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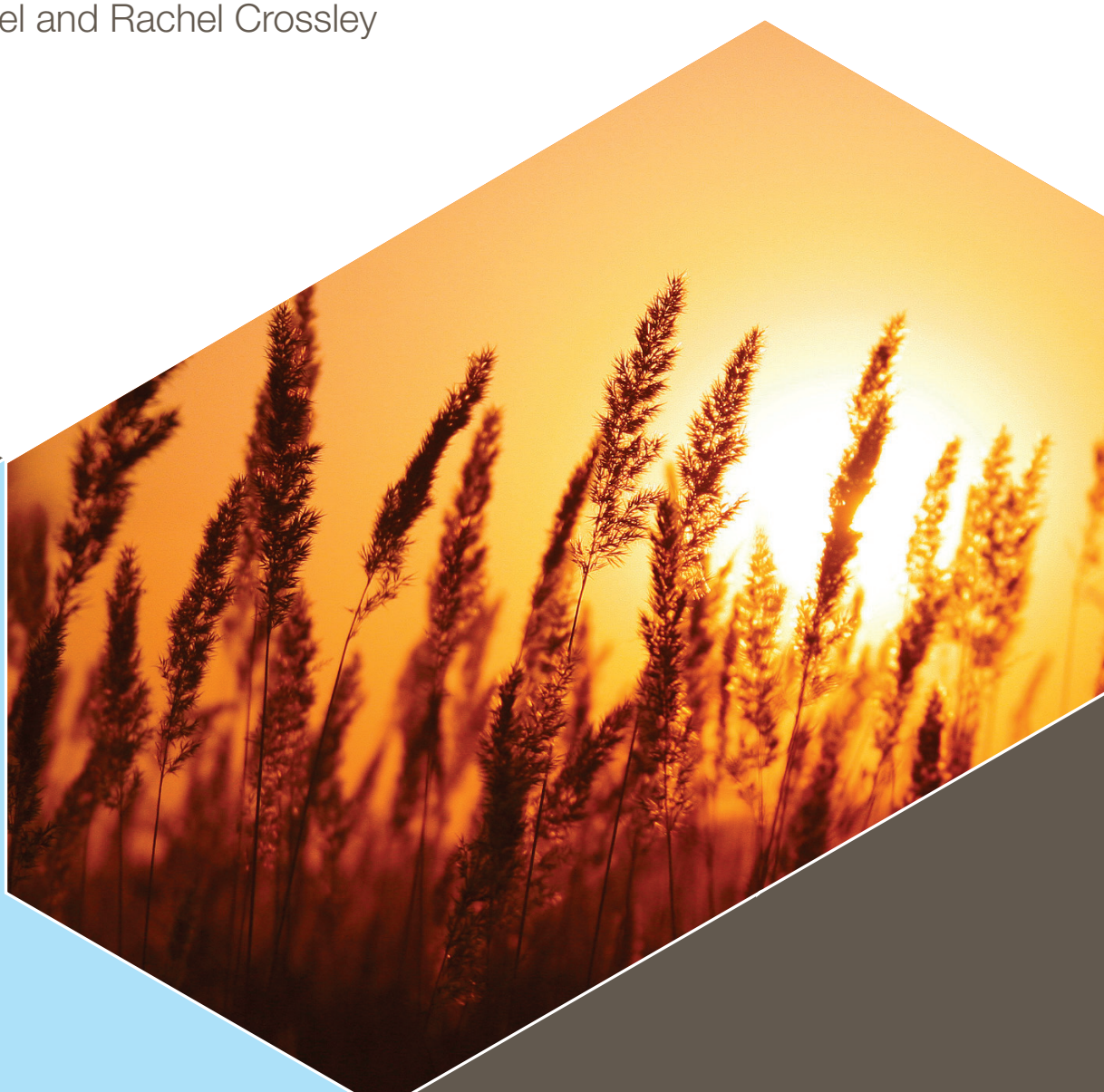
Food security, risk management and climate change

David Michael and Rachel Crossley



FOOD SECURITY, RISK MANAGEMENT AND CLIMATE CHANGE

Australian Food Security: Impact of Climate Change and Risk Management: How prepared are Australian food industry leaders?

Wondu Business & Technology Services

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The role of NCCARF is to lead the research community in a national interdisciplinary effort to generate the information needed by decision-makers in government, business and in vulnerable sectors and communities to manage the risk of climate change impacts. NCCARF staff provided exceptional support through quick response to queries and referrals to other research being undertaken in similar areas. Food industry organisations from farm input suppliers through to production, distribution and storage, processing and food retail and wholesale activities participated by responding to detailed questions about risk management and food security. The cooperation of the managers from these organisations was exceptional and made a significant contribution to the content and quality of the report.

A Steering Group of five to seven persons met on three occasions and provided guidance and constructive comments during and between meetings. Again, the views expressed herein are not necessarily shared by any or all of the Steering Group members. In July 2012, a presentation on the project was delivered to the World Congress on Risk at Darling Harbour, Sydney, under the title 'Impact of Climate Change for Risk management: How Prepared are Food Industry Leaders?' (Michael 2012). The Society for Risk Analysis is a world leader in risk assessment with monthly publications of *Risk Analysis*, which has included a number of articles over the year on quantitative methods for risk analysis including applications to climate change and food security.

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Abstract

This report is about food security, climate change and risk management. Australia has enjoyed an unprecedented level of food security for more than half a century, but there are new uncertainties emerging and it would be unrealistic – if not complacent – to assume the same level of food security will persist simply because of recent history.

Domestic demand for food by 2050 is likely to be almost 90% above what it was in 2000, accompanied by a similar rise in demand for exports. It is reasonable to assume a low level of tolerance by the Australian public for any threat to food security. However, there is potential for systemic risk to food security from a coincidence of small risks affecting the Australian food supply.

While this project is directed to Australian food security it is equally important to recognise that Australia (with 0.3% of the world's population and 3.4% of the world's arable land) has an important and growing responsibility for supporting food security in other countries, including the People's Republic of China (PRC), which has 22% of the world's population and 7% of its arable land. A Joint Australia–China Food Security Forum and a new Department of Food Security are suggested as measures to elevate food security to a policy priority.

One way of dealing with growing uncertainties is to lift the quality and coverage of risk management in public and private organisations. Risk management practices affect the adaptive capacity of organisations (and individuals), and resilience to uncertainty and extreme events – including those arising from climate change. Improved risk management can create value for commercial and public organisations, including policy-makers and regulators. It can improve confidence, which drives the investment that underpins food security.

Data were collected from more than 36 case study organisations (both foreign and local) operating in the Australian food-supply chain, showing that 56% of firms have formal risk management frameworks and the remainder a more informal approach – though one that is often well suited to their individual circumstances. Previously used risk management practices require substantial improvement to cope with and exploit the uncertainties that lie ahead.

Three risks are identified as major constraints to adaptive capacity of food organisations operating in Australia:

- risk management practices
- an uncertain regulatory environment – itself a result of gaps in risk management
- climate change uncertainty and projections about climate change impacts, also related to risk management.

The lack of good quality information about the impact of climate change is constraining effective risk management, and most organisations consider that better-quality information about climate change impacts is essential. At the same time, there is evidence that some food organisations are not fully utilising the growing bank of information on climate change impacts. Uncertainty is everywhere in natural systems,

and climate change is an integral part of the natural system – hence the importance of risk management practices in dealing with uncertainty.

Regulatory uncertainty is ranked highly as a risk facing Australian food industry organisations, and this view mirrors international rating agency indexes on competitiveness and the cost of doing business. Australia is now ranked poorly by the World Economic Forum at 75th out of 142 countries on the 'burden of government regulation'. Policy-makers face complex challenges in dealing with food regulations that animal welfare, but not always with concern for food security. This report suggests that improved risk management can improve the resilience of commercial food organisations and the business climate for food security.

1 Executive summary

1.1 What the report is about

This study of food security examines the implications of climate change impacts for food security, adaptation to climate change and risk management. It illustrates the status of risk management and opportunities for improvement in the Australian food industry through a series of detailed case studies along the supply chain. Improved risk management can take the adaptive capacity of operating firms, and their supporting infrastructure and service providers, to a new level, with associated benefits for food security. In well-run organisations (public or private), effective risk management is usually the prime task and responsibility of the CEO (assisted by the Chief Risk Officer) or the General Manager and the Board, who ultimately have the risk oversight responsibility. The report is not about quantification of risks and solutions to uncertainty, which can only be dealt with at an organisational level.

1.2 Who is the report targeted at?

The study is targeted at commercial firms, policy-makers, regulatory enforcers and non-profit organisations providing support services and products along the Australian food-supply chain. Improved food security ultimately provides benefits for consumers by reducing their vulnerability to adverse changes in access to high-quality food. Improved risk management can create value and improve confidence among food suppliers, and this can lead to increased investment with a positive impact on adaptive capacity and food security. Improved risk management also strengthens accountability and governance, with benefits for managers (in both public and private organisations), directors, shareholders and external stakeholders.

1.3 Background

There is a growing sense of urgency about the need to protect future food security, both in Australia and offshore, as it becomes clearer that a higher price may have to be paid for food security and for access to the resources that produce and distribute food. Food security is defined by the United Nations (UN) (FAO 1996) as existing 'when all people, at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life'. The Australian food industry features a large number of diverse organisations (more than 700,000) of varying size and structures. Food retailers/wholesalers distribute over 80% of food required for local consumption, and assume an important leadership role for food security. Food storage, distribution and trading organisations take a large proportion of Australian-produced food to international markets, and contribute substantially to food security in those countries. They also draw on international supplies to satisfy local demand. Food security takes on added importance in developing and less-developed countries where poverty levels are high and vulnerability to shocks in food availability is often extreme. Most case study respondents for this study consider that supply of food to international customers is just as important as supply to domestic customers. Australia has an international development program for improving the food security of developing countries by improving their own capacity to produce food. This complements Australian food exports, which are especially important to countries that are vulnerable to climate change and to those that have no comparative advantage with regard to the food

products and commodities that Australia exports, including many grains and livestock products. Australia has 3.4% of the world's arable land and just 0.3% of its population. Foreign investment in Australian farm land, food processing and distribution and storage has played a major role in providing capital, technology and skills for development and improved productivity. More recently, foreign investment by government-owned enterprises has increased, and is motivated partly by strategies to strengthen food security in those enterprises' countries of origin.

1.4 Aims/objectives

An important aim of this project is to improve the level of awareness about high-quality risk management techniques and strategies for dealing with food security against a background of climate change uncertainty, adaptation to climate change and growing awareness of a diversity of risks extending from new technology to the regulatory environment, economy, health and markets, both financial and those for products.

1.5 Methods used

Information has been collected from more than 36 case studies along the Australian food-supply chain to gain an understanding of existing risk management practices; how value is added through risk management; constraints to implementing effective risk management practices; the role of new technologies in risk management; and possible interventions to reduce or remove constraints to effective risk management. The study relies on case studies to illustrate the complexity and scope of issues being dealt with in risk management along the whole food-supply chain, rather than a large number of observations to generate, at significant cost, statistically significant results about one or two issues that may not be able to capture the full complexity of food security. The case-study approach is also likely to appeal to commercial leaders, on whom effective risk management depends. The primary data is supplemented with a wide-ranging review of existing literature and information on risk management, food security and climate change in Australia and overseas. The analysis is based on identifying gaps in risk management performance, which leads to discussion of interventions that have potential to close the gaps. Effective risk management is process driven, and for that reason is best matched to each organisation's management, standards of governance and risk management culture.

1.6 Results/key findings

Food security is not just about food or security. It extends through supply and demand for food to access, the way in which food is used, and how people look after and take responsibility for their personal health. That is, education and health are important components of effective food security. Australia historically has enjoyed a high level of food security. Relatively high per capita incomes, supporting social security and high-quality human, biosecurity and animal health systems, a modern and competitive food retailing sector, low trade barriers and a globally competitive agricultural sector underpin Australia's food security. Australia also has shown a very strong capacity to adapt to difficult circumstances, due in part to experience in working with a difficult climate and the incentive system for mobilising resources and effort. The private sector is the dominant provider of goods and services in the Australian food system, but high-quality regulatory support is vital in safeguarding health, bio-security and food product quality without it becoming an unmanageable burden on both commercial operators and regulatory enforcers. An excessive regulatory burden has the potential to

compromise food security and adaptation to climate change. At the same time, the targets of regulations have to manage their obligations with the most effective risk management framework and processes available.

One of the problems facing policy-makers and regulators is that regulations can obscure the perceptions of risk, and also amplify the risks of certain activities. This can happen, for example, when ad hoc regulations deliver less than what is expected and produce unintended outcomes.

Looking further ahead, there are mixed indicators arising from growth in population and per capita consumption of food; uncertainty about the terms of trade; emission-reduction commitments and incentives to switch land-use for increased sequestration; uncertain extreme climatic events; increasing resource constraints (especially fuel and oil); soil degradation; biodiversity preservation demands; lower R&D expenditure; export commitments to help sustain global food security; incentives to switch land use from food to energy production; threats of food-borne infectious disease outbreaks; and growth of foreign government-owned investment in land and water that can divert production away from traditional market channels. By themselves, none of these risks is likely to be cause for concern about food security. The real risk is from a systemic convergence of negative external shocks including the re-emergence of an extended drought overlaid by longer-term climate change. To this scenario can be added the potential of an increase in risk velocity – that is, the speed and direction of change from one or more risks.

It is equally important to recognise that there is also the risk of a convergence of several positive external shocks, including better than expected climate change impacts, higher productivity growth, lower population growth, lower per capita food consumption and better than expected adaptation to food-borne illnesses. This alternative risk scenario could actually lead to lower commodity and food prices, increased adjustment pressure at the production level but improved food security and welfare for consumers. Growth in productivity is one market driven strategy for dealing with both extremes of uncertainty. Commercial food firms have to deal in a balanced way with both the opportunities and negative uncertainties that lay ahead. Policy-makers and regulators may have to be more vigilant about the negative uncertainties, relying more on competition to take care of the opportunities that lie ahead, though that will depend on their own risk management frameworks.

Improved risk management has potential to improve capacity to deal with either the negative or positive sides of uncertainty in the future with beneficial outcomes for food security. In other words, there are both challenges and opportunities involved in dealing with the uncertainties, and those organisations with the best risk management practice are likely to emerge as the most resilient players.

The capacity of the Australian food industry to adapt to the uncertainties that we face is being constrained by three major influences:

- patchy evidence that uncertainty is being managed with best risk management practices in either public or private sector organisations
- the regulatory burden and the capacity to deal with the burden of regulation
- uncertainty about climate change impacts and lack of confidence in climate change impact projections.

Nearly 60% of case study respondents in the Australian food industry have formal risk management systems in place. Not surprisingly, most of the formal risk management systems are at large firms in processing, distribution, storage and retail enterprises. To deal with increasing uncertainty from a diversity of sources (Figure 1), organisations with formal risk management systems are in the midst of significant change and are starting to take a more holistic approach to risk management, improved resilience and business continuity planning.

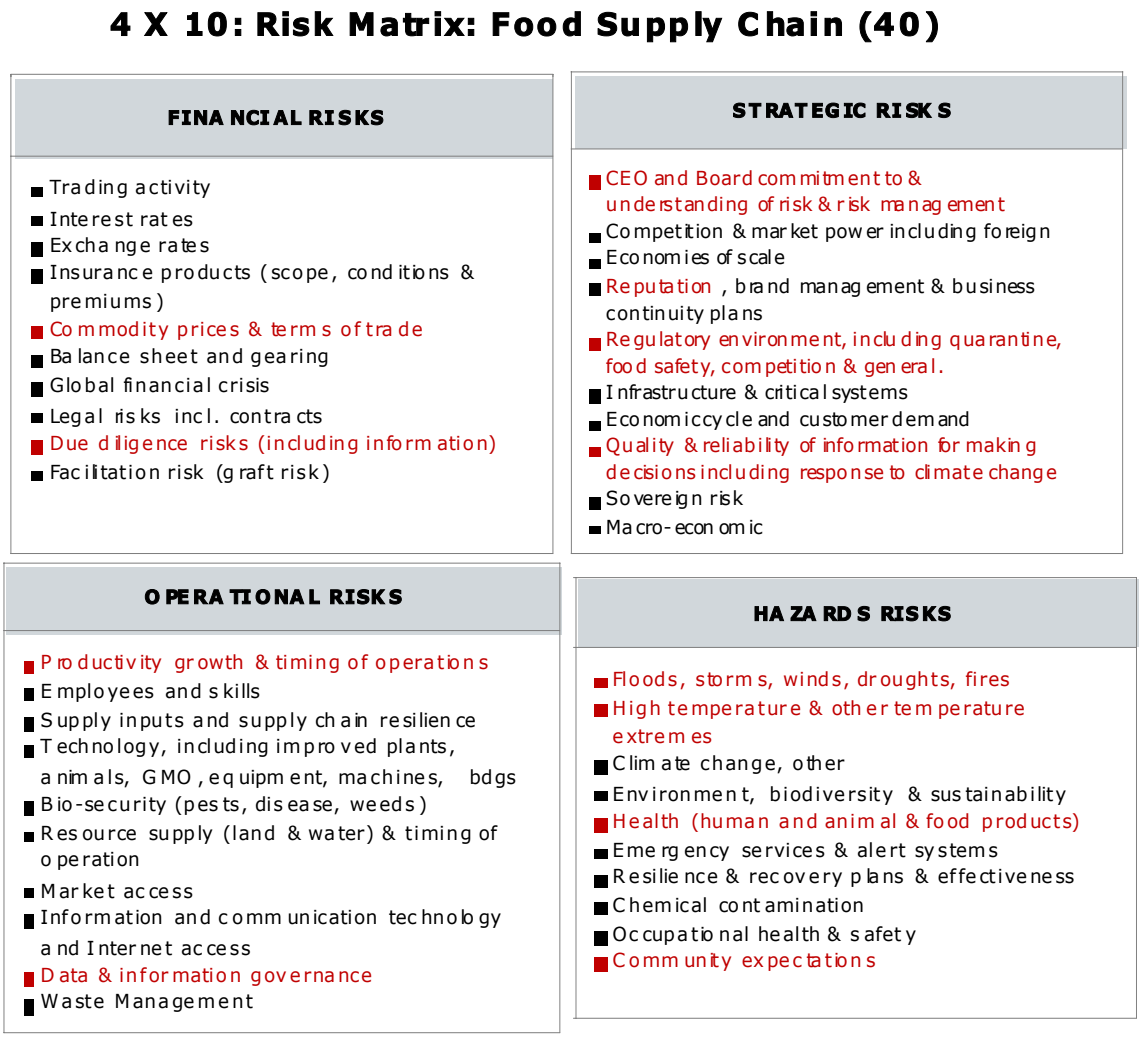


Figure 1: Risks identified from all sources: by category

Senior managers are reviewing objectives and criteria for evaluating risks, and strengthening their surveillance of risks – not just for regulatory compliance requirements, but more for enhanced control of their destiny and objectives as well as to improve accountability for performance. This is a positive development. This change in the management of uncertainty is also extending to some smaller firms, with advanced management processes including family-run production and processing firms. Risk-based regulation is not, however, always evident in either policy-setting or regulatory enforcement organisations in Australia, which is estimated by the World Economic Forum to have one of the largest regulatory burdens in the world. Regulatory fatigue is a distinct threat to food security in Australia, in part because of the erratic presence of risk-based regulation. This is one of the reasons for suggesting that a

feasibility study be undertaken into establishing a Department of Food Security in DAFF or Treasury, or within a ministry where proper and complete attention can be given to the complete range of policy issues affecting food security.

There is significant variation in practices within the group, with formal risk management systems and fewer than 50% of organisations with formal risk management systems considering that they comply fully with the international standard on risk management, ISO31000:2009. Even those that consider they do comply with this standard have patchy records on details, including audits and treatment of risks and stakeholders, and commitment to risk management by senior management. Fewer than 50% of respondents indicated that risk management was a regular item on the agenda of monthly meetings, and fewer than 60% judged their management as highly committed to effective risk management. Information system security seems to be more under control within regulatory authorities than private firms, suggesting scope for improvement within the commercial sector.

Out of 20 identified risks, regulatory and political risk is rated highly and as almost certain by over 60% of respondents, with potential for a major impact over the next decade (Figure 2). Production risk caused by climate change is rated next, and as almost certain by 38% of respondents. This is due largely to the close relationship between climate and on-farm productivity though the impact may be reduced with improved risk management.

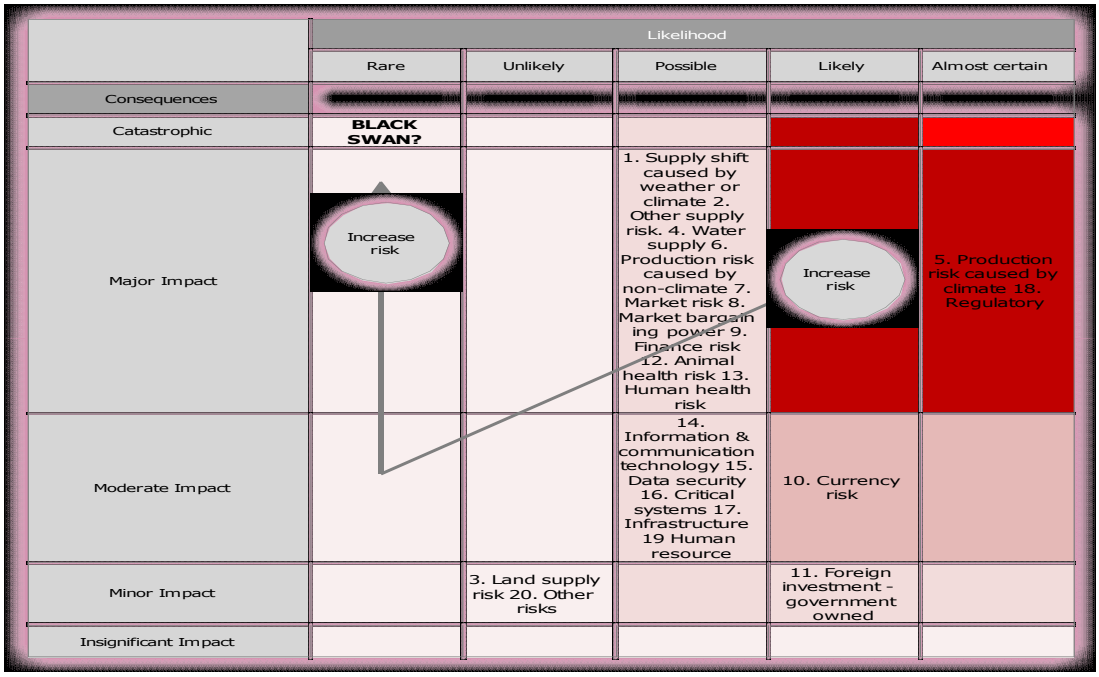


Figure 2: Risk rankings, based on most frequent case study responses after mitigation

Organisations are implementing controls against a background of individual risk criteria (that is, the standards, expectations, policies and values against which their risks are rated). It is neither possible nor desirable to scope, quantify or evaluate risks for any organisation in this research because of the individual nature of risk management, which to be effective requires integration into the organisation's governance standards, strategy and planning processes, values and culture. This is the essence of ISO

31000, and one of the reasons why it is recommended for wider adoption. Moreover, it is emphasised that maps of likelihood and consequences raise serious questions about emerging conditions such as climate change and interaction with other stressors, including health, water, regions, vulnerable populations, national security, infrastructure and economic conditions.

There are significant interdependencies along the food-supply chain, reflecting the global nature of food production, distribution and consumption. Specialisation underpins competitiveness and the interdependencies, but it also exposes the sub-sectors to external influences, which underlines the importance of resilience to unforeseen events. The interdependencies extend across multiple dimensions, including economic, information, geographical, ecological, health, vulnerable consumers, animal welfare, mechanical, logistical, biosecurity and climatic categories. Food security would be enhanced by having improved multi-dimensional models to demonstrate the cascading impact of unforeseen events and interventions.

The case studies indicate that a range of risk mitigation activities are being used, including use of formal risk management frameworks, training for employees and partners, internal codes of conduct, due diligence into business partners and other service providers, installation of alert systems for high-risk events, traceability systems for risk management activities and integration of risk into decision-making staff responsibilities. Assets are being reallocated and relocated, and products redesigned, inventory is being secured, new plants and animal varieties are emerging, and practices are changing. Insurance is being used to transfer or finance risk. Generally, however, the use of mitigating activities is patchy, reflecting the overall framework used or not used for risk management. Allocation of resources to risk risk-mitigation activities requires detailed examination of objectives, the context in which the organisation is operating and a process that facilitates continuous improvement.

Uncertainty is almost everywhere within the natural systems on which food production security is based. In these circumstances, diversity at every level plays an important role in food security, and even the relatively small micro-enterprises in urban agriculture have their role.

Figure 3 shows a map of the processes that could be used to establish a framework for continuous improvement of risk management. Section 4.2.1 contains more details on the use of risk mitigating activities. The qualitative matrix of consequences and likelihood shown in Figure 2 is illustrative of the average case study response, and not representative of any one organisation. An effective risk management plan could be built at an organisational level around the ISO 31000 principles, framework and process (refer to Figure 43 below). Nevertheless, it seems important to recognise that the investment climate (including the regulatory burden) has influence on risk management processes and treatments undertaken by commercial firms. That is, the investment climate can be both a source and moderator of risk.

Climate change impacts have been identified as a source of risk by 62.5% of all respondents, but for organisations with informal risk management systems the inclusion of climate change is higher (68%), in part reflecting the relatively high proportion of agricultural producers in this group. While 57% of organisations with formal management systems have included climate change as a source of risk, fewer than 60% have actually included it in their risk management programs. Other risk mitigation activities include acquisition of regional climate data from BOM and other agencies, internal training (100% of organisations with formal systems), business partner training (68% of formal systems), internal codes of conduct (95% of formal systems), auditing (85% of formal systems), due diligence of suppliers and partners

(72% of formal systems), alert systems for new and emerging risk (74% of formal systems), highly committed management of risk (57% of formal systems), regular discussion of risk at monthly meetings (43% of formal systems), traceable risk management activities (48% of formal systems), alert systems for high-risk events (57% of formal systems), integration of risk into job functions (19% of formal systems) and adoption of new technologies (including precision farming, improved plant and animal breeds, and improved management practices) and management practices (over 70% of respondents agreed that new technology and innovative management practices could provide solutions for most risks of climate change). Changing land use, relocation and biotechnology were also rated highly as controls for reducing uncertainty caused by climate change.

Over 70% of firms with formal risk management systems are developing their environmental systems and regulatory compliance to enhance their capacity to cope with climate change. Most respondents (formal and non-formal systems) indicated they were quite confident or extremely confident in their capacity to deal with climate change, though producers with extensive (more climate exposed) production systems tended to be less confident compared with other industry categories. 'Optimistic bias' (and 'pessimistic') may be present in surveys of confidence.

Operators with formal risk management systems tended to be more confident about their capacity to manage climate change. In turn, this may be expected to lead to increased investment from this group and eventually to create the potential for a competitive advantage from climate change. Formal risk management takes on added importance with large capital investments, including infrastructure (both private and public), and firms with large numbers of transactions. Nevertheless, nearly all commercial respondents indicated that they were gaining a competitive advantage from their risk management expertise through lower costs, better marketing and more precise timing of activities. Most organisations with formal risk management have alert systems in place for activating a control response to high-risk events.

1.7 Implications for relevant stakeholders

The standout message from this research is that best practice risk management has an important role to play in adaptation to climate change and other sources of uncertainty. There is, however, considerable potential to improve risk management practices across all public and private organisations. Special attention is required at a policy level for dealing with high-impact and low-probability risks, especially the diverse risks that now exist across regions, functions and products. Add to this the potential for risk aversion and enthusiasm by public officials to avoid being wrong (that is, epistemic risk), resulting in risk burdens being transferred to food chain operators, and a 'wicked policy' (refer to note 6) challenge emerges for food security. In addition, legacy risk systems often feature silo-styled structures that are effective in dealing with specific exposures like food safety, biosecurity and health, but often lack integration into an overall risk management framework.

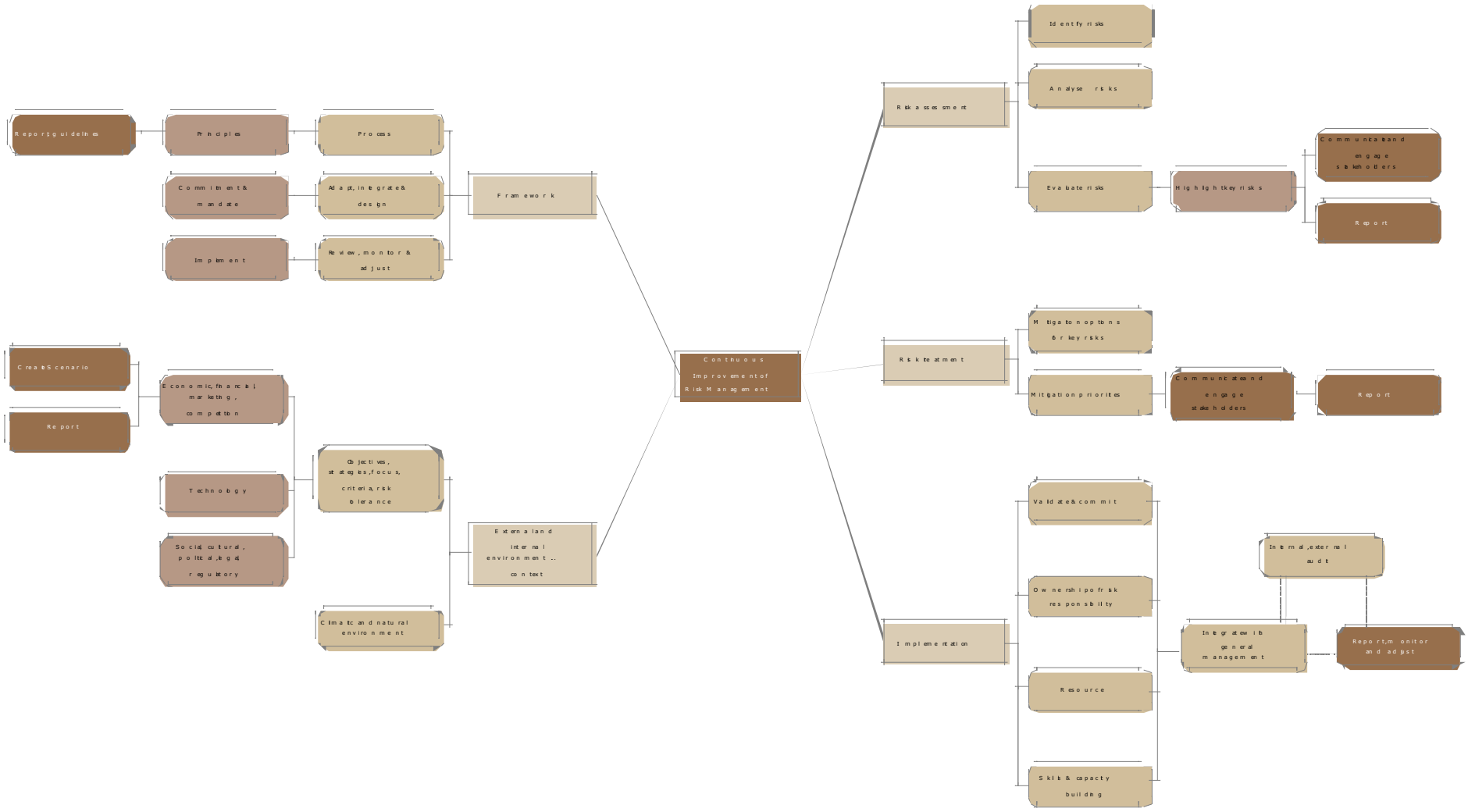


Figure 3: Risk management process for continuous improvement

Food industry enterprises and their support services along the whole supply chain may have to go to another level in risk management practices to preserve not just their competitive position but also the food security standards to which Australia has become accustomed. Australian food retailers have a very important leadership role in food security in every state, and it is expected that they will have internationally best-practice risk management systems in place to ensure resilience to extreme events. The strength of risk management at the food retail level is, however, only as strong as the weakest link. For this reason, the risk management practices among suppliers and support services, including infrastructure, regulatory support, processing, bulk commodity storage, and handling and production take on equal significance. Food security is driven in part by foreign investment – including that from China, which is also a vital market for Australian exports. There should be an improved-quality debate on China's investment in Australian farmland and food assets, improved transparency of investment activity and national interest tests, improved governance of investing organisations and improved exchange of information about capital flows between the two countries. This background prompts a recommendation for formation of a public forum for dialogue on China and Australia's joint investment in food security.

1.8 Recommendations

The recommendations are based on principles of intervention to overcome market failure due to:

- the presence of private or public good characteristics
- the presence of externalities
- moral hazard
- economies of scale.

1.8.1 Information gaps

In the interest of protecting food security, further research should be undertaken to identify the information requirements for effective risk management of climate change impacts at regional and activity level in the Australian food industry, to analyse the role of the market, and the public and private sectors, in mobilising this information for effective risk management and to develop options and recommendations for the public and private sector to provide this information, including possible public–private partnerships. Further research should also be undertaken into the impact of information gaps, which have potential to leave those affected more vulnerable to climate change impacts.

1.8.2 Lifting the regulatory burden on food security

- There should be further research into regulatory barriers (both food and non-food) that are contributing to uncertainty in the Australian food industry. This would include identification of regulatory risk at Commonwealth, state and local government levels, evaluation of the cost and benefits of compliance (including time and monetary value) and recommendations for improvement over a specific timeframe.

- There should be a feasibility study into establishing a new Department of Food Security.

1.8.3 Infrastructure bottlenecks to food security

There should be a detailed examination of the infrastructure bottlenecks (especially roads) affecting Australian food security, including identification of priorities for development across all states and territories.

1.8.4 Building skills and capacity

There should be further research into the design of a viable risk management training program for trainers (both private and public) and operators along the food-supply chain (that is, training for producers, processors, storage and transport, etc.), with specific attention given to developing skills to comply with the new ISO standards for risk management, resilience and continuity management. In addition, school educators should be encouraged to adopt food security as a topic for primary and secondary education.

1.8.5 Food-borne infectious diseases and health

There should be a wide-ranging study on the impact of climate change for the health of food production, distribution, product quality and microbiological safety – ideally with regional impacts considered. It could be integrated with a parallel study on animal health impacts on food security. It could also examine ways of improving awareness about excessive food consumption, which can compromise food security.

1.8.6 New technologies and innovative products and work practices

Constraints to private-sector adoption of new technologies and innovative work practices in the whole Australian food-supply chain should be elevated to a policy priority status. Increased R&D and support for extension would be likely to enhance adoption of new technologies and innovative work practices, including farming carbon in the soil. Opportunities to develop new insurance products for dealing with climate change should be examined further including encouraging recognition of risk management practices in insurance premiums.

1.8.7 Low-probability, large-impact policy initiative

To minimise strategic surprises from high-impact, low-probability risks to the food industry, there should be a discussion paper prepared on systemic risk in the Australian food supply and delivery systems. It would examine the impact and preparedness of organisation for a coincidence of shocks that may arise from climate change, normal weather events, government policy, international events and other external influences. It would examine ways of including high-impact, low-probability risks more consistently in policy-making.

1.8.8 Foreign investment from sovereign governments

It is recommended that transparency of foreign government investment (direct or indirect) in Australian agricultural and food processing, storage and distribution assets be improved significantly without diminishing the incentive for foreign investment in agriculture or the food sector. Joint ventures and public–private partnerships with sovereign wealth funds could be examined as a way of encouraging improved accountability to domestic stakeholders. A Joint Australia–China Food Security Forum should be established to meet annually and commission a series of research papers on matters affecting food security in the two countries, including foreign investment, having regard to the national interest of both countries in food security.

1.8.9 Improved input–output models

It is recommended that improved input–output models be developed to enhance understanding of interdependencies and cascading effects from external influences, ad-hoc interventions and unforeseen events on food security, having regard to both international and domestic consumers, regional impacts and different categories of influence (e.g. economic, policy, ecological, logistical, etc.).

2 Objectives of the research

Food security is not a new concept, and neither is the role of climate change or unsustainable consumption and supply. Palaeontologists hold generally to the view that human migrations in pre-history followed the movements in populations of mega-fauna (large beasts), the prevalence and viability of which as a food source depended heavily on climate change (Martin 1967). In the transition from the Pleistocene (11,700 to 2.6 million years ago) to the Holocene (11,700 years ago to the present) era (the Quaternary period), many mega-fauna animals became extinct. This extinction is thought to have been due to either climate change or overkill, though it was most likely both. Most agricultural producers, at least in Australia, are familiar with climate variability and natural events, and the consequent challenges in achieving balance, sustainability and continuity. Pre-history records suggest it would be unusual if climatic instability and overkill did not persist or return with some uncertain degree of volatility, especially if the lessons of history are ignored. There is, however – perhaps unfortunately – nothing certain about the lessons of history. These lessons contain a mixture of certain reliable observations, known uncertainties, assumptions and, even more challenging, 'unknown unknowns'. Pate-Cornell (2011) categorises uncertainty into three classes: 'aleatory' uncertainty that represents the inherent randomness of a process (e.g. natural events); 'epistemic' uncertainty that represents the state of our knowledge about a known process or model' and, finally, 'ontological' uncertainty that represents the possibility of events occurring about which we have no knowledge – and usually this lack of knowledge is invisible. This project and report was always going to be incomplete because of the uncertain nature of food security, climate change and risk management itself. The best claim is that it (the project) contributes in some small way to reducing epistemic and ontological uncertainty.

This project examines the implications of climate change impacts for risk management, and measures the preparedness of food industry leaders for riskier operating scenarios, including – though not limited to – the highly improbable and unpredictable events with massive impacts, named elsewhere as the 'Black Swans' (Taleb 2010). The 'Black Swan' event has three features. First, it is an 'outlier' observation (or possibly a group of outliers) with no past record pointing to it being a possibility.[1] Second, it is associated with an extreme impact, which may be positive (e.g. mobile phones or a series of favourable climate years in a typically dry climate) or negative (e.g. global financial crisis or terrorist attack). Third, analysts – including statisticians – tend to ignore it until after the fact, when it then becomes explainable and part of accepted wisdom.

The combination of warmer, drier and more volatile climatic conditions, limits to supply of arable land, subsidised competition from bio-fuel crops and a growing population suggests increasingly volatile supplies of foodstuffs and prices in both Australia and offshore. There is a growing sense of urgency to protect future food security, both here and offshore, as it becomes clearer that a price may have to be paid to protect resources for food production and to enhance sustainability for future generations.

