

Victorian Food Supply Scenarios

Impacts on availability of a nutritious diet

Summary – April 2011

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Overview

There are resource allocation and management decisions being made now in Victoria, and Australia, that will have significant implications for the flexibility and options for our food supply in the next decades and for future generations of Australians. This research explores how these decisions will impact on our ability to provide a reliable surplus of the foods required for a nutritious diet, whilst providing for ongoing health of the environment, the economy and ultimately the wellbeing of people and communities (both farming and urban communities).

The Victorian Food Supply Scenarios project has been a 12-month research project funded by the Victorian Health Promotion Foundation (VicHealth) through the Healthy Eating stream of their Research Innovation grants, provided to research a new concept or methodology relevant to the theory, policy and practice of health promotion.

The primary purpose of this project was to develop and demonstrate a new methodology to link land and resource use with availability of a nutritionally adequate food supply for Victoria's population. The research made new use of an existing physical model of the Australian economy developed by CSIRO (one of the project partners) to track the complex interaction of land and resource systems as they affect the availability of food. The research was undertaken within strict time and resource constraints and there was consequently a limit to the analysis of data sets and settings. The assumptions, approximations and generalisations are noted throughout the report.

The tensions identified through this work are significant, in spite of levels of uncertainty resulting from the project constraints. They strongly suggest that a sophisticated and strategic approach to resource allocation is urgently required, if the multiple objectives of food security, energy security, greenhouse emissions reductions, sustainable resource use, a healthy environment and a viable economy are to be achieved. The outcomes do not provide any easy answers, or suggest that one approach to these issues is clearly better than another. It sets out a framework for more detailed investigation of some very critical questions, by developing and demonstrating a methodology that can be extended to test various options for 'food security policy'.

The key messages, context, assumptions, methodology and results are explained and discussed in detail in the full report, with a high level summary provided below.

Context

Availability of sufficient foods for a nutritious diet

This project is focused on food availability: "*sufficient quantities of food of appropriate quality*, supplied through domestic production or imports (including food aid)" (FAO 2011); this recognises that the irreducible base of food security is the physical ability to provide for the nutritional needs of the population. We use an indicator of 'net food availability' i.e. how much of each food group under investigation is produced in Victoria / Australia, compared to that required.

Food availability is necessary, but not in itself sufficient, to ensure that a household or population is food secure. This analysis does not discount the critical importance of other aspects of access to food that affect security, e.g. price, consumer preferences, advertising, food safety and so on, but they are outside the scope of the research.

It is assumed that it is possible to import food, and other critical resources, if required; however relative levels of domestic sufficiency are compared under different scenarios. It is also assumed that food produced is physically available to consumers i.e. that the systems function effectively to distribute food (even if those systems operate differently across the scenarios).

Nowhere to hide

There are four over-arching drivers that shape this research: climate change; oil; fertilisers and population growth. These drivers contextualise the challenges we face in securing food availability. While these issues may not be fully in our control, it is the divergent strategies for our response that shape future scenarios. In this analysis we have assumed:

- Climate change is already occurring and is a result of human activity through the emission of greenhouse gases into the atmosphere. It will intensify in the study period, as the climate system responds to levels of greenhouse gases that are already in the atmosphere.
- Ambitious action to reduce emissions by 2030 is necessary and will occur.

- Australia's oil production has peaked and increasing imports are required to meet increasing demand. The International Energy Agency suggests that global (conventional) oil production peaked in 2006 (IEA 2010). The increasing cost (energy and financial) of extracting oil resources means that costs will rise significantly. This will drive substantial transformation of the economy, with implications for the food system.
- Increasing global demand, and challenges to the supply, of fertilisers (particularly phosphorus) will reduce availability and increase cost.
- Global population growth will continue, as it will in Australia.

Key Messages

Food availability is complex – it is closely linked with resource and land use, trade, employment and energy and water usage. Assessing or managing food availability requires a coherent assessment of the interactions of all of these factors.

