements of the business. We've had new technologies.. We're now using crop modeling with more intensity… we're also conducting a number of research trials… that's 10 000–40 000 tonnes that we produce every year. There's no reason why that couldn't be value added through an intensive animal system here and we move 2,000 tonnes of animals and a high value product at that. We're also keeping all of that high value nutrient nearby so the carbon footprint for fertilizer manufacturing reduces… the single thing that's stopping us is water' (Grain farmer A).

Discussion

In the farming practices in our case-study areas in Northern Victoria and in the documents discussed we observe a significant risk of perverse outcomes. We do not presume any specific links between these selected policies and the practices of the interviewed farmers. Our purpose was to look at how these different actors are making sense of energy and climate issues and what this means for decision-making and options as each constructs it.

In discussing farming practice changes, we observed examples of moves to higher-input, energy-intensive systems as a direct response to drought. For example, in the irrigation areas, the modernization project has meant an increased reliance on a non-gravity fed system where the added electricity costs are indirectly and directly borne by the farmers. In the dry-land areas we observed an increased reliance on water cartage for stock with the attendant fuel costs and an increase in the extent of high-input cropping systems (across landscapes that were previously too wet). These cropping systems require significant investment in machinery and field infrastructure. In livestock systems, local farmers have reported a significant increase in reliance on supplementary feed (that is grain or hay – often grown in high-input systems) either bought in or grown on farm. Before the drought, supplementary feeding used to be employed as a strategy just for a short time, rather than a year-round feeding programme. There are cases of farmers taking this to the level of intensive feed-lot systems on farm – in the case of both sheep and cattle. These sorts of practice changes may well be an effective response to the short-term impacts of drought but they have the potential to lock in higher energy costs as input costs continue to increase.

In applying Barnett and O'Neill's (2010) five pathways to our case-studies, it is clear that there is an overall potential for maladaptation. Adaptation to climate variability within the 'business as usual' model for these production systems is increasing dependency on fossil fuel-based inputs, increasing exposure to rising energy costs associated with peak oil and also contributing to increasing emissions. The lack of policy incentives to encourage change to alternative sources of energy at a time when the changes to water provision are creating opportunities for new infrastructure and a rethinking of the farm operation system is perverse. As Gunderson et al. (2002, p. 325) noted, 'with a pragmatic focus on policy implementation, most agencies seem to have a twofold strategy that is aimed at reinforcing the status quo: prove that extant policies are correct, and don't act until confident of what to do next'.

These farms have had a disproportional level of stress that contributes to farmer vulnerability at social and ecological scales. The powerful in the agri-food system continue in the same circles (existing energy hegemony and food supply hegemony). The cost of the new irrigation system will impact disproportionately on the already 'shocked' farmers and increasing energy costs exacerbate their disadvantage. Opportunities to disconnect from the current production model may in fact arise, based on the general crises associated with peak oil – the extent of which will be experienced across the whole sector from production to consumption – as one of our interviewees noted. The off-farm flow-on costs will be significant for Australian farmers both internally (long distances) and internationally (very long distances) remembering that the post-farm gate costs are higher than on-farm production costs for food supply chains (Heller and Keoleian, 2000). However, opportunities are only such if there is flexibility to take advantage of these; the more cash strapped and asset dependent the farmers are, the less chance there is to avoid tipping points or anticipate innovative approaches. At the farm scale, this process reflects the limitations of previous decisions, pointing to the creation of path dependency. This is decision-making based on past assessments and ways of doing things, rather than fresh evaluation of current conditions or future possibilities.

Path dependency, therefore, is probably the most complex kind of maladaptive response to explore. This is because it is implicit in multiple scales of engagement within a system without being explicitly represented in the policy change process. The government promotion of large farms and corporate farm structures reinforces a certain economic path that, as McMichael (2009), for example, argues, requires a homogenization of global farm production. This effectively operates to limit economic viability for non-conforming farmers operating in independent ways – ways that are perhaps viewed as anarchic and unpredictable by the agriculture bureaucracy. It makes the small and middle-sized family farm, which has been described as 'inefficient' since the days of white colonization and the transportation of a yeoman farmer idyll to Australia (Lake, 1987), disappear in the aggregation of land and titles, and in the loss of farm autonomy. Bureaucratic path dependency at a policy level reinforces economies of scale – that is, 'get bigger' – as if the agricultural markets will continue as previously despite the shocks associated with climate change and peak oil – and as if the best scale of response is for all farms to be uniformly large. As Cooper (in Brooks et al., 2009, p. 748) argues, the emphasis on modernization as a 'transition from "inefficient" subsistence to "efficient" commercial production' continues.