A major problem in dealing with this volatile environment is the presence of risks in the tail of the distribution of possibilities for supply and the lack of analytical tools for accurately predicting the probability or likelihood of a severe event occurring. As a

[1] An outlier observation is described by Barnett and Lewis (1984) as 'an observation that appears to be inconsistent with the remainder of that set of data'.

result, there is a tendency to not recognise a catastrophic event until it is too late and the event starts to impact adversely on investors, consumers (especially the most vulnerable) and/or other stakeholders. Irrational decision-making is shown – at least in the finance sector – to be more commonplace than previously recognised in efficient market theory, as well as at a board level, among senior managers, and even among risk managers and auditors themselves. Does it also exist in the food industry? Does it matter? This project attempts to answer these questions by examining how well Australian food-supply chain enterprises are prepared for uncertainty and extreme events, and whether or not risk management is a priority among senior managers.

Existing enterprises all have some forms of risk management strategies in place, but it is the quality and capacity for implementation that may show the greatest variability, and this project examines these aspects. The inclusion of cross-checks and controls that anticipate errors may be one way of dealing with the risks of remote possibilities with big impact. An important reason for the presence of risk management gaps is the difficulty of translating probability (a theoretical and imaginary concept to most operational practitioners, even some managers) into a material and readily understood impact like damages, disruption, loss and dissatisfaction. At the same time, it is equally important to recognise that the risks to food security from climate change also contain opportunities for gain as well as loss – though it is rarely a zero-sum game.

The project evaluates how these material impacts are managed in what is likely to be an increasingly uncertain environment. A risk management road map is produced showing where food security is now; possibilities in terms of where to go for the future; and how to get there, with recommendations for further research. This project examines the type and use and expected change in use of risk management products and services among leaders of more than 36 Australian food industry suppliers, producers, processors, distributors, retailers and regulators.

The objectives of the project are to:

1. Improve the level of awareness about high quality risk management techniques and strategies in dealing with food security, supply of food stuffs and climate change.
2. Identify and examine the current state of risk management awareness and practices employed in the Australian food industry at a senior management level, using the 36 case studies, to provide a picture of ‘where we are now’ in terms of formal and informal risk management systems, perceptions of likelihood and consequences of particular risks and constraints to effective risk management.
3. Review at a global level the research on risk management in the food industry.
4. Identify and examine innovative risk management products being used, or that have potential for use in the food industry.
5. Identify the impact of new and emerging risks and new and emerging risk management practices for dealing with food security, supply of foodstuffs and climate change, providing a picture of ‘where to go’ for improvement and ‘how to get there’.
6. Examine the risk management training needs and capacity to supply those needs in Australia.

7. Make recommendations for further research and development (R&D) into risk management for the food industry and adoption of improved risk management practices.
8. Contribute to improved and enduring food security for Australian consumers.

Food security is a subject with a potentially vast scope. The project endeavours not to repeat research being undertaken elsewhere. For this reason, there is little treatment of water (although it is listed as an area of uncertainty in the case study questions), which is an important component of food security but is being dealt with in other research projects. Coal-seam gas is another subject that has potential impacts on water, land and food security, but that is beyond the scope of this project. Urban expansion of land is not dealt with in this report. Food security in less-developed countries is not examined in this project, but reference is made to the linkages between Australian food security and global food security. Measures that shift the burden of food insecurity from domestic to offshore consumers have to be recognised in any sound and sustainable food security policy framework.

3 Research activities and methods

The methodology provides a balance between quantitative and qualitative dimensions of risk assessment and management, and involved the following tasks:

- Review of risk management information and existing research. This review is structured around food supply activities from production through to retailing. The review had a focus on existing research about the uncertainty of climate change impacts at different levels of the food-supply chain, recognising that food security is not just about food production.
- Examination of new risk modelling, assessment and management methods and implications for food security, including a risk management road map showing (from the primary data) 'where we are now', 'where we want to go' and 'how to get there'.
- Development of a picture of perceptions about likelihood and consequences of particular risks, risk-treatment methods and constraints to risk management using data collected from 36 survey interviews. The number of interviews was based on having some representation from each activity along the supply chain, including support service and coverage of all states and regions of interest. The complexity of the risk management subject and level of detail, as well as the requirement for senior management participation does not lend itself to standard survey designs with large numbers of observations. There would, however, be some non-response bias among the existing 36+ cases. Enterprises that did not respond indicated various reasons for not participating, including 'confidentiality', 'don't believe in climate change', 'CEO does not wish to discuss the subject because of political consequences', 'too busy', 'too many other risks to deal with' and various others. The judgement of the authors is that respondents would tend to have more formal and developed risk management systems, or that risk would constantly be on their agenda – even for those with informal risk management systems. That is, the case study results of this study may show a better picture of risk management in the Australian food industry than is actually in place.
- Case study interviews are also enhanced with several key issue case studies to highlight matters that have emerged from the information review, including resilience in dealing with adverse climatic conditions, regulatory and political issues, urban agriculture, infrastructure resilience and the shared interests of Australia and China with regard to dealing with food security.
- In developing the discussion about gaps and where to go next, the analysis is guided by evidence of market failure and whether interventions to correct gaps should be undertaken by the private or public sector. However, it is largely the private sector that delivers food security, and for this reason there is a focus on measures to build capacity and resilience in this group. This does not diminish the role of regulatory arrangements that govern biosecurity, health, competition

and other areas including interventions to support better information about climate change.

The only support service from which case study data were not collected was health; information about this subject was collected through discussions with several health experts and a review of existing research. Over 25% of responses were from agricultural producers (including some with partly vertically integrated operations) and 16% were from processors (also including some with vertically integrated operations) (Figure 4). Across the states, 59% of respondents had some form of representation in NSW, 45% in Victoria and about 14% for each of the other states and regions (Figure 5). Larger firms tended to have representation in at least two or three states, often across all states and regions. Over 24% of respondents had turnover of more than $750 million per year, and 24% had turnover of less than $5 million per year. Responses were received from three foreign-owned corporate firms, none of which has government ownership, either direct or indirect. Government-owned investors or firms with government ownership and investment were approached to participate in the project but declined. Over 12% of responses came from organisations with regulatory functions or not-for-profit objectives.

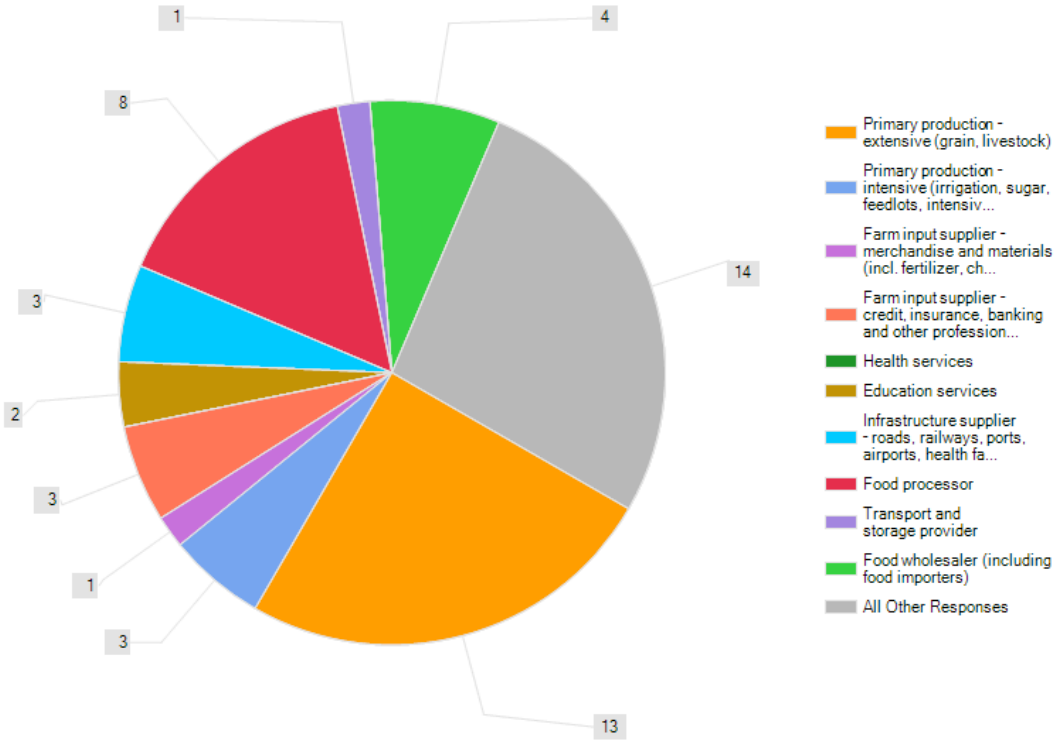


Figure 4: Case study response numbers: by food chain activity

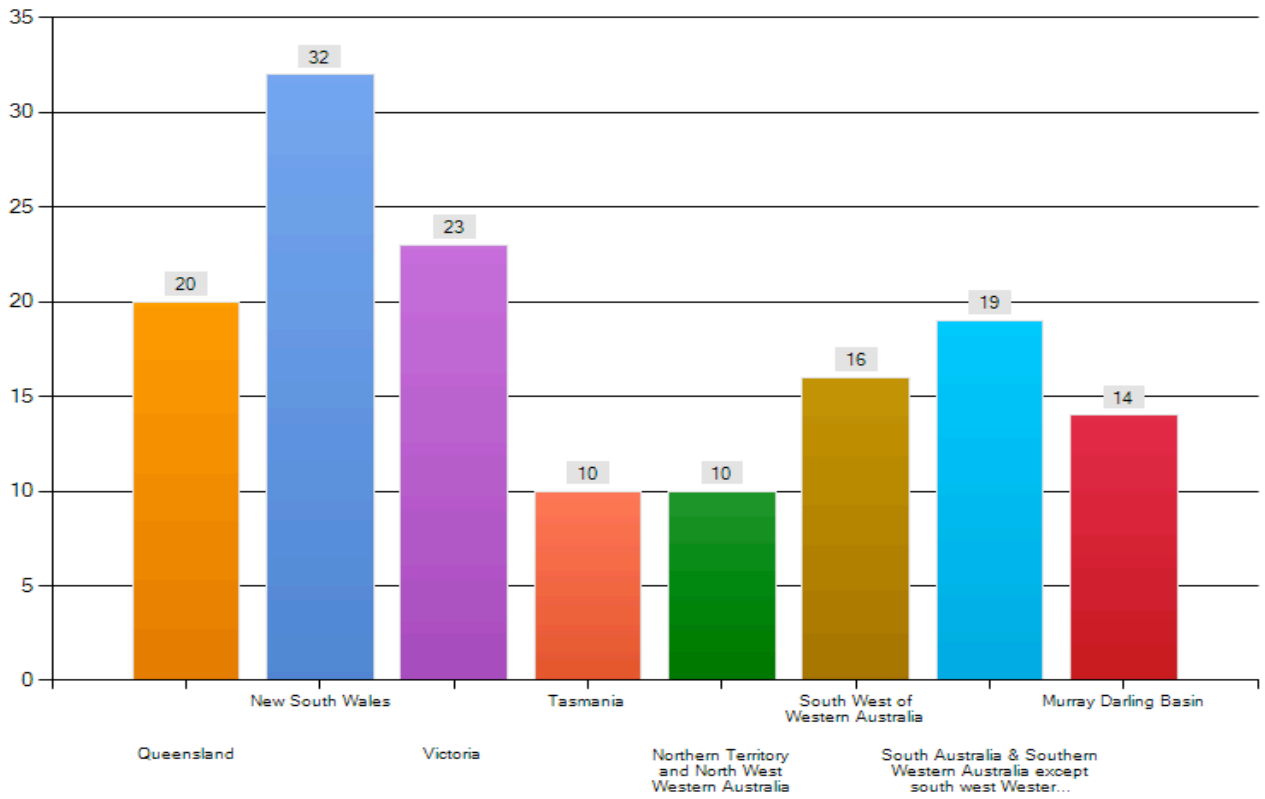


Figure 5: Respondents with presence in different states and regions of Australia (number of respondents)

4. Results and outputs

4.1 Review of food security and risk management information

In summary, the review of information shows that the existing evidence points towards Australia having a high level of food security at this time. That is, 'a large proportion of all people, at all times (recent, at least) in the country have access to sufficient, safe and nutritious food to maintain a healthy and active life'. There is more to food security than either food or security. Access, support services and practices in handling, distribution and consumption of food are seen to be central to food sufficiency. Relatively high per capita incomes, supporting social security and high-quality human and animal health systems, a modern and competitive food retailing sector, low trade barriers and a globally competitive agricultural sector underpin Australia's food security. Looking further ahead, however, there are mixed indicators arising from growth in population and per-capita consumption of food; emission reduction commitments and incentives to switch land use for increased sequestration; extreme climatic events; increasing resource constraints; soil degradation; biodiversity preservation demands; lower R&D expenditure; export commitments to help sustain global food security; incentives to switch land uses from food to energy production; threats of infectious disease outbreaks; and growth of government-owned foreign investment in land and water that is planned to take production away from normal Australian market channels. Individually, none of these risks is likely to be a cause for concern. The real risk is from a convergence of negative external shocks – a Black Swan scenario, characterised by low probability with a large impact, which may happen when several of these uncertain events coincide. At the same time, it is equally important to recognise the risks are not just in one tail of the distribution. There are opportunities and there is also the risk of a convergence of positive external shocks featuring increased supply, lower population growth, lower per-capita consumption and better than expected adaptation to food-borne illnesses – all of which would be positive for food security. Australia already has a growing overweight and obesity problem, and solutions to this problem seem to rest more with the behavioural and sociology characteristics of consumers. Evidence about existing risk management practices and plans to improve resilience suggest challenges in adaptation to extreme events. Nevertheless, there is a growing body of research on climate change at a regional level to help affected organisations prepare for the future. The UK government's Blackett Review of high-impact, low-probability risks provides some principles to deal with what might be classified as a 'wicked' policy problem (one with extreme levels of uncertainty), and to guard against a Black Swan event in Australian food security. Food industry enterprises and their support services along the whole supply chain may have to go to another level in adjustment and improved risk management practices to ensure food security.

4.1.1 Context and background

Climate and climate change are linked fundamentally with food production and food security. Irrespective of the source of climate change, agricultural production is extremely sensitive to climate variability and extremes in climate such as droughts, floods, storms and temperature extremes. The Intergovernmental Panel on Climate Change (IPCC) (2007a) noted the uncertainty surrounding non-linearity between agricultural production and mean climate change:

> *Recent studies indicate that increased frequency of heat stress, droughts and floods negatively affect crop yields and livestock beyond the impacts*

> *of mean climate change, creating the possibility for surprises, with impacts that are larger, and occurring earlier, than predicted using changes in mean variables alone … Climate variability and change also modify the risks of fires, pest and pathogen outbreaks, negatively affecting food, fibre and forestry.*

At the same time, there is potential for positive impacts from higher temperatures and increased rainfall in cool, higher-latitude areas. Agricultural production and productivity are affected directly by several climate change variables, including (US Environmental Protection Agency 2011):

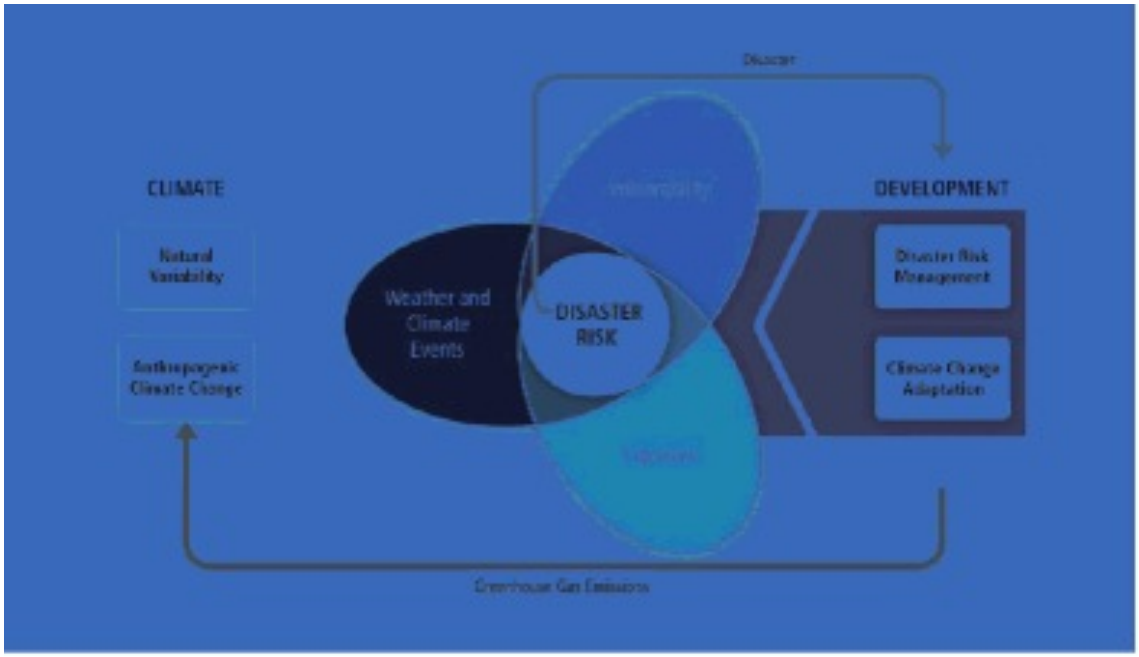
- climatic variability and the presence of extreme events
- increased average temperatures
- changed average rainfall and seasonal distribution of rainfall
- increased concentrations of carbon dioxide (CO_2) in the atmosphere.

The Bureau of Meteorology (BOM) (2011a) has a detailed web resource showing risks associated with climate and the use of climate information in agricultural risk management processes, supported by specific information on climate change (BOM 2012a). The Bureau also has an extensive program of research developing improved climate-prediction tools supported by user-friendly outputs and improved accuracy of the outlooks (BOM 2012b). Hennessey (2011), at the Climate Variability and Change Program, CSIRO, has published more than 100 reports on the regional impact of climate change. Nichols (2008) examined Australian climate and weather extremes, noting that a small change in the average of a climate variable such as temperature can mean a large change in extremes of temperature, both frosts and heatwaves. He observed the following projections (all with considerable uncertainty across regions and over time) for extreme events for Australia:

- increase in frequency of days over 35ºC by 2020
- decrease in frequency of days below 0ºC by 2020
- increases in intensity of heavy daily rainfall events, but with considerable spatial variation
- decrease over north-east Australia of the number of tropical cyclones, accompanied by an increase in intensity
- decreased hail frequency in certain districts
- increase in large hail (2 cm diameter) and reduction in average recurrent interval for hail exceeding 6 cm diameter in Sydney
- more droughts over most of Australia by 2030
- increased frequency of extreme fire danger days (except Tasmania).

The uncertainty of projections across diverse climate indicators presents obvious challenges for managing the risks of climate change impacts. At the same time, it also seems to offer potential gains for those organisations that can create and implement an effective risk management framework that provides resilience to extremes. Adaptation can limit the impacts of climate change (Howden and Filmer 2008).

A Draft Report from IPCC (2012) states that 'climate extremes, exposure and vulnerability are influenced by a wide range of factors including anthropogenic climate change, natural climate variability and socio-economic development' (Figure 6). The inclusion of natural climate variability and socio-economic development factors adds clarity and transparency to the risk management challenge because it recognises the diverse drivers of climate change, which all have the potential to impact on their risk management controls and food security. The IPCC finds that the frequency and intensity of heatwaves, wildfires, floods and cyclones are increasing, and that it is almost certain (99–100%) that the frequency and magnitude of daily temperature extremes will increase over the twenty-first century on a global scale: peak temperatures are 'likely' (66–100% certainty) to increase – compared with the late 20th century –- up to 3°C by 2050, and 5°C by 2100; and it is 'very likely' (90–100% certainty) that the length, frequency and/or intensity of warm spells, including heatwaves, will increase over most land areas.



Source: IPCC 2012

Figure 6: Managing the risks of extreme events and disasters to advance adaptation

From an examination of the literature on improved models for dealing with climate change, there is evidence of wide and intensive debate about the relevance, robustness and practicality of decision-making models that can deal with the uncertainty of climate change. This debate about the robustness of models for treatment of uncertainty is not confined to climate change. Taleb (2010) is extremely critical of standard statistical models that use the normal (Gaussian)[2] distribution curve to analyse empirically many situations that contain unknown influences with potentially large impacts. His main point is that the structured randomness used in engineering models such as quantum physics has been picked up and applied carelessly to many

[2] The 'Gaussian' distribution is commonly known as the 'normal distribution', which is used to describe the distribution of a large number of events where the sum of all values has a probability of 1. There is a probability of 0.683 of being within one standard deviation of the mean.

real-world economic, social, environmental and financial situations, which do not have similar structured and predictable randomness. Taleb says many of these models fail to consider events (abnormal observations and unknowns) that are outside the historical data sets on which they are built, and the impact that these events can have on the predictive ability of models. Small changes in input, originating from measurement errors, can lead to massively divergent projections – even if it is assumed that the model has the right equation. Taleb blames the global financial crisis on neglect of the events not measured in the tail of distributions in many financial products that have been used in risk management. With regard to climate change and what might be causing it, Taleb worries more about the fact that 'we have no proof that we are not harming nature' because of the unknowns rather than the absence of 'proof that we are harming nature'. The IPCC would probably agree generally with this point. Taleb (2010) suggests that there need to be more demands on proving there is no disruption to an old system that has worked well over a long period of time. This line of reasoning can lead directly or indirectly to, among other things, the concept of 'business continuity planning'.[3]

It has been estimated that the loss of wealth in the global financial crisis between September 2007 and March 2009 was US$50 trillion (Summers 2009). Taleb (2010) blames it on failure of the 'human mind' and a tendency towards illusionary understanding – a consequence of too many people thinking they know what is going on in a world that is more complicated than they realise. In short, it seems to be a case of 'not knowing what we don't know'. Summers' (2009) comments may have stimulated concerns about the risk of a repeat financial crisis and a focus on financial risk management. While the fear of a major systemic financial failure remains, the World Economic Forum (2012a, 2012b, 2012c) points towards water supply and food security as risks with a higher likelihood of occurring, and with almost the same impact as the financial crisis.

Not everyone agrees with Taleb about either his philosophy regarding risk management or his wide-ranging criticism of statistical methods. Pate-Connell (2011) states that, 'Clearly, one cannot assess the risks of events that have really never been seen before and are truly unimaginable. In reality, there are often, precursors to such events. The best approach in that case is thus a mix of alertness, quick detection, and early response …' Pate-Connell suggests improved monitoring of signals, precursors and near-misses, as well as reinforcement of the system and a thoughtful response strategy. While statisticians in particular seem to be the group most offended by Taleb's blunt ideas and writing, there is little doubt that he has had impact, with growing attention to 'outlier' observations and near-misses having large consequences. Nobody who is serious about food security can ignore these developments.

Taleb's interest in the failed application of the Gaussian model would probably appeal to agricultural geneticists (plant and animal), because it is they who have searched often for those positive outliers with desirable traits in the normal distribution tails. For example, productivity gains of 3% or more per year have been achieved by the intensive livestock and grains industry, with a large part of that coming through identification of genetic outliers in plants and animals with a positive impact on

[3] Business Continuity Planning (BCP) is described by Elliot et al. (1999) as '...planning which identifies the organization's exposure to internal and external threats and synthesizes hard and soft assets to provide effective prevention and recovery for the organization, whilst maintaining competitive advantage and value system integrity ...' This issue is examined further below in the review of food industry management of risks.

productivity. The presence of low-probability events with large impact and importance is not likely to surprise agricultural plant and animal geneticists.

Sniedovich (2011) supports Taleb's concern about the treatment of uncertainty in probability-styled models dealing with information gaps. Information gap decision theory has been adopted in a number of environmental and financial risk assessments as a practical tool for the management of severe uncertainty.[4] Daish (2011) observes that 'uncertainty is everywhere' in natural systems, and that it is a central constraint to effective decision-making. Decision-makers depend on the reliability of scientific knowledge to make informed and well-guided decisions; however, uncertainty exists within both scientific knowledge and the implementation of decisions. Across disciplines, uncertainty is termed and treated differently, and this prompted a call from Daish for a unified framework for dealing with uncertainty. Otherwise, the treatments can become another source of uncertainty. Similar sentiments were expressed by Haimes (2009) in calling for a 'concerted effort to improve our understanding of the commonalities and differences among diverse fields in risk assessment'. While climate change assessment is seen by Daish to have the clearest guidelines for treatment of uncertainty, that may change with the passage of time.

The most direct and highest-priority policy response to the high-impact, low-probability risks embodied in the 'Black Swan' has been from the UK Cabinet Office and Ministry of Defence, which commissioned the Blackett Review of these particular risks (Government Office for Science 2011). The Blackett Review explores the best ways to approach identification, assessment and management of high-impact, low-probability risk. Eleven recommendations were made to improve the quality of treatment of 'Black Swan' risks, including greater use of external experts to inform risk assumptions, judgements and analysis (to guard against epistemic risks – that is, the risk of being wrong); optimal and efficient balance of resources to address high-impact, low-probability risks; enhanced warning systems; strengthening mechanisms to review risks and 'near-misses'; and assessment of linked and compounding or cascading risks. The potential for compounding or cascading risks seems to be potentially high for the food industry, due to the close linkages all the way along the supply chain from production through processing and retailing to end consumers. The Blackett Review has examined a number of key questions, including 'How can we ensure that we minimise strategic surprises from high impact low probability risks?', concluding that these risks require specific attention and planning.

Hayes (2011) reviewed uncertainty and uncertainty analysis methods used in risk assessment, with attention given to the sources of uncertainty and identification of practical treatments to improve quantitative and qualitative methods. He concluded that some quick improvements could be achieved by eliminating what may be seen as correctable sources of uncertainty (e.g. vagueness and ambiguity, which contribute to linguistic uncertainty).[5] Hayes observes that risk assessment is often performed in the absence of empirical observations, in which case elicitation techniques can be used to extract views from stakeholders. The World Economic Forum (2012a, 2012b)

[4] Information gap theory is a non-probability-based method for analysis, planning, decision-making and design under uncertainty (http://info-gap.com). It seeks to aid decision-making by starting with a model where certain parameters are explicitly unknown. It then includes assumptions for that parameter that may be well outside any past observations, and assesses how sensitive outcomes are to this outlier or error observation. It then builds robustness into the model for desired minimum outcomes or desired levels of tolerance for uncertainty. It seems to have potential for climate change analysis for those who have a need to work with complex models (e.g. insurance companies). In principle, it is also relevant to food security.

[5] Hayes (2011) identifies four sources of uncertainty: linguistic uncertainty (arising from vagarious nature of language); epistemic uncertainty (arising from our limited understanding of natural systems); natural variability; and decision uncertainty (arising from values and management influence).

conducted a survey of 469 experts in risk assessment to elicit average values of the likelihood and impact of 50 global risks. A set of 50 risks was used from previous identification work, and revised through a series of workshops and interviews with leading risk-assessment experts. The 50 risks were then allocated into five categories: economic, environmental, geopolitical, societal and technological risks. In 2011, the risks perceived as having the highest potential impact were economic and environmental. In 2012, there was a shift in the impact rankings, with economic and societal risks emerging as the categories of most concern. Societal risks include, among other items (e.g. unsustainable population growth), water supply and food-shortage crises. Failure of climate change adaptation is still rated as a serious component of environmental risk. Jones and Preston (2010) have suggested a reorientation of measuring adaptation from an assessment focused solely on anthropogenic climate change to broader issues of vulnerability and resilience. This adds to the complexity of the adaptation challenge from climate change. Lonsdale et al. (2010) conclude that effective adaptation will require acceptance that the 'business-as-usual' case will be insufficient for dealing with adaptation challenges emerging with climate change impacts. Adaptation is complicated by the need to make important decisions with imperfect knowledge and significant uncertainty arising from the absence of clear agreement about the problem definition, ambiguity about how improvements can be made and unbounded limits to the time and resources involved to address the problem. From a public policy perspective, these features take the form of a 'wicked'[6] problem. It may also be the same for the more complex organisations in the food-supply chain, including vertically integrated retailers with branches spread throughout the country.

The IPCC (2012) assessed the relationship between climate change and extreme weather and climate events, and the implications for sustainable development and society. They conclude that the character and severity of impacts from climate extremes depend not only on the extremes themselves but also on extreme exposure and extreme vulnerability. Adverse impacts are considered disasters when they produce widespread damage and cause severe change in the normal functioning of communities. Climate extremes, exposure and vulnerability are affected, as discussed above, by several factors, including anthropogenic, natural and socio-economic development influences. Disaster risk management and adaptation to climate change aim to reduce exposure and vulnerability, and to increase resilience to the potential adverse impacts of climate extremes. The IPCC (2012) concludes that adaptation and mitigation of climate change can complement each other and reduce the risks of impacts from climate change. The question of alignment of adaptation and mitigation with food security seems to have attracted less attention. The Prime Minister's Science, Engineering and Innovation Council (PMSEIC) (2011) pointed to the UK government's Low Carbon Transition Plan's (Department of Energy and Climate Change (DECC) 2009) recognition of its role in ensuring safe, affordable food supplies, balanced by the need for the agricultural sector to adapt to the impacts of climate change and safeguard environmental resources such as biodiversity and water quality. Friel (2010) argues that a broader view of food security is required for Australia in the twenty-first century, one that judges the food system for its nutritional quality, social value and impact on the environment. It is, however, even broader than that because

[6] Darwin et al. (2002) developed the concept of a difficulty gauge for decision-making, starting with 'tame' problems, when information is relatively good and reliable, moving through stages of 'tricky', 'wild' and 'wicked' as uncertainty grows. Many decisions in the past have been based on 'certainty, rationality and predictability' and that has been effective for 'tame' problems. Climate-change impacts, however, are moving the decision-making environment rapidly forward through the 'tricky' and 'wild' stages to the 'wicked' stage.

of Australia's role as a supplier of food for developing countries, where it may mean the difference between survival and malnutrition. The complexity of the relationship between mitigation, adaptation, food security, international trade and obligations, and resource use is just starting to be recognised. It has all the features of a 'wicked' problem.

The World Food Summit of 1996 defines food security as existing 'when all people, at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life' (FAO 1996). Access is intended to include both physical and economic access to food that meets people's dietary needs as well as their food preferences. This definition expands the scope of food security to food supply, processing, nutritional value, distribution and vulnerability of consumers outside the standard distribution systems. These issues are typically raised more often in a developing country context, but looking forward it is not that certain all developed countries will continue to retain their current development status; in any event, it is difficult to look at food security as simply a national issue because of the globalisation of trade and investment.

Food quality and safety and sustainability are intended to be assured through a national and international network of standards and public controls (Will and Guenther 2007). Food Standards Australia & New Zealand (FSANZ) develops standards to cover the food industry in Australia and New Zealand. In dealing with food security, there is the potential role of more generic standards for improving risk management and resilience to climate change. ISO 31000:2009 is a new non-certifiable generic standard intended to provide a common approach in support of standards dealing with specific risks (Standards Australia 2009). The standard gives generic guidelines for the principles and the adequate implementation of risk management. It is not intended to be used for the purposes of certification. It has been adopted as AS/NZS ISO 31000:2009 by Standards Australia and Standards New Zealand as their National Standard for Risk management. Under the new standard, risk is now defined in terms of the influence of uncertainties on objectives while previously the standard focused on risk as being the chance of something happening and that would have an impact on objectives. It could be viewed as addressing some of the concerns about information gap uncertainty. The new standard highlights eleven principles for effectiveness and with which organisations are encouraged to comply:

- creation and protection of value
- being an integral part of all organisational processes
- helping make informed decisions
- explicitly taking account of uncertainty
- contributing to a systematically, structured and timely approach for efficiency and consistency
- using the best available information
- being tailored to the organisation's risk profile
- recognition of capabilities, perceptions and intentions of external and internal people
- being transparent and inclusive, with all stakeholders represented and participation from decision-makers at all levels
- being dynamic, iterative and responsive to change
- facilitating continual improvement of the organisation.

ISO 31000 is supported by ISO 31010, which deals with risk-assessment techniques. Business continuity management is covered by AS/NZS 5050, and provides further support for disruption risk assessment within ISO 31000. ISO 22301 is a new international standard to enhance continued operations in the event of a disruption due to a disaster. ISO 28000:2007 is a specification for supply chain security management systems. ISO 28002:2011 describes requirements for development of resilience in supply chains. The Draft AS 5334 covers principles and generic guidelines on the identification and management of risks that settlements and infrastructure face with climate change. It also supports ISO 31000.

The emergence of a revised and potentially complex risk management standard and supporting implementation standards, along with emerging resilience standards, raises the question of value for money and whether it is worth the investment. Doherty (2006) estimated that a sophisticated and comprehensive approach to risk management could increase a company's value by 3–5%. This estimate was based on integration of risk categories, including financial and non-financial risk. It also applied mainly to large listed companies. With the increasingly volatile business, environmental and social conditions, it would seem that the returns may even be higher now than when Doherty examined the issues in 2005–06. Furthermore, the gains may also be as relevant to small businesses and non-profit organisations as they are to large companies, especially for organisations with growth potential, large investment opportunities and large numbers of transactions (see below).

4.1.2 Agricultural production, ownership, land use and farm inputs

Howden et al. (2011) has set out a food production and security adaptation challenge for Australia, based on an assumption food production will need to increase by 70% or more by 2050 to satisfy growth in demand. This is to be achieved against a background of growth in population[7] and per capita consumption; emission reduction commitments; climate change; incentives to switch land-use for increased sequestration; increasing resource constraints (nitrogen, phosphate, water and fuel); land and soil degradation; biodiversity preservation demands; lower R&D expenditure; export commitments to help sustain global food security; and incentives to switch land uses from food to energy production. To this list might also be added certain types of foreign investment. Moir (2011) recently gathered information about foreign investment in Australian agricultural production and food processing, pointing to the important contribution foreign investment has made to Australian agriculture through investment and growth in productivity, at the end of 2010 an estimated 11.3% of Australian agricultural land and 1% of agribusinesses were estimated to be wholly or partly foreign owned. There has been some activity by foreign government-owned entities acquiring Australian farm land where the produce is sent directly through vertical distribution channels to their home markets. This may be seen as an additional issue for food security, but at this time the level of government investment in Australian land and agribusiness is relatively low. It is, however, a situation that could change quickly, especially as both the Chinese National Cereals Oil and Foodstuffs Corporation (COFCO) (Asian Agribusiness Group 2012) and Hassad (from Qatar) have signalled

[7] Australia's population is expected to grow from an estimated 22.6 million in 2011 to 35.9 million by 2050 (an increase of 59%), assuming annual average population growth of 1.2%, 1.9 births per woman and net annual overseas migration of 0.6% of the total population (Treasury 2010). This estimate is above the United Nations' (2011) projections, which indicate an Australian population of 31.4 million by 2050 (an increase of 39%) and 36 million by 2100. There is no evidence that these projections have included additional population movements into Australia as a result of adverse climate change impacts.

intentions to expand foreign investment in agriculture and food processing. Hassad Food is now ranked as one of the biggest investors in NSW agricultural land (*Property Observer* 2011). The Foreign Investment Review Board examines all investments by foreign governments to ensure the activity is consistent with the national interest. Moir (2012) recommends improved and more regular collection of information about foreign investment in Australian agribusiness. With regard to the distribution of produce from foreign government-owned entities, there is some evidence of conditions being part of the approval to ensure a proportion of output is sent to traditional market channels (Michelmore 2012).

In 2004 the United Nations projected that the world population would increase to around 9 billion by 2050 and stay around that level through to 2300 (United Nations 2004). The 2010 revised estimates increased the projected global population to 9.3 billion persons by 2050 (up from 7 billion in 2011, an increase of 33 per cent) and to 10.1 billion by 2100. Most population growth is expected to take place in developing countries – in particular, the least developed – underlining the importance of exports and development for food security in these countries. Some analysts believe significant mass migration may occur in response to climate change (Stephenson 2010). This may result in faster growth in Australia's population than the projections of either the United Nations or the Australian Treasury (refer to note 7). This has implications for demand for food and health services.

Howden et al. (2011) point to the constraints of lack of information about impacts from climate change and adaptation options. In addition, significant uncertainty surrounds existing information. Increasing the resilience of livestock and cropping production enterprises is seen as a policy priority, with a view to improving capacity to adapt to change through adopting new technologies and strategies that can cope with critical temperature thresholds. Hayes and O'Rourke (2012) reviewed research progress in the delivery of livestock genomics technologies. They found that, relative to intensive animal systems (e.g. poultry), applications of genomic technology have been more difficult for livestock run under extensive systems (beef, dairy and sheep) because of the need to predict performance of animals across different breeds, which means large numbers of animals are required for development. Australian wheat researchers are now working with the Centre for International Maize and Wheat Improvement to identify new dwarf varieties and traits with increased tolerance to drought and salt conditions (Locke 2012).

Orgill (2012) presented the results of research into farming carbon in soil, noting that productivity is closely linked to soil functions that depend on decomposition of organic matter. Carbon inputs (e.g. biomass) have to exceed losses (e.g. from decomposition) to increase soil organic matter. Carbon in soil depends on soil type, climate, vegetation and land management. Soils vary in their capacity to sequester and protect carbon. There are expectations that growth in soil carbon can contribute significantly to the mitigation process, which implies reduced requirements for other supply-reducing options.

Quiggan and Horowitz (2003) examined the cost of adjustment to climate change and concluded that welfare would be reduced when the speed of climate change exceeded that of the normal market driven adjustment in stocks of capital, including both long-lived investment (ports, dams, irrigation systems, grain handling facilities, etc.) and natural assets (forests, ecosystems). The uncertainty of climate change impacts, which adds to the complexity of making an investment decision (see above), may result in sub-optimal investment decisions. For example, farmers faced with a run of dry seasons must choose whether to continue to make investments in their existing location or sell out and move to a more favourable climate, or do nothing. If the run of

dry seasons turns out to be just a random event, those who sell may have made a costly error. On the other hand if the climate has undergone a permanent change, those who stay may regret the decision and those who move could be more than satisfied. Nevertheless, those who stay with the dry climate may be able to expand at a lower cost (as others shift and land prices fall) and achieve the economies of scale for low-cost operations that were otherwise difficult to achieve. These extremes of uncertain outcomes can fuel the strategy of doing nothing or at least improve understanding of why some operators appear to be electing to do nothing. The key issue seems to be whether or not producers and other supply chain participants can adjust to a new influence on climate in the same way they have learned to adjust to seasonal changes and longer term changes to natural events such as the shifts between El Niño and La Niña climate events.[8] In this case, the producers who do learn to take their adjustment to a new level will gain a benefit, and presumably continue with the investments required for operating in that adjusted environment. It is not just producers facing the adaptation challenge, however, because some of the biggest challenges and potentially most expensive mistakes exist beyond the farm gate. For example, should capital expenditure on railways and grain storage be deferred or wound down or relocated after five years of continuous drought? If the dry seasons continue, a decision to defer may turn out to be satisfying for all. On the other hand, if seasonal conditions turn around (as has happened across Australia over 2009–11), a decision to run down the grain storage and railways may turn out to be very inefficient and give rise to significant harvest losses and wastage. The new standards (see above) offer a way forward for dealing with these complex situations.