In this project, we have developed and tested three scenarios (elaborated below and Figure 1) to explore food availability and to investigate its interaction with population, resource use and the economy. One scenario, labelled as “*Adjustment*”, assumes free markets and high levels of international trade; “*Control*”, as the second scenario, assumes strong policy and regulatory intervention in the market to ensure the domestic supply of core foods; the third, “*DIY*”, envisages a more decentralised future with light, mostly local, government intervention.

The scenarios reflect different strategic approaches to the issue of food availability and create divergent sets of variables for modelling: energy demand, efficiency and sources; allocation of land and water resources; levels of waste and losses; levels of water and fertiliser efficiency in agricultural production; and transport patterns and modes. Key findings are outlined below.

All foods are not created equal

By considering the needs for a nutritious diet, rather than the diet as typically consumed, this project has revealed early and immediate tensions in availability of the foods required. An overall surplus of ‘food products’ is not the same as production of a nutritionally adequate food supply¹. Examples of the tensions in providing for a nutritious diet identified through this research are shown in Table 1 and include:

- Australian production of fruit and vegetables already falls short of providing sufficient serves of these foods to meet the recommended food intake patterns.
- Two of the scenarios reallocate land from one type of production (grazing) to another (fruit and vegetables) in an attempt to maintain sufficient production of required foods at a national and Victorian level respectively. This is successful in providing fruit and vegetables but creates other tensions, resulting in shortages of dairy (by 2030) and lamb (by 2060).
- Some food crops can be used as biofuels. Two of the scenarios see diversion of cereals, sugar and oil crops to 1st generation biofuels, with one producing a serious conflict between food and fuel by 2030.
- In all scenarios, Victoria becomes borderline or a net importer of cereals by 2030. Australia retains a cereal surplus to 2030, but it is in steady decline in all scenarios.

The project shows that under the expected future conditions (climate change, increasing population and diminishing availability of oil), the domestic production of a surplus of required foods – at either Victorian or Australian level – must not be taken for granted.

No such thing as a free lunch

Ultimately the successful provision of food is determined by the bio-physical factors necessary for its production (land, soils, sunlight, nutrients, feed-stocks) and the availability of resources required for organising production, processing and distribution. The scenarios test challenging, but realistic, possibilities for change to availability, allocation and use of resources.

These impact on:

- Use of land, water and energy resources;
- Production and distribution infrastructure;
- Targets for reduction in greenhouse gas emissions;

¹ Nutritional health requires both adequate amounts of food to meet human energy requirements and adequate variety of foods to provide the diversity and amounts of nutrients required.

- Levels of import reliance for oil and fertilisers; and
- Settings for key economic indicators (i.e. GDP; unemployment and trade balance) that are considered representative of healthy economic activity.

Land: Productive land area reduces in all scenarios, due to varying combinations and rates of diversion to forests (for carbon sequestration and bioenergy) and urban land expansion. The change of land use from irrigated to dry-land production also has an impact.

Water: Large reductions in water extraction for irrigation fail to avert 'negative' environmental flows in key river systems, in two out of the three scenarios (Figure 2).

- The Victorian irrigation districts analysed (*Gippsland and Murray*) have negative environmental flows by 2040-50 even with the greatly reduced extractions in *Adjustment and Control*. The *DIY* scenario has a 75% reduction, which stabilises and maintains environmental flows throughout the study period, although *Murray* is still declining.
- River systems with 'negative' environmental flows for any period of time are unlikely to support food production in the longer term. It should be noted that the reduced extraction levels, while large, are not at the extreme (high climate change) level that CSIRO (2008) suggested may be required for the Victorian regions of the Murray Darling Basin. This tension clearly cannot be sustained.

Greenhouse Gas Emissions: all scenarios have significantly reduced greenhouse emissions by 2020, with two meeting IPCC requirements for Annex 1 countries at a national level (Table 2).