As Bäckstrand (2010) notes, most insidiously, policies are framed in such a way that when the twin challenges of energy security and climate change appear together, they are framed as a positive opportunity, downplaying the conflicts and trade-offs that would be the reality of implementing changes to fundamentally transform production and consumption systems. Adaptation itself has significant impact on society as history indicates (Brooks et al., 2009) – including a societal view of how to relate to the environment as we exit the twentieth century's resource management strategy for the twenty-first century associated with SES and their adaptive capacity (Holling and Meffe, 1996; Walker and Salt, 2006) – and this transition is not compatible with 'business as usual'.

In this article, we have engaged with what government and global organizations are 'saying' about climate change and peak oil by analysing their published policies. We have applied these policy directions to our case-studies of farming in the north-east of Victoria, Australia. In general we find a linear view of change, still described as 'progress' and still associated with the current productivity models. 'Shocks' – such as long-term drought (or sudden floods) associated with climate change, or increased energy prices – are superficially acknowledge in these policy models as 'blips' on the path. This suggests significant risk both in terms of path dependency and in a failure to acknowledge the possible lock-in effect of particular pathways in isolation. The potential for non-linear large-scale shocks is not considered and on-ground, farmers are encouraged to pursue high risk strategies (for example, high-input systems) that lull them into a false sense of security. There is also the reality that as articulated in their policy statements, the global arbiters of these production systems most threatened by both predictable and unpredictable change are fundamentally not able to imagine a non-cause and effect response. This results in there being only one active direction open to policy-makers and that is to frame 'progress' as some kind of inevitable path, a kind of acceptance that does not encourage adaptive change at any level.

Adaptation is a process of deliberate change in anticipation of or in reaction to external stimuli and stress. The dominant research tradition on adaptation to environmental change primarily takes an actor-centered view, focusing on the agency of social actors to respond to specific environmental stimuli and emphasizing the reduction of individual vulnerabilities. An SES analysis incorporating a resilience approach (Folke, 2006) (which we have labeled a twenty-first century approach) takes a more dynamic view, and promotes adaptive capacity as a core feature, anticipating system change and multiple adaptive responses. These implicitly reflect the interconnection between policies and actors, acknowledging uncertainty, and thereby exposing its components – countering the likelihood of maladaptive responses.

Our case-studies' excerpts point to local incremental adjustments that mirror the policy analysis. There is little expectation of transformative action. As these interviews indicate, individual sources of resilience exhibit adaptive action at some small scale. Individuals may survive in the short term because of the variables inherent in their operations, but the likelihood of longer-term survival (and the desire to survive in those particular configurations) remain unknown.

Conclusion

The purpose in predicting maladaptive responses is to avoid them. We looked to policy analysis and its recommendations to consider how global, national and state policies informed our experiences of interviews with farmers in the north-east of Victoria around climate change and peak oil. We concur with others that when setting policy priorities for climate change adaptation, the objective is not to increase emissions or rely on resources that are becoming increasingly scarce and expensive. When prioritizing energy security (oil), the intention must be to decrease emissions and consider the implications of a changing climate; and, when setting priorities for emissions reduction, we cannot rely on resources that are becoming increasingly scarce and expensive and must consider all energy sources alongside the implications of a changing climate. In this way, the interconnectivity of system dynamics must be acknowledged as the basis for all policy directives.

Policy incrementalism reinforces tinkering at the reductionist end of the adaptive spectrum, oblivious to systemic logic – making minimal changes to current policy directions, perhaps even labeling those made as 'adaptive', but in effect maintaining 'business as usual'. This incrementalist approach reproduces itself at each scale of engagement and across scales, exposing the 'locked-in' reality of policy decision-making.

In the presence of strong hegemonic powers that are vested in 'business as usual', we can only expect that the risks will be high and the shocks severe as the current resource management approach spirals down. We read the international, national and sub-national documentation on energy and climate change as conceptually vague about innovation and adaptation, expecting them to mysteriously emerge, presumably at local levels, to sustain the current assumptions of food and energy policy in a time of climate change. The time-lag associated with stepping away from conventional production-line approaches and imagining radical infrastructure change is ignored in all levels of policy documentation. For the majority of farmers in Northern Victoria the range of options in which they can 'innovate' or 'adapt' has narrowed to only those existing within the current agro-industrial structures. In this their maladaptive responses mirror the global downward resource trajectory because of their best intentions to maintain 'business as usual'.

Notes

1. Between 1997 and 2002 the increase in food-related energy flows made up 80% of energy flow increases in the US.

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