These findings highlight the value of information about climate change and dynamic decision-making frameworks for dealing with that information. Many producers base their decisions on extensive experience with particular geographic regions and inter-generational transfer of that information. It has been an extremely successful model for many agricultural and food producing businesses, and an integral part of their informal 'business continuity planning'. These informal systems may, however, be challenged by the emergence of extreme events or departures from long-term averages due to the presence of an additional and uncertain layer of climate change, and with which they have less experience. There are diverging views about adjustment capacity in the farm sector and the pressure created by climate change. Kingwell (2006) concludes, in a review of climate change impacts, that 'the likely gradual unfolding of climate change should provide farmers in many regions and industries with sufficient time to utilise or develop adaptation strategies. Many of these strategies are likely to be based on farmers' current responses to climate variability …' Quiggan and Horowitz (2003) seem less confident about the capacity of producers to cope with extreme events that have large costs, even though their probability of occurring may be low. The IPCC (2007b) projects a generally negative impact on agriculture for Australia, with expectations of water security problems and declining production of agriculture and forestry across southern and eastern Australia. There is, however, expected to be wide variation in the impact across regions and over time. For example, just within southern Western Australia, wheat yields are expected to decline in the eastern part of the northern wheatbelt, but increase in the southern wheatbelt (Van Gool 2009). Howden and Jones (2004) project the likelihood of large positive benefits of climate change at Wagga Wagga (NSW) and Emerald (Qld).

[8] El Niño refers to the extensive warming of the central and eastern Pacific that leads to a major shift in weather patterns across the Pacific. In Australia (particularly eastern Australia), El Niño events are associated with an increased probability of drier conditions. The term La Niña refers to the extensive cooling of the central and eastern Pacific Ocean. In Australia (particularly eastern Australia), La Niña events are associated with increased probability of wetter conditions (Bureau of Meteorology 2012b).

To further complicate the quality of information available to food industry operators, there are different views from different scientists. For example, climate models from the CSIRO indicate south-eastern Australia is facing a significantly drier future. In contrast, Opdyke (2012), from ANU's Department of Physical and Mathematical Sciences, using paleoclimate[9] data and models, says the south-east of Australia is likely to become more wet than dry.

Moir and Morris (2011) conclude that, '[T]here is no foreseeable risk to Australia's food security. Australia produces twice as much food as it consumes, produces almost all its fresh food, and can easily afford the food it imports …' This conclusion seems to assume that average climatic conditions and high income levels persist in Australia without extreme events. It may, however, be less applicable to people on lower incomes in Australia and in less-developed countries, an estimated 40 million of whom rely on Australian-produced food.[10] The Australian Bureau of Statistics (2011a) estimates that the poorest 20% of households in Australia account for 1% of total household net wealth. Despite this, food security for the poor in Australia seems to be relatively assured through a solid safety net system, with no signs it is about to be dismantled.

When negative forces affecting agricultural supply coincide with sharp shifts in demand, it can generate extreme shifts in prices with implications for food security. Figures 7 and 8 show price movements for food and selected agricultural input prices over the past half-century, together with movements in monthly price volatility. The prominent features include the surge in prices over the past five years and the spikes in volatility that occurred in 1970–79 and 2000–09. In a study of rising international food prices, the World Bank concluded that increased bio-fuel production had contributed to the rise, noting that 'almost all of the increase in global maize production from 2004 to 2007 (the period when grain prices rose sharply) was used for bio-fuels production in the U.S., while existing stocks were depleted by an increase in global consumption for other uses' (World Bank 2009). Another contributing factor to the 2007–08 global surges in food prices has been international market trade barriers including subsidies (which kept prices low, investment incentives weak and production in the hands of inefficient producers), tariffs, quotas, export credits and other non-trade barriers. Intuitively, international trade seems to be a vital requirement for food security because it facilitates access to products that may not be available locally in the event of an extreme event such as drought or flood. In brief, the spikes in agricultural commodity prices show just how sensitive they are to external shocks.

At the same time, there is the chance of abnormally low prices when above-average rainfall gives rise to surplus production, raising the possibility that producers will face more pressure to adjust than in the past. The possibility of abnormally high agricultural commodity stocks arising from climate change has not been examined in research, but the uncertain nature of climate change impacts and the presence of large areas of land (especially in the Northern Hemisphere) that are likely to benefit from climate change suggest it is another risk area. These swings in prices and production have the

[9] Paleoclimatology is the study of past climates experienced over the entire history of the earth, using data from rocks, sediments, ice sheets, trees, coral shells and fossils.

[10] In response to concerns about food security in developing countries, Muir and Morris (2011) conclude that, 'Australia produces far more food than it consumes and has the income to meet all its food security needs. However, its surplus food production meets only a small part of world food consumption needs. Australia's greatest contribution to global food security will be through provision of technical cooperation assistance to food-deficient countries … Australia will feed far more of the world's poor by providing technical assistance that helps them in feeding themselves, thereby enhancing their economic development and thus their ability to afford food.'

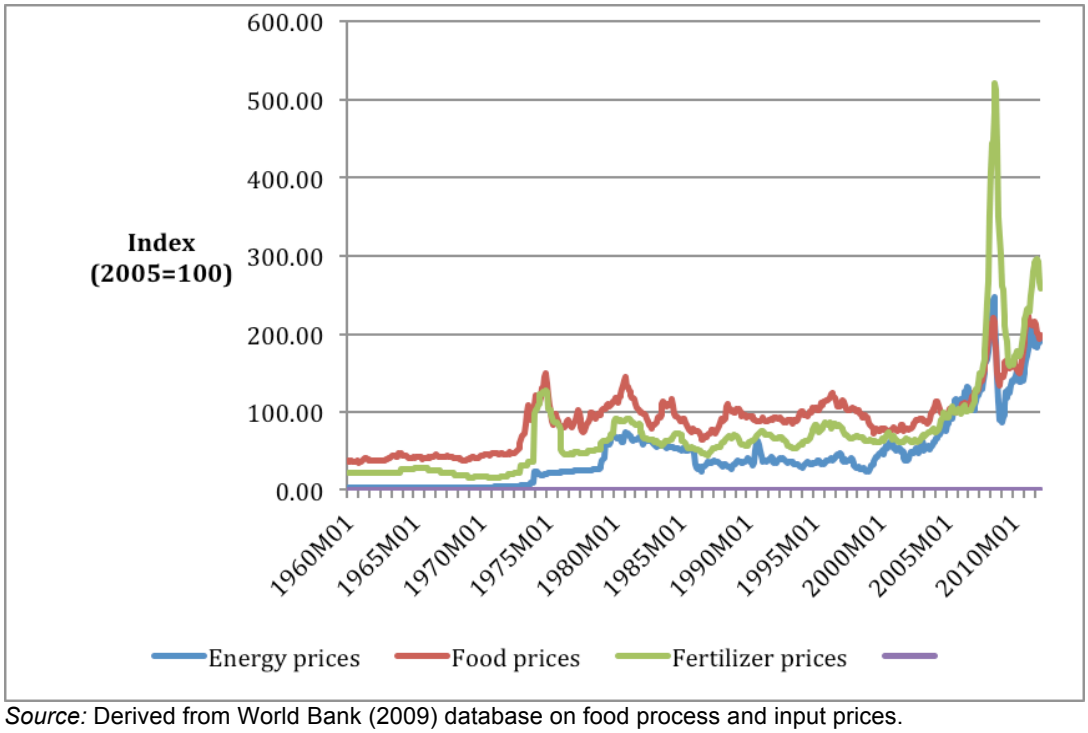
potential to be accentuated by climate change impacts, raising the question of whether producers have the capacity to adjust to a new level of price volatility. At the recent 2012 ABARES Outlook conference, it was stated by the ABC:

> *Australian wheat production is forecast to fall by 13% to around 26 million tonnes in 2012–13, reflecting an assumption of a return to average yields and an expected smaller area planted. Area planted to wheat is forecast to fall by 3% to 13.7 million hectares as the forecast prices for wheat, relative to other major crops, become less favourable.*

The presence of price extremes underline the importance of productivity and growth in productivity in agricultural production through adoption of improved work practices and new technology and adjustment into efficient sized farms that can produce high quality food at the lowest cost. The Australian Academy of Science recognises that gene technology has a key role to play in enhancing global food security and that gene technology can play a role in the alleviation of malnutrition, enhancing sustainability and securing yields worldwide.

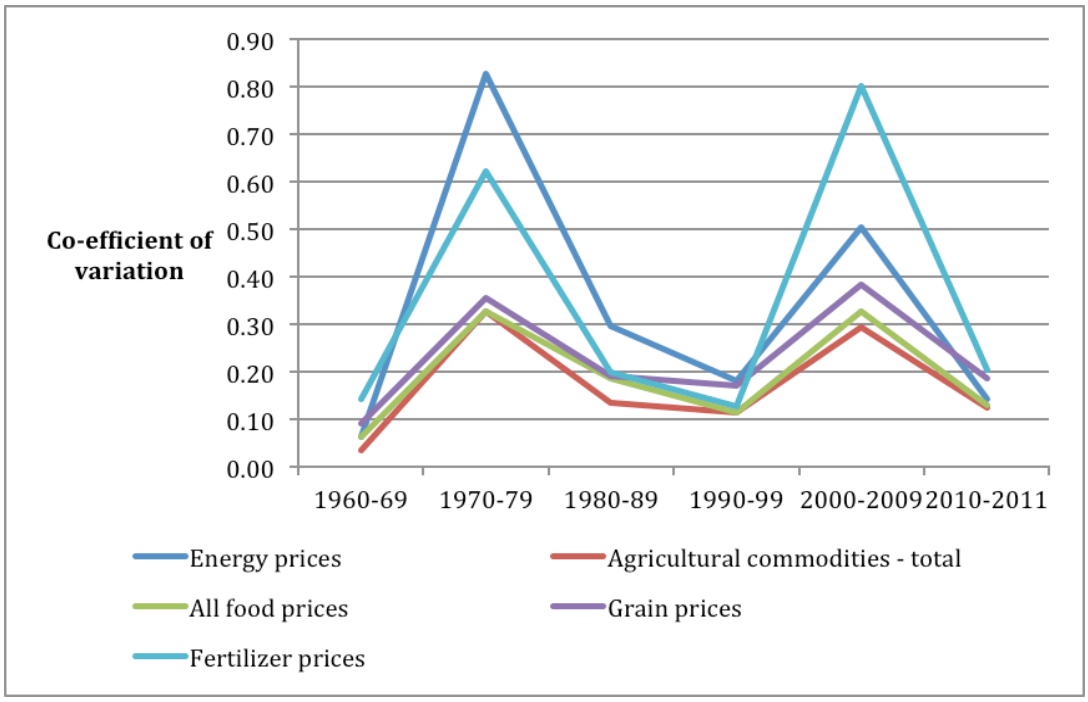
In Australia, the Office of the Gene Technology Regulator (OTGR), within the Commonwealth Department of Health and Ageing, administers the national regulatory systems for gene technology as set out in the *Gene Technology Act 2010*. Among other responsibilities, the OTGR protects the health and safety of Australian people and the environment by identifying risks posed by or as a result of gene technology and by managing those risks through regulating certain dealings with genetically modified organisms (GMOs). The OTGR addresses risks to the regulatory process in addition to setting risk-derived regulatory goals and key performance indicators in its strategic and operational plans. Licences issued by the OTGR are subject to the Risk Assessment and Risk management Plan (RARMP), which applies a Risk Analysis Framework (RAF) to all GMO applications.

The Consultative Group on International Agricultural Research (CGIAR) (2011) has a specialised collaborative research program on Climate Change, Agriculture and Food Security (CCAFS). CCAFS is lead by the International Centre for Tropical Agriculture and is dealing with a diverse range of issues, including farm management practices, adoption of new technologies and policy development. Innovation and research are viewed as critical components of improving agricultural productivity and food security.



Source: Derived from World Bank (2009) database on food process and input prices.

Figure 7: Price indices: energy, food and fertiliser, 1960–2011, by month (2005=100)



Source: Derived from World Bank (2009) database on food prices and input prices.

Figure 8: Selected food and energy price variation: 1960–2011 (coefficient of variation, monthly prices for selected 10-year blocks, plus 2010 – January 2012

Among the productivity improvement technologies and systems being developed in Australia is precision agriculture (PA) and use of machinery equipped with variable rate technology (VRT) (Graham 2012). Fewer than 15% of Australian farmers are estimated to be using PA beyond a basic level but wider adoption is considered critical if the Australian grains industry is to reach an annual average growth rate in productivity of 3%. Case study 4.3.4 (below) provides more details on VRT.

At the 2012 World Economic Forum (WEF) meeting, Bill Gates of the Bill & Melinda Gates Foundation urged increased commitment to agricultural research, supported by a belief that agricultural productivity in developing countries could be improved by between 200 and 300%.

The WEF (2012a) highlighted:

> *Today, 925 million people are hungry, with 29 countries listed as 'extremely alarming' on the global hunger index. Food production will need to double by 2050 to feed a population forecast to hit 9 billion. In addition, 30% of crop production is at risk from climate change and up to 40% of food is lost, wasted or spoiled in the supply chain. Despite these challenges, panellists are optimistic that a food crisis can be averted.*

A recent McKinsey & Company (2012) report argues that 20% of the required improvement in productivity of resources to meet growth in demand over the next 25 years is readily achievable but the remaining improvements will be hard to capture.

4.1.3 Food processing and food security

There has been surprisingly little investigation of the impact of climate change on interconnected food-supply chains, including processing. It is, however, at the inter-connected enterprise and supply chain level that the response to climate change and flow-through effects to consumers will take place with implications for food security, both nationally and globally. Sjauw-Koen-Fa (2010) highlights the importance of improved integration across processes and more rapid transformation of the global food-supply chain to improve sustainability. Bartos and Balmford (2010) identified and examined threats to resilience of the Australian food-supply chain. They found it vulnerable to large-scale events (e.g. human or animal pandemics or food shortage) or combinations of events that could affect multiple stages of the food-supply chain at the same time (e.g. electricity failure combined with floods or fires). Bartos and Balmford (2010) also found that the effectiveness of adaptation and response to extreme events in Australia is constrained by unclear guidelines for where public and private sector responsibilities start and end, leading to terms like 'donor fatigue' when private-sector firms are called on to deliver public-sector services. This is a recurring theme in studies of the Australian food industry.

A survey of 82 Australian food manufacturing enterprises in 2011 noted the low export orientation of this sector (Grant Thornton 2011). The majority of food processors export less than 5% of their output, and most are not exporting and have no plans for exports in the future. The poor export performance of food processing is contributing to a growing deficit in trade in processed food products. Woodhouse (2012) reports on O'Brien, a leading food processor, attributing the poor competitiveness of Australia food processing to several factors, including inadequate rate of growth in productivity, disconnection between productivity and labour costs, lack of economies of scale at the farm level and concentration of bargaining power at the retail level. There are

exceptions, however, with higher growth in more specialised and elaborately transformed food products. At Bega Cheese, for example, exports have accounted for 13% of revenue, due mainly to growth in sales of value-added, retail-ready products. An earlier investigation by Wondu Business & Technology Services (2000) found that foreign-owned food and fibre manufacturing firms in Australia with more than 50% foreign ownership were more export oriented than Australian owned firms, and that this self-evident edge in global competitiveness was due to adoption of new technology and preparedness to restructure their workplaces. The Australian Food and Grocery Council (AFGC) (2011) estimated the trade deficit in processed food products was $2.7 billion and growing, due in part to the strength of the Australian dollar. This led to a statement that this could be of concern to food security and uncertainty caused by climate change, but the logic behind this conclusion is not evident. While international trade cannot guarantee food security, there is significant evidence to show that 'strong, efficient and dependable international markets are a vital source of food security for countries around the world' (Brown, Laffan and Wight 2008). The AFGC (2011) also judged that 'the introduction of a price on carbon will initially impose additional cost on the Australian food and beverage industry and introduce new risks and uncertainties. However, it will create business opportunities for those entities sufficiently nimble to identify and exploit them.'

Ericksen, Ingham and Liverman (2009) examined the impact of global environmental change on food-supply chain systems, noting the focus of research on agricultural production. They concluded that food systems are what actually deliver food security, and need more attention than simply focusing on technologies to increase agricultural yields. The Norwegian Centre of Expertise in Culinology (2012) developed three 'radical' global scenarios for the food industry, based around expected shortages in raw materials leading to sharp food price rises; growing controls on emissions; and growing awareness of the nutritional value of food. It is an interesting picture, but while scenario analysis can contribute to risk management and development of investment plans, it may also have its own shortcomings, including the use of unrealistic or irrelevant goals and expectations (Maack 2001). Defining the scenarios and having them aligned closely with stakeholder situations and strategies for growth seems to be important. Broadleaf Capital International et al. (2006) used scenario analysis in a study of climate change impacts and risk management undertaken for the Australian Greenhouse Office. This study highlights, among other items, the importance of achieving balance between climate and non-climate risks and integrating climate change risk management within a broader risk management framework. Shell Oil is a leading exponent of scenario analysis, and has over 30 years' experience in applying the method to large and complex investments in a rapidly changing environment (Cornelius et al. 2005). Cornelius et al. state that:

> *[F]orecasts – which are usually constructed on the assumption that tomorrow's world will be much like today's – provide an inappropriate tool to anticipate shifts in the business environment … Scenarios are not projections, predictions, or preferences; rather, they are coherent and credible alternative stories about the future. They are designed to help companies challenge their assumptions, develop their strategies, and test their plans … Given the irreversible character of most investments, scenario planning can usefully be combined with real options analysis, an approach that emphasizes that many investments create important follow-on opportunities for a company.*

The CSIRO (2011) has undertaken some research to improve the efficiency of conversion of agricultural materials into food, including reduced energy and water use

and greater use of waste residues. Food safety and longevity are processing attributes with implications for climate change impacts and food security.

The cascading impact of extreme events on food security was examined by Abhas et al. (2012), who urged greater attention towards the full impact of measures designed to prevent flood damage. In some instances, flood risk can be reduced in one area with a water diversion structure; however, the risk may partly be shifted to another location, or even a different activity in a supply chain. Urban centres are vulnerable to extreme events, interrupting distribution of food from factories and farms to cities and regional and urban centres, which is where most consumers reside.

Food manufacturers also have specific programs dealing with food security, Unilever, for example, has recognised agricultural productivity being threatened by changing weather patterns, water scarcity and unsustainable farming practices (Unilever 2009). Unilever developed a Sustainable Agricultural Program with good agricultural practice guidelines to enhance sustainable supply.

4.1.4 Infrastructure for food security

The Critical Infrastructure Resilience Strategy ('the Strategy') (Attorney General's Department 2010) describes the Australian government's approach to infrastructure as being to 'help achieve the continued provision of essential services … this Strategy encourages and enables critical infrastructure organisations, through a range of initiatives and activities, to better manage both foreseeable and unforeseen or unexpected risks to their critical infrastructure assets, supply chains and networks (the objectives of this Strategy).' As a result of significant private ownership or operation of a large proportion of critical infrastructure assets, the strategy emphasises the importance of partnerships and cooperation in sharing information between the relevant public and private organisations. Towards this end, the Trusted Information Sharing Network (TISN) has been established for Critical Infrastructure Resilience (CIR) as the primary organisation for building the partnership between the private and public sectors. The strategy comprises six components for building CIR. These include 'development and promotion of an organisational resilience body of knowledge and a common understanding of organisational resilience'. The emphasis on organisational resilience is intended to build organic capacity to manage the risks of extreme or 'rapid onset' events, instead of rigidly developing plans to deal with pre-defined and limiting scenarios. The philosophy behind this approach is captured by the Attorney-General with the following introduction to the strategy:

> *The time has come for the protection mindset to be broadened – to embrace the broader concept of resilience … The aim is to build a more resilient nation – one where all Australians are better able to adapt to change, where we have reduced exposure to risks, and where we are all better able to bounce back from disaster.*

The TISN comprises seven critical infrastructure sectors, one of which is the food chain, with others including transport, communications, water services and energy – all of which have significant interdependencies with the Australian food-supply chain and food security. A further component of 'the strategy' is the Critical Infrastructure Program for Modeling and Analysis (CIPMA), which is developing, through an impact model, improved understanding of the relationships of critical infrastructure networks in response to disasters and threats. This is expected to improve, among other things, understanding of how the economy and population will be affected by disruptions to a

particular service. Health and food-supply chains are, for unexplained reasons, not included in CIPMA.

The FAO (2008a) prepared a technical document on the linkages between climate change and disaster risk-reduction and management, with a particular focus on the implications for agriculture and food security. Particular impacts of climate change covered increased frequency and intensity of extreme events such as droughts, floods, tropical storms and wildfires. It was observed that 'in the period between 2000 and 2007, of the more than 230 million people affected annually by disasters about 98 percent were due to climate-related hazards, predominantly floods and windstorms, followed by droughts'. Abhas et al. (2012) observed that floods were the most frequent of all natural disasters. In 2010 alone, 178 million people were affected by floods. The total losses in exceptional years such as 1998 and 2010 exceeded US$40 billion. More than 90% of the global population exposed to floods lives in Asia. The Queensland Floods Commission of Inquiry (2011) indicated the floods of December 2010 and January 2011 strained the resources of the state more than previous droughts had done (with funds allocated mostly to urban infrastructure, some of which helps in food distribution). The FAO (2008a) concluded that:

> *Climate variability will result in more frequent and intensive disasters – with the most severe consequences on the food security and livelihoods of agriculture-dependent populations in vulnerable countries … Changing climate patterns thus increase the urgency to invest in disaster risk-reduction activities, preparedness and management above and beyond other efforts directed toward climate mitigation and adaptation …*

The FAO (2008a) concluded that climate change will have profound implications for food security across the globe. Climate change is happening together with rapid changes in the global economy, communications technology, and adoption and social support structures, which are generating both threats and opportunities for climate risk-reduction and response. The FAO (2008a) identifies food availability, weather extremes, disease (malaria and cholera) and access as the key food security issues for the twenty-first century.

The anticipated impacts of climate change on transport infrastructure in regions of Virginia in the United States have been examined with a view to prioritising elements of long-term strategic plans as part of a broader program of the US Federal Highway Administration's efforts to improve understanding of the vulnerability of critical transport infrastructure (Center for Risk management of Engineering Systems 2012). A scenario-informed multi-criteria priority-setting analysis framework has been developed to aid understanding of vulnerability, priority-setting and decision-making. Infrastructure Australia (2012) has developed guidelines for scenario modelling of drivers of priority changes, including dealing with the impact of change on the demand for infrastructure and the maintenance of existing infrastructure networks. Climate change is identified by Infrastructure Australia (2012) as one of the nine key challenges to the delivery of national strategic and economic benefits from infrastructure reform and investment initiatives.

Davies et al. (2009) examined links between climate change adaptation, disaster risk-reduction and social protection, observing that the people most often exposed to severe climate events are those with the most limited capacity to adapt, especially people in developing countries. This prompted development of a concept labelled 'adaptive social protection' with a view to integrating climate change impacts into social protection policies and programs. The report by Davies et al. (2009) is applied mainly to developing countries. Nevertheless, it seems important to recognise that poor

communities are not confined to developing countries or excluded from Australia, now or in the future. For this reason, any interventions to build the resilience of all Australians to adapt to climate change would probably need to consider use of the social support infrastructure in reducing vulnerability. Nevertheless, as Abhas et al. argues, there are still potential and significant benefits in even the most vulnerable individuals and households developing their own action plans for dealing with disasters and participating in the development of business and government continuity plans to enhance resilience in a more comprehensive way.

The IPCC (2012) concluded (with 'high agreement and robust evidence'), among other items, that:

> *[N]ational systems (including for infrastructure) are at the core of a country's capacity to meet the challenges of observed and projected trends in exposure, vulnerability and weather and climate extremes. Effective national systems comprise multiple actors from national and sub-national governments, the private sector, research bodies and civil society … playing differential but complementary roles to manage risk …*

NCCARF (2012) has supported a range of diverse studies into the role of local government in facilitating adaptation to climate change. These include an examination of the Risk Assessment Model used in the United States to improve resilience of the transport system:

> *The goal of the Risk Assessment Model is to help transportation decision-makers (particularly transportation planners, asset managers, and system operators) identify which assets (a) are most exposed to the threats from climate change and/or (b) could result in the most serious consequences as a result of those threats. Assets in this context refers primarily to infrastructure assets (such as bridges and roads), but could include other assets that benefit the transportation system such as a coastal wetland buffer.*

The NCCARF database also contains a report on critical infrastructure in Ireland, which highlights the links between water supply, food security, flood management and energy supply.

4.1.5 Food retailing and food security

Despite its vitally important role in delivering food to consumers, few studies have examined the impact of climate change on the retail sector or the implications for risk management practices employed by this important sub-sector, either in Australia or overseas. It is retailers who are essentially the supply chain leaders in delivering food and food security to consumers, especially in developed economies like Australia. It is also the most highly concentrated sector of the food-supply chain. Retailers themselves tend to have formal and advanced risk management policies. Woolworths (2009), for example, has a 'Risk management Framework', which among other things requires that risk management in all operations 'must create and protect value'. The Risk management Framework conforms to ISO 31000:2009. Wesfarmers Limited (both retailer through Coles and input supplier for agricultural production) has a detailed Risk management Policy Statement (2008), which is reviewed annually or as required. The 2008 Statement of Wesfarmers is heavily weighted towards financial risk, and it is unclear whether food security and climate change are regarded as 'material business

risks' or not. Metcash (refer also to case study below) has a detailed and formal risk management policy statement that is in line with ISO 31000 and indicates that its 'aim is not to eliminate risk, but rather to manage the risks involved in all Metcash activities in order to maximise opportunities and minimise negative consequences'.

PriceWaterhouseCoopers (2009a) observed a narrow silo mentality in management of risk in many corporations, leaving them less prepared to identify and deal with bigger and diverse risks in a volatile business environment. Retailers tend to have detailed risk management policies for dealing with specific areas (silos), such as food safety, quality control, finance, human resource errors and construction operations, including contracts for supply. Coles Group (2012), for example, has detailed requirements for suppliers to show how contract works will be completed without risk to health and safety. The public evidence on food retailing, however, points to concerns with siloed approaches (that is, cells of risk management that are not fully integrated into an overall risk management framework) to risk management, and that they may not be exploiting all the opportunities for creating value out of best practice risk management. This raises the question of the role of ISO 31000:2009 from a macro perspective of food security. This standard places proper emphasis on integrating the process for managing risk into the overall governance, strategy and planning processes with a view to facilitating achievement of objectives and protecting the value of the organisation. There is less said about external costs and benefits of protecting value through, for example, shifting of the burden of risk – especially when an industry has a high concentration of ownership.

Bartos and Balmford (2010) reviewed policy work on food chain resilience undertaken by the Department of Agriculture, Fisheries and Forestry (DAFF). This study covered food retailing, distribution and manufacturing. The main finding was that that while the Australian food-supply chain has demonstrated a high degree of resilience,[11] there are factors on both the demand and supply side of the chain that are decreasing future resilience. The main area of vulnerability, as described above, was identified as large-scale events, or combinations of events that affect multiple activities of the food-supply chain at the same time. Industry interviews undertaken in this study indicated limited willingness of commercial operators to contribute to community-welfare objectives in the event of a crisis. This limited willingness may, as discussed, be entirely consistent with ISO 31000:2009, though that ultimately will depend on the coverage of corporate governance policies, and whether or not they extend to externalities and/or brand image is at stake. Mixed and ambivalent messages were received by Bartos and Balmford (2010) about the roles and responsibilities of commercial enterprises and government in emergency situations. While commercial firms were keen to ensure continuity of supply for their enterprises, they also had a view that governments had an important role to play in ensuring continuity of supply beyond what might be considered normal commercial service boundaries. A number of challenges for food-supply chain resilience were identified, including scale factors (adaptation breaking down beyond a certain population or geographic scale); scope (some types of foods being more vulnerable than others); temporal (resilience may break down beyond some duration level); distributional (some population segments may be more vulnerable than others); and industry influences. Among the areas for further investigation was a recommendation to address governance issues involved in food supply-chain resilience planning.

[11] Resilience is defined in this study as the '…capacity of organisations or systems to return to full functionality in the face of disruption…'

Best practice food distribution systems were examined by Estrade-Flores (2010) to provide an overview of barriers and opportunities to the application of novel food strategies for reducing greenhouse gas emissions in Australia and Victoria. This study is mostly oriented towards strategies and actions for reducing emissions and climate change impact, rather than adaptation to climate change impacts. Several background observations are made, however, that are relevant to adaptation, including:

- The Australian food-supply chain is more reliant on local supply than some other countries. For example, about 50% of vegetables and 95% of all fruit consumed in the United Kingdom are imported, compared with around 20% of all fruit and vegetables consumed in Australia. For fresh produce, the UK retailers indicated that at least 95% is imported.
- Australian production (98% of mass) of vegetables is dominated by outdoor paddocks without glasshouse protection, while in the United Kingdom the high-yielding protected areas account for 10% of total production. Estrade-Flores recommends further investigation of the carbon footprints of climate-protected covered production versus outdoor production from a carbon footprint perspective. At the same time, the location of climate-protected areas near population centres may reduce vulnerability to climate change impacts, especially transport disruption. This may be true, but it may also involve higher production costs and higher food prices.

Estrade-Flores (2010) identifies a number of food retail initiatives for reducing GHG emissions, including 'lean' and 'just-in-time' distribution. The question of whether or not these inventory-saving initiatives are simultaneously increasing exposure to climate change impacts was not addressed. In addition, the issue of transferring the risk from retail to other parties in the food-supply chain was not addressed. Cost reduction was seen as the main motivator for retailers adapting changes.

Creese and Marks (2009) observe that climate change is seen by food retailers as both a risk management problem and an opportunity. Woolworths is reported to need a significant increase in investment in its own infrastructure if it is to deal with the impacts of climate change.

In a submission to the 2008 Senate Select Inquiry into food production in Australia, Food Legal (2008) observed that Australian supermarkets supply up to 80% of Australian food sold at the retail level, but hold little or no reserves or food storage facilities.[12] Their logistics systems are built on short-term stock-minimising strategies, an observation made in several other studies. These systems are based on minimal buffer stocks and an absence of long-term stockpiles. Food Legal (2008) concluded that 'the consequence of low inventory levels would turn into a major problem of widespread food shortages within a very short timeframe (probably less than a week) in the event of any major crisis or catastrophe such as a human influenza pandemic'.
The concept of stockpiling has been examined elsewhere as an intervention to support oil security. Davies and Mortimer (2012) examined Australia's energy security, which was defined as 'adequate, reliable and affordable' supply. The United States has a government-controlled Strategic Petroleum Reserve stockpile. Davies and Mortimer (2012) conclude that a 'simple stockpile isn't, in itself, a hedge against disruption, although it can be helpful in smoothing out short-term disruptions as part of a collective

[12] In this study's discussions with retailers, it was indicated that Australian food manufacturers, wholesalers and retailers hold, in aggregate, inventory for about 30 days of consumption in Australia and 90% of households hold inventory for two to five days of consumption.

strategy. An end-to-end industrial capability and capacity and ready access to world markets are (more) important components of resilience.' They suggest a 'more cost-effective approach might be for the Australian Government to buy "ticketed stock" (options to purchase oil) on the world market and exercise them should circumstances demand it'. While food has many different characteristics from energy (for example, shelf life), Davies and Mortimer (2012) note that modern food production is energy intensive, and that the 'green revolution' that has enabled improved food security at a global level has been enabled by fossil fuels – directly in the form of mechanisation, and indirectly through the production, transport and application of fertilisers.

Amartya Sen (2006), the Nobel Prize-winning economist, argues the accumulation of food stocks in India to support low prices for grain has failed to contribute to either low food prices or a reduction in poverty. Stockpile transaction costs are seen to be a major cause of the problem. The prevalence of underweight children in India (estimated to be 60 million) is amongst the highest in the world, and nearly doubles that of Sub-Saharan Africa (World Bank 2006). The World Bank says that

> *the commonly-held assumption is that food insecurity is the primary or even sole cause of malnutrition. Consequently, the existing response to malnutrition in India has been skewed towards food-based interventions and has placed little emphasis on schemes addressing the other determinants of malnutrition (including exposure to infection, young child feeding and caring practices).*

4.1.6 Health and food security

Human health impacts from climate change have been examined broadly within the communicable (infectious – including water – vector and food-borne diseases) and non-communicable (chronic, including mainly cardiovascular disease, cancer, chronic lung diseases and diabetes) disease categories. McMichael et al. (2002) conducted a risk assessment of climate change and human health for Oceania, noting health risk impacts from water- and food-borne diseases, and food and water shortages. Most research into the climate change health impacts seems to be on infectious disease possibilities. However, Friel (2010) argues that there are links – direct and indirect – between climate change mitigation and adaptation policies, and chronic diseases such as cardiovascular diseases and some cancers.

Climate change poses threats to human health, safety and survival via weather extremes and climatic impacts on food yields, fresh water, infectious diseases, conflict and displacement (McMichael 2011). These risks to health are not fully recognised. McMichael (2011) elaborates with the following statement about historical evidence on human health and food:

> *(i) Long-term climate changes have often destabilized civilizations, typically via food shortages, consequent hunger, disease, and unrest.*
> *(ii) Medium-term climatic adversity has frequently caused similar health, social, and sometimes political consequences.*
> *(iii) Infectious disease epidemics have often occurred in association with briefer episodes of temperature shifts, food shortages, impoverishment, and social disruption.*
> *(iv) Societies have often learnt to cope (despite hardship for some groups) with recurring shorter-term regional climatic cycles (e.g., El Niño – except when extreme phases occur).*

(v) The drought–famine–starvation nexus has been the main, recurring, serious threat to health.

Warming this century is not only likely to greatly exceed the Holocene's natural multi-decadal temperature fluctuations, but to occur faster. Along with greater climatic variability, models project an increased geographic range and severity of droughts. Modern societies, although larger, better resourced, and more interconnected than past societies, are less flexible, more infrastructure dependent and densely populated – and hence are vulnerable.

McMichael says there are many ways in which human health impacts of climate change could affect food production, distribution, quality and microbiological safety, but most are theoretical and more research is needed on the subject.[13] In Africa, it is virtually certain that the spread of malaria due to climate change will affect manual farm labouring and food yields. Climate-related microbiological contamination is very likely, especially in poorer countries. Flooding and diarrhoeal disease readily extend into contaminated farm products. Dengue fever and malaria are expected to spread south in Australia with the anticipated shift upwards in average temperatures (Beebe et al. 2009).

Food quality under climate change is also at risk. Food may be contaminated more easily, and people may be forced to eat this lower quality food if shortages emerge (Hall 2012). About one-third of gastroenteritis infections are estimated to be food borne in Australia, and more in less-developed countries. Hall et al. (2011) estimate a 2.48% increase in the probability of gastroenteritis for each 1ºC increase in temperature, concluding gastroenteritis to be more common in the hotter northern part of Australia.

The World Health Organization (WHO) (2009) examined the impact of climate change for diseases and maintenance of basic health. It found the major diseases to be most sensitive to climate change are diarrhoea, influenza, vector-borne diseases like malaria and infections associated with under-nutrition, with children living in poverty being the most vulnerable. Many of the main infectious diseases are observed to be transmitted by water and contaminated food and insects – all of which are sensitive to weather extremes and changes in averages such as temperature. Urban populations in large cities located in the tropic are exposed most to heatwaves, floods and infectious diseases. The WHO also notes, however, that climate change impacts will not all be harmful. A warmer climate is expected to reduce mortality and boost food production in northern high-latitude countries. The WHO (2009) concludes that 'ongoing climate change, coupled with globalization, will make it more difficult to contain infectious diseases within their current ranges'. The WHO also urges greater appreciation of the human health dimension to climate change, with a view to developing effective policy that goes beyond development and environmental perspectives. Strengthening of public health was seen to be a central component of adaptation to climate change.
Patz et al. (2003) note that centuries of data show that climatic conditions affect epidemic infections. Changes in mean climatic conditions and climatic variability are also shown to affect human health through indirect pathways, particularly changes in biological and ecological processes that influence infectious disease transmission and food yields. Climate is one of several important factors influencing the incidence of infectious diseases. Socio-demographic influences (human migration and travel), drug

[13] Personal communication, 13 March 2012.

resistance and nutrition, agricultural development,[14] water projects and urbanisation are seen by Patz et al. as other important influences on infectious diseases. Patz et al. conclude that:

> *In this era of global development and land-use changes, it is highly unlikely that climatic changes exert an isolated effect on disease; rather the effect is likely dependent on the extent to which humans cope with or counter the trends of other disease modifying influences … Seasonal fluctuations of infectious disease occurrence imply an association with climatic factors. However, to prove a causal link to climate, non-climatic factors must [also] be considered …*

Many studies demonstrate seasonal fluctuations in infectious diseases, but there are few that document long-term trends in climate–disease associations. In order to draw a causal relationship between climate change and patterns of infectious disease, research needs to show consistent trends across diverse populations and geographic regions.

Lake et al. (2009) examined the effects of temperature on reported cases of a number of food-borne illnesses in England and Wales, and also investigated whether the impact of temperature changed over time. Food poisoning, campylobacteriosis, salmonellosis, Salmonella Typhimurium infections and Salmonella Enteritidis infections were positively associated with temperature in the current and previous week. Only food poisoning, salmonellosis and S. Typhimurium infections had been associated with temperature two to five weeks previously. They concluded that adaptations to temperature imply that estimates of how climate change may alter food-borne illness burden are overly pessimistic.

Harley et al. (2011) reviewed the current situation and potential climate change impacts for respiratory, diarrhoeal and vector-borne diseases in Australia, concluding that climate change will have significant and diverse impacts on human health – especially the incidence of infectious diseases. This study also concludes that 'other factors will be at least as important, often more so, than climate change in determining population risk, for example, water storage practices in the case of dengue fever'. Harley et al. caution that 'there is uncertainty associated with climate modelling and greater uncertainty, therefore, in predictions of infectious disease incidence with climate change'. To deal with the risks, they suggest 'all parts of the health system, including surveillance, environmental health, and medical services, will need sufficient flexibility to assess and respond to these changes (that is, changes in the incidence of infectious diseases)'.

Kalkstein and Valimont (1987) examined literature on the variable impact of climate on human health. They found weather had a profound effect on human health, especially mortality and morbidity levels. Large increases in mortality have been observed during heat and cold periods, but hot weather extremes appear to have a more substantial impact on mortality than cold wave episodes. Measures to facilitate acclimatisation to

[14] Patz et al. (2003) states that agricultural development can lead to an increase in diarrhoeal disease. In intensely stocked farmland, heavy rains can cause contamination of water resources by *Cryptosporidium parvum*oocysts. Infiltration of high-quality water treatment and supply systems can occur: a 1993 occurrence in Milwaukee, USA, resulted in 400,000 cases of cryptosporidiosis. Intensive cattle farming and livestock operations in combination with factors related to watershed management have been implicated in such outbreaks. A similar mechanism is involved in giardiasis, where a variety of animals may serve as reservoirs of Giardia lamblia and contaminate surface water with their excreta. Predicted flooding accompanying climate change could increase the water contamination trends associated with agricultural development.

extremes have the potential to neutralise the effect of extremes on mortality, but the main constraint to achieving that may be infrastructure capacity (for example, electricity to run extra demand for air-conditioning and cooling fans). Kalkstein and Valimont (1987) also indicated that indirect effects (e.g. morbidity impact on productivity) of climate change may be significant and need more investigation.