- The scenarios have different levels of ambition in reducing greenhouse gas emissions (shown as the 'Target' settings in Table 0-1).
- The settings for the *Adjustment and Control* scenarios 'overshoot' their emissions reduction targets and achieve greater reductions on 1990 levels than were sought by 2030, but fail against later targets.
- *DIY* has the most ambitious targets. It is the only scenario that does not achieve its intended 2030 reduction level at a Victorian level, but it exceeds IPCC requirements by 2020 and its own 60% reduction target at a national level in 2030.
- *DIY* is also the only scenario that is able to sustain emissions reductions beyond 2040. This is due to a reduced per capita consumption of good and services (and correspondingly energy use) across the economy, which has negative implications for GDP per capita and unemployment (as currently measured).
- In the other two scenarios, the economic indicators remain 'healthy' but greenhouse gas emissions start rising again from 2040. This is due to increasing energy demand outpacing efficiency gains and the net benefit from carbon sequestration in forests declining as land availability reduces.

Oil (Figure 3): one scenario achieves a high level of energy security and significantly reduces imported oil reliance, although massive and immediate intervention is required.

- The *Control* scenario achieves the most significant reduction in imported oil dependence, due to an immediate shift to electric vehicles (all new passenger vehicles from 2011) and rapid scale-up of gas for electricity and transport fuel. This leads to electric vehicles using more electricity than buildings by 2030 and sees conventional gas resources under severe strain by 2060.
- The substantial diversion of crops for biofuels in *Adjustment* and *DIY* has an impact on oil demand, but is marginal compared to the decline in Australian oil production. It is a large diversion of food for a minimal energy gain.
- All of the possibilities for fuel substitution that are not quantitatively included in the project would have other costs elsewhere e.g. increased greenhouse gas emissions (coal-to-gas and coal-to-liquids) or environmental damage (and additional loss of agricultural land or water resources) from accessing non-conventional gas resources.

Phosphorous (Figure 4): all scenarios reduce reliance on imported phosphorus, but retain a large requirement.

The significant reductions in imported phosphorus requirements achieved are largely due to demand-side measures, including:

- Change of diet (the requirement for a nutritional diet modelled in this project has a significantly lower requirement for meat products than the Australian average. (The *Control* and *DIY* scenarios reduce the proportion of meat and dairy products being produced);
- Reducing waste / loss levels in some scenarios; and
- Agricultural efficiencies that reduce demand for phosphorus (relative to amount of food produced).

These unresolved tensions mean that the results point to a need to investigate the above issues in greater detail. For example, a net zero environmental flow in key river systems is not an acceptable (or viable) outcome. Similarly, constraints on global oil supply or domestic gas could mean that the energy use assumed in this work is either not possible or prohibitively expensive. Testing how and whether these tensions can be resolved becomes a priority for further work.

Methodology

The purpose of this project was to develop and demonstrate a new methodology to link land and resource use with availability of a nutritionally adequate food supply for Victoria's population. To do so, it has built the capacity of the CSIRO stocks and flows model as a platform for on-going 'what-if' investigation of Victorian and Australian food supply security.

The three elements of the methodology developed are:

1. Determining the amount and variety of foods required to meet the recommendations of nutrition reference standards for the population;
2. Constructing qualitative scenarios to frame divergent socio-economic and technical trajectories; and
3. Translating qualitative scenarios to quantitative scenarios and analysing their implications.

Food requirements for a nutritious diet

The Australian Guide to Healthy Eating (AGTHE) defines a nutritious diet as one that meets the key nutrition reference standards. The aim of the AGTHE is to, "encourage the consumption of a variety of foods from each of the five food groups every day in proportions that are consistent with the Dietary Guidelines for Australians" (Commonwealth Department of Health and Ageing 1998).

An estimate of the amount and variety of foods required to meet the recommendations of nutrition reference standards for the population was obtained by:

1. Selecting foods to represent each food group;
2. Selecting the population categories for which the nutrition implications would be assessed;
3. Determining the number of recommended serves for each food group; and
4. Estimating the amounts of foodstuffs required to meet the nutrition reference standards for the population.

Qualitative Scenarios

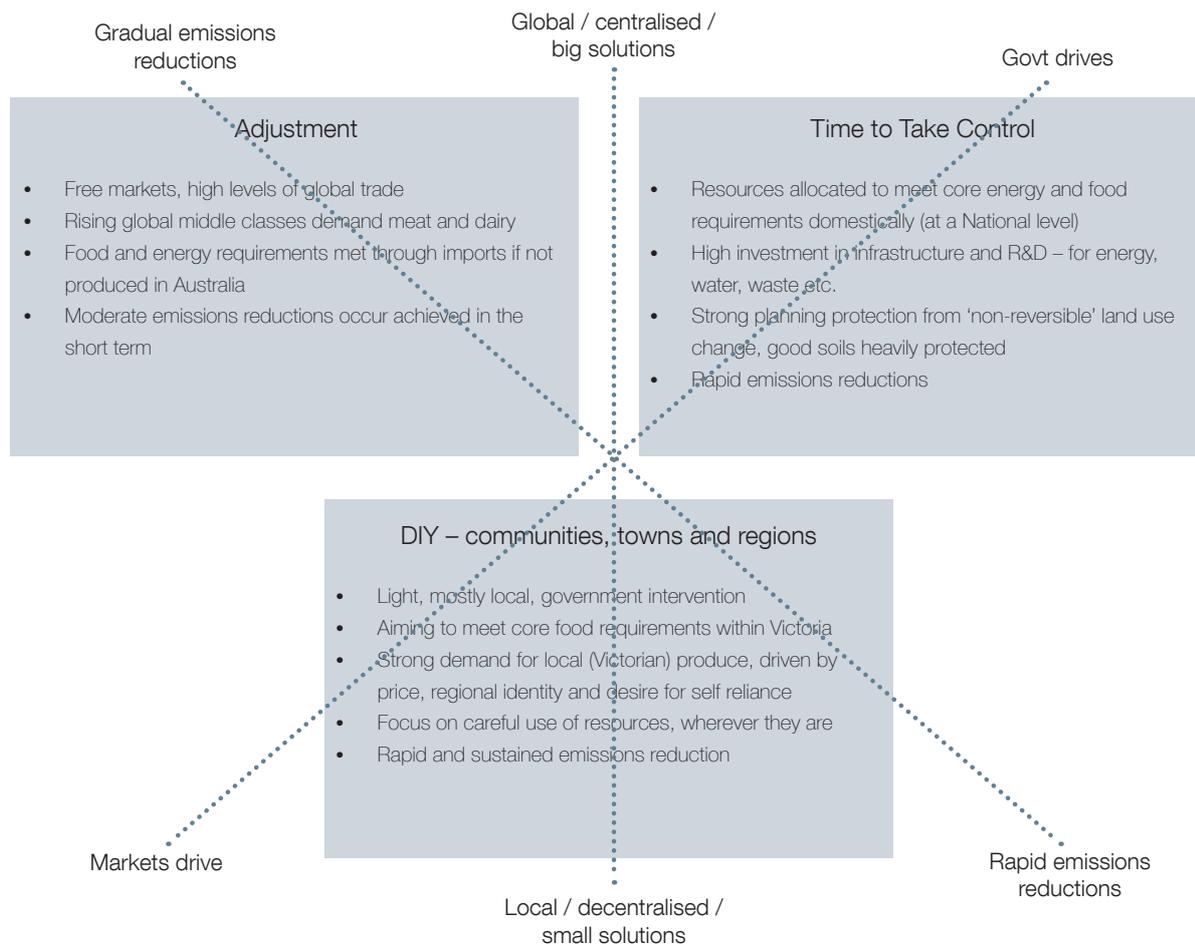
This project developed and used 'what-if' or 'exploratory' scenarios. These have plausible, internally consistent story lines containing different social, cultural, political and economic regimes. The resulting qualitative scenarios (Figure 1) describe different sets of operating conditions resulting from different responses to identified drivers and dynamics that will impact on food supply. They can be used to explore different policy or strategic approaches to key issues.

The scenario development drew on international precedents as well as a participatory stakeholder process in Victoria.

The scenarios were differentiated along three axes:

- Speed and effectiveness of greenhouse gas emissions reductions;
- Extent to which governments intervene to manage food and energy security concerns; and
- Scale of solutions: global, national or local / regional solutions.