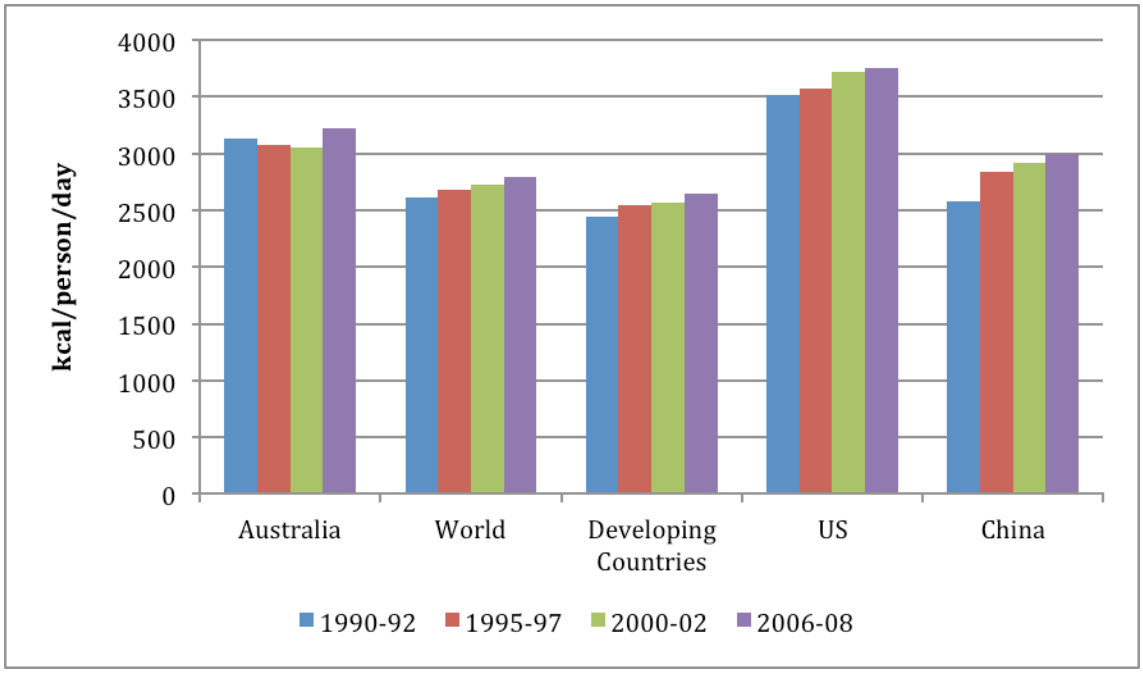
The World Economic Forum (2012b) rated vulnerability to pandemics as an important societal risk, though not as being of as much concern as other societal risks such as unsustainable population growth rates and water supply crisis. A US study found that food insecurity and insufficiency were associated with adverse health and development outcomes, including poor school performance and depression (Jyoti et al. 2005).

The Department of Innovation, Industry, Science and Research (2011) has developed a Business Continuity Guide to help Australian businesses examine the potential impact of a human influenza pandemic on their operations to prepare plans for an event of this nature. The Department of Prime Minister and Cabinet (2009) has prepared a National Action Plan for Human Influenza Pandemic, which includes a component on 'Being Prepared for a Human Influenza Pandemic – A Business Continuity Guide for Australian Businesses'. The National Action Plan has been developed jointly by the Commonwealth, state and territory governments and the Australian Local Government Association (ALGA), against a background of evidence from the WHO that the world is moving closer to an influenza pandemic. It is not expected that a virus would originate and develop into a pandemic form in Australia because of the high standards of human and animal health and farming practices. The more likely scenario is that it will emerge overseas and arrive via border movements. A number of measures are being introduced to prepare for this type of emergency, including a heightened quarantine response.

Australia's food and grocery industry has developed a resource called the Pantry List (http://www.afgc.org.au/pantrylist.html) to help households and families prepare for emergencies. The idea is that people can help themselves manage their way through a potential crisis by ensuring the household has an adequate supply of food, water and essential items to cope with a prolonged emergency situation caused by fires, storms, utility failure, pandemic or earthquake.

It's also relevant to note in the context of food security that Australia does have a growing obesity problem. In 2007–08, it was estimated that 61% of Australian adults aged 18 years and over were either overweight or obese (Australian Bureau of Statistics 2011b). Fewer adults were normal weight or overweight in 2007–08 than in 1995, but the greatest increase was in the obese category, with the proportion of obese adults rising from 19 to 24%. This has arisen from the continued growth in already high per capita food consumption at the same time as physical work has been reduced (Figure 9).

Animal health is considered to be impacted by climate change in four ways: heat-related diseases and stress; extreme weather events; adaptation of animal production systems to new environments; and emergence or re-emergence of infectious diseases, especially vector-borne diseases dependent on environmental and climatic conditions (Foreman et al. 2008). The presence of effective and responsive veterinary services is seen to be essential, along with coordination with public health services, as many emerging human diseases exhibit zoonotic characteristics.



Source: Derived from FAO Statistics Division 2012.

Figure 9: Dietary energy consumption (kcal/person/day), Australia and selected countries and groups

The Commission of European Communities (2009) examined the human, animal and plant health impacts of climate change, resulting in a White Paper on 'Adapting to climate change: Towards a European framework for action'. Among the observations of this 'White Paper' is the view that climate change has already had an impact on animal disease occurrence, as evidenced by changes in non-statutory diseases (e.g. parasitic diseases, nutritional disorders, sunstroke and dehydration) and statutory diseases (vector-borne (e.g. Bluetongue) and non-vector-borne (e.g. avian influenza). The role of wildlife in transmission of animal diseases such as avian influenza, swine fever and tuberculosis was highlighted. This White Paper proposes increased resilience of the health and social systems, to be achieved through improved surveillance and control of health impacts, including epidemiological surveillance and improved control of communicable diseases. The White Paper observes that

> *climate change is not creating many new or unknown health threats, but it will increase certain interactions between environment and human health with stronger and more pronounced effects than currently seen. Most public health measures and systems are already in place but they need to be tuned to the new situation and demands.*

Black et al.(2009) note that Australia has a first-class animal health protection system and support service (including legislative backing), but

> *enhancements still need to be made to Australia's animal health system, for example: re-defining the science-policy interface; refining foresight, risk analysis, surveillance, diagnostics, and emergency management; improving approaches to education, training, technology transfer, communications and awareness; and engaging more with the international community in areas such as capacity building, the development of veterinary services, and disease response systems.*

4.1.7 Other support services for food security

In the 35-year period ended 2005, it is estimated that 80% of insured losses across the globe were due to weather or weather-related events, and that 50% of them occurred during 2004–05 (Gero 2006). Weather-related events continue to be the main insurance item, and nineteen out of the 20 most costly insured events in Australia are weather related (Gero 2006). Climate change is affecting the insurance industry in the form of more severe and more frequent storms, floods and tropical cyclones, fires and droughts. Small changes in climate are seen to have a sharp impact on hazards (Table 1).

Table 1: Change in climate and hazard impact

Hazard	Change in climate variable	Resulting change in hazard
Cyclone	2.2ºC mean temperature increase	Increase of 5–10% in cyclone wind speed
Bushfire	1ºC mean summer temperature increase	17–28% increase in bushfires
Drought	1.3ºC maximum temperature increase	25% increase in evaporation leading to increased bushfire risk
Flood	25% increase in 30 minute precipitation	one-in-100-year flood becomes one-in-seventeen-year flood frequency
Wind gusts	25% increase in peak gusts	650% increase in building damage

Source: Gero (2006).

Insurance premiums are expected to rise in the absence of disaster-mitigation strategies such as improved planning and building controls, river and catchment management, and improved assessment of current and future flood risks (Searle 2011).

Insurance has an increasingly important role in nearly all climate change scenarios. New products are being developed to cope with the change. The Munich Climate Insurance Initiative (Munich Re 2008) developed a new product proposal comprising a combination of risk pooling and risk sharing, based on two pillars: A Prevention Pillar and an Insurance Pillar with two tiers: A Climate Insurance Pool (Tier 1), which would absorb a pre-defined proportion of high-level risk of disaster losses in vulnerable countries; and a Climate Insurance Assistance Facility (Tier 2), to provide technical assistance and other forms of assistance to enable public–private insurance systems that provide cover for the middle layers of risk in vulnerable countries. The MCII is pitched at developing countries.

A number of insurance companies have expressed views about the role of insurance in pricing climate-related risks. Zurich Financial Services Group (2009) describes what it calls ‘the exceptional complexity of the climate risk challenge’. Insurance is seen as

having the ability to encourage risk reduction by establishing risk-based pricing signals in the form of premium charges.

The problem becomes complex, however, because insurance works best in protecting private assets, while climate change risk extends to both private assets and public goods. This is potentially market failure through the presence of 'externalities' (refer to discussion below). Insurers are seen as having an important role to play in adaptation to climate change by, for example, supporting the introduction of building codes and new technologies that improve resilience. Insurance-linked securities are seen as an important asset class for facilitating pooling of catastrophic risk and distributing it through the wider capital markets. White and Cahill (2011) conclude, however, that there is no silver-bullet insurance solution to climate change. Climate change hazards are escalating and increasing losses, but many insurers are slow to respond, or not responding, to the scale of risk or potential opportunities. While there is evidence that the insurance industry has invested heavily in models predicting possible extreme weather-related events, significant uncertainty remains about predictions and difficulty in developing and implementing products that are easily understood and implemented.

Index-based insurance for dealing with weather events has grown with support from international development agencies, though it is also growing in the United States (Miranda 2011). Index insurance is being used for area-yields, rainfall, satellite-measured vegetation indices, regional livestock mortality and other areas (including El Niño events). The advantage of index insurance is simplicity, being objectively and reliably measured, and having a high correlation with losses of the insured and lack of influence from either the insured or the insurer. However, high basis risk (the gap between the actual damage and the index) can reduce the value of the index tool to producers.

4.2 Data collection and results

4.2.1 General risk management features

Detailed data were collected through a combination of face-to-face and telephone interviews and online surveys from 52 organisations operating in the Australian food industry as either in-line product and service providers or specialised support services, including regulatory agencies. Of the 52 respondents, there were 36 fully completed responses (69.2%) and the remainder partially completed for reasons of confidentiality. Three foreign-owned companies provided information and the balance were Australian companies, partnerships and public organisations. With regard to the use of formal risk management systems, 56% of the 52 respondents have formal systems for managing risk and 44% have informal risk management practices (Figure 10). Smaller organisations tend to have more use of informal risk management systems than larger organisations, especially the very large organisations with turnover above $750 million per year.

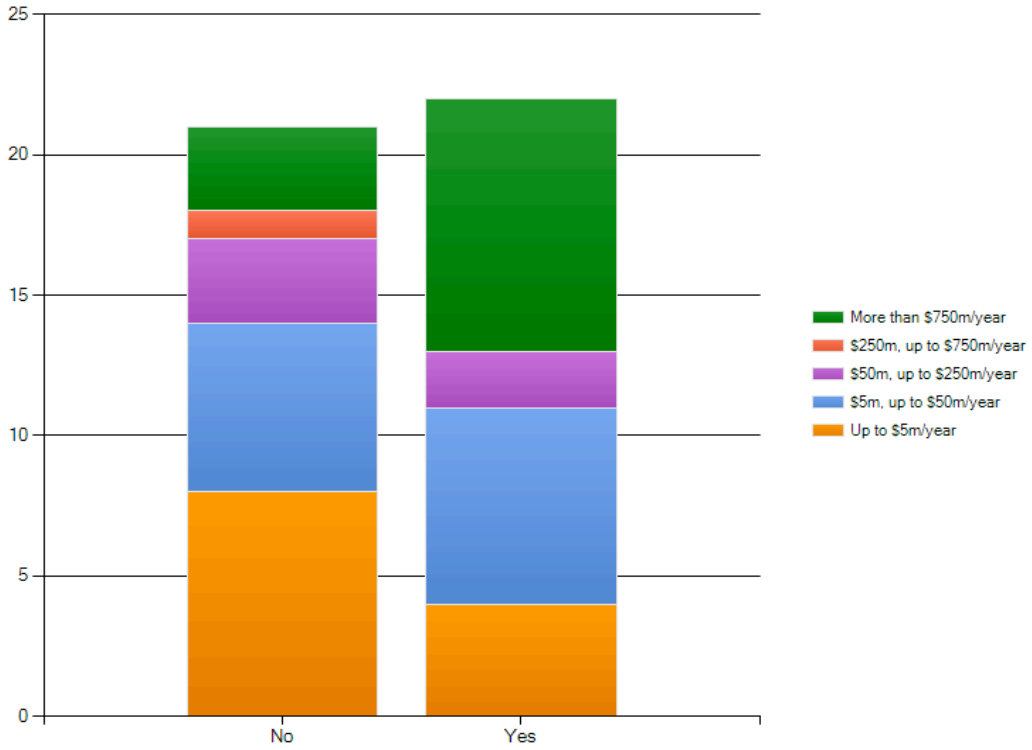


Figure 10: Case study respondent numbers with informal (no) and formal (yes) risk management systems.

Over 85% of organisations with formal risk management systems indicated that they believed their systems were excellent or very good in terms of helping them achieve their objectives and adding value, although one organisation indicated that its risk management framework was in urgent need of improvement to help it achieve objectives and add value.

There are, however, significant differences in the scope and depth of all risk management systems. For example, climate change impacts were identified as a source of risk by 62.5% of all organisations, with 37.5% not identifying climate change as a risk. Organisations with informal management systems had a slightly higher tendency (68%) to include climate change as a risk – a reflection of a relatively large proportion of agricultural producers in this group. While 57% of organisations with formal risk management systems identified climate change as a risk, fewer than 60% of this group actually included it in their risk management programs with mitigation activities for control (Figure 11). A number of organisations with formal systems (over 30%) indicated that climate change could be included as a risk, possibly within the next three years, and one training organisation indicated that climate change was embodied in other components of its risk management framework.

Internal training was the only risk mitigating activity included in all of the formal risk management programs, although 95% also had internal codes of conduct and 85% had auditing of compliance activities. Several respondents indicated that they used outside external advisers to undertake regular reviews of the components in their risk management framework. Sustainability and waste reduction was mentioned as another component. One organisation indicated that it managed risk through two frameworks, one based on an ERM system and the other through a specialised section for food safety.

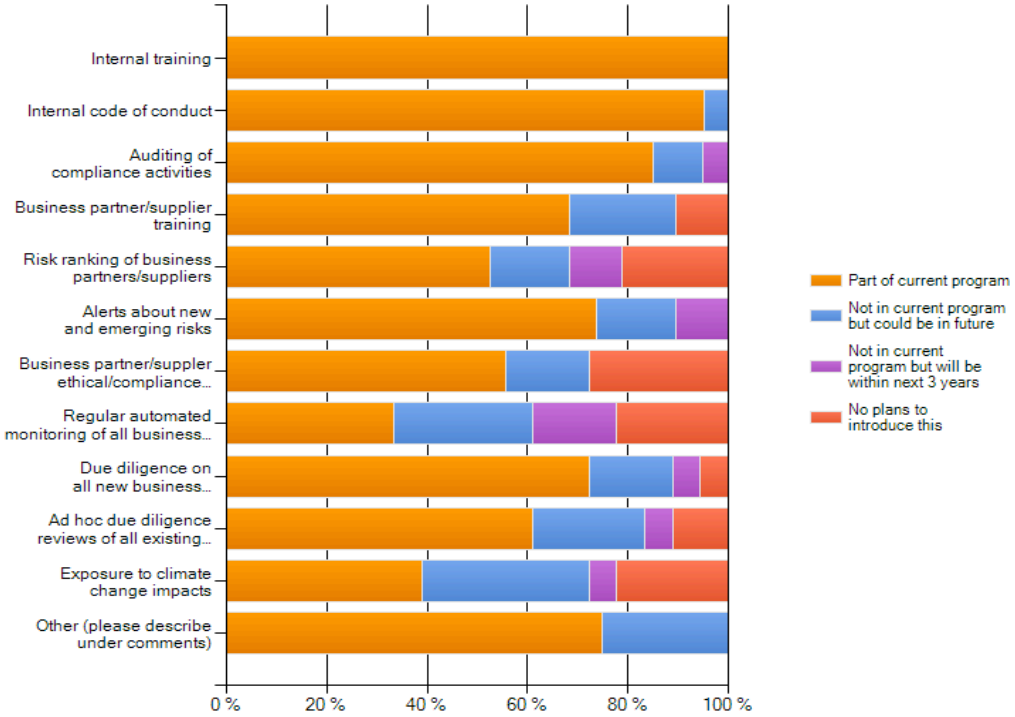


Figure 11: Risk mitigation activity by organisations with formal risk management

Inclusion of business partners in risk management systems shows significant variation in responses, especially with regular automated monitoring of business partners and suppliers.

Due diligence was always undertaken into the risks of acquisition targets by 45% of organisations with formal risk management systems, and almost 90% of organisations conducted due diligence internally.

Over 85% of organisations indicated that their management was highly committed or quite committed to effective risk management, but risk management topics were only raised continuously (e.g. at monthly meetings or more frequently) by 43% of respondents (Figure 12).

Over 85% of respondents indicated their risk management systems were secure but accessible for decision-makers, and over 25% indicated that they had a risk-alert system in place and it applied to all identified risk areas. A further 35% indicated that they had an alert system in place but it only applied to certain activities and 15% indicated that they had no alert system. Most respondents indicated that at least 50% of employees had risk considered as a stated condition of their job functions.

Over 50% of organisations with formal risk management systems indicated that their risk management systems complied fully or mostly with the principles and guidelines of ISO 31000, but many were unable to judge their degree of compliance (Figure 13). Internal processes for managing and monitoring risk management appear to be taking on increased importance.

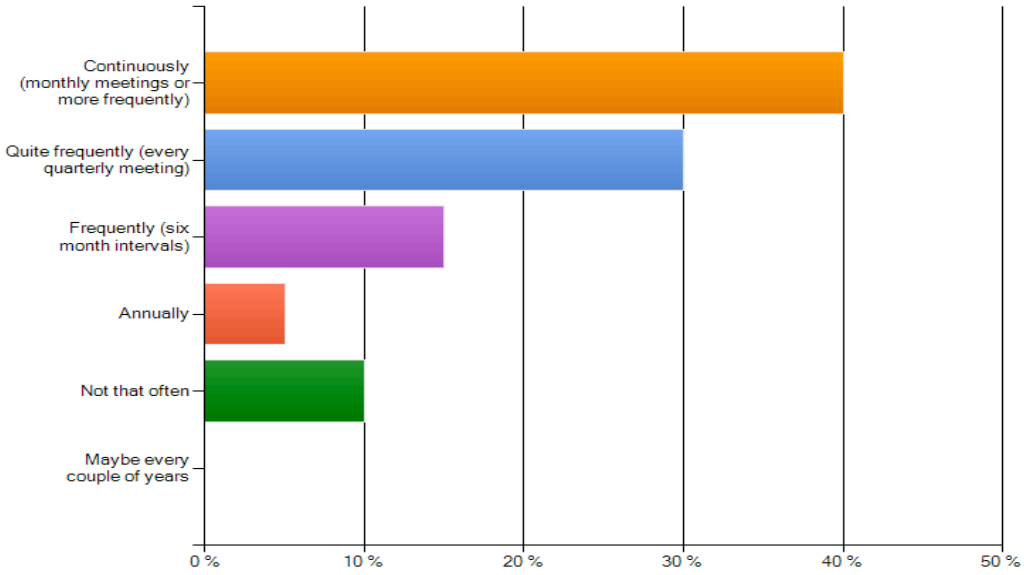


Figure 12: Frequency with which risk management topics are raised at meetings in formal systems

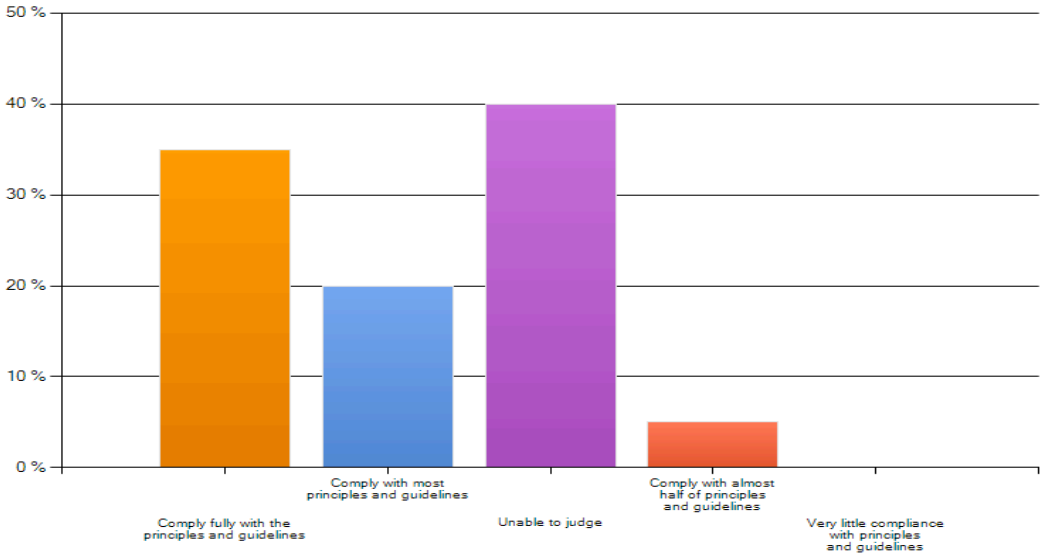


Figure 13: Compliance with ISO Standard 31000: Risk management Principles and Guidelines

4.2.2 Value created from risk management

Almost 80% of all responding case studies indicated that they were creating value out of uncertainty because they had a good understanding of risk and its potential for good and bad results. A larger proportion (90%) of organisations with formal risk management systems believed they were creating value out of uncertainty because of their understanding of risk, compared with 64% for organisations with informal systems.

Over 70% of respondents indicated that they were creating value from their risk management in the form of lower costs, better marketing and more precise timing of activities. These same respondents said they were continually reviewing risks to which they were exposed so that at any time all significant risks were considered whenever they made a decision.

For extreme events, a number of respondents (32.5%) were ranking risk on the basis of expected value – that is, the product of likelihood and damage or value at risk. A further 15% treated risk on the basis of expected value but usually added some cross-checks to improve confidence. Several firms were using an entirely different process for dealing with rare events having a high impact.

The risk rated most likely to become reality over the next decade was regulatory and political risk, which 43% rated as 'almost certain', a further 13% rated 'likely' and a further 32% as 'possible'. Production risk caused by climate change and currency risk were also rated as 'almost certain' by 27% of respondents (Figure 14). These risks were rated after adjustment for mitigation activity.

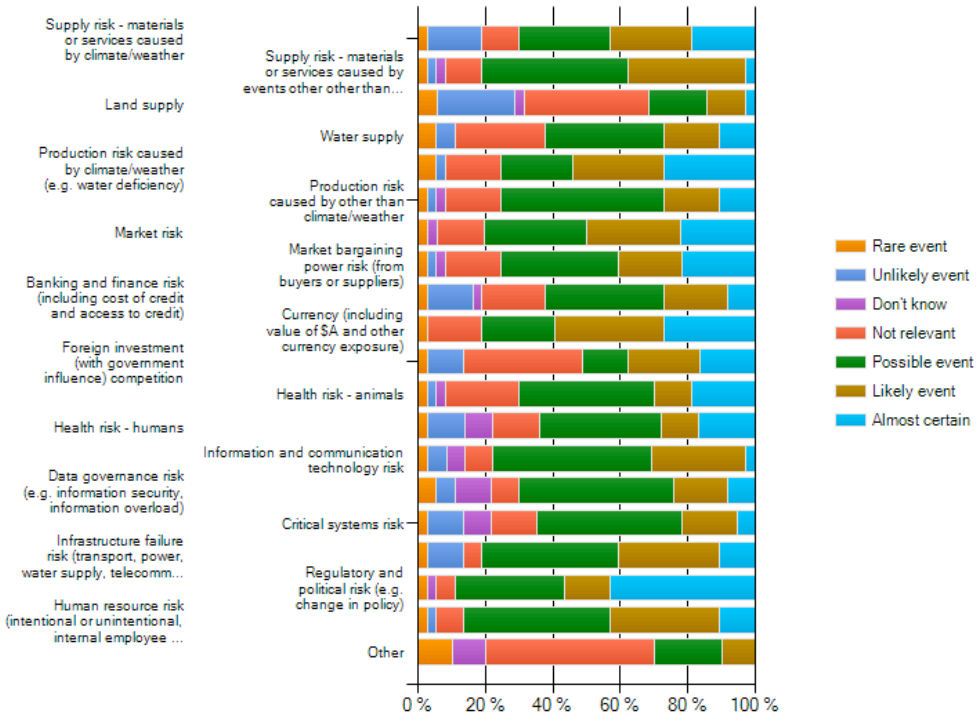


Figure 14: Likelihood of risks becoming reality over the next 10 years: all respondents

With regard to consequences, production risk caused by climate change was rated by over 16% of responses as having a potentially catastrophic impact over the next 10 years, with a further 43% indicating a major impact. Water supply and market risk were rated the next highest risks in terms of consequences, with more than 50% of respondents indicating that they would have catastrophic or major consequences (Figure 15). Human health risk also emerged as the risk with the third largest catastrophic consequences. These responses were based on residual risks, after controls had been implemented to manage risk to an acceptable level. More than 65% of the risks listed were rated as having the potential for a major impact over the next decade.

Several respondents qualified their response in terms of ambiguity in their interpretation of some questions, including the likelihood of disease incursion being difficult to estimate because of the influence of numerous external and internal influences and interrelationships. In addition, water supply was seen to require making a distinction between rainfall and stored water. The absence of a clear definition of 'critical systems risk' was also rated as a source of ambiguity. The bundling of climate and weather risk was also commented on as inappropriate, and should have been unbundled to capture the distinctively different impacts of the two sources.

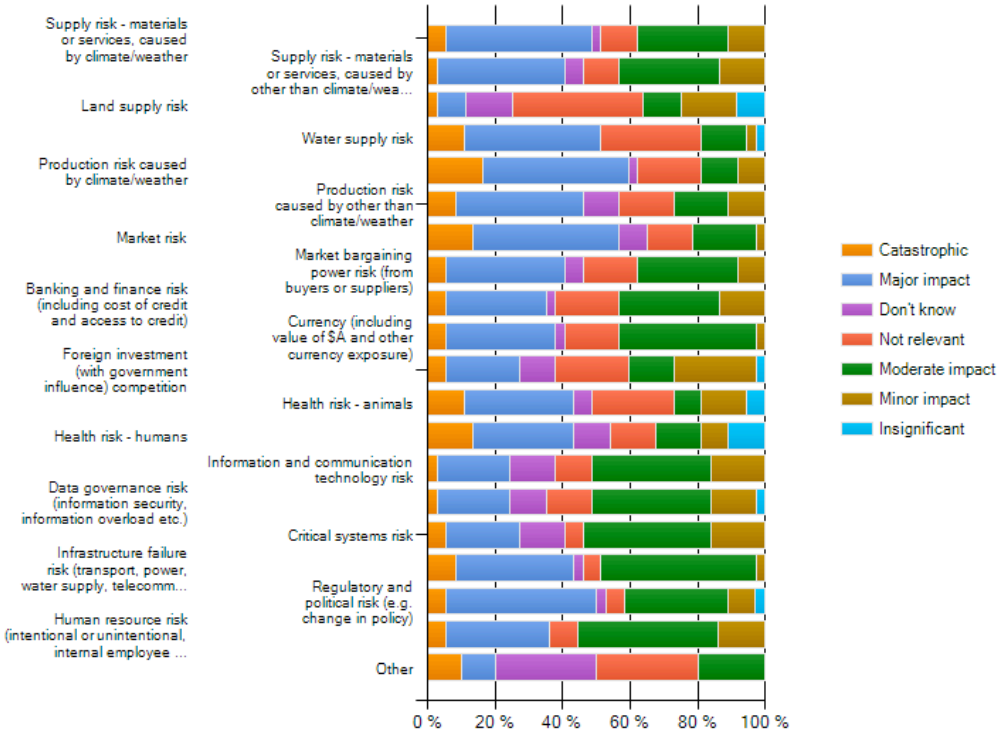


Figure 15: Consequences of risks: ratings by all respondents

Respondents were using a range of information sources to identify and rank risks emerging from climate change impacts, but over 80% indicated they were using public information provided by agencies such as the Bureau of Meteorology, Climate Kelpie, IPCC, FAO, NOAA, WMO and World-weather. Nearly 50% of respondents indicated that they were using regional risk data that they had compiled internally. Some of these organisations had internal climate specialists, highlighting the importance now placed on climate and weather information. Some respondents indicated that they were integrated their weather and climate information into other services, including economic, crop and grain-production information services. Some (less than 20%) due diligence was undertaken into the providers of prediction and forecasting services.

Over 50% of respondents indicated that the carbon tax and carbon farming initiative would have either a zero or minor impact on them, but several respondents indicated strongly that these interventions would 'significantly impact' their stakeholders, either directly or indirectly.

4.2.3 Processes employed in managing risk

Nearly 70% of respondents indicated that their obligations to supply international customers were just as important as supplying Australian consumers. Only one respondent strongly disagreed with the statement that 'international customers are just as important as obligations to supply Australian consumers'.

Most respondents were unsure about the impact of house brands on resilience to climate change, and nearly 50% disagreed with the concept that vertical integration would improve capacity to cope with climate change impacts; however, several organisations indicated strong agreement that vertical integration would help capacity to cope with climate change.

Nearly 80% of respondents indicated that communication of risk management processes was a high and ongoing priority in creating an effective, open and transparent risk management culture in their workplace.

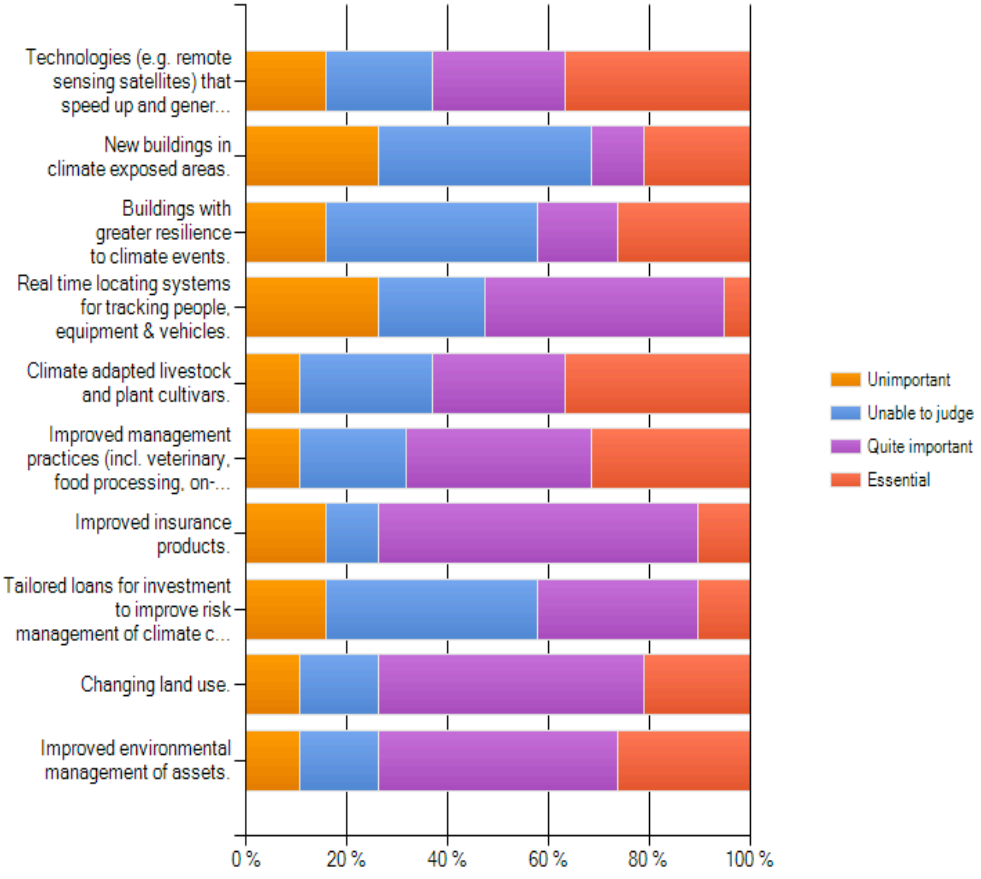


Figure 16: Ratings of new technologies and managing practices for coping with climate change

4.2.4 New technologies, practices and investment for managing climate change risk

Over 70% of respondents agreed, strongly or moderately, that new technologies and innovative management practices could provide effective solutions for the management of most risks from climate change impacts (Figure 16). Climate-adapted livestock and

plants were rated as essential by 43% of respondents and over 35% rated improved management practices (including veterinary, food processing and on-farm) and biotechnology as essential measures for adapting to climate change. Improved insurance products, changing land use and precision agriculture were rated as quite important by 65% of respondents.

4.2.5 Constraints to effective management of risks of climate change impacts

Over 80% of respondents indicated that a lack of good quality and reliable information about climate change was a moderate, severe or binding constraint to their capacity to implement an effective risk management culture for dealing with climate change impacts. The same number indicated that uncertainty about future climate change scenarios was also a severe constraint (Figure 17). Other constraints that were rated as moderate to severe or binding by more than 50% of respondents included:

- capacity to identify, analyse and evaluate risk
- high cost of risk management products
- increased number of extreme events
- regulatory uncertainty
- trade barriers to imports and exports
- poor infrastructure.

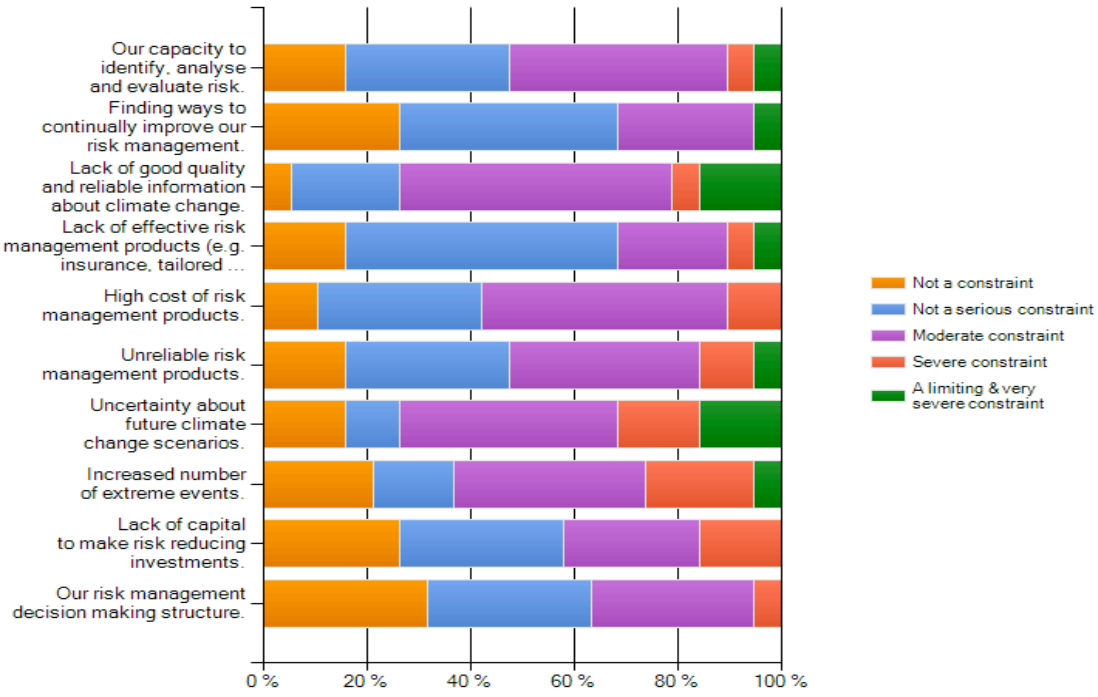


Figure 17: Constraints to implementing an effective risk management system for managing climate change impacts

One respondent stated that:

> *Climate change forecasts cannot come down to individual property scale, and what happens on one property may be different to what is happening within larger geographic areas from time to time. History shows to date*

that in our region management decisions made on long term weather forecasts would be bad decisions.

Another commented that, 'Government inaction or delayed action on climate change issues is a constraint to effective risk management.'

4.2.6 Interventions to remove constraints on risk management for managing climate change impacts

More than 30% of respondents indicated it's essential (and over 88% rated it either useful or essential) for there to be more stable and predictable regulations as an intervention for overcoming constraints to managing climate change impacts (Figure 18). Respondents expressed limited support for subsidies but nearly 70% considered the Government had an important role to provide better quality information on climate change impacts. One respondent indicated Government has a responsibility to focus on improving risk management to facilitate adaptation to severe weather (not just climate change) through provision of improved risk data and better land planning decisions and improved building codes. Many respondents favoured the private sector becoming more involved in providing better quality information on climate change impacts.

Over 70% of all respondents indicated they are quite confident or very confident about their organisation's capacity to deal with the risks to which they are exposed (Figure 19). Organisations with informal risk management systems and producers operating with extensive land management tended to be slightly less confident about dealing with their risks.

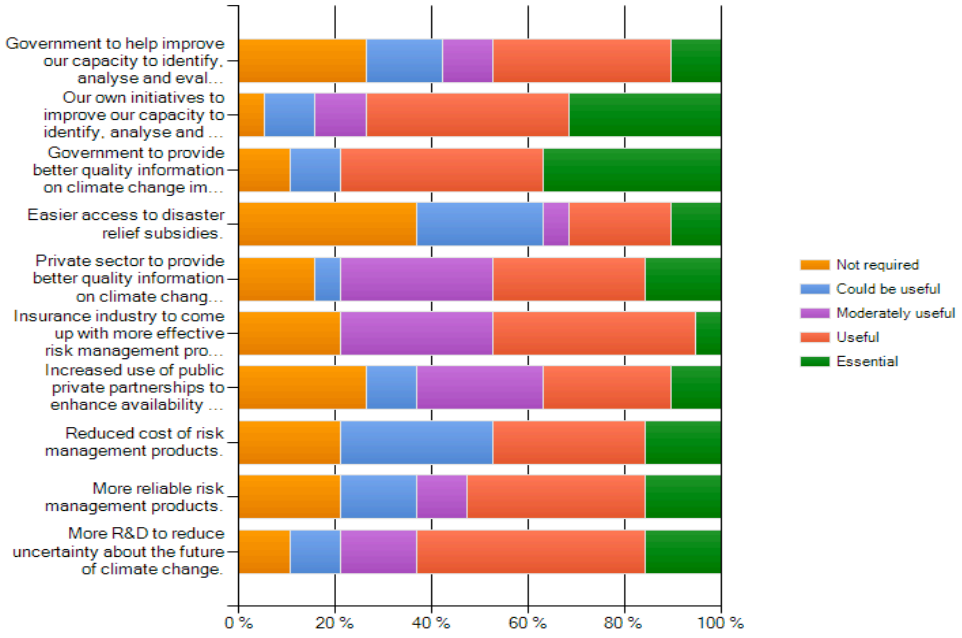


Figure 18: Interventions favoured to overcome constraints

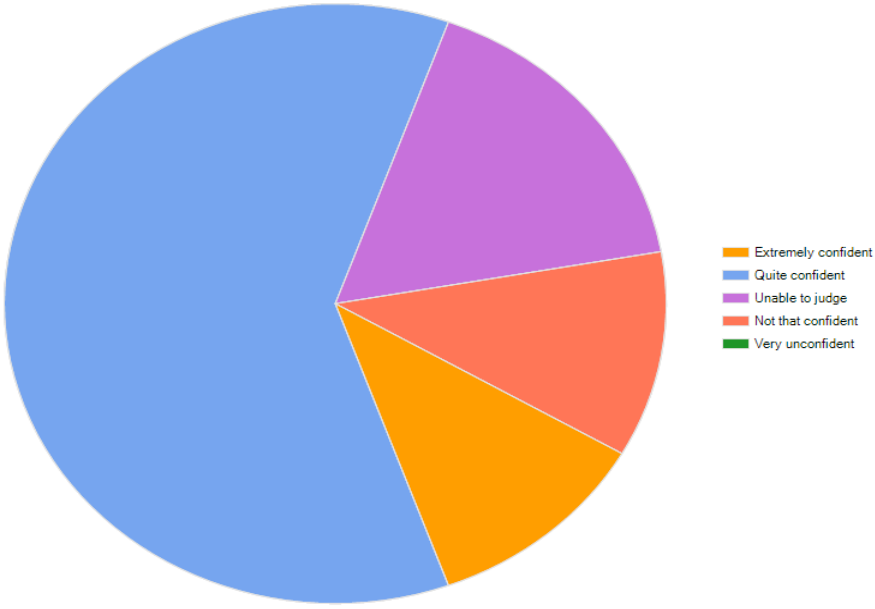


Figure 19: Confidence of organisations in dealing with risks to which they are exposed

4.3 More detailed case studies of key Issues

This section contains several more detailed case studies of firms, concepts and issues raised and highlighted by food industry organisations in discussions about experiences and ways forward for dealing with climate change.

4.3.1 Livestock genetic improvement: Hazeldean and growth in productivity for food security

With a history extending back nearly 150 years, Hazeldean has an unrivalled position in Australian agriculture when it comes to resilience and management of uncertainty and risk caused by weather fluctuations. This includes ten major droughts over the twentieth century and a few in the nineteenth century, and already a couple for the twenty-first century. Hazeldean Pty Ltd is a pastoral enterprise that has been owned and operated by the Litchfield family of Cooma since 1865 – almost the same time BHP Billiton started. The company specialises in the production of superior seed-stock for the beef, sheep and wool industries of Australia, and is also a significant supplier of commercial stock for the Australian meat industry and supermarkets. Hazeldean is a world leader in the use of measured performance and supply of high-performance livestock. The business comprises Hazeldean Merino sheep, Angus cattle and Senegus cattle. With properties in two distinct and very different regions of NSW, Hazeldean is able to provide clients with superior genetics adapted and acclimatised to all areas of Australia. With a total flock size of over 30,000 sheep, Hazeldean Merinos has one of the largest individual stud gene pools in Australia, making intense selection pressure possible in the breeding program. Hazeldean has been involved in many on-farm bloodline comparisons, including a comparison with 40 other seed stock suppliers in all parts of Australia. In the bloodline comparison trials, increases generated by

Hazeldean rams over other ram sources have been as high as $10 per head in the first generation.

Today, fifth-generation Jim Litchfield is Managing Director of the company, which now comprises three properties in New South Wales, two in the Monaro region of south-eastern NSW near the town of Cooma (*Hazeldean* and *Myalla*) and the other in the Riverina district near the town of Hay (*Rosevale*). It also has distribution arrangements in South Australia and Queensland.

'Droughts, genetics, farm management and farm scale have a big impact on productivity,' says Jim Litchfield. 'With rain, genetically improved stock, large scale and good farm management then anything is possible and productivity improvement gains of 3% per year are achievable.'

Litchfield says that droughts [Figures 20–21] are more difficult and trickier to manage than floods [Figure 22), at least in the properties where the company is located:

> *With droughts it's the uncertainty about the end that makes them difficult to manage, whereas with floods you can at least see the end. Supplementary feeding can lead to cash deficits and accumulated losses that can stretch operations to the limit if you make the decision to go down that path. But there are also opportunities in weather fluctuations and the same may exist with climate change featuring longer-term changes in average temperature and rainfall. From a strategic perspective opportunities to buy and sell land during weather changes can fit in with both your asset management and operational management. It is important, however, to keep an eye on economies of scale in decisions to buy and sell land. If you acquire land in geographically diverse areas you might pick up some benefits from the climatic diversity but that can be all lost in extra costs if you don't have an efficient scale of operations.*

Figure 20: Sheep at Hazeldean's *Rosevale* property on the Riverina, NSW

Once you have the scale right then you have to focus on the farm management, genetics and management of an uncertain climate. We don't have a formal risk management system but that doesn't mean we are not thinking about climate and how we are going to deal with the next shift in the weather or any one of the myriad of risks that we have to deal with every day. That's part of agriculture in Australia. In fact we are as concerned about the uncertainty of fuel, oil and energy prices and availability as much as anything.

Figure 21: Dust storms in the drought at *Rosevale*

Figure 22: The rains come to *Rosevale*

4.3.2 Creating value through improved risk management at Metcash

'Food retailers are always at the frontline of food security because we are the interface with consumers,' says Steven Newton, former General Manager of Risk at Metcash.

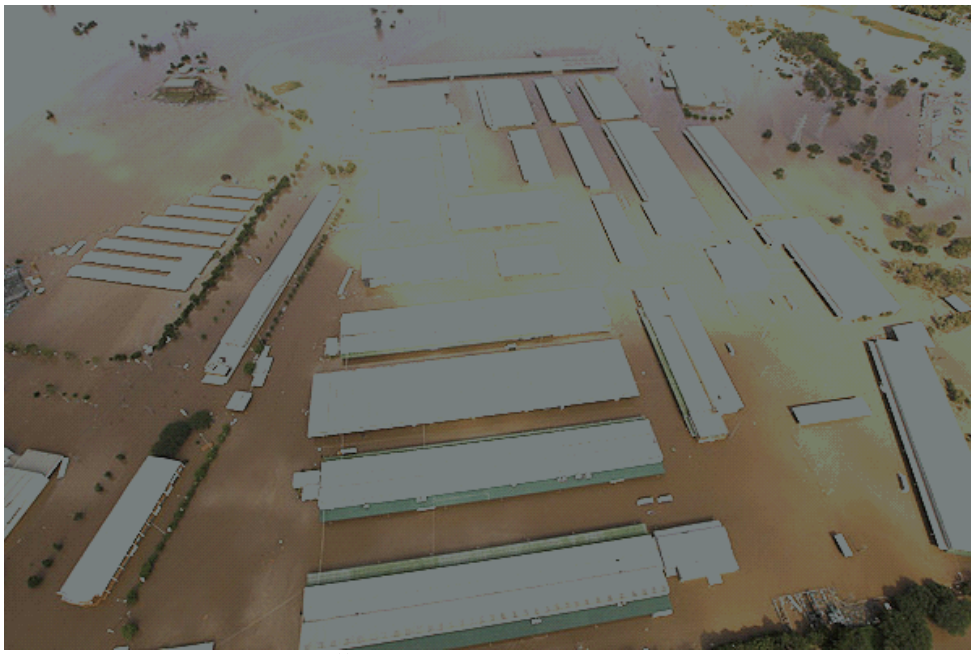
When the Federal Court dismissed an appeal by the ACCC and approved Metcash's takeover of Franklin's supermarkets in November 2011, it was supported by the ACCC's own 2008 findings that 'the acquisition was unlikely to lessen competition in any of the relevant markets'. While most attention in food retailing is focused on growth in market share of the two majors, Coles and Woolworths, investigations tend to find competition is 'extreme' and 'increasing', against a background of cost and risk management competition that is driven in large part by strong economies of scale and vertical integration. Vertical integration is shown to work best when reliance on 'arm's length markets is too expensive or too risky' (Stuckey 1985). The acquisition of Franklin's (now part of IGA) has given Metcash a potentially double-edged improvement to its competitive position against the two major retailers in NSW. The group's scale has also improved over the last decade, along with the improved cohesion of its vertical linkages between supply, storage, distribution and wholesale/retail. There is a further potential gain through the group's expertise in risk management, built upon a scalable Enterprise Risk management (ERM) System that some ERM experts say is best practice when compared with other firms of a similar nature.

The ERM system is now the building block for its advanced risk management framework at Metcash, and that system conforms to AS/NZS ISO 31000:2009. At present, it contains about 860 risk items that are allocated to fifteen categories: asset management, business continuity, compliance and legal, employees, financial reporting, criminal activity, health/safety/environment/community (HSEC), information technology, reputation, solvency, operations/warehouse, merchandise, customer and supplier, and sustainability. Metcash's ERM has an advanced risk-assessment system in place, with support from its Group Risk Department (formed in 2009) and the Metcash Audit Risk and Compliance Committee at a board level, with complete commitment from the board, executive and operations management staff. All key employees with decision-making responsibilities have risk incorporated into their job specifications. This system is now being extended to their sustainable supply chain policy, with all business partners and suppliers now being assessed as part of the ERM.

The defining features of Metcash's risk management systems are integration, collaboration and a binding requirement for risk management to add value. Risk management is not just a box-ticking and compliance issue at Metcash. Many risk management systems across today's businesses are built on legacies from the past, which inevitably involve silo development and maintenance in silo structures that become clunky, and typically fail the serious risk management tests of effective integration and collaboration between divisions and functions.

With ERM, Metcash has found the inclusion of climate change impacts to be a 'business-as-usual' add-on. It has provided the resilience and capacity to deal with extreme events, including the Queensland and NSW floods (refer to Figures 23–25) and at the same time create value from lower costs for insurance premiums (underwriting companies in London say the Metcash ERM is 'close to the best' in the world) and reduced capital costs and increased revenue from strategically located investments in modern, large-scale warehouses. The risk-assessment process at Metcash is undertaken by Group Risk teams, which facilitate risk assessment and implementation through workshops and training to ensure proper attention to risk

identification (which includes all risk events, incidents, 'near-misses', critical control points), risk analysis (including sources of risk and their respective positive and negative impacts, likelihood of occurrence and review to ultimately determine residual risk) and risk evaluation (to assist in ranking and prioritising all identified risks for effective risk management). A comprehensive independent external risk review takes place every one to three years in key risk areas.



Brisbane Markets inundated by flood waters, Rocklea

Photo: Tim Winborne
(13th January 2011)

Figure 23: Rocklea Fruit and Vegetable Market during the Brisbane floods

The ERM at Metcash is highly scalable, and potentially provides the foundation for growth in market share where risk management expertise may become the defining measure of competitiveness in the decades ahead. Steven Newton says the company is 'well placed to identify and manage the risks of climate change because of [its] high capacity to adapt and deal with the uncertainties that lay ahead … but poor community resilience and infrastructures, uncertainty about future climate change scenarios and the growing number of extreme events remain as challenges to be dealt with by all of us". Metcash joined with Woolworths and Coles and their carriers (including shipping companies) in the 2011 Queensland floods to largely maintain supply to 1200 supermarkets across the state.

4.3.3 Insurance for disasters affecting the food industry

Following the series of storms, floods and cyclones that affected Queensland and Victoria over 2010-11 the Australian Government initiated the Natural Disaster Insurance Review (Department of Treasury 2012). It was not the capacity of the insurance industry that stimulated the review because the industry had shown it had financial capacity to deal with extreme events including, for example, the Victorian bushfires of 2009.

Figure 24: Truck traffic jam of bulk food items and retailer store deliveries, en route to northern NSW and Queensland flood-impacted warehouses

Source: Metcash (2011).

Figure 25: Metcash Queensland warehouse, prepared and ready before the flood crisis hit

It was the absence of flood insurance for many policy holders that stimulated the inquiry. Home insurance policies have, in the past, typically covered storm damage including water related damage but many do not cover flood damage or had opt-out options that many had taken without full awareness of the consequence. Many small businesses found themselves with similar policy situations. In addition, it is estimated that up to 80% of businesses are under-insured by 10% or more and that only 40% of Australian businesses have business interruption insurance (Cain 2011). A recommendation of the Natural Disaster Insurance Review is that all home insurance, home contents and home unit insurance include flood cover with no opt-out. Affordability is to be enhanced, with government support for a reinsurance facility. Small business insurance for flood damage is to include flood cover on an opt-out basis.

A natural disaster can financially cripple a business in a very short time, even if it has insurance. Full understanding of risks and the role of insurance in covering those risks is a critical requirement for all businesses operating in disaster prone areas and industries. Food is no exception. Property and business interruption insurance are almost always part of an effective risk-mitigation strategy. Cover for business interruption policies (BIP) typically extends to loss of revenue or profits as a result of some type of external intervention in operations. BIPs may not cover fixed costs, only loss of profits while the business is closed. The policy-holder bears the responsibility of proving that, on the balance of probabilities, its loss was caused by an insured peril (Brookes and Goodridge 2011). Three requirements must usually be satisfied:

1. The insured must sustain some sort of “physical damage” as a result of an insured peril.
2. There must be an interruption to the insured’s business as a result of that physical damage.
3. The damage must have resulted in a measurable business interruption loss.

Zurich Financial Services Group (2009) highlights that the time to prepare for a disaster is well before it occurs. A well-designed insurance plan sets out all the steps and requirements that need to taken, both before and after an event. Dealing with climate change is a challenge for both mitigation and adaptation. The insurance industry seems to have unexploited potential to encourage risk-reduction by introducing more risk-based pricing tools, with premiums set according to risk management practices in place in both businesses and households. In the course of this study of the food industry, a number of organisations indicated that improved insurance products were essential or quite important for managing their exposure to climate change impact risk. It is noted, however, that insurance works best and most simply in protecting private assets, but climate change risk involves exposure for both public and private goods, and often it is not easy to unbundle the two:

> *Insurance works most effectively in undistorted markets, while proposals to combat climate change routinely mention grants, subsidies, penalties, and the creation of additional rights and obligations. And while insurance (like most businesses) works best in a stable, consistent and predictable environment, the current patchwork of rules and regulations embeds a political risk that the rules of the game will almost certainly change somewhere along the way. (Zurich Financial Services Group 2009)*

4.3.4 Precision agriculture for improved productivity

It is possible that some – maybe even a large part – of the solution to problems of food security caused by climate change impacts is sitting dormant in the masses of agricultural data stored and collected over many years and now resting in unexploited filing systems. Precision agriculture (PA) offers a new way to exploit the data on intra-paddock variability in yield, nutrition, moisture availability, soil structure, pH and biomass. It uses information technology, Geographical Information Systems (GIS), satellite imagery, geo-spatial tools and Global Positioning Systems (GPS) to capture data within paddocks for analysis using the best crop and environmental science, coupled with sound economic assessment, to ensure the optimal application of everything to suit every crop or pasture for every point on the paddock. The expected outcome is improved productivity, lower costs and potentially improved quality. PA is now being adopted widely across the major agricultural crop-producing countries. The International Society for Precision Agriculture (ISPA) (www.ispag.org) is about to hold its first international conference on PA. ISPA has divisions covering almost anything showing variation, ranging from crops and livestock through to precision carbon management and women as operators in precision agriculture.

Tim Neale, Director of Precision Agriculture (Australia) says the essence of PA is that it enables the improved practices and optimisation of inputs that generate cost reductions and improve productivity:

> *For example, PA has enabled crop frequencies in northern NSW and southern Queensland to be increased from 0.9 to 1.5. It makes the most of whatever moisture is available. Evaporation losses in many of the cropping areas of Australia amount to 70% or more. PA can convert some of these evaporation losses to evapo-transpiration gains with associated impact on yield.*

When the intra-paddock variability in input requirements is coupled with the growing variation in climatic conditions[15] across many regions of Australia, there is potential for an escalation in risk. It can be a problem for farming practices based on traditional practices and guesswork, or an opportunity for those based on PA with the knowledge for adaptation to local paddock and weather conditions. PA offers a technological solution to improved risk management and a reduction in the uncertainty accompanying climate change. At the same time, it is making a positive contribution to food security.

Griepentrog (2012) expresses some caution that:

> *many farmers in Germany are reviewing precision farming in terms of site-specific treatments with slightly more reservations. Often, machinery manufacturers simply promised too much, too fast. Or farmers with the new technology find themselves drowning in a flood of data without knowing how to apply it.*

According to Tim Neale:

[15] 'Australia and the globe are experiencing rapid climate change. Since the middle of the 20th century, Australian temperatures have, on average, risen by about 1°C with an increase in the frequency of heatwaves and a decrease in the numbers of frosts and cold days. Rainfall patterns have also changed - the northwest has seen an increase in rainfall over the last 50 years while much of eastern Australia and the far southwest have experienced a decline.' (Bureau of Meteorology 2012)

PA is a skill intensive approach and technology. You have to be able to use the new technology and make sense of the data and information, converting it from numbers and packets of information to knowledge that improves productivity and profitability. One of the problems we have in Australia is a skill shortage in using and applying PA technologies. We run the risk of not keeping up with the pace of PA adoption in other agricultural producing countries.

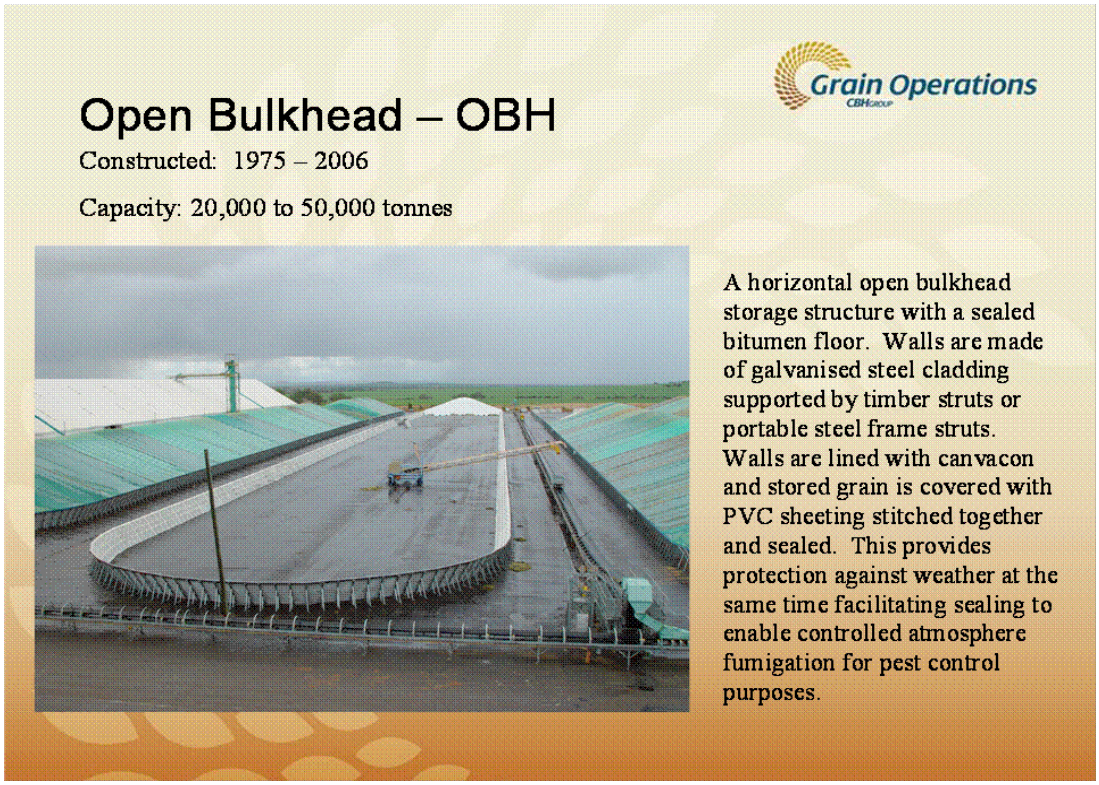
The Precision Agricultural Laboratory at Sydney University was established at the start of 2012 to 'provide excellent PA science and training, leading agricultural industries towards incorporating practical, sustainable precision agricultural management techniques' (Precision Agriculture Laboratory 2012). Precision Agriculture (www.precisionagriculture.com.au) offers specialised training in PA components, including variable rate and spatial data management. The University of New England is now offering a two-year part-time Graduate Certificate in PA. Machinery maker Case-IH is now offering a training package in conjunction with Swiss based SGS to make the most of its PA software.

4.3.5 Grain handling and storage: A cooperative structure and strategy with a long-term view on capital investment

Founded in 1933, Cooperative Bulk Handling (WA) is Australia's largest and arguably the most successful cooperative in Australia, accounting for 18% of total turnover from the top 100 Australian cooperatives in 2011 (Cooperatives Australia 2011). A substantial capital expenditure program (average of $78 million per year over the last five years and $128 million in 2011), accompanied by a comprehensive risk management system, underpins CBH's position as a leader in the Australian grain industry, with operations extending along the value chain from grain storage, handling and transport to marketing, shipping and processing across three estates, as well as joint ventures in processing in Vietnam and Indonesia. In 2010, CBH was awarded the NAB Agribusiness Risk management Award for excellence in risk management. Rob Maurich, the Chief Risk Officer at CBH, says management and the Board at CBH are highly committed to excellence in risk management. He says:

We spend more on risk management and have a bigger capital expenditure commitment than most of our corporate competitors because our 4700 grower members are our primary stakeholders and they are prepared to take a long-term view on investment and we are restricted from distributing profits to them. They want internationally competitive storage and handling charges as well as the best quality services. It is one of the ways that we return value to our growers. We have capacity to handle 20 million tonnes per year and have averaged more than 10 million tonnes per year over the past five years.

Capital investment in grain storage and handling is being spread across low-cost, open bulkhead designs (Figure 26) and the more expensive closed facilities (Figure 27). Many of the legacy facilities are closed and located in traditional grain-growing areas.



Source: Cooperative Bulk Handling.

Figure 26: Cost-effective and flexible: Open-bulkhead grain storage in Western Australia

Source: Cooperative Bulk Handling

Figure 27: Closed-bulkhead receival, storage and export terminal: Albany, Western Australia

The open-bulkhead facilities offer the advantage of low cost, but can also increase exposure to adverse weather events, which can damage the grain until it is covered after harvest. Over time, there has been a shift of grain production in the state to southern areas, and this transformation – along with a shift in land use away from livestock towards grain and the adoption of new technology – is driving rapid expansion of grain production in Western Australia.

The risk management system at CBH complies fully with ISO 31000, and risk management topics are reported continuously at monthly board meetings. The group's activities expose it to a number of risks including production (caused by weather cycles and climate change), market, currency, credit and liquidity risks. For example, the average grain deliveries into the northern port of Geraldton total 1.6 million tonnes, but in 2011 the amount was 3.6 million tonnes. 'For the last decade we have been experiencing 40% shifts from year to year in production quantities on an overall level,' says Rob Maurich. 'Sometimes the impact of reduced grain production in one region such as the northern region can be offset by more favourable conditions in the south.'

The group measures market risks from its market exposures using value-at-risk (VaR) techniques. Management recognises the limitations of VaR in that it is not a fair representation of absolute loss; instead, it calculates what a loss would be at a particular confidence interval under normal market conditions. To balance this, CBH also uses stress test measures to reflect capital at risk in extreme situations.

Among the risks facing CBH and rated as almost certain with a major impact on the group's objectives is regulatory risk. The group faces regulatory hurdles from competition laws, export marketing rules, quarantine and inspection, and testing and transport. Grain Express has been introduced as a logistics and coordination model to support the 'strategic storage sites strategy' and for dealing with multiple buying orders at least cost, but it has attracted the attention of the ACCC. Regulatory uncertainty is rated as a severe constraint to effective risk management, along with a lack of effective risk management products (including insurance and tailored finance), and the high cost and unreliability of risk management products. As a risk-mitigation tool for growers, the group has introduced a multi-peril crop-cover policy to help growers protect all or part of their production. Premiums range from 2–10% of production costs, depending on location and proportion of the yield that is insured. CBH reduces its exposure through reinsurance.

Among the interventions that would help CBH manage its risks better for the future are better quality information on climate change impacts, reduced cost and more reliable risk management products, more stable and predictable regulations, improved infrastructure and increased use of public–private partnerships to enhance the availability of better quality risk management products.

4.3.6 Food security for Australia and China: Shared interests

With 22% of the world's population and 7% of the world's arable land, there is growing interest in creating a sustainable solution to China's potential problem of food security (McBeath 2010).In contrast, Australia has 0.3% of the world's population and 3.4% of the arable land (derived from FAO Statistics 2012). An estimated 29.8% of the population in China lives below the international poverty line of $2 a day (Purchasing Power Parity) (World Bank 2011). China has made exceptional progress in providing food security for its population of 1.3 billion people against a background of industrialisation (44% of GDP is now from the industrial sector), urbanisation (an

estimated 44% of the population in China now lives in urban areas) and environmental pressure. While agriculture's share of GDP has fallen from 25.1% of GDP in 1989 to 10.3% in 2009, the annual growth in the agricultural sector is averaging about 4.5% per year. Continued growth in agricultural productivity is a basic requirement for food security in China, where it is also recognised that imports will play an expanded role in food security. It is estimated that China will need to produce 580 million tons of grain by 2020, an increase of 8% on current levels, to maintain its current self-sufficiency target of 95%, which looks increasingly difficult to achieve with land being lost to urbanisation and depletion of surface and aquifer water resources (Ash 2011). This suggests an increasing role for imports to assure food security in China. China is Australia's most important export market for agriculture. In 2011, agricultural exports to China were estimated to be $5.9 billion, equivalent to 17.2% of global agricultural exports from Australia (Department of Foreign Affairs and Trade 2011).

Among the major food-producing areas of China is Heilongjiang, also known as the 'great northern granary' (Zhou 2011). Heilongjiang's grain production has been increasing at about 5 million tonnes per year from its fertile black soil plains. Heilongjiang is also noted for its local state-owned enterprise, the diversified Heilongjiang Beidahuang Nongken Group Co. (known as BDH Group), which manages and operates several million hectares of grain-producing land in China. In 2011, BDH Group announced plans to acquire 200,000 hectares of farmland across several countries, including Argentina, Australia, Brazil, Russia, Venezuela and Zimbabwe. The BDH Group has acquired land in south-west Western Australia, with plans to produce, harvest and distribute grain production directly back to China. It has recently reached agreement with private owners and the government of Argentina to develop 234,500 hectares of farmland in Patagonia. BDH Group is providing capital and technology while Argentina provides the land for production of soybeans and other crops. Without the capital and technology from BDH, food production in Argentina is likely to be lower and food security compromised. Global production by the BDH Group is understood to be around 17.5 million tonnes of grain per year. It also has operations covering oil crops, beets, fruit, meat, milk and marine products.

BDH Group is reported to have nine branches in China, 30 holding companies, six joint-stock companies and one Shanghai-listed company (Heilongjiang Beidahuang Agriculture Co. (SHA:600598), which is reported to have revenue of around $1billion in 2010) (Shanghai Stock Exchange 2011). Globally, sovereign wealth funds are now estimated to be valued at US$5 trillion (Sovereign Wealth Fund Institute 2012).

Under the Australian government's foreign investment screening arrangements, all proposed investments by foreign government-related organisations, including investment in agriculture, must be examined and subject to the 'national interest test' (Foreign Investment Review Board 2012a). The national interest test assesses the affect of investments on national security, competition, the economy, the community and other government policies. The government also considers the type of investor and the extent to which an investor operates independently of foreign governments. Proposed foreign investment in the Australian agriculture, forestry and fishing sector decreased from $2.3 billion in 2009–10 to $1.4 billion in 2010–11 ($4 million of which was from China), though the number of proposals stayed constant, at seventeen (Foreign Investment Review Board 2012b). In addition, all investors – both foreign and domestic – must comply with Australian law. The Australian Competition and Consumer Commission assesses all proposals that have the potential to raise competition concerns, including any potential competitive affects of agribusiness supply chain acquisitions by foreign investors. A number of case study respondents in this study considered competition from foreign investment with government influence to be a likely or almost certain risk over the next 10 years, and several indicated that this

investment would have at least a major impact (either negative or positive) on their organisational value. There are several cases in which investment from China has been used by the farmland seller to settle unsustainable debt levels, which means replacement of debt with equity capital. There is no evidence of negative impacts from foreign investment in the Australian agricultural, distribution, storage or food processing sub-sectors.

4.3.7 Urban agriculture and food security

According to Julian Cribb, author of *The Coming Famine:*

> *By 2030 there'll be many cities with 30 million people. If those cities produce none of their own food, they're totally dependent on a river of trucks. If that river fails [due to an oil crisis, a local war, or a disaster like the Queensland floods] those cities would be starving within three days. If we can get the world's cities back to producing 20, 30 or even 40 per cent of their own food, and only relying on the landscape for the balance, we'll have a more sustainable agriculture and more sustainable cities. (White 2011)*

Whether alarmist promotional commentary or just recognition of future uncertainty, this type of comment does have impact on public opinion.

The FAO (2000) has examined policies for urban food supply and distribution, identifying three areas for concern about this as a viable source of supply:

- efficiency of production and processing
- efficiency of distribution
- health and environmental standards at all stages, including treatment of waste.

Food security fundamentally requires an efficient and safe food supply and distribution system, with effective safeguards with a view to meeting the target of ' all people, at all times having access to sufficient, safe and nutritious food to maintain a healthy and active life' (FAO 1996). It isn't simply a matter of locating food production sites near consumers in the suburbs, because it is often more cost-effective and environmentally beneficial to source product from distant locations. Williams (2008), for example, found the carbon footprint of several meat products imported into the United Kingdom from New Zealand had lower emissions per unit of consumed product than locally produced product, even though they had to be transported halfway around the world.

According to the United Nations Development Program's urban agriculture network, around 15% of the world's food is now grown in urban areas, a figure that appears to be increasing (Pearce and Furubjelke 2011). It is estimated that one in three urban households worldwide grow some food. The peri-urban areas of Australian cities accounts for an estimated 25% of the value of Australia's agriculture (Houston 2005). The Sydney region alone is estimated to account for 40% of the value of vegetable production in NSW (James 2009).

The contribution of urban agriculture to food security seems to have most value through diversification, which can reduce the uncertainty of supply being sourced and

distributed through concentrated marketplaces that may become vulnerable to extreme events. The call for improved policies to support urban agriculture extends beyond developing countries, and mostly it is not about turning high-rise buildings or urban shopping centres into farms – although that is happening on some rooftop spaces. The City of Oakland in the United States, for example, has established a Food Policy Council (Oakland Food Policy Council 2011), which aims to have a food system that delivers healthy food, a healthy environment, a healthy economy and healthy food choices. Among the measures being introduced at Oakland is a city policy and program strategy to support urban agriculture, including rezoning, public land access for community agriculture, promotion of sustainable agricultural practices for backyard agriculture and community agriculture, identification of vacant or under-utilised land that could be used for urban agriculture, identification of public–private partnership possibilities to support infrastructure required for urban agriculture (e.g. waste management) and identification of partnerships between local and state governments to support urban agriculture. Oakland estimates that agricultural production on unutilised public land alone could supply 5% of the city's vegetable needs. Household and community farms are believed by the City of Oakland to have potential to produce lower cost and higher quality fruit and vegetables, while at the same time, diet-related diseases can be reduced from their production activities.

4.3.8 Regulatory and political risk

From the case studies, the one area of risk on which there is wide agreement is regulatory and political risk. A large majority of respondents indicated that the chance of regulatory risk ranged from possible to almost certain, and many considered that the consequences for organisational value would be catastrophic or major. Among the risks cited include unforeseen trade barriers (export and import), product rules and competition laws. It is not clear whether the regulatory risks are specifically tied to food or general regulations (e.g. taxation, labour laws, etc). Food Standards Australia New Zealand (FSANZ) administers the Australia New Zealand Food Standards Code with a partial cost recovery through user charges, which are currently under review. Food labelling laws have been reviewed recently, resulting in the report *Labelling Logic*, with 61 recommendations designed to enhance food safety, preventative health, new technologies and consumer values (Blewett et al. 2011). Food regulation in Australia extends across all three levels of government and several departments. Food regulations cover how, where, when and who grows, transports, stores, processes, packages, inspects, tests, exports, imports, displays and sells food. There seems to be significant emphasis in the many reviews of food regulations that food must be safe to eat and consumers must be protected from misleading advertising. There is less concern about food security as defined in this report. It is beyond the scope of this project to identify how many pieces of legislation actually have impact on the food-supply chain. There have been a number of studies into general regulatory risk and the cost of regulations on business in Australia. The Productivity Commission (2008) conducted a performance benchmarking study of business regulations across state and Commonwealth jurisdictions. This study revealed significant differences in the quantity and use of different regulations across states and the Commonwealth. For example, Queensland has over 70,000 pages of regulations (from Acts, statutory rules and other legislative instruments, including guidelines, orders and instruments) compared with over 188,000 for the Commonwealth and 21,000 for the Northern Territory. The quantity of regulations with which business must comply is a direct indicator of compliance costs, but the quality of regulation is an equally significant – if not more important – driver. The Productivity Commission (2008) also found that there were significant differences in development and administration of regulations across jurisdictions, and few mandatory requirements for consultation on regulatory proposals.

In addition, the proportion of regulatory proposals subject to regulatory impact analysis or compliance cost estimation is low. Regulatory costs have impact on the economy (national, state and regional), businesses, government and consumers.

Risk-based regulation has emerged over recent years as a response to complaints about the costs of regulations (Peterson and Fensling 2011). By having a focus on risks, rather than prescriptive rules, it was found that better outcomes could be achieved with limited resources and fewer regulations. Risk based regulation is, however, more complex than traditional approaches to regulation. Attention to enabling factors such as governance, evaluation and regulator capabilities can enhance efficacy and efficiency.

Jacobs and Cordova (2005) examined good practices for regulatory inspections in World Bank development projects. They found four basic features in a good inspection system:

- It encourages compliance with clear and legitimate government regulations by detecting and deterring non-compliance consistently and fairly.
- It reduces uncertainty and regulatory risks for businesses by operating transparently and under the rule of law.
- It limits corruption by reducing the opportunity for abuse of discretionary powers.
- It minimises costs to businesses and optimises costs to governments by using resources efficiently to target the highest risks.

In the World Bank's 'Cost of Doing Business (CODB)' database, Australia is now ranked 15th in the overall ease of doing business out of 183 countries. In some categories of the CODB, the ranking is quite low for a developed country. For example, Australia is ranked 30th for barriers to trade, 53rd for tax payments, 37th for accessing electricity, 42nd for dealing with construction permits and 65th for protecting investors. In contrast, New Zealand is ranked 3rd in the world for the overall ease of doing business and ranks above Australia on every indicator except resolving insolvency.

The World Economic Forum (WEF) (2012) survey of international competitiveness shows a similar picture to the CODB. Australia's rank has deteriorated from 16th out of 242 countries in 2010–11 to 20th in 2011–12. At present, Australia is ranked 75th on the burden of government regulation, 88th on the extent and effect of taxation, 37th on the overall quality of infrastructure, 33rd on the quality of electricity supply, 23rd on technology adoption, 26th on innovation and business sophistication, and 27th on company spending on R&D. The two areas where Australia ranks relatively highly on are health (ranked 8th) and education and training (ranked 11th).

Achieving the right balance for regulation of the food industry requires, among other things, advanced risk management skills to deal with food safety, compliance and efficiency, and costs. The Australian and New Zealand Food Regulation Ministerial Council (2011) issued a policy guideline with principles on food safety management for general food services and closely related retail sector services. The principles highlight, among other measures, the protection of public health and safety, the need for standards to be based on risk analysis using the best available scientific evidence, the

desirability of an efficient and internationally competitive food industry, and that the regulatory measure should be proportionate to the level of risk.

4.3.9 Resilient infrastructure for food security

Food security depends to a large extent on the resilience of critical infrastructure. Infrastructure enables the delivery of essential services that support the food-supply chain including transport, water, power, health, education, communication, critical systems[16] and emergency services. The Australian Government has developed a Strategy to enhance resilience of critical infrastructure (Attorney General's Department 2010). This Strategy recognises that a significant proportion of Australia's critical infrastructure is privately owned or operated on a commercial basis and, in most cases, the owners and operators of critical infrastructure are best placed to manage risks to their operations and determine the most appropriate mitigation strategies. There is some evidence that capital markets are prepared to pay premiums for infrastructure assets that have greater resilience to economic volatility (Infrastructure Investor 2012). Australia is ranked 18th out of 154 countries in the World Bank's Logistics Performance Index (LPI).[17] The LPI is a composite measure of logistical performance and is made up of several categories, one of which is infrastructure which measures the quality of trade and transport related infrastructure (e.g. ports, railways, roads, information technology). Australia is ranked lower than Canada, the United States, China/Hong Kong and Germany on both the overall LPI and the Infrastructure category.

A large number of case study respondents for this study indicated that infrastructure was a possible, likely or almost certain risk over the next 10 years, and most indicated that the consequences could be either catastrophic or major on organisational value, with many others indicating a moderate impact. Critical systems risk was rated similar to infrastructure risk. Over 50% of respondents indicated that infrastructure was now constraining their capacity to implement an effective risk management culture for dealing with climate change impacts because they had little control over the service. Over 55% of respondents indicated that improved infrastructure would be a useful or essential intervention for overcoming constraints for dealing with climate change impacts.

The Australian federal, state and territory governments define critical infrastructure as follows:

> *… those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of the nation or affect Australia's ability to conduct national defence and ensure national security … it is important to note that some elements of critical infrastructure are not assets, but are in fact networks or supply chains. For example, bringing food from the paddock to the plate is dependent not only on particular key facilities, but also on a complex network of producers, processors, manufacturers,*

[16] Critical systems are systems in which failure can have a major or catastrophic impact on life, the environment and/or functionality of assets. Measurement indicators include reliability, safety, availability, security and functionality.

[17] The Logistics Performance Index is an interactive benchmarking tool created to help countries identify the challenges and opportunities they face in their performance on trade logistics, and what they can do to improve their performance – the LPI 2010 allows for comparisons across 155 countries. More details can be viewed at: http://info.worldbank.org/etools/tradesurvey/mode1b.asp.

distributors and retailers and the infrastructure supporting them … (Attorney-General's Department 2010)

To promote resilience at every step of the supply chain, the International Organization for Standardization has developed a new standard (ISO 28002:2011), which places greater recognition on external influences and the extended supply chain. The standard is expected to 'enhance prevention, protection, preparedness, mitigation, response, continuity of operations and recovery from disruptive incidents'. More generally, ISO 280002:2011 complements ISO 31000. A number of case study respondents with formal risk management systems and compliance with ISO 31000 seemed to fall short when it came to encouraging improved risk management practices with suppliers. One of the reasons for this was that they had no influence over a number of key suppliers, including infrastructure.