Figure 1: Scenario Logic Diagram



The scenarios describe a 25 year horizon for scenario thinking, for both practical and strategic reasons. This time frame is sufficiently removed from the present day that most workshop participants and readers are able to suspend intellectual or business commitments to 'what will happen'. 25 years is also a sufficiently long period that real structural change can take place. While settings are amended to 2035, the results of the modelling are shown to 2060 so that longer-term implications of the settings can also be considered.

Quantitative Scenarios

The qualitative scenarios were translated into quantitative scenarios, to enable analysis of:

- Land moved from food production to urban uses, forests for sequestration and energy;
- Reduced availability and reliability of irrigation water – increased proportion of dry land agriculture;
- Energy efficiency, changes to energy mix and demand reduction;
- Fuel efficiency, fuel substitution, change of mode and demand reduction; and
- Agricultural production efficiencies in water and fertiliser use.

When translated into quantitative scenarios, they are still 'exploratory'. The numbers, proportions and results are set to allow exploration of critical relationships – when we increase X, Y also changes, when we decrease A, we see a significant change in B, C and X. With food we are dealing with a very complex set of interrelated systems – policy or action considering one issue, such as water or energy or land, in isolation from the others will simply displace problems to elsewhere in the system. In practice, none of the scenario parameters are tightly defined and it is possible to adjust the value of some of those parameters so that net food deficits are reduced or inadvertently increased; the results of such adjustments will of course be some change in other system functions.

In this first stage of research, many tensions remain unresolved. These become a priority for further work, for further iterations of scenario settings and modelling, to see whether (and how) they could be resolved.

Market forces allocate resources – they do not make them exist

There is a prevailing argument that constraints on food or energy supply will be partially or largely overcome through 'market forces' as price signals drive innovation, technology development and efficiency improvements. The research has not ignored these issues, they are explored through the scenarios as factors that determine the allocation of resources. Key points relating to prices include:

- The effects of changing prices are implicit in all scenarios – the price signals, market structures and government actions are defined outside the model, but are translated as assumptions about efficiencies or establishment of the new technologies or practices (i.e. assuming that they become economically feasible responses to tensions exposed through the modelling).
- There are both physical and financial constraints to resource extraction, regardless of what level prices for key resources reach. For critical resources like oil, continually increasing prices are unlikely to be economically sustainable, reducing the capital available to access the remaining resource or to develop substitutes.
- By assessing the physical limitations, it is evident that there are real constraints on how much can actually be provided from what is ultimately a finite resource base.

Vulnerabilities and resilience

The structural differences of the scenarios would be likely to affect the resilience of each food system – the extent to which food availability can be maintained, or the food system can 'bounce back', in the event of shocks or rapid systemic change. Further analysis would be required to improve understanding of the extent to which the surpluses and deficits within the scenarios represent vulnerabilities that could seriously affect food availability.

There are signs of vulnerabilities in global trade patterns that raise questions about reliance on imported foods to meet core nutritional requirements. These include: an increasing incidence of governments responding to domestic food security concerns by slowing or banning exports of food (and fertilisers); severity and frequency of extreme weather events disrupting both production and distribution of food; and potential for energy and food constraints to directly impact on distribution systems, and/or trigger social and political unrest.

Tight profit margins on food products, for example, will make some current sources unprofitable as the price of fuel rises and local suppliers become more competitive. Retail industries will need to either re-evaluate the 'just-in-time' business model, which assumes a ready supply of energy throughout the supply chain or increase the resilience of their logistics against supply disruptions and higher prices. (Lloyd's Risk Insight 2010)

What next?

Research

Research extensions to this project would all involve further development of this physical modelling capability for greater understanding (and improved adaptive management) of complex change in the food system, and to further inform policy and practice. Priorities would be to conduct more detailed analysis of key tension areas, to work to resolve tensions (to test whether and how this could be done) and to evaluate issues of resilience. This project provides a strong foundation for the identification (in collaboration with policy-makers), of policy opportunities, gaps and barriers across the food system and how potential policy interventions might be prioritised. More detail is provided in the full report.

Opportunities

For Australia's future development, addressing the issues and challenges explored in this project will require substantial reconfiguration of the food system. While no scenario provides an 'easy answer' to how this can or should be done, they all suggest possible responses and solutions that can be further explored. This is not a challenge unique to Australia; in the conduct of this research it became clear that many countries and regions were already grappling with the issues we explored and in many contexts the need for innovation is being given a high priority.