4.4 New developments in risk management

There is a surge of interest in managing risk as a consequence of several factors, especially the growing awareness of risks to which businesses, governments and people are exposed, and the growth in information and communication technology, including the digital world, which is expanding the capacity to deal with risk. In addition, there is growing interest in strengthening the links between risk management, and governance and accountability. Governance is no longer simply a compliance issue. These developments are generating organisational change, improved understanding of risk, new and modified products and services for managing risk and, ultimately, more confidence in managing risk. This section covers a small selection of the new developments in risk management, which are judged to be among the leading influences on risk management in the decade ahead.

4.4.1 Adaptable and flexible standards

These are several standards now providing guidelines for entry and continuous improvement of risk management practices and performance:

- ISO 31000:2009 (Risk management Principles and guidelines), which is supported by ISO 31010 (Risk assessment techniques).
- ISO 31004 (Guide for implementation of ISO 31000:2009) and which is still under development.
- ISO 28002:2011 (Resilience in the supply chain).
- ISO 22301 and/or AS/NZS 5050:2010 (Business Continuity, managing disruption risk).
- DR AS 5334 (Climate change adaptation for settlements and infrastructure, Draft).

In addition to the ISO standards, there is an *Enterprise Risk management – Integrated Framework*, developed for the Committee of Sponsoring Organisations of the Treadway Commission (COSO) by PriceWaterhouseCoopers LLP to enhance internal control and improve enterprises risk management.

In brief, there are performance-enhancing risk management standards that now fit almost any sized organisation and type of management. Furthermore, several are non-certifiable and highly user friendly, with the capacity to merge into either the most complex multinational organisation or even the most basic of general management frameworks, including micro, small and medium-sized enterprises.

ISO 31000 is a generic standard intended to provide a common approach in support of standards dealing with specific risks. This standard gives generic guidelines for principles and the adequate implementation of risk management. It is not intended to be used for the purposes of certification. It has been adopted as AS/NZS ISO 31000:2009 by Standards Australia and Standards New Zealand as their National Standard for Risk management (Standards Australia 2009). There are several other standards also dealing with specific risk management practices, which are relevant to listed food companies. For example, AS 8000 sets out corporate governance principles, including 'understanding and managing risk to minimize the negative aspects and maximize the opportunities'. Under the new ISO 31000 standard, risk is now defined in terms of the influence of uncertainties on objectives while previously the standard focused on risk as being the chance of something happening that would have an impact on objectives. It is an important change, which could be viewed as addressing some of the concerns about information gap uncertainty and 'Black Swan' styled events. The new standard highlights eleven principles for effectiveness and with which organisations should comply:

- Creation and protection of value.
- Being an integral part of all organisational processes.
- Help in making informed decisions.
- Explicitly taking account of uncertainty.
- Systematic, structured and timely approach for efficiency and consistency.
- Based on the best available information.
- Being tailored to the organisation's risk profile.
- Recognition of capabilities, perceptions and intentions of external and internal people.
- Being transparent and inclusive with all stakeholders represented and participation from decision-makers at all levels.
- Being dynamic, iterative and responsive to change.
- Facilitating continual improvement of the organisation.

Effective monitoring, evaluation and communication of risk management performance is an integral part of an effective risk management system. This includes identification of near-misses, and lucky events and circumstances that might happen every now and then, but not forever.

Emergencies, crises and disasters with major or catastrophic impact can happen, and more often than not they carry challenges for even the best-designed risk management systems. If suppliers are unable to deliver and customers unable to reach distribution points, the ability of an organisation to achieve its objectives and targets is reduced.

ISO 28002:2011 has been developed as a guide to enhancing resilience at every step of the supply chain. The resilience of food-supply chains in particular is only as strong as the weakest link. ISO 28002:2011 is a standard to enhance supply chain resilience through adoption of processes to enhance prevention, protection, preparedness, mitigation, continuity of operations and recovery from disruptive incidents. It has particular application to supply chain leaders.

4.4.2 Improved measurement for improved management of risk

A well-known and relevant management axiom states that if something is not measured, it cannot be managed. This applies to risk management and virtually any practice, process, function or product where improvement is required. ISO 31010 provides guidance on the selection and application of techniques in assessment of risk, including provision of information for effective decision-making in managing risk. Within the risk management process, this standard covers the requirements for communication, understanding the context (internal and external factors), risk assessment (identification of risks, risk analysis and risk evaluation), risk treatment, and monitoring and review.

Many firms in the Australian food industry are familiar with Hazard Analysis and Critical Control Points (HACCP) (covered also by ISO 22000) and Hazard and Operability (HAZOP) assessment for identifying hazards and controlling processes to protect quality and safety. These and many other risk-assessment techniques require from the start, and during all subsequent operation, an effective and reliable information-collection and management system.

As firms in the food-supply chain improve their risk management practices and systems, they are likely to confront a proliferation of data, driven by the almost unlimited demands of a comprehensive risk management system, and enabled by continuous expansion in capacity of new information and communication technology. The collection of environmental data is among the leading sources of data proliferation. Already firms from production through processing and distribution to retailing and infrastructure are finding the amount of data available for analysis is exploding at an exponential rate. McKinsey Global Institute (2011) comments that 'the scale and scope of changes that such "big data" are bringing about have reached an inflection point … collecting, storing and mining big data for insights can create significant value for the world economy, enhancing the productivity and competitiveness of companies and the public sector and creating economic surplus for consumers.' These observations are as relevant to the Australian food-supply chain as any sector. Information and communication technology was rated as a possible to almost certain risk by 85% of survey respondents, and nearly 60% indicated that the consequences of failure would be major or moderate. Data-governance risk (e.g. information security and information overload) and critical systems risk were rated similarly high in terms of likelihood and impact. New technologies that speed up and generate reliable information about emerging climatic events were rated as essential or quite important by 55% of operators and precision agriculture (e.g. GPS guides, digital farm maps, satellite imagery, vulnerability maps etc) were rated essential or quite important by 82% of respondents.

The responses from food industry operators indicate that the whole process of assessment and management of risks, along with the technological solutions, is extremely data intensive, and transformation of this data into effective knowledge for decision-making is a priority.

Gaining access to critical, timely and reliable data required for managing climate change risk is also viewed as a potentially serious constraint to adaptation. At the NCCARF and ANU workshop on adaptation experiences, investors indicated that it was difficult to gain access to reliable data on climate change impacts at a local level, and that this was emerging as a constraint to investment by institutional investors where climate change impacts were recognised as a risk.

Along with the explosion of data availability is a concomitant growth of uncertainty about what the data mean. Nearly 80% of respondents to the survey indicated that a lack of good-quality and reliable information about climate change and uncertainty about future climate change scenarios were moderate, severe or limiting constraints to having an effective risk management system.

The McKinsey Global Institute (2011) describes five ways to gain leverage from 'big data':

- improved transparency, access and timeliness of collection and release of information
- use of data to expose variability and improve performance
- segmenting populations to customise response
- using automated algorithms to replace and support human decision-making
- innovating with new business models, products and services.

Critics of 'big data' concepts express reservations about a lot of costly data being collected and saved forever without being used, and the leap from data and information collection to genuine knowledge improvement can remain a large gap. The design of an effective information-management system with resources and leadership is taking on added importance in dealing with the proliferation of data and ensuring that information is used to create value and to help achieve objectives. Furthermore, an effective information system has to be capable of dealing with data and information security. Of the survey respondents with formal risk management systems, about 50% indicated their systems were secure but also easy to access. Over 50% of respondents indicated that human resource risks were likely or almost certain events over the next 10 years, with a potentially major to catastrophic impact.

Exploratory analysis of big data has the potential to uncover new facts about customers, markets, partners, costs and operations – information that businesses can use to their advantage (Gaines 2012). This includes climate change impacts where the volume of data is accumulating at an unprecedented rate. Lewis (1999) warned us more than a decade ago about the dangers of information overload leading to adverse effects on human health. Today, there is a constant torrent of information, often updated by the minute, from researchers, television, radio, the internet, social media (Twitter, Facebook, LinkedIn) email, voicemail, faxes (where they are still used), cell phones, smartphones, pagers, billboards, junk mail, newspapers (where they still exist), magazines, books, catalogues and smoke signals (understood to be still used, among other places, at the College of Cardinals in Rome to indicate the selection of a new Pope). The capacity of modern computers and processing systems has the potential to relieve information overload and exploit the value of early and accurate data that is relevant to knowledge building, all of which means improved risk management for those who wish to exploit it. Gaines (2012) believes exploitation of 'big data' is not just confined to large companies. The authors of this project agree. A

number of case study respondents are capturing, storing and analysing data across a vast range of categories, from genetics in livestock breeding to climatic variables at a property level and segmented population markets.

Abraham (2012) examined a case of data breach, remediation and prevention at an energy company, which seems to have a 'hacker-proof' information system but when put to the test failed substantially. It is relevant to food security organisations:

> *Fundamentally, the energy company suffered from a culture problem. Rather than fostering an information-sharing, open culture, the organisational culture was based on silos, islands of authority, and a 'don't rock the boat' mentality … the status quo consisted of manual communications and coordination, tracking through spreadsheets maintained in different departments, and infrequent testing and validation of controls and analysis of policy violations and loss events. Current operating procedures failed to consider key vulnerabilities. In addition, there was insufficient insurance coverage, a gap in contractual stipulations, failure to validate third-party operating procedures and controls, and specifically, failure to consider risks associated with external access to customer data and related safeguarding options … As a result of fallout from the security breach, there was turnover in the board and management.*

This example underlines the importance of organising data collection in a way that builds and enables effective knowledge management. Collections of data can be enabled through adaptation and use of the latest information and communication technology, but to have value, the data have to build on the knowledge of the user to offer new and unique insights and experiences not available through traditional methods. Exploitation of 'big data' requires a strategic perspective that extends beyond information and communication technology. Organisations that reach this level of understanding are then positioned to convert it into commercial benefits, including reduced insurance premiums (refer to Metcash case study in section 4.3.2) and longer term contracts, both of which offer pathways to reduced uncertainty. Larger organisations require in-depth understanding of organisational behaviour and industrial psychology to make progress in this area – otherwise, they will continue to be influenced and constrained by the silos of the past. There is some evidence of this in the case study response to insurance products. A number of respondents indicate that there is a need for new and improved insurance products for dealing with climate change (Figures 16 and 17). One respondent is going direct to underwriters to present its credentials for low insurance premiums on the grounds of its superior management information system.

4.4.3 Dealing with extreme events

Until recently, risk has been frequently defined in terms of probability and adverse effects on value. Expected value (EV) is a probability weighted average measure of all possible values that a random variable can take, and has been used to make investment decisions, operational decisions and gambling decisions. Value at risk (VaR) also uses probabilities to estimate worst-case scenarios with various levels of confidence – typically 95–99%. It has been popular in finance. There are several methods for calculating VaR, including historical observations; expected return and standard deviation; and Monte Carlo simulations. The problem with the standard VaR

is that the estimated worst-case scenarios usually are based on normal distributions using historical data, and extreme events or movements are ignored; this means the potential risk can be understated. A famous illustration of the failure of EV and VaR was at the hedge fund Long-term Capital Management (LTCM). The VaR model at LTCM is reported to have estimated its daily risk to be $45 million, but it ended up losing $1.71 trillion in one month of trading (Morley 2000). The normal distribution-driven VaR had estimated that such an outcome should only have occurred every 800 trillion years. Nocera (2009) concludes the widespread use of VaR underpinned the global financial crisis. Haimes (2009) warns about using EV as the sole criteria for risk in decision-making because of its inherent limitation in dealing with events of high consequence and low probability – that is, the events that may happen 1% or less of the time. Haimes urges more attention in decision-making on 'expected catastrophic' impact or 'unacceptable risk', drawing attention, as an example, to the chaos that would happen if bridges, homes and industrial buildings were constructed to withstand the average, normally distributed wind or earthquake. CBH (refer to case studies section above) is enhancing VaR by using stress test measures to reflect capital at risk in extreme situations.

Haimes (2009) suggests that the use of models based on conditional expectations can add significant value to decision-making in risky environments. The Partitioned Multi-objective Risk Method (PMRM) identifies a number of damage (or opportunities, depending on what the objective is) ranges or partitions, and generates conditional expectations of damage, given that the damage falls within a particular range. This still requires estimation of partitions, but the possibility of a catastrophic event with low probability is now included in the model. The PMRM generates a number of conditional risk functions (or damage functions) that represent the loss, given that the damage falls within specified probability ranges.

Conditional probability is not a new concept, and originated with Bayes in the eighteenth century. In short, it is based around the concept of incorporating evidence or new information to update beliefs in an adjusted model. A Bayesian model is understood to have been used in the risk assessment of the Murray Darling Basin Plan (Murray Darling Basin Authority 2012). PMRM splits or partitions the outcome possibilities into ranges, each with different risk profiles. PMRM was designed to deal with extreme events. While conceptually simple, the PMRM does rely on defining inputs for which there is little or no data, and eliciting this data from experts can still be a challenge. Nevertheless, it does provide a focus on the extreme event and searches for a structure that is ignored by standard EV and VaR methods. Conditional VaR (CVaR) has been developed and experimented with to improve the standard VaR. CVaR is the expected loss for a desired confidence level, given that the loss is greater than or equal to the loss at that level. That is, it measures the downside of risk, assuming all risks are known. It doesn't measure unknown risks unless they are explicitly included. CVaR can be adapted to active risk management of assets, and may find application in areas of the food-supply chain, with large numbers of assets having non-symmetric loss distributions – a situation that might not be uncommon in situations exposed to unpredictable climate conditions.

4.4.4 Risk management of information gaps

The results of this study indicate that the most common risk management constraints faced by Australian food organisations are a lack of good-quality and reliable information about climate change and uncertainty about future climate change scenarios. Over 80% of case study respondents indicated that these information gaps were a moderate to severe or binding constraint to effective risk management. This

prompted a call by many survey respondents for interventions to improve the quality of information on climate change impacts. Information gap decision (IGT) theory has arisen to deal with conditions of severe uncertainty with a view to improving robustness and resilience to failure caused by information gaps. The Australian Centre of Excellence for Risk Analysis (ACERA) was established at the University of Melbourne to 'develop the practice of risk analysis by creating and testing methods, protocols, analytical tools and procedures to benefit both Government and the broader Australian community'. ACERA funding is managed by DAFF, and a large part of its research has dealt with biosecurity and information gaps, including environmental management issues. ABARES has produced a number of research publications and several software tools for improved risk management, including:

- the Multi-Criteria Analysis program for Spatial Decision Support, featuring integration of mapped information with other related desk top information on risk analysis (stated to be suitable for managers, policy-makers and land use researchers)
- a growth outlook tool suitable for livestock producers, which uses rainfall and indices of soil moisture and pasture growth for the previous nine months and an outlook for the next three months for over 3300 locations across southern Australia

Hayes (2011) conducted a detailed review of uncertainty and uncertainty analysis methods used in risk assessment. He identifies four basic sources of uncertainty:

- uncertainty that arises through the vagarious nature of language (linguistic uncertainty)
- uncertainty created by our limited understanding of natural systems (epistemic uncertainty).
- uncertainty created by the irreducible variation in these systems (variability)
- uncertainty associated with our value systems and management decisions (decision uncertainty).

It is important to keep these different sources of uncertainty separated and under control during risk assessments. It has been shown that risk assessments that do not explicitly attempt to separate linguistic uncertainty and epistemic uncertainty from variability can provide ambiguous and/or over-confident predictions (Hayes 2011).

IGT has been developed as a non-probabilistic tool to deal with situations of extreme uncertainty – that is, where the payoff generated by a decision depends on an unknown parameter. It has been used in environmental analysis, though Sniedovich (2011) provides a detailed but constructive critique of the model's non-probabilistic validity and claim to be suitable for dealing with severe uncertainty. It is seen to be built around the 'Radius of Stability' model, which is not that new and may have its origins with Wilf (1960). Sniedovitch (2011) expresses reservations about using IGT for treatment of events with severe uncertainty. He suggests that better results may be achieved with 'Robust Optimization' models when dealing with severe uncertainty. This

type of model is suitable where robustness is sought against uncertainty and/or variability in the value(s) of problems. Mulvey et al. (1995) describe a solution as being solution robust if it 'remains close to optimal for all scenarios of the input data', and model robust if it remains 'almost' feasible for all data scenarios. Instead of point estimates, problem data is described by a set of scenarios.

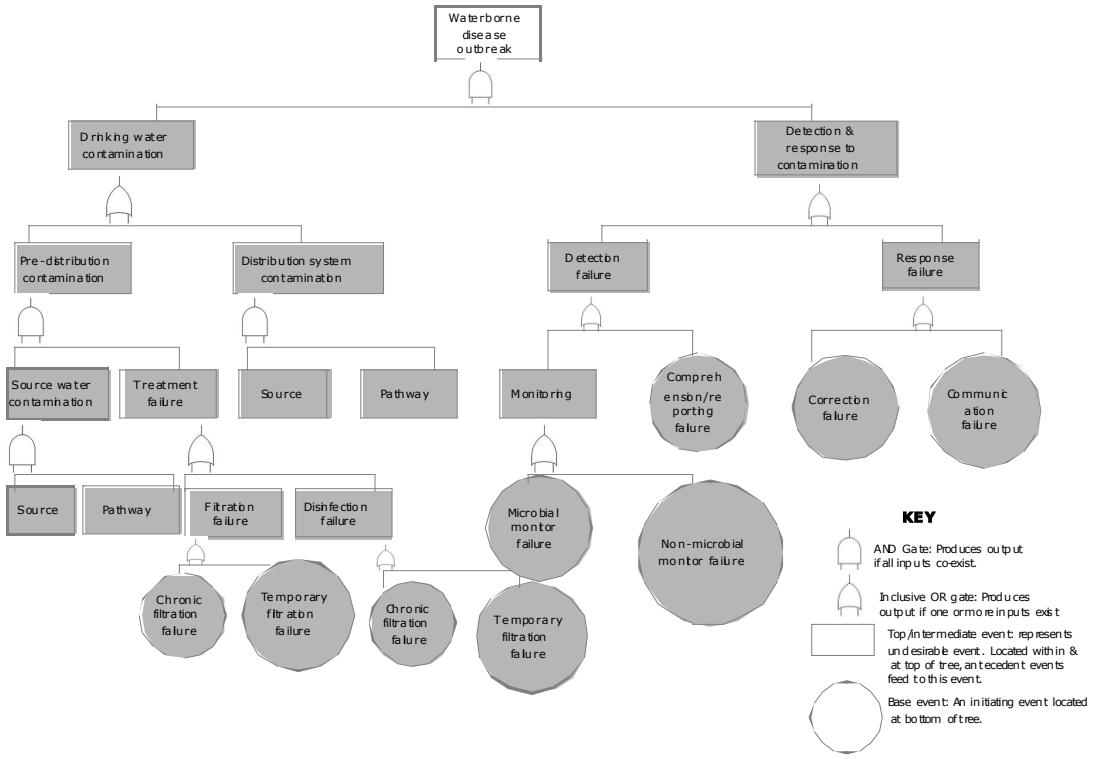
Mulvey et al. applied the robust optimisation model to several food industry situations, including feed ration formulation and a power system capacity expansion decision that is not unlike a decision to build a bulk commodity storage terminal. Demand for grain storage varies over time – within the day, between seasons and between years. Investments in handling facilities and transport add to the complexity of decision-making in this area. Risk-solving software has made analysis relatively easy using robust optimisation models, but problems remain in dealing with non-linearity. Weaver and Moon (2011) used robust optimisation to enhance ERM strategy for food perishables, showing that the robust optimisation model can prevent or limit loss when a firm encounters the worst-case demand.

4.4.5 Reliability and fault trees

Fault tree analysis has been used to examine the reliability of systems and to isolate the contribution to unreliability of particular components from which corrective actions can be initiated. In brief, an undesired state of the system is specified and the component sources (human and physical) of failure identified. The fault tree is a logic-based graphic representation of the sequential and parallel combinations of faults that can give rise to reliability problems. Haimes (2009) defines reliability as the conditional probability that the system (or component thereof) will perform its intended function(s) throughout an interval, given that it was functioning correctly at the start. Fault tree analysis can identify potential weaknesses in a system or the most likely causes of failure.

Domenech et al. (2010) used fault tree analysis to supplement predictive modelling in an assessment designed to improved food safety in pasteurised milk. Risebro et al. (2007) used it to examine the causes of enteric disease outbreaks in public drinking water supplies (Figure 28). Fault trees were used by Arvanitoyannis et al. (2007) in conjunction with HACCP to enhance food quality control in chocolate manufacturing plants.

Fault tree assessment attributes include that it is visual, with easy-to-follow and easy-to-see cause–effect relationships (Erickson 1999). It is probability based, which may mean eliciting input data from stakeholders. It has limitations, however, when required for applications that require minute detail about cause and effect, and tends to have application where visibility of the chain of events causing failure is required. This situation is changing, with increased availability of software that is capable of handling complex structures and relationships. It seems to have most application where it is used as a supplement to other models.



Source: Risebro et al. (2007)

Figure 28: Fault tree graphic: Water-borne disease outbreak

Haimes (2009) notes that the fault tree has attributes in identifying components that may require attention to prevent system failure, but it is important to recognise that standard fault-tree analysis assumes independence of components. Many systems contain components that are highly correlated with each other, and it is therefore important to closely examine the relationship between variables of interest, otherwise the true drivers of failure may not be identified and reliability compromised. Fault tree objectives can also be compromised by information gaps and an absence of qualitative data on significant components that can be measured only with qualitative data (e.g. human errors).

4.4.6 Scenario analysis

Scenario analysis is a strategic planning methodology for identifying and analysing future events and outcomes that are considered possible and relevant to planning for uncertainties. It has been used in planning for extreme events, including 'Black Swans', but Taleb (2010) says 'scenario analysis' and 'stress testing' are 'sucker's methods' because they still don't know what to stress test for or what scenario is relevant, since we don't know enough about what the future scenarios are to even guess what they might be. Scenario analysis emerged formally at Royal Dutch Shell to support strategic planning in that company and out of concern for traditional forecasting methods (Grayson and Clawson 1996). It was observed that:

> *Forecasts are not always wrong; more often than not, they can be reasonably accurate. And that is what makes them so dangerous. They are usually constructed on the assumption that tomorrow's world will be much like today's. They often work because the world does not always change. But sooner or later forecasts will fail when they are needed most: in anticipating major shifts in the business environment that make whole strategies obsolete. (Wack 1985)*

Scenario planning has at least one measurable impact on decision-makers: improved awareness about future possible outcomes and the usefulness of being prepared for them. Godet (2000) observes that 'anticipation is not widely practiced by decision-makers because when things are going well they can manage without it and when things are going badly it is too late to see beyond the end of their noses'.

From the start, it is useful to keep in mind that scenarios are not predictions or forecasts about the future. Khan and Weiner (1967), military planners who are credited with being the originators of scenario planning, believed scenarios can answer two types of question:

- How might some hypothetical situation come about, step by step?
- What alternatives exist at each step for preventing, diverting or facilitating the development of this scenario?

Hawken et al. (1982) identify five basic categories that would, through trends, drive or influence scenarios: they are values; climate; the economy; energy; and availability of food. Within the climate category there have been several projects dealing more specifically with climate change. Broadleaf Capital International et al. (2006) used scenarios to define how the climate may be assumed to change in the future as part of a risk management framework. Garnett et al. (2012) scoped future scenarios for Northern Territory pastoral lands, and the people and managers who live and depend on those lands. An interactive 'Pastoral properties simulator' was developed around five future scenarios: business as usual; food first (food shortages); integrated future (diversity of enterprises on land that may now be only cattle grazing); quality first (featuring demand for higher quality product and reduced livestock numbers); and a worst-case scenario (featuring adverse climate change impacts, high fuel and energy prices, expansion of weeds and disease, and low productivity). The Victorian Centre for Climate Change Adaptation Research (VCCCAR) (2011) has used scenario planning for policy-making under conditions of complexity and uncertainty, and planning for climate adaptation. VCCCAR believes scenario planning is more relevant as a risk management tool under conditions of increasing uncertainty, which is often the case with extended time periods.

Scenario planning can be used – and possibly best used – as an enabler or facilitator for other risk management tools. Haimes (1981), writing at about the same time that scenario planning was emerging, developed Hierarchical Holographic Modelling (HHM) as a method (see below) for capturing the linkages and interdependencies between large-scale and complex systems and structuring of scenarios. It seems capable of augmenting scenario planning and provides benefits through reducing some of the fuzziness often associated with scenario planning.

4.4.7 Multiple objective analysis

Once upon a time, people and organisations had somewhat simple objectives, often with just one or maybe two dimensions like having sufficient food and shelter or, later on, maximising profit or wealth of shareholders, or providing a storage service for a cooperative member. These circumstances lead to advances in single-objectives models and simple optimisation solutions. There have always been multiple dimensions to decision-making, but there is now much more clarity and transparency about its multiple dimensions. Even in the most simple areas of decision-making, like share investment and design of optimal portfolios to maximise wealth, there is growing interest in multiple dimensions such as second-order risks,[18] sustainability of returns, short- and long-term returns, investment in environmental portfolios, and so on.

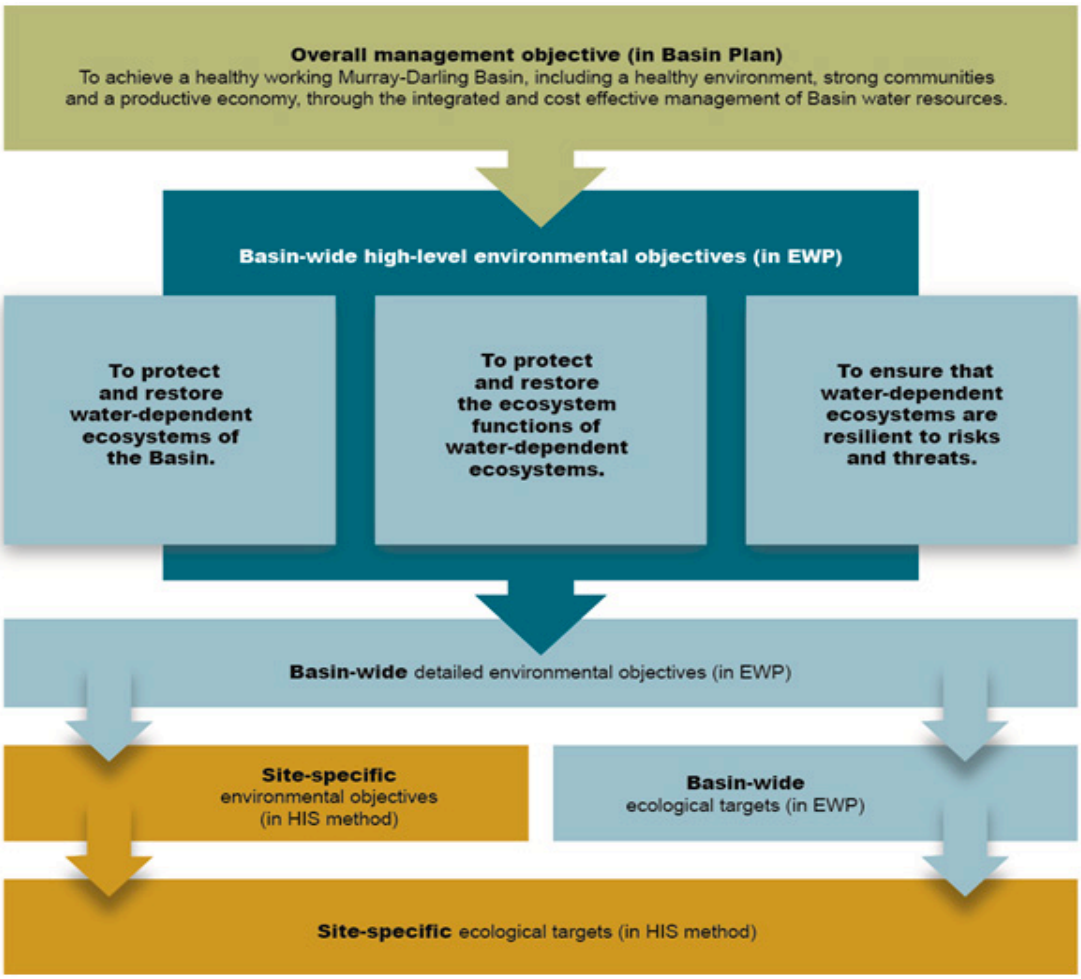
Multiple-criteria decision-making (MCDM) – or multiple-criteria decision-making analysis (MCDA) – has emerged as a method for structuring problems with multiple objectives. Once it is accepted that there are multiple criteria to consider, it becomes increasingly difficult to calculate an optimal solution for the problem without reaching agreement between the stakeholders on preferences and compromises, including for any redistribution effects. An optimal solution for MCDM, using Pareto conditions, can be defined as existing up to that point when an improvement in any one of the objectives can only be achieved at the expense of deterioration in the chances of achieving one of the other objectives. In the broader field of policy-making, it is recognised that, to avoid stagnation, compensation may be required (or at least be potentially payable from the benefits) for those adversely affected by a deterioration in one or more objectives. The Draft Basin Plan issued by the Murray Darling Basin Authority is an example of a hierarchy of multiple environmental objectives and ecological targets for the determination of environmental water requirements (Figure 29).

An inherent problem with the Pareto-optimising model is that it becomes increasingly complex as the number of objectives is expanded, and there is no better example anywhere in the world than that of the Murray Darling:

> *One of the key actions to achieving a healthy working Murray Darling Basin is the need to ensure that there is balance between the water needs of communities, industries and the environment, while at the same time protecting and restoring the ecological and other values of water-dependent ecosystems so they remain healthy. (Murray Darling Basin Authority 2012)*

The dilemma is that any reduction in the objectives to simplify modelling compromises the outcome by reducing the frontier of production and environmental possibilities to potentially inferior outcomes. One way of dealing with this problem is to examine the objectives with decision-makers to draw out priorities. This can be achieved through a process of questioning about how many units of one objective would be acceptable as a trade-off for another. Haimes et al. (1974) developed the Surrogate Worth Trade-Off Method (SWT) for dealing with multiple objectives while preserving non-inferior solutions. It has been used for water resource systems analysis.

[18] First-order risks can be viewed as the first round or initial impact risks of a directional nature like exposure to market price uncertainty. Second-order risks emerge in response to a first order shift and may not follow in a symmetrical way. For example, volatility may change. These second-order effects have prompted growing interest in measuring second order effects.



Source: Murray Darling Basin Authority (2012).

Figure 29: Hierarchy of environmental objectives and ecological targets for the determination of environmental water requirements

In a similar vein, a trade-off procedure has been used for some time in product design and development using a statistical technique known as conjoint analysis to determine how users value different features that make a product or service. It is used frequently in consumer testing of new products and services.

The main advantage of conjoint analysis over MDS is that it has a direct relationship with the product or service attributes though that can also be a problem when the attributes are chosen in advance as is the typical case. Paul Green developed multidimensional scaling (MDS) techniques and conjoint analysis for the design of new products and services (Green and Rao 1972). Conjoint analysis is gaining increased interest in the health sector as a technique to measure patient and other stakeholder preferences, and to identify and evaluate the relative importance of feasible outcomes. The International Society for Pharmocoeconomics and Outcomes Research (ISPOR) now has a special working group on developing conjoint analysis for improved health outcomes.

4.4.8 Organisation of risk management and Integration of components: Governance, accountability, compliance

Governance, risk management and compliance (GRC) is a term that has gained increasing coverage over the past decade, especially since the global financial turmoil of 2007 and before that the regulatory changes initiated by the Sarbanes-Oxley Act in the United States, the Higgs Report in the United Kingdom, development of the Australian Stock Exchange (ASX) Corporate Governance Guidelines in Australia, OECD Corporate Governance Guidelines and various standards for good governance, codes of conduct for organisations and so on. Corporate governance guidelines now have almost universal recognition of risk management and the requirement to effectively manage risk. It is now more than simply a compliance issue. The ASX (2007) guidelines for governance principles state:

> *A decade ago, the term 'corporate governance' was barely heard. Today, like climate change and private equity, corporate governance is a staple of everyday business language and capital markets are better for it.*

There have been various definitions presented for governance (United Nations Economic and Social Council 2006). The World Bank (1993) defined governance as 'the method through which power is exercised in the management of a country's political, economic and social resources for development'. Organisations other than the 'country' structure could be used within this definition. For example, a corporation may also be the family farm. The ASX (2007) defines 'corporate governance' as 'the framework of rules, relationships, systems and processes within and by which authority is exercised and controlled in corporations':

> *It encompasses the mechanisms by which companies, and those in control, are held to account. Corporate governance influences how the objectives of the company are set and achieved, how risk is monitored and assessed, and how performance is optimised.*

The ASX governance guidelines contain eight principles for corporations and listed organisations:

- Lay solid foundations for management and oversight.
- Structure the board to add value.
- Promote ethical and responsible decision-making.
- Safeguard integrity in financial reporting.
- Make timely and balanced disclosure.
- Respect the rights of shareholders.
- Recognise and manage risk.
- Remunerate fairly and responsibly.

Risk management is embodied directly in Item 7 of the ASX principles, and indirectly within most of the others. The ASX Principles state that 'a company should establish a sound system of risk oversight and management and internal control', noting a range of guides on risk management including ISO 31000 and the COSO Integrated Risk

management-Integrated Framework. The risk management system is recommended to include identification, assessment, mentoring and management. The ASX guidelines state further that:

> *each company will need to determine the … 'material business risks' it faces. When establishing and implementing its approach to risk management a company should consider all material business risks. These risks may include but are not limited to: operational, environmental, sustainability, compliance, strategic, ethical conduct, reputation or brand, technological, product or service quality, human capital, financial reporting and market-related risks.*

It seems to be just a matter of time before all supply chain participants will be brought into the risk management and governance systems of the supply chain leaders. The hierarchical nature of the food-supply chain means the risks of the whole chain are going to be governed to some extent by the weakest link (refer to next section for some solutions to this problem).

There is an alignment between the ASX principles for good governance and the ISO 31000 standards. While the ASX principles are directed at listed organisations, they are just as relevant for unlisted organisations of various sizes, along with regulators, a number of which exist in the Australian food-supply chain. It is increasingly evident that the growing convergence of governance, risk, accountability and compliance is leading to the emergence of a specialised Risk Officer. Several of the case study firms examined in this project have specialised risk management professionals with the capacity to deal comprehensively with risk management in order to both protect organisational value and exploit the opportunities arising from uncertainty.

The OECD (2010) found that:

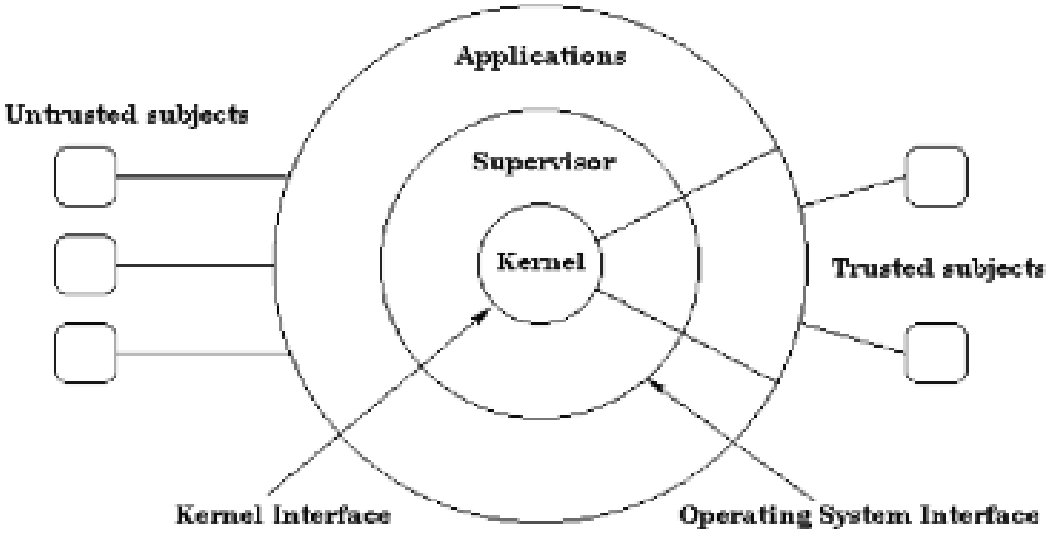
> *there is great potential to improve the operation of risk policy as few governments have taken steps to develop a coherent risk governance policy for managing regulation … Risk-based approaches to the design of regulation and compliance strategies can improve the welfare of citizens by providing better protection, more efficient government services and reduced costs for business ...*

The OECD review of regulatory reform seems as relevant to Australian regulatory authorities, including food industry regulators, as it is to other countries and their regulators.

Many case study respondents rated regulatory risk as an almost certain element of their risk exposure, and most considered it possible to almost certain to occur over the decade ahead. Moreover, regulatory risk was seen as often likely to have either catastrophic or major consequences for their businesses. Many respondents indicated regulatory uncertainty was constraining their risk management systems. Responses from regulators also suggest some organisations have significant potential to improve their risk management systems, including those with formal risk management systems. At least one regulator indicated urgent improvement was required to their risk management framework in terms of helping them achieve their objectives.

4.4.9 Security kernels

The growth in storage and processing capacity of computerised information and communication systems has created challenges for safeguarding information systems and selection of reliable software, systems, personnel and operating partners. The security kernel is the centre or nucleus of network security, and has emerged as a critical solution component to create a trusted computing base and information network. The kernel is essentially an information gatekeeper that ensures it is impossible to access data when and where the user is not authorised (Figure 30).



Source: Houvinen (1998)

Figure 30: Structure of kernel-based operating system

Food security is exposed to weaknesses in security kernels which may be technological or policy driven. Network security policy describes the rules and regulations of computer access and use. The modern food system is an intensive user of information and new technology and it is an important source of competitive advantage throughout food-supply chains. At the same time, intensive users of information and associated technology are exposed to the associated risks of attack and faults.

Nearly 40% of case study food firms are developing their data collection and information and management systems further to enhance their capacity to deal with climate change. Information and communication technology risk, data governance risk and critical systems risk is ranked as possible to almost certain by over 50% of case study organisations. Over 20% of firms indicated these risks are likely to have a major or catastrophic impact on organisational value.

4.4.10 Hierarchical holographic models and others

The food-supply chain features close linkages between the vertical stages of sourcing inputs, production, distribution (to both export and local users) and storage, processing and wholesaling and retailing. At the same time, there are support activities (infrastructure, technology, human resources, regulators, education and health

services) that enable food products to flow safely and efficiently along the chain to end consumers. The risks associated within each of these supply chain stages and support activities contribute to the risks of the food-supply chain system. The risk of the overall system is only as strong as the weakest link. If infrastructure fails, for example, there is greater risk that the food delivery system will fail unless an effective substitute or support mechanism is in place and capable of being used by a large proportion of participants.

Hierarchical Holographic Modelling (HHM) was developed by Haimes (2009) to structure and evaluate the risks of large systems with sub-systems. It seems to be well suited to the food industry, and is especially appropriate for supply chain leaders. It has been used in models of water distribution (Haimes 1974), intelligence analysis and tracking for control of terrorism (Horowitz and Haimes 2003), critical infrastructure (Ibarra et al. 2006; McDaniels et al. 2007) and various research projects on complex ecological and sustainability risks. An important feature of HHM is that it can capture graphically the inherent diversity and scope of risks of a system that otherwise can be overwhelming in terms of details and uncertainty about whether or not all risks are considered.

HHM starts typically with an identification of the key risk issues, which are then decomposed into head topics and a hierarchy of sub-head topics. The head topics present decomposition options, which could be of a functional nature, temporal, product (e.g. food type), technology, environmental and so on.

A generic agricultural food-supply chain map is shown in Figure 31 for illustrative purposes only. This could be the start of an HHM for a diversified food conglomerate, out of which key risks are identified and decomposed (for example, Figure 32).

Application of the HHM model requires careful definition of the objectives. For example, the objective of the risk assessment might be to estimate the impact or consequences of a supply chain disruption on the output of a particular firm or supply chain or region. There are various ways and levels of detail for developing the model that supports the objective. Haimes (2009) and Ibarra et al. (2006) describe models that can be broken down to include functional, geographic and temporal perspectives by incident, financial loss, disruption, environmental damage and so on.

It's emphasised that there is no generic HHM applicable to all food organisations. The risk criteria are based on the unique objectives and standards of an organisation, and the external and internal context in which it is operating. The HHM model can be partitioned into sub-domains for more detailed analysis once the objectives are agreed and the scope of risks identified. These partitions could be based on timeframes (that is, long-term strategic scenarios and/or short-term scenarios), regions, operational decision-making and so on. Within the partitions, risk criteria can be used to tailor priorities based on objectives, and the degree and consequences of risks related to particular activities. Figure 31 shows a hypothetical matrix of risk likelihoods and consequences for a hypothetical food organisation using some of the case study interview results.

The next step in a HHM model could be an examination of interdependencies along the food-supply chain which are typically strong from several perspectives, ranging from physical flows of commodities and products at both a regional and infrastructure level through to information flows and economic impacts and multipliers.

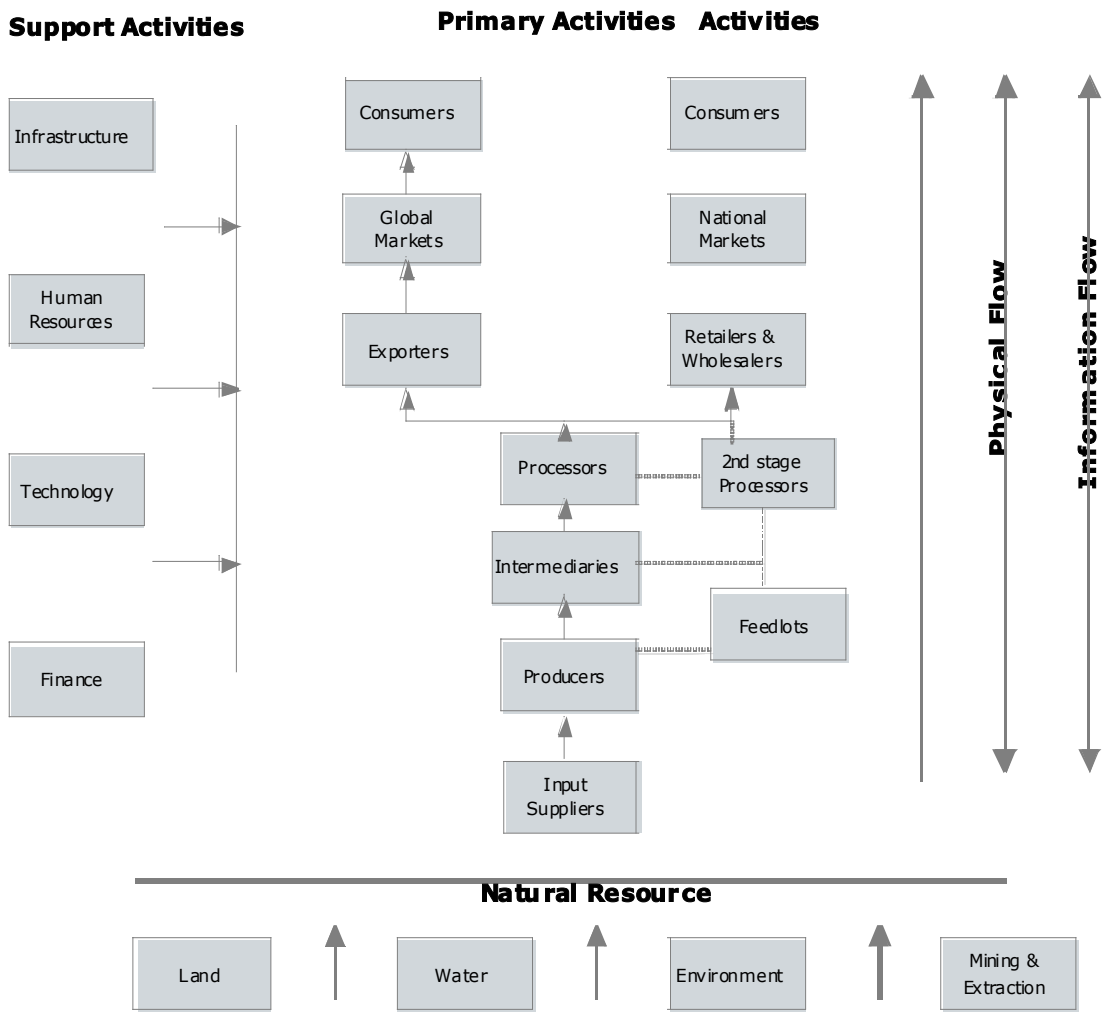


Figure 31: Food-supply chain map: by activity, resources and flows

At each of these levels, objectives and risks can be analysed for decision-makers with responsibilities for the associated performance area. The likelihood and consequences of risk areas can be assessed with a matrix-styled concept map, as shown generically in Figure 33. This figure is based on average responses to all risks identified in the question sheet, and includes responses that indicated the risk is/was not relevant and also responses that indicated they did not know or could not judge the likelihood or possible consequences. Further insights into these risks can be found through examination of median or mode values (Figure 32). The preferred way of examining the consequences an impact is at an individual organisational level. Moreover, it is emphasised that these maps of likelihood and consequences raise serious questions about emerging conditions such as climate change and interaction with other stressors, including health, water, regions, vulnerable populations, national security, infrastructure and economic conditions. The US Environmental Protection Agency has identified regional and international impacts of climate change, noting that 'climate change is an inherently global issue, the impacts will not be felt equally across the planet'. That qualification can be extended to firms – that is, the impacts of climate change will not be felt equally across firms and farms, even within the same districts.

Interregional linkages between commodity production, storage and distribution, imports, exports, first and second stage processing and retailing and wholesale take on particular significance in the Australian food-supply chain, especially when extreme events occur (e.g. floods, droughts). Quantification of risks from the selected dimensions is being undertaken with input–output models (national, regional levels, Bayesian models, multi-level risk models and many others (Haimes et al. 2007). The potential of input–output models for mapping the interdependencies along food-supply chains and vulnerability to external shocks is unexploited. Among the advantages of input–output models is access to regularly updated data at regional, national and sub-industry levels.

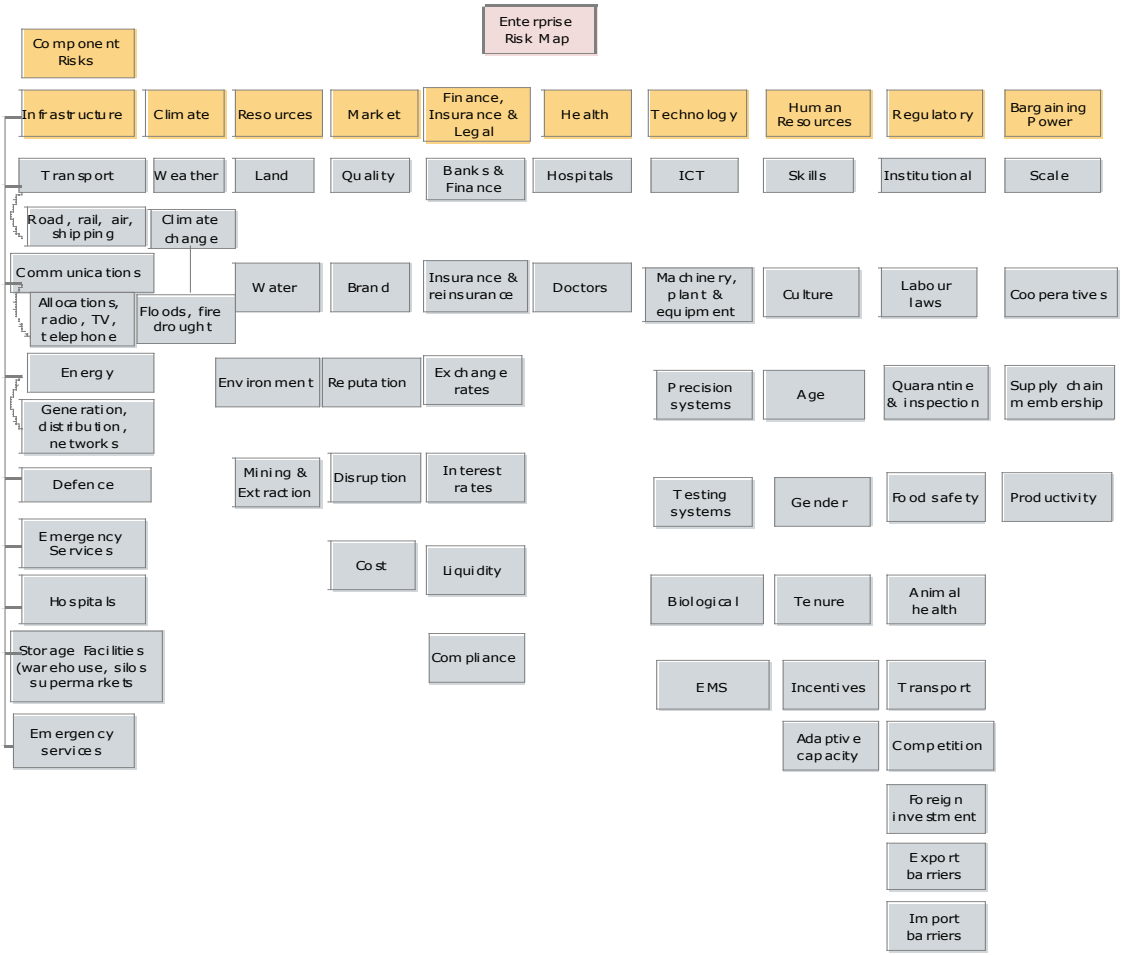


Figure 32: Initial synthetic food-supply chain risk map

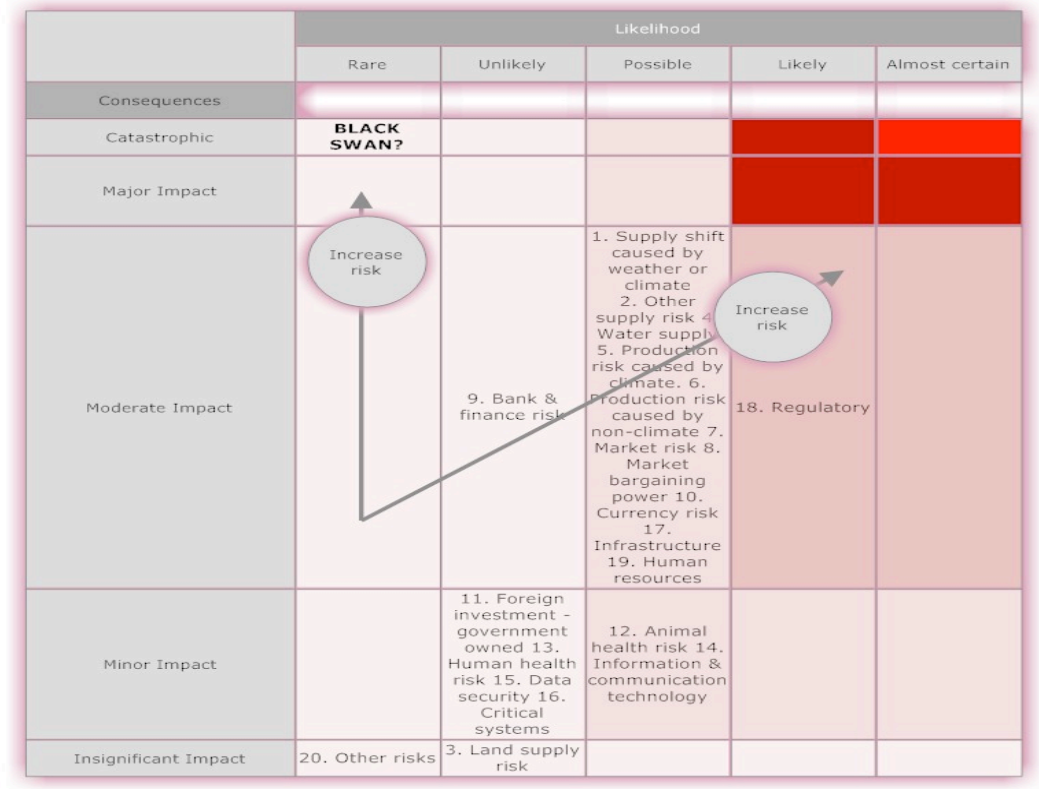


Figure 33: Risk concept map: Hypothetical, based on average case study responses, after mitigation

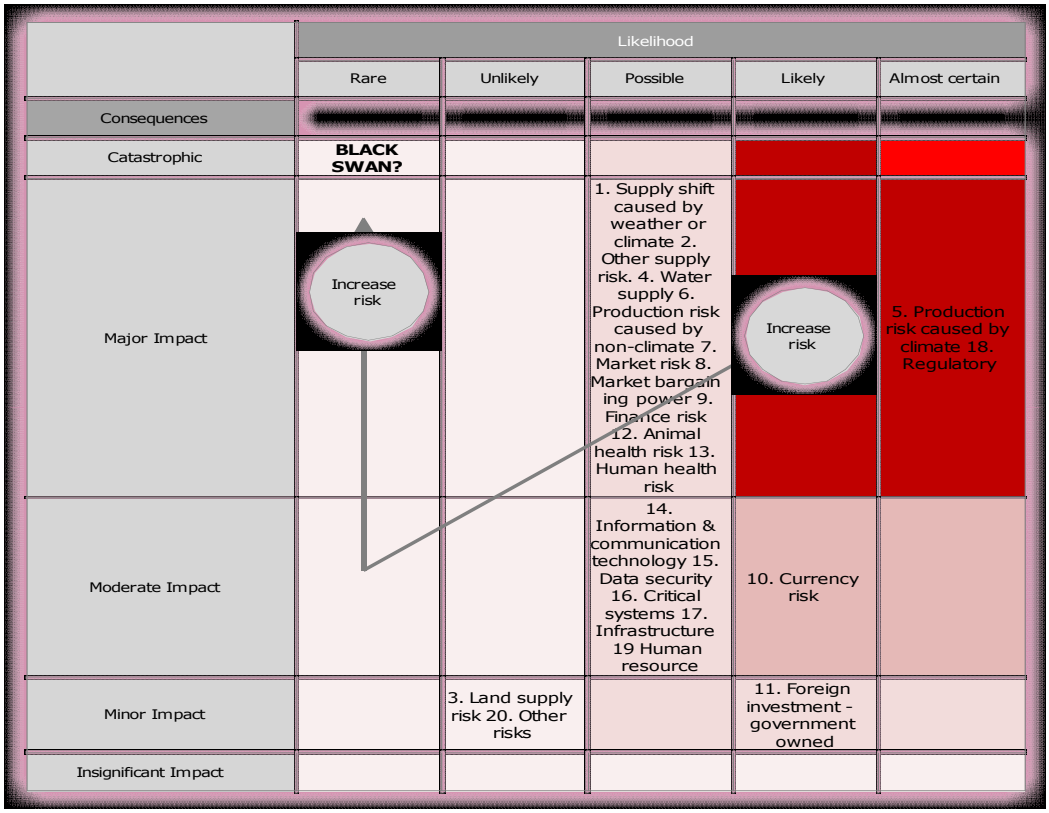


Figure 34: Risk concept map: Hypothetical, based on mode, after mitigation

4.4.11 Business Continuity Management (BCM)

Business Continuity Management (BCM) is defined as the development, implementation and maintenance of policies, frameworks and programs to assist an entity manage a business disruption, as well as build business resilience (Australian National Audit Office 2009). It applies to both public and private organisations. BCM is an essential part of good governance, effective risk management and the capacity of an organisation to manage unexpected incidents, respond to emergencies (including floods and fires) and recover from disasters. Several leading food case study organisations have effective BCM programs and practices in place, which are monitored or audited along with regular performance reviews – often within an ISO 31000 framework or within ISO 22301 or AS/NZS 5050: 2010.

As with governance and risk management, BCM requires commitment from the most senior levels of management to ensure that a BCM culture is in place. One indicator of BCM is resilience, which is defined as the adaptive capacity of an organisation to a changing and complex environment. Risk management, BCM and resilience converge in terms of contributing to effective governance and protecting organisational value, policies, values and goals.

BCM takes on added importance as a measure for dealing with extreme events, including adaptation to climate change impacts such as floods, storms, fires, droughts and pandemics. The Department of Agriculture, Fisheries and Forestry (2012) has a detailed business continuity framework that is consistent with recognised standards, ensures regular review and continuous improvement, and promotes an internal culture of collective and individual responsibility for effective BCM. Among the organisational features of DAFF's BCM are:

- the appointment of a Critical Incidence Manager in response to any significant business interruption
- the assignment of BCM responsibilities at senior levels of management
- the requirement for an Audit Committee to evaluate BCM performance
- the appointment of a BCM improvement committee.

The Australian National Audit Office (2009) has designed a comprehensive Guide for BCM, and although it applies mainly to public organisations it is equally applicable to private sector businesses, including small businesses. Several state governments, industry organisations and Emergency Management Australia have developed BCM toolkits and training course for small businesses:

- http://toolkit.smallbiz.nsw.gov.au/chapter/18/88
- http://www.sa.gov.au/
- http://www.smallbusinessforum.com.au/do-you-have-a-business-continuity-plan/
- http://www.em.gov.au/.../Business%20continuity%20Management.DOC.

Organisational leadership plays a critical role in risk management, BCM and resilience. Without committed leadership, it is difficult, if not impossible, to achieve the organisational culture required for managing risk effectively and comprehensively. The Australian Emergency Management Institute (2012) offers a professional development program to enhance leadership skills in managing crisis situations, and improving

resilience through effective BCM. Unprecedented incidents and events sometimes require different, innovative and more flexible thinking about ways of responding to non-typical events.

4.4.12 Transformation now or later: Real options

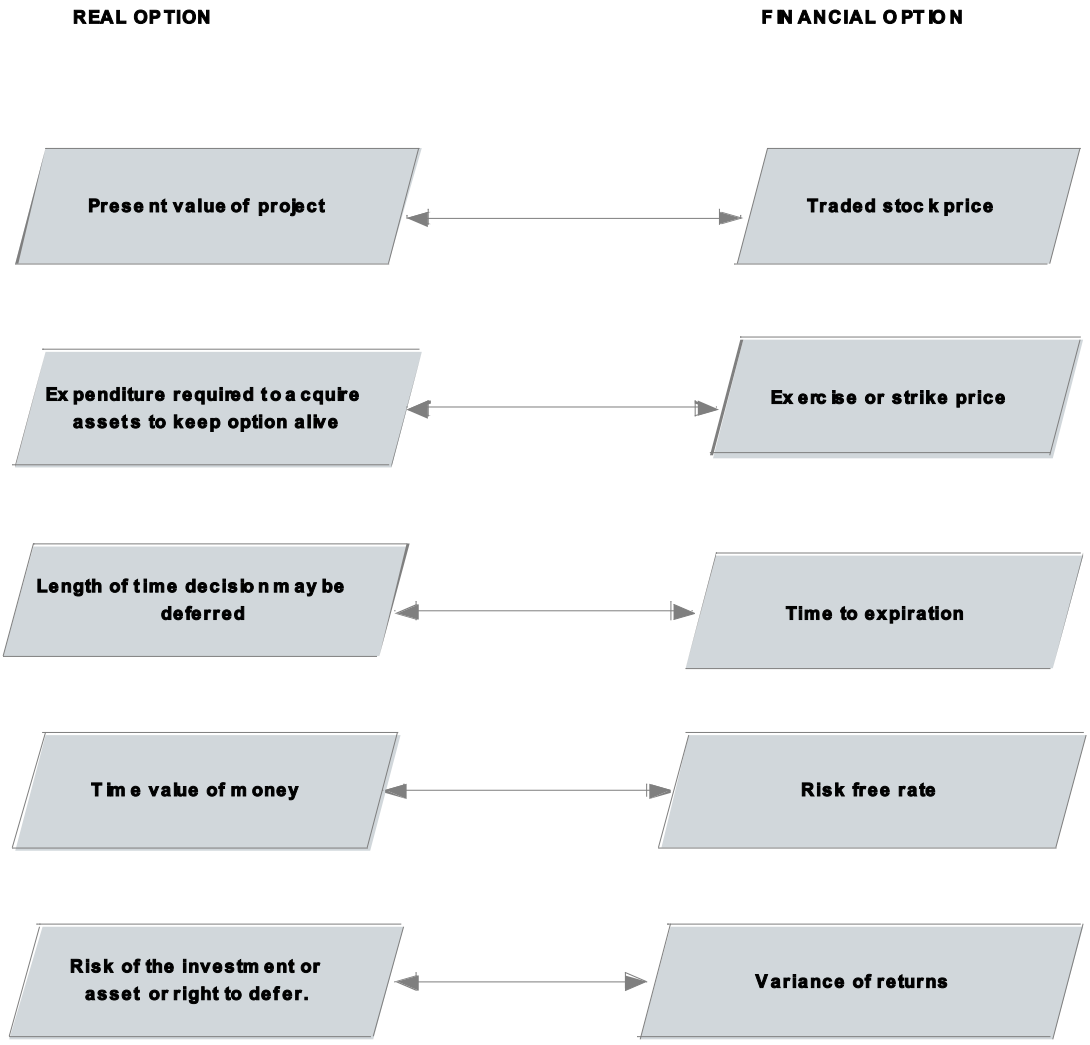
Real options may have potential for dealing with the uncertainty of climate change impacts and the regulations surrounding climate change. A real option has similar conceptual features to the more familiar financial option, the main difference being that it is not a financial derivative but a real option for a tangible asset. It provides a right but not an obligation to fully invest, for example, in a building or water dam, or even defer expansion or relocation of an investment. The real option has potential value for dealing with activities that feature significant uncertainty about the future value of an asset or series of cash flows, or costs or benefits. It may, for example, be useful for locking in a right to some asset where the quality of information about it improves over time. A real options approach underpinned the Productivity Commissions (2012) recommendation to prioritise reforms that deliver benefits in the current climate and defer decisions based on possible future but highly uncertain climate scenarios. Improved risk management and capacity to adapt to climate change are seen by the Productivity Commission as high priorities because they can generate benefits with few regrets, regardless of what happens in the future – for example, improved risk management will be useful irrespective of the type of risk being prepared for.

Valuation of options is based around a current spot price or asset price or investment cost; an estimate of future volatility and strike price or exercise price; and the time from now until the option has to be exercised or expiry. The premium for financial options is determined generally in financial markets through exchange trade options. The link between real and financial option inputs for valuation is shown in Figure 35.

The market and non-market valuation is where the real option differs significantly from the financial option because there is no ready market at expiration or exit for the real option. Real options can be classified into three main groups: invest/grow options, defer/learn options and disinvest/shrink options; however, as Mauboussin (1999) observes, real options are more relevant to strategic planning and a new way of thinking about uncertainty and how value can be created from uncertainty. Australia's agricultural producers will be familiar with the flexibility of the real options framework because they have implicitly been using it for many years (e.g. when they send breeding stock away on agistment or sell non-breeding stock during droughts. This provides security of access to scarce stock should the drought break or security of cash should it continue). In a similar vein, production of animals such as sheep for joint production of wool and meat provides an option to exploit one or the other when planning for uncertain future terms of trade. Dobes (2010) identifies a number of real options for dealing with climate change, the most prominent of which is investment in adaptation to uncertain climate change impacts including the subject-matter of this project. Among the examples cited by Dobes (2010) are:

- *Construction of a new airport runway.* In a hotter climate, longer runways may be required to enable planes to develop sufficient lift to take off safely. It is expensive to build a long runway immediately, and may turn out to be an unnecessary cost if temperatures do not increase as much as anticipated. A 'real option' could be the construction of a normal runway, but accompanied by the purchase of additional land at the end of the runway to allow for a possible extension later, if required.

- *Building protective barriers to guard against uncertain future floods.* Instead of immediately building an expensive high protective wall, a real option would be to construct only the base of a wall or embankment, but one that is capable of supporting, say, a 10-metre wall.
- *Building structures with flexibility to cope with varying climatic conditions.* The case study in section 4.3.5 shows how CBH has taken advantage of low-cost open grain-storage facilities to create additional capacity with the option to provide cover if climatic conditions change at some future point to justify further investment.



Source: Adapted from Luehrman (1968).

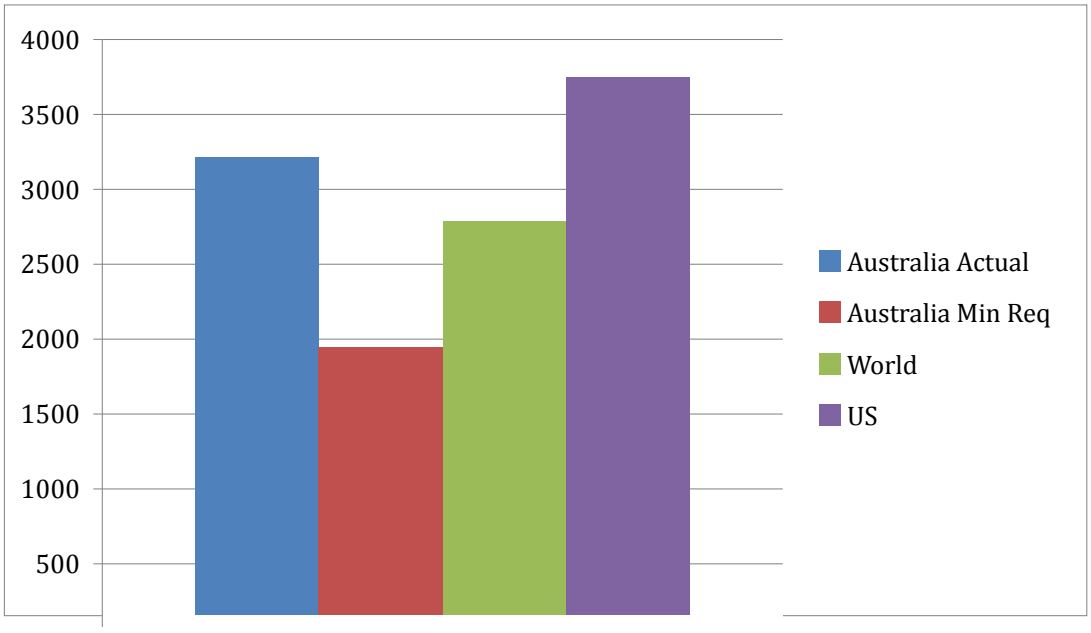
Figure 35: Link between real options and financial options

5 Discussion

5.1 Current situation and where we are now

Food security is delivered in Australia by a large and diverse number of businesses of various sizes, from agricultural production, through transport and storage, to processing, wholesale and retail. Support services, including traders and regulators, along with input suppliers of merchandise, add to the complex linkages of the food-supply chain. The Australian Bureau of Statistics (2012) estimated there were 2.1 million businesses operating in Australia in 2011, and more than one-third of these businesses (covering agriculture, storage and handling, food processing, restaurants, food transport, trading and regulation) are estimated to be operating in the food-supply chain in some way. Food retailers are reported to account for 32% of the road transport task (Waters 2012).

Australia currently has a high level of food security, with 'a large proportion of all people, at all recent times having access to sufficient, safe and nutritious food to maintain a healthy and active life'. Relatively high per capita incomes, supporting social security and high-quality human and animal health systems, a modern and competitive food retailing sector, low trade barriers and a globally competitive agricultural sector underpin Australia's food security. This background enables most people to enjoy a relatively high level of food consumption, as evidenced by consumption of dietary energy (Figure 36). Nevertheless, there are still around 105,000 people classified as homeless in Australia (Australian Bureau of Statistics 2008) – equivalent to 0.525% of the population – though there is some controversy over the validity of the estimates and the classification of actual and potential homelessness (Johns 2011).



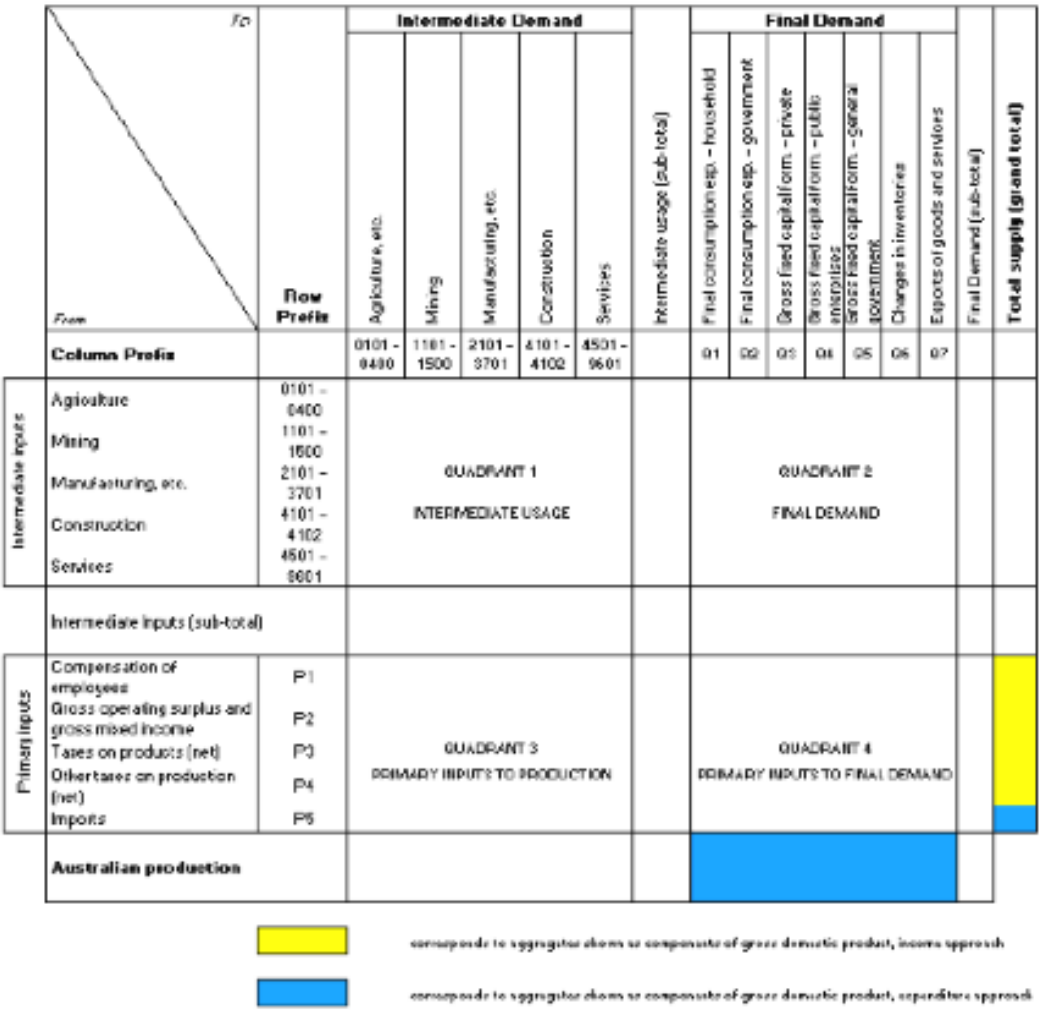
Source: Derived from FAO Statistics (2012).

Figure 36: Dietary energy consumption Australia, the United States and the world (kcal/person/day)

Food industry operations have close and dependent links along the supply chain, which creates potential vulnerability to systemic risks that could be driven by a convergence of negative influences, including climate change impacts, lack of adaptation and fuel supply disruptions. In addition, the velocity of risk (rate and change in direction of risk) may not be as stable as it has been in the past. Continued growth in population and per capita consumption of food, coupled with emission-reduction commitments and incentives to switch land use for increased sequestration, increasing resource constraints, soil degradation, biodiversity preservation demands, export commitments to help sustain global food security, incentives to switch land uses from food to energy production, threats of infectious disease outbreaks and growth of government-owned foreign investment in land and water have the potential to change food security stability in Australia. The likelihood of an adverse shift in food security seems low at a time of favourable weather conditions in Australia. Food security is likely to remain favourable for the future, with effective planning for the risks that lie ahead. At the same time, there is also upside potential to exploit.

The interdependencies along the food chain create the potential for cascading or chain-reaction effects from extreme or unforeseen events. Input–output models (Figure 37) have been used to identify and assess economic and physical dependencies along supply chains. Owusu, Mohamed and Anassimov (2010) used risk vulnerability co-efficient factors and input–output data to calculate cascading impacts from interruptions to critical infrastructure systems, observing that the impact varies according to resilience of the infrastructure to external influences and assumptions about the risk coefficient factors. There are multiple interdependencies along the food-supply chain including economic (captured by input–output tables), ecological, health, mechanical, logistical, jurisdictional and scale factors. Input–output tables reveal various levels of dependencies on imports for different food categories, ranging from almost 50% for seafood to less than 1% for poultry. Exports account for a significant proportion of final demand for meat and grains (22%) but less than 3% for poultry (Table 2). The food and agricultural sectors are relatively intensive users of road transport and transport support services (Table 3).

Several case study respondents indicated fuel and energy to be a high-likelihood risk with potential for a significant or catastrophic impact. Australia's domestic energy consumption (i.e. industry and household energy use) was 3,962 PJ in 2009–10, an increase of 39 PJ (1%) from 2008–09. The main fuels consumed were natural gas (24%), electricity (22%), diesel (18%) and petrol (16%) (ABS 2012). Along the food-supply chain agriculture (109 PJ), food manufacturing (125 PJ), transport (163 PJ for food (estimate of this study) out of 544 PJ for transport total), wholesale and retail (63 PJ for food (estimate of this study out of 121 PJ for wholesale and retail total) are the main users. Manufacturing is the largest user of domestic energy and food accounts for 12.1% of total manufacturing use. Total energy use along the food-supply chain in Australia is estimated to be 460 PJ, equivalent to 16% of net energy use by Australian industries. Manufacturing and transport are relatively intensive users of energy. Estimation of risk coefficient factors for energy and fuel use and resilience to shocks for the various categories of dependencies along the food-supply chain is beyond the scope of this project but it’s an area that would benefit from further research.



Source: Australian Bureau of Statistics (2012a).

Figure 37: Input–output table structure, industry by industry matrix

From the results of this study, 57% of food chain case study operators indicated that they had formal risk management systems and 43% informal systems, suggesting some awareness of the importance of effective risk management but with room for improvement. Firms with informal risk management frameworks and systems don't necessarily have risk constantly in their planning frameworks, and this is often suited to their size, structure and strategies for growth. At the same time, organisations with formal systems don't necessarily have the effective risk management systems suggested by the title. Three organisations with formal risk management systems indicated their risk management systems were in urgent need of improvement, or that they were unable to judge whether their systems were adding value and helping them to achieve their objectives. Several other firms that rated their risk management systems as excellent were not evaluating the risk of their suppliers or business partners. Firms with large turnover, large numbers of employees, large numbers of transactions, and large and lumpy capital investments have the most developed risk management systems. This is expected, as both the volume of transactions and the timing of capital investments affects the potential for exposure to uncertainty. Over 50% of firms with formal risk management systems judged that they complied fully with

most or all of ISO 31000:2009 principles, but many also indicated that they didn't know whether they complied or not.

Table 2: Food supply and use, industry and households: Australia, 2007–08 ($m)

Product	Industry use	Household final cons	Exports	Change inventory & other	Total supply
Sheep/grains/beef/ dairy	18,802	80	6,062	2,712	27,656
Poultry	3,795	626	124	34	4,579
Other agricult.	9,722	5,037	712	536	16,007
Aquaculture	584	473	68	63	1188
Fishing, hunting & trapping	921	437	354	45	1,757
Agriculture services	5,451	58	437	239	6,185
Meat & meat products	9,941	5,198	6,565	41	21,745
Processed seafood	1,426	505	475	–20	2,386
Dairy products	5,300	4,952	2,647	–7	12,892
Fruit/veg manufacture	1,838	3,738	605	11	6,192
Oils and fats	1,743	605	203	-9	2,542
Grain milled products	2,645	2,101	910	-5	5,651
Bakery products	1,951	4,794	455	9	7,209
Sugar & confectionery	2,636	3,090	1,180	–9	6,897
Other food manufactured	5,055	4,195	610	169	10,029
Soft drinks	1,641	3,477	174	–155	5,137
Beer manufactured	1,366	2,188	156	22	3,732
Wine, spirits	2,732	3,307	3,651	386	10,076
Retail trade (total)	4,827	64,782	555	3076	73,240
Wholesale trade (total)	49,136	30,322	10,952	20,182	110,592
Food & bev. services	9,011	43,458	2,468	0	54,937

Source: Australian Bureau of Statistics (2011c).