Significant opportunities that are referenced in the qualitative scenarios but have not been accounted for in the quantitative analysis include: use of waste-water; re-cycling of organic waste and other products to produce energy, food and fuel; reduction of emissions in agriculture and sequestration of carbon in soil; next generation biofuels, and so on. It is likely that these could make significant contributions to easing the tensions identified and should be priorities for further research and action.

Policy

A key question arising from the analysis is about how use of limited and contested resources can be optimised to meet critical objectives. This raises fundamental issues about how we frame decisions about land and resource use, particularly in light of concerns about food availability. Are the critical objectives 'profit' or 'productivity', or 'resilience'? Should we plan for short-to-medium term targets (on the assumption that future technological gains will ease the tensions) or should we focus – now – on the long-term public good based on more conservative technological assumptions?

- For policy makers, the challenge is to optimise use of land and resources for the public good, ensuring that appropriate incentive structures stimulate private enterprise and innovation to this end.
- Given the long-term constraints, using price as the only mechanism to determine the flow of land and resources in the short term (i.e. to highest value use) could effectively reduce the resource base and options available to meet population requirements.
- Sensible and strategic decision-making about how resources are used needs to be informed by an evidence base that accounts for physical realities as well as economic drivers. The methodology outlined here could be further developed to this end.
- The assumptions and variables defined in this work point to where more specific policy tools may be applied, and can inform policy frameworks for considering these issues. Key areas for policy consideration are:
 - Reducing waste – closing cycles and increasing resilience of production and distribution systems (reducing extent of losses to extreme events);
 - Obtaining multiple outcomes from land and resources, including: 'mosaic' farming for food, energy, biodiversity and carbon sequestration; and urban and peri-urban food production to utilise 'waste' water and nutrients concentrated in population centres;
 - Preventing irreversible loss of food production capability, particularly relating to non-substitutable foods (e.g. fruit and vegetables);
 - Regenerating soil quality and capability to meet the challenge of reduced fertiliser availability;
 - Reducing overall energy and transport demand in both household (passenger) and industrial (freight) sectors;
 - Technology and practice change for energy and fuel efficiency, including development of substitute transport fuels and transformation of the transport system;
 - Water and nutrient availability and use – developing alternative water and nutrient resources that do not impose additional energy costs; and
 - Prolonged challenges to food availability or security. Could the welfare and emergency food systems cope with extended price impacts of food availability issues?

Tables

Table 1: Net Food Availability

| | Adjustment (Vic) | | Control (Aus) | | DIY (Vic) | |
|------------------|------------------|------|---------------|------|-----------|------|
| | 2030 | 2060 | 2030 | 2060 | 2030 | 2060 |
| Vegetables | | | | | | |
| Fruit | | | | | | |
| Milk | | | | | | |
| Meat | | | | | | |
| • Beef | | | | | | |
| • Lamb | | | | | | |
| • Nuts | | | | | | |
| Cereal grains | | | | | | |
| • Food and feed | | | | | | |
| • Including fuel | | | * | * | | |
| Oil | | | | | | |
| • Food and feed | | | | | | |
| • Including fuel | | | * | * | | |
| Sugar** | | | | | | |
| • Food and feed | | | | | | |
| • Including fuel | | | * | * | | |

| | | | | | | |
|------|---------------|---------------|------------|---------------|---------------|------|
| Key: | Large surplus | Small surplus | Sufficient | Small deficit | Large Deficit | N.A. |
|------|---------------|---------------|------------|---------------|---------------|------|

* Minimal use of biofuel in Control.

** Victoria's negligible sugar production is not expected to change, so is a state-level deficit in all scenarios.

Table 2: Achieved Emissions Reduction (On 1990 levels)

| | | Victoria | | | Australia | | |
|------------|----------|-----------------------|----------|------|-----------------------|----------|------|
| | | 2020 | 2030 | 2060 | 2020 | 2030 | 2060 |
| Adjustment | Target | 25 – 40% ² | 15 – 20% | 45% | 25 – 40% ² | 15 – 20% | 45% |
| | Achieved | 0% | 24% | +29% | 12% | 42% | +4% |
| Control | Target | | 60% | 80% | | 60% | 80% |
| | Achieved | 15% | 62% | +2% | 27% | 86% | +8% |
| DIY | Target | | 60% | 90% | | 60% | 90% |
| | Achieved | 27% | 57% | 62% | 35% | 71% | 63% |

| | | | | |
|------|--------------------|-----------------------------|--------------|---------------------|
| Key: | Exceeds target set | Reduction but not to target | No reduction | Increased emissions |
|------|--------------------|-----------------------------|--------------|---------------------|

² IPCC expectations for Annex 1 countries – for 50% chance of limiting global warming to 2°C.

Additional Figures

Figure 2: Net Environmental Flows (All)

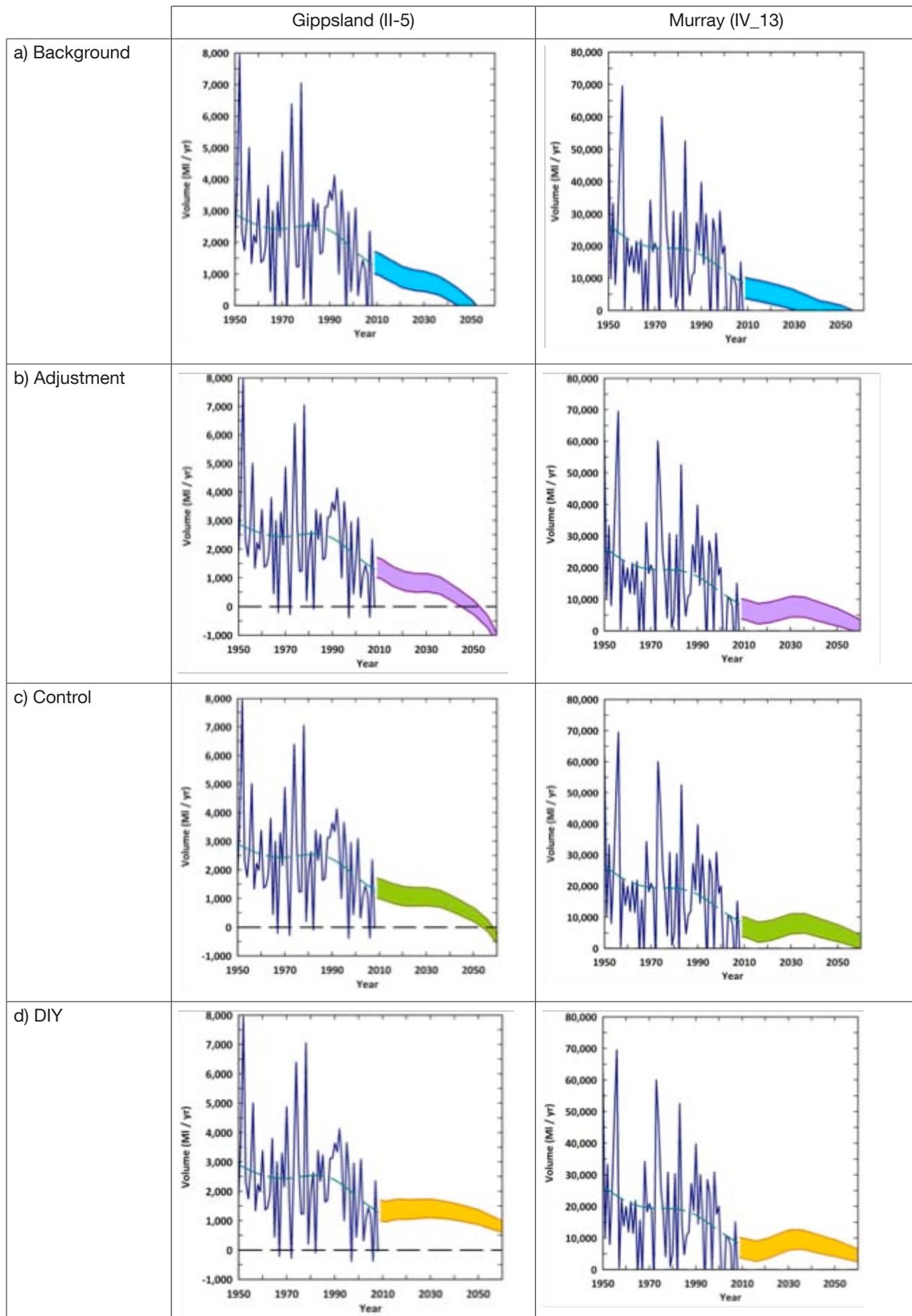


Figure 3: Net Oil Import Volume (All)

(Crude and Refined)

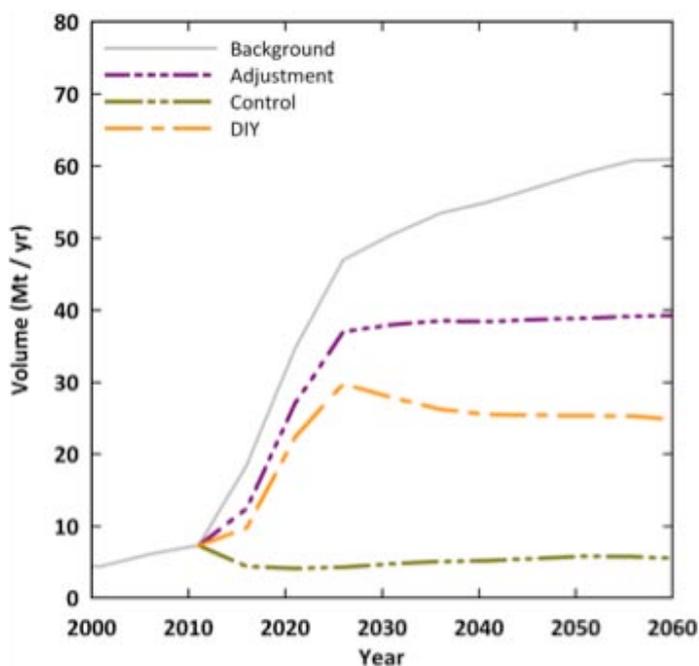
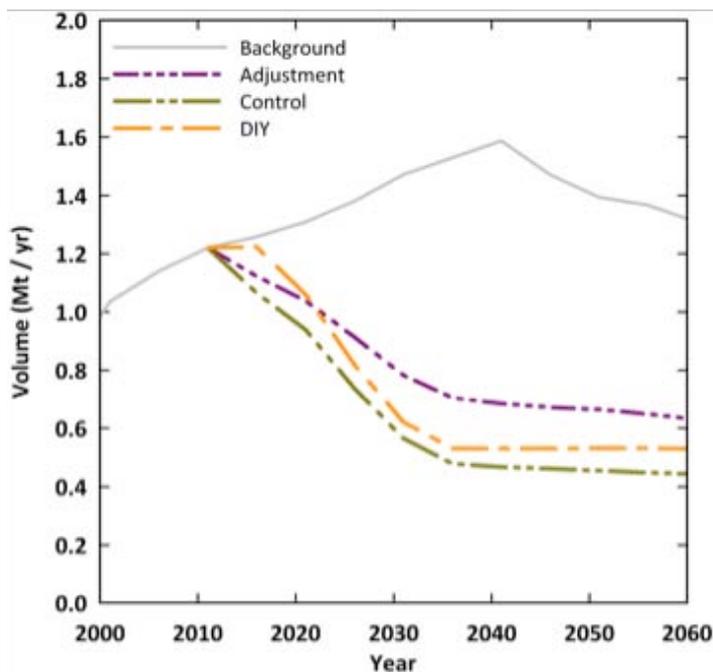


Figure 4: Net Phosphate Import Volume (All)

Phosphate fertiliser (incl. rock phosphate fertiliser volume)



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The full report (and more detailed information from the project) is available from <http://www.ecoinnovationlab.com/research/food-supply-scenarios>.