Table 3: Input use: infrastructure services, agriculture and food ($m), 2007–08

Product	Road transport	Rail transport	Air transport	Transport support	Telecom
Sheep/grains/beef/dairy	666	41	41	720	35
Poultry	102	5	3	138	9
Other agricult.	282	7	30	88	57
Aquaculture	13	0	1	5	2
Fishing, hunting & trapping	11	0	1	11	5
Agriculture services	122	3	10	38	23
Meat & meat products	1,357	16	5	115	45
Processed seafood	43	0	5	18	3
Dairy products	433	9	2	129	64
Fruit/veg manufacture	322	6	24	16	10
Oils and fats	67	3	9	17	3
Grain milled products	275	29	29	258	37
Bakery products	181	1	10	42	26
Sugar & confectionery	178	5	23	93	21
Other food manufactured	291	12	25	232	32
Soft drinks	93	1	7	93	32
Beer manufactured	153	10	5	145	8
Wine, spirits	145	5	12	37	29
Retail (total)	297 (571)	4 (4)	171 (329)	397 (764)	1020 (1,961)
Wholesale (total)	778 (1,496)	10 (19)	495 (952)	5166 (9,935)	1,258 (2,419)
Food & bev. services	787	13	76	115	585
Total	6,596	180	984	7,873	3,304

Source: Australian Bureau of Statistics (2011c)

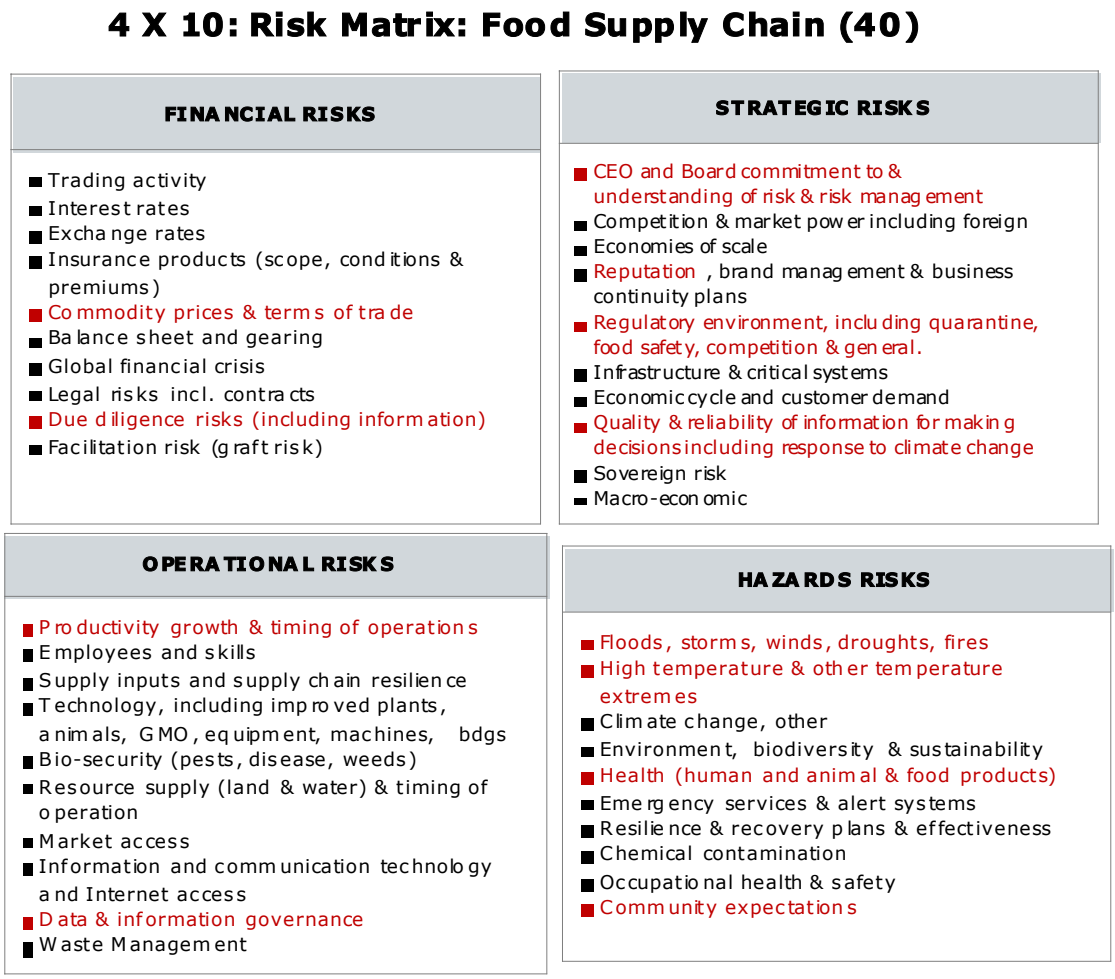
While many organisations with formal systems believe their systems are excellent or very good in terms of helping them achieve their objectives, too many appear not to have exposure to climate change impacts included in their risk management program. Climate change may be included in Environmental Management Systems, which are more often than not part of formal risk management programs. All firms with formal risk management systems have internal training as part of their risk management systems, and nearly all have internal codes of conduct. Less than 40% of firms with formal systems have regular automated monitoring of their business partners and suppliers. Over 40% of firms always perform due diligence into the risk of acquisition targets, but only 17% perform due diligence into the providers of forecasting and prediction services though lack of good quality information about climate change impacts is rated

as a constraint to effective risk management by almost 80% of organisations. Due diligence is conducted mainly internally, with about 20% using outsourced services. In preparing for future climate change impacts, most attention is directed to improved environmental management systems (66% of respondents with formal systems) and dealing with government risk regulations (40%).

Over 85% of respondents indicated their management was highly or quite committed to effective risk management and 43% indicated risk management was raised as a topic at monthly board meetings or more frequently.

Mixed messages emerge from the case studies about the quality of risk management in the Australian food industry. Smaller firms with fewer employees and fewer transactions have informal risk management systems, and many of these firms are in production or processing, or specialised support services. A number of these firms are dealing constantly with the same diversity of risks facing larger firms (as listed in Figure 38), ranging from markets to financial and environmental uncertainty; however, they don't have the same exposure to transaction volumes or the large lumpy investments. Resource constraints limit the capacity of small businesses to introduce advanced risk management systems, but in any event many of the small operators have long and substantial intergenerational experiences that provide them with sound risk management skills, given the size and nature of their business. A formal risk management system is not necessarily a sufficient requirement for an effective risk management system, with a few organisations rating their formal systems as ineffective or unable to be judged. More generally, the intensity of competition within the Australian food industry should ensure the most resilient firms with the best risk management systems improve their competitiveness. That is not necessarily the case with regulators who don't face the day-to-day pressure of a marketplace. Over 70% of case study organisations indicated regulatory uncertainty was a moderate to severe or binding constraint. Regulatory uncertainty, along with lack of good-quality and reliable information about climate change was rated by most organisations as the main constraint to the effectiveness of their risk management systems. Infrastructure is also rated highly as a constraint.

More than 60% of respondents rated human and animal health as possible, likely or almost certain risks to be dealt with over the next 10 years, and over 40% considered these risks would have either a catastrophic or major impact on them if they occurred. Health affects food security in several ways, but mainly via food-borne infectious diseases, which have the potential to penetrate food-supply chains and also have impact on productivity of labour in food organisations. The strong interdependencies along the food-supply chain facilitate information flows, but at the same time create the potential for vulnerability to extreme events, especially at a regional level and also within other countries depending on Australia for supply.



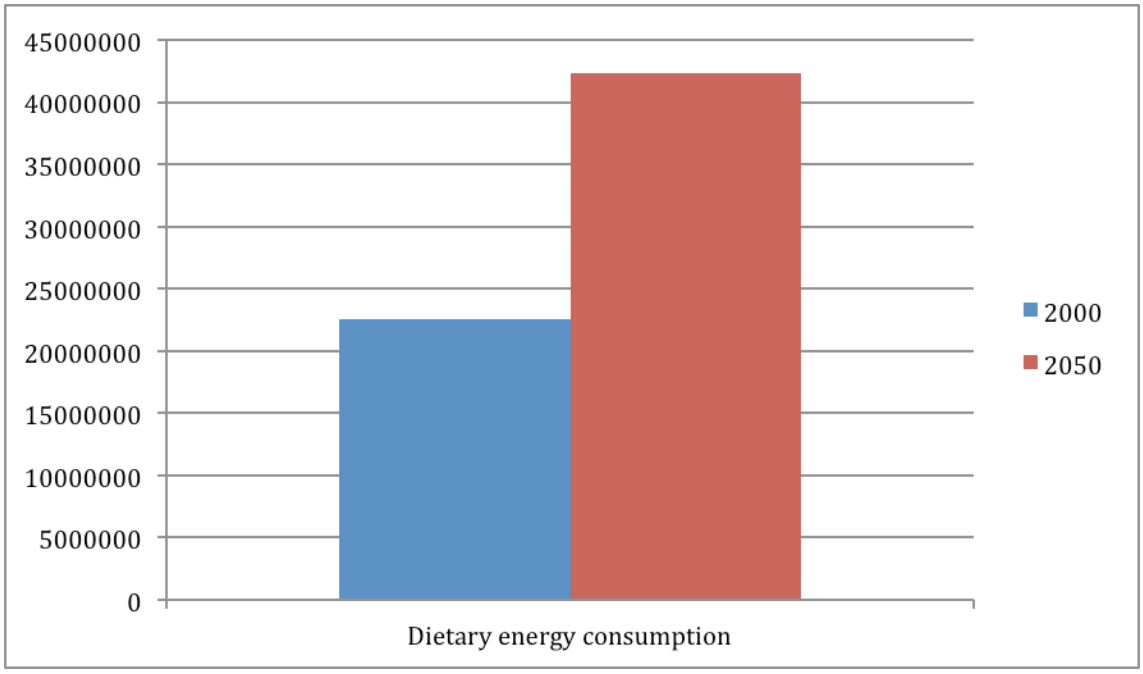
Source: Derived from all study sources

Figure 38: Risks identified from all sources, by category

More generally, there was reasonable awareness among the case study respondents of the role that improved risk management can play in building the resilience of their own organisations and to food security. Furthermore, there was significant awareness of the upside of uncertainty, with over 75% of the respondents indicating that they created value out of uncertainty through their sound understanding of risks. The case studies are likely to be representative of leaders in the Australian food-supply chain.

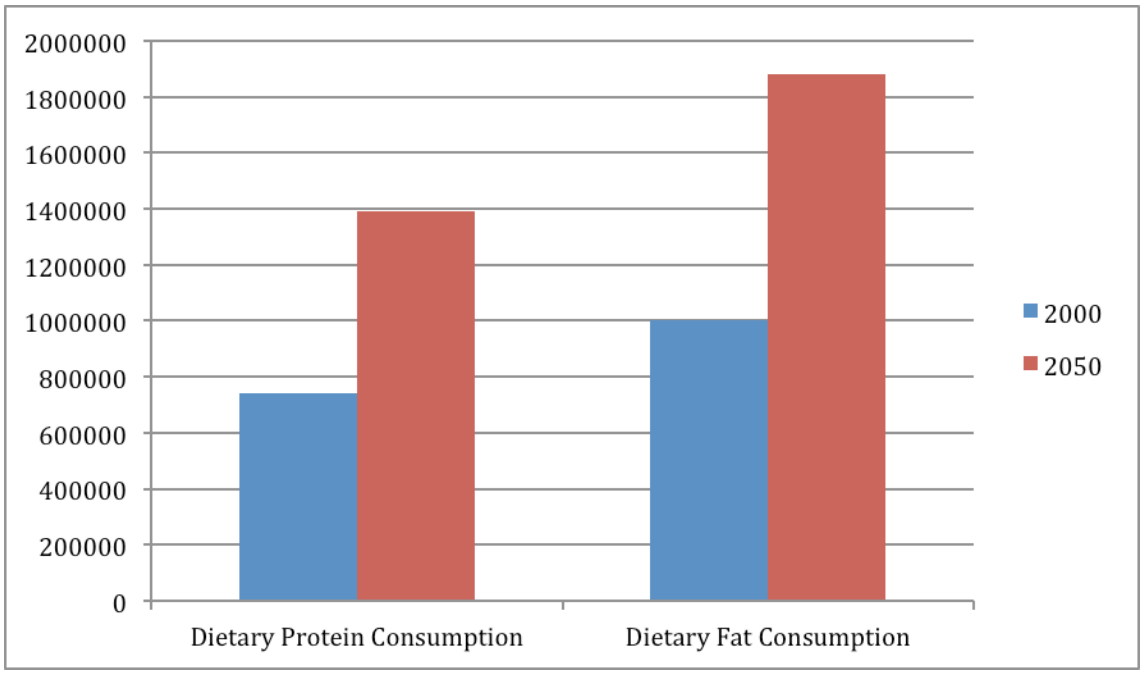
5.2 Future situation and where we could be or want to be in 35 years

The review of information and results of the case studies point to growing challenges in coping with uncertainty along the food-supply chain, both in Australia and overseas. First, without any change in per capita consumption of energy, fats and proteins, Australian food consumption is projected to be almost 90% higher in 2050 than it was in 2000, based on the population growing to 36 million people by 2050 (Figures 39 and 40). Over the half-century from 2000 to 2050, the Australian population is expected to grow by the same amount that it did over the previous 100 years.



Source: Derived from FAO Statistics (2012) and the Treasury (2010).

Figure 39: Dietary energy consumption: Australia, projections (million kcal)



Source: Derived from FAO Statistics (2012) and the Treasury (2010).

Figure 40: Dietary fat and dietary protein consumption projections (million grams)

Australia now has a relatively high level of self-sufficiency in food and significant capacity through high income to import any food required to make up deficits. For example, over 80% of cereals and over 40% of meat produced in Australia is exported, though that percentage varies significantly with climatic conditions. For the future, however, it is possible that the self-sufficiency now enjoyed will be under pressure from a combination of population growth and supply constraints. The case studies indicate a reasonably high level of confidence in dealing with the risks to which organisations are exposed, including climate change. Over 70% of respondents indicated that they were extremely confident or quite confident in dealing with the uncertainties to which they were exposed and nearly 50% indicated that their skills in managing climate change impacts were not a constraint to their capacity. This confidence was not tested to improve understanding of the basis, but it is an area for further research. A study of livestock and grain producers in the United States found 'optimistic bias' in climate change risk judgements where respondents rated the impact of climate change risk on themselves and their families lower than they rated it for nearby communities in the same districts (Safi et al. 2012). There may still be valid reasons for this if respondents believe communities have less capacity to adjust than individual producers do. Nevertheless, there may also be misplaced confidence, leaving enterprises with 'optimistic bias' that is vulnerable to climate change impacts.

Nearly 40% of respondents indicated climate change impacts had not been identified as a source of risk to their organisations and over 60% indicated that government assistance to improve capacity to identify, analyses and evaluate risk would be useful. There is some potentially contradictory evidence from the case studies, with several organisations rating the lack of good-quality information about climate change as a constraint to effective risk management, even though they don't include climate change as a source of uncertainty. This may, however, be due to perceptions about unconvincing quality of climate change impact projections. It may also be due to gaps in respondents' data-collection systems because the quantity and quality of climate information are changing daily. For example, climate models of CSIRO predicted the 2010–11 wet periods with a high level of accuracy 12–18 months ahead of the events (Beer et al. 2012). Climate change forecasters tend to have more confidence in the accuracy of their forecasts than the food industry case study users.

Food security in Australia is based on a unique and complementary combination of private and public organisational activity. The capacity to cope with the uncertainties that lie ahead will be driven largely by the resilience, and the risk and general management skills of these organisations. For this reason it seems important to be aware of and to reduce, where possible, the constraints to which these food organisations are exposed in creating an effective risk management culture for dealing with climate change impacts.

Two constraints stand out from the case studies as either severe or limiting an effective risk management culture for dealing with climate change:

- a lack of good-quality and reliable information about climate change (only 21% indicated that this was not a constraint)
- regulatory uncertainty (fewer than 30% indicated that this was not a constraint).

Additional constraints rated as having a moderate impact included:

- capacity to identify, analyse and evaluate risk
- high cost of risk management products (e.g. insurance, tailored finance)

- uncertainty about future climate change scenarios
- increased number of extreme events
- infrastructure reliability
- trade barriers to imports and exports
- lack of skills in managing the risks of climate change impacts.

From the information gathered in this study, these are the components of the existing road map that lead to uncertainty (see Figure 41).

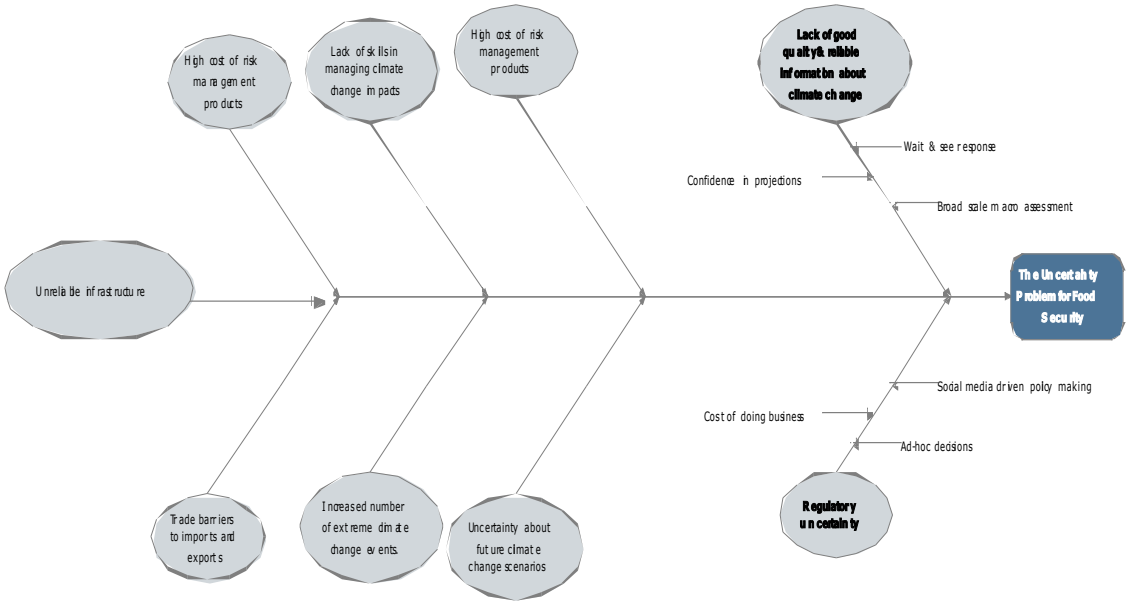


Figure 41: The uncertain road for food security

By 2050, there is likely to be almost universal agreement that Australia will still have to be a food-secure country, with a large proportion of all people, at all times, having access to sufficient, safe and nutritious food to maintain a healthy and active life. In addition, there is clearly a serious commitment among Australian food producers to international obligations.

Food security is ultimately an income or poverty problem, solved most readily through continued economic growth, which gives consumers the income and access to acquire the sufficient, safe and nutritious food required to maintain a healthy and active lifestyle. Australia's export destinations have to have the income to import the food. Nevertheless, Australia also has an obligation not to add to food security problems (by absorbing scarce global supplies of food and adding to price pressures) in other countries – especially the least-developed economies.

5.3 Roadmap to future food security

The Productivity Commission (2012) stated that 'uncertainty surrounding changes to the frequency, intensity, location and timing of extreme weather events requires a risk management approach to adaptation', and that 'policy reforms that would help people, firms and governments deal with *current* climate variability and extreme events should

be prioritised'. The case for reforms to address barriers to adaptation to uncertain *future* climate trends is seen by the Productivity Commission to be less clear, in part because of the risk of getting it wrong (especially where there are large up-front costs and uncertain future benefits) and in part because much of the adaptation is already taking place and is expected to continue to be implemented by households, businesses and communities.

The risk management approach has the potential to moderate or resolve the constraints listed above, and for this reason it is seen as the focal point for food security and dealing with the impacts of climate change and other external and internal influences on organisations. This applies to commercial as well as regulatory and non-profit organisations along the Australian food-supply chain.

There are various risk management products and approaches now available for all public and private organisations to help them make improvements to their risk management practices and outcomes achieved, some of which are described in Section 3.4. In designing a roadmap for future food security based around improved risk management the following 10 features are seen to be important, if not vital:

1. *Flexibility and adaptability*. Given the large number of diverse organisations operating in the Australian food-supply chain, any risk management framework or process has to be able to be integrated into the organisation's existing structure, beliefs, legacies and management processes without too much overhead cost in learning, understanding and acceptance. That is, it has to have the capacity to suit small, medium or large organisations with either formal or informal approaches to risk management, and should also be useful to organisations with varying levels of belief about what is driving climate change. At the same time, some organisations will want to take their risk management to the limit, and the roadmap has to be able to accommodate that desire.
2. *Explicit recognition that risk typically has two tails or consequences, positive and negative.* Climate change impact studies tend to over-emphasise the negative consequences but, as demonstrated in the cases studies of this research, more than 75% of food organisations believe they can protect and create value out of uncertainty because of their understanding about the presence of both positive and negative consequences.
3. *Continuous improvement of the risk management framework, processes and practices* to encourage, if not ensure, effective management of risk.
4. *Consideration of all stakeholders in the risk management framework and process for managing risk.* This has capacity to draw all members of the food-supply chain into the risk management framework, not just commercial operators but also regulators. The impact of regulatory risk, as discussed above, is rated among the most severe constraints facing food organisations. Ad hoc changes to regulations with short notice on food-supply chain organisations are the fuel for uncertainty, and a clear risk to food security because they damage confidence which underpins investment and adaptation.
5. *Improvement of organisational resilience.* The likelihood of extreme events may remain relatively low, but the impact can be potentially severe or even catastrophic. Providing explicit recognition of extreme events as a separate risk with a low likelihood of occurrence can or would be included in an ideal risk management framework.
6. *Accountability and ownership of risk.* Without accountability and ownership of risk, the whole process of risk management can become a major source of uncertainty, not just for the initiator but also all other stakeholders. It also affects

the whole set of standards for governance and legal liabilities for managers and directors.

7. *Preserves and enhances the safety and security of the food-supply chain.* Food security requires safety and security of food products and services, as well as human health, to be preserved in the most efficient way possible.
8. *Environmentally sustainable.* Without an environmentally sustainable food-supply chain, long-term food security is fundamentally compromised and unable to deliver the basic charter of food security.
9. *Robust process*, designed for continuous operation with very low down time, failure rate, variability and very high insensitivity to a continually changing environment (refer to Glossary). Robustness underpins operators, managers, directors, and stakeholder confidence and trust in the decision-making process. It requires commitment from the most senior levels of management and directors.
10. *Stimulates innovative management and an educated appetite for risk.* An effective risk process requires basic recognition that value is created from managing uncertainty. The one sure way of eliminating or minimising risk is for food enterprises to do nothing, or to minimise activity to avoid exposure to uncertainty. For example, a food producer may decide the risks of production are too high and decide to relocate to a lower-risk country. This could have a very negative impact on food security. Relocation to another country with a more favourable investment climate would be good for importers but not necessarily for food security.

The International Standard ISO 31000:2009 appears to have the scope and adaptive capacity to suit many of the diverse organisations in the food-supply chain and resolve a number of the constraints to uncertainty now threatening food security (Figure 42). An effective roadmap for food security can adapt the ISO 31000:2009 process (Figure 43) to suit the circumstances of any food organisation wanting to take the necessary steps towards resilience and best practice in risk management. It is noted that there is no simple roadmap template for each and every organisation to follow, because organisations have different objectives and different external and internal influences affecting their risk management processes.

Making the risk management process work effectively requires leadership and commitment from the most senior levels of management, regardless of what risk management process is adapted and across the private, public and non-profit sectors. Without this commitment to integrate the risk management framework into everyday operations, strategic planning, values and culture, the road forward is set to become increasingly bumpy – especially when competitors seize on the opportunities offered from effective risk management.

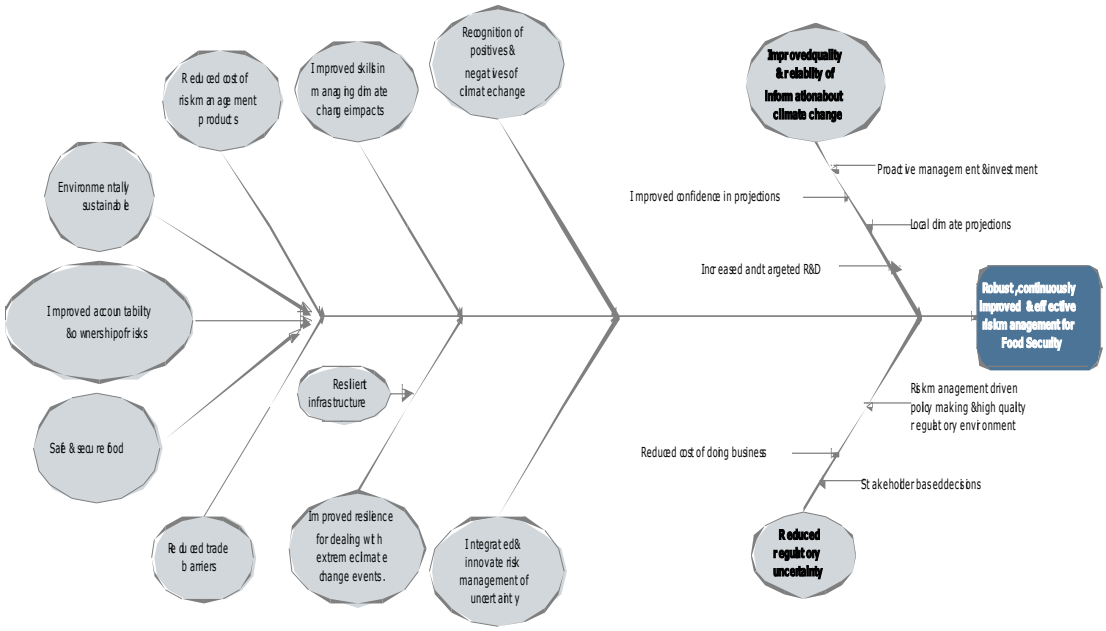
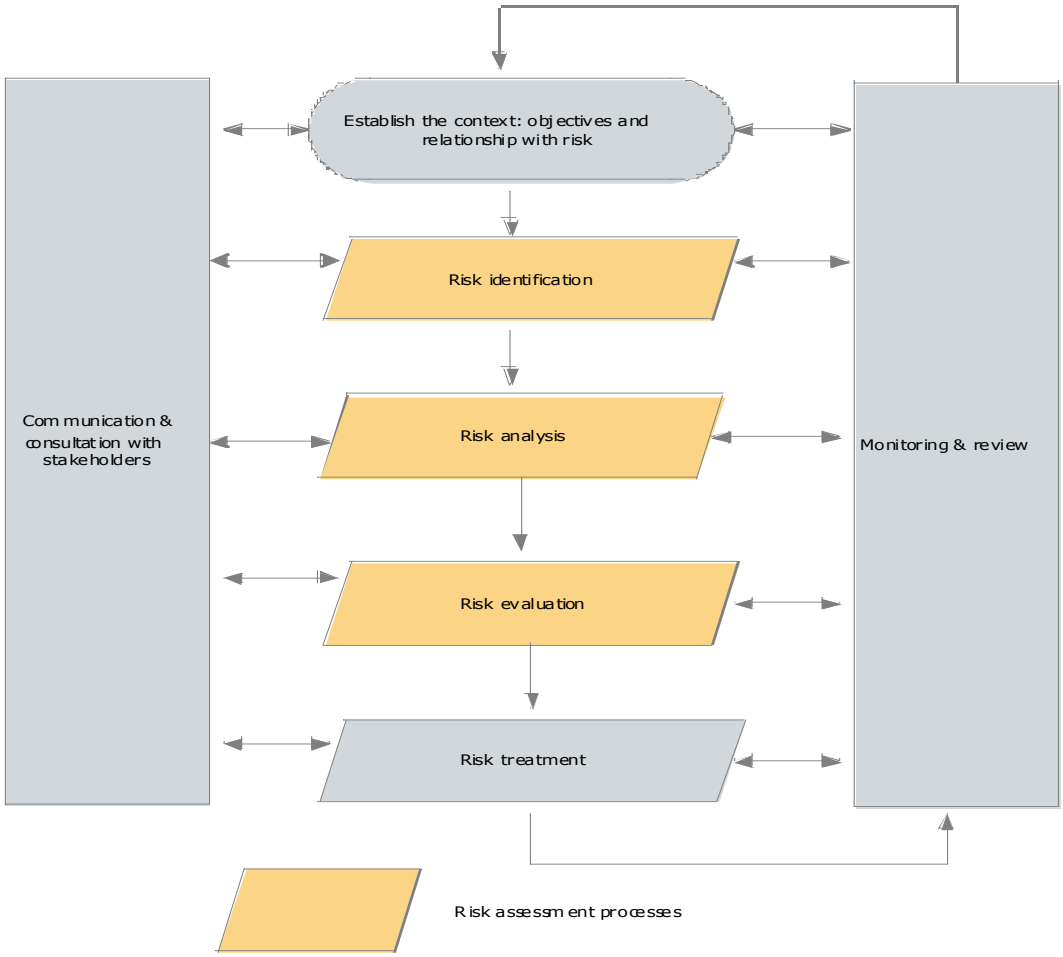


Figure 42: Roadmap to improved food security



Source: ISO 31000: 2009.

Figure 43: Risk management process roadmap

6 Gaps and future research directions

6.1 Principles for Intervention

Any case for government intervention to support food security has to stand the traditional tests for market failure. The test basically follows the line that market failure is a necessary but not sufficient condition for intervention (Wondu Holdings 2000). It is also necessary to demonstrate the economic, social and environmental benefits of the intervention will outweigh the costs. In addition, from a more practical perspective, an intervention has to be funded.

There are four potential sources of market failure:

- the presence of private or public good characteristics (Mansfield 1975)
- the presence of externalities
- moral hazard
- economies of scale.

This study's examination of the food-supply chain shows widespread evidence of both extreme commercial competition and market failure. There is a huge number of organisations (more than 700,000) involved in the Australian food-supply chain, but just two firms account for 80% of the retailing interface with consumers. That doesn't necessarily mean competition is lacking, because competition rules are present and actively implemented by ACCC and markets are largely contestable. Moreover, it doesn't necessarily mean that every intervention is good for food consumers because they benefit from the low-cost delivery systems resulting from the economies of scale that create the concentrated retail market. There is some evidence from case study retailers that intervention on the grounds of anti-competitive behaviour may have interrupted the efficient delivery of food during the Queensland floods. Retailers sometimes have to cooperate to preserve functionality of delivering food, but doing this may contravene competition rules. This would seem to be a case for the unwritten law of 'common sense' to prevail to enable food supply to be continued in exceptional circumstances. In many situations, 'principles-based regulation' instead of 'rules based regulation' can lighten the load on both producers and help preserve food security for consumers.

The moral hazard problem exists when there is some asymmetry of information between the producer and consumer, including the quality of a good or service that may not be readily or materially evident. Food Standards Australia and New Zealand develops and administers the Australia New Zealand Food Standards Code, which lists the requirements for foods including additives, food safety, labelling and GM foods. Enforcement and interpretation of the Code is the responsibility of state and territory departments and food agencies. The Victorian government has announced (Sullivan 2012) an inquiry into their food regulators, Prime-Safe and Dairy Food Safety Victoria. The regulatory framework for Australian food is designed basically to protect food quality, biosecurity (including protection of Australian agriculture from invasive pests and diseases) and confidence, but it has costs for producers, processors, distributors, traders and retailers. The case studies suggest that the regulatory arrangements for food are a major source of uncertainty, and that their risk management systems are being stretched in coping with the risk. Regulatory agencies, however, have indicated

that their risk management systems are effective, and that 'regulatory fatigue' is essentially a 'non-issue'. This implies food industry operators may have to examine more closely their risk management systems with a view to improving controls for management of regulatory risk.

Among the important externalities for the food industry and food security is biosecurity. The Department of Agriculture, Fisheries and Forestry (DAFF) has primary responsibility for managing Australia's biosecurity system, which covers animal, plant, food and quarantine operations. This biosecurity system is under review to ensure that it can meet future challenges such as increased global movements of people and goods, and climate change. The changing global environment means it is seen to underpin a need for greater emphasis on managing biosecurity risk both onshore and offshore, with a view to reducing risks reaching the border, and taking actions onshore to deal with incursions. The highest biosecurity risks are being identified as a priority for treatment. DAFF is understood to have a risk management system that complies fully with the principles and guidelines of ISO 31000.

DAFF has indicated its core priorities in managing biosecurity are to:

- manage Australia's biosecurity by effectively identifying and targeting 'risks that matter most'
- partner with other governments, industry, clients and stakeholders to manage Australia's biosecurity
- deliver biosecurity services to support access to overseas markets and protect the economy and the environment from the impacts of unwanted pests and diseases
- support Australia's reputation as a competitive exporter of agricultural goods and products.

DAFF has indicated that it will continue to conduct its biosecurity business in line with its legislative responsibilities. Several reforms are being implemented for biosecurity, and further information is available at the following website: http://www.daff.gov.au/bsg/biosecurity-reform. At the border, through the Australian Quarantine and Inspection Service, DAFF plans to continue to deliver inspection and certifications services, and to facilitate the movement of people and goods. DAFF is also to continue to conduct risk analyses, including import risk analyses, and development of recommendations for biosecurity policy, as well as providing biosecurity policy advice. Treatment of invasive weeds is among the risk priorities. It would be useful to link this review to food security. Biosecurity is clearly an important requirement for sustainable production and continuous productivity improvement.

Other externalities may exist with insurance. Zurich Financial Services Group (2009) believe insurance markets for climate change products are being distorted by subsidies, penalties, grants and various rights and obligations that are affecting incentives. Some of these interventions are related to direct actions to enhance adaptation to climate change but is an area that requires more investigation as insurance is an important control measure for any effective risk management framework.

R&D is the most often cited case of market failure and case for government intervention on the grounds of its public good characteristics. Again, the same rules apply to justify intervention and support, that is, it's necessary to demonstrate (ex ante, in this case) the economic, social and environmental benefits of the intervention will outweigh the costs – in this case, the R&D project costs.

A number of research gaps have emerged in this project, the main area being in the quality of information about climate change impacts – especially at a local level. A number of other research projects seem relevant to alignment of food security, adaptation to climate change and management of risk, including improved understanding of the commercial implications of measures to change soil carbon levels

6.2 Information gaps

The competitive private sector undertakes a large part of the activity required for an efficient and safe food-supply chain that delivers food security. This is supported by food safety standards and infrastructure. There are, however, information gaps emerging, which are contributing to uncertainty. The most prominent of these is climate change impact uncertainty, especially at the regional and local levels. The Productivity Commission (2012) has recommended that companies and households requiring more detailed or localised information should expect to pay for that information unless there are strong public good elements that warrant government support. Food security may be a case that does warrant support because of the significant externalities involved in food security (for example, social impact on people with low incomes).

Participants from the Investor Group on Climate Change at the NCCARF Workshop on 'Informing Adaptation Policy' indicated significant problems are being encountered at a local level in gaining access to existing data on climate change impacts. Almost 80% of case study respondents for this study indicated that lack of good quality information about climate change impacts was a constraint to effective risk management. Risk management of climate change is an information-intensive process, and in many (though not all) cases, this activity takes on the features of a public good. In some situations, it is reasonable to expect the private beneficiary to absorb the cost of information collection for their risk management process, especially when they are in a position to capture commercial benefits from it.

Information gaps can also affect confidence levels in unpredictable ways. While more than 70% of respondents are confident about their capacity to deal with climate change impacts, research from the United States suggests 'optimistic bias' may be a problem with perceptions about capacity to deal with climate change impacts. Enterprises and groups prone to 'optimistic bias' may be more vulnerable than others to the impacts.

In the interest of protecting food security, further research should be undertaken to identify the information requirements for effective risk management of climate change impacts at a regional and activity level in the Australian food industry, to analyse the role of the market and public and private sector in mobilising this information for effective risk management and to develop options and recommendations for the public and private sectors to provide this information, including possible public–private partnerships. Further research should also be undertaken into Information gaps that have the potential to leave those affected more vulnerable to climate change impacts.

6.3 Lifting the regulatory burden on food security

As indicated above, many case study respondents indicated that regulatory risk was possible to almost certain, and many considered that the consequences on organisational value would be significant. These views are similar to other assessments by international agencies, including the World Bank and World Economic Forum (section 3.3.8), showing Australia to have a relatively high general regulatory burden. Among the risks cited by this study's respondents are unforeseen trade barriers (export and import), product rules and competition laws. One of the risks to food security is that commercial organisations will implement their risk management frameworks to best practice standards, identify local regulations as a serious risk with high consequences, and decide to relocate to another country. Other risks include shifting out of food to a less risky business or winding down investment in an existing risky food business. The Australian and New Zealand Food Regulation Ministerial Council (2011) policy guideline contains principles on food safety management for general food services and closely related retail sector services, and this seems to be a step in the right direction towards a more balanced approach to regulation and recognition of competitiveness. This guideline, however, does not deal with the more generic regulatory constraints, including Australia's very low ranking on gaining construction permits, protecting investors, paying taxes (including taxes on property transfer) and trading across borders. The Productivity Commission (2012) recognises the important role of building the adaptive capacity of organisations to cope with uncertainty.

One of the problems facing policy-makers and regulators is that regulations can obscure the perceptions of risk, but also amplify the risks of certain activities.[19] This can happen when regulations fail to meet expectations, and when the cost of interventions diminishes the capacity of targets to adapt to uncertain events.

The United States established the Office of Risk Assessment and Cost-Benefit Analysis (ORACBA) in 1994 to ensure that major regulations proposed by the USDA were based on sound scientific and economic analysis. ORACBA conducts thorough investigations that make clear the nature of any risk, alternative ways of or interventions for reducing the risk, the reasoning that justifies the proposed rule, and a comparison of the likely costs and benefits of reducing the risk. It would, for example, be almost impossible to introduce an ad hoc intervention that banned exports of livestock or food products without it being examined and endorsed by ORACBA.

More generally, this study points towards significant challenges in preserving food security in Australia and continuing its commitments to other countries, including many from the less-developed country group where poverty levels are often high. It would be desirable to have a better balance between rules and principles-based regulation, with more use, where possible, of principles instead of inflexible rules.

It is also evident that food security is a wide-ranging issue, with significant cross-cutting policy implications that extend across agriculture, manufacturing, retailing, transport, environment, health, trade and social security. It is about more than just biosecurity or quarantine or health; it is also more than R&D and food security for international development.[20] Dealing with the risks of food security extends well beyond the typical agricultural or food agency functions (e.g. through to health, welfare and infrastructure).

[19] Goddard K. (International Law Analyst, Geneva), personal communication.

[20] An Australian International Food Security Centre is being set up in ACIAR (2011).

For this reason, it may be necessary to have a more multi-functional department or section dealing with risk. It is beyond the scope of this project, but it is concluded that there is a case for examining the establishment of a Department of Food Security and where it might be located. The location could be at DAFF or Treasury, or within a division where it would have enough influence to provide the balance required to preserve food security over the years ahead where challenges may be much higher than previously experienced. This department would have a focus on domestic food security, but also with recognition of the implications of domestic policy for global food security.

The significant interdependencies and linkages along the food-supply chain mean that responsibilities extend across different departments from production through processing to support services, including health, the environment and infrastructure. There is no organisation charged with responsibilities for food security.

There should be further research into regulatory barriers (both food and non-food) that are contributing to uncertainty in the Australian food industry. This would include identification of regulatory risk at Commonwealth, state and local government levels, evaluation of the cost and benefits of compliance (including time and monetary value) and recommendations for improvement over a specific time.

There should be a feasibility study into establishing a new Department of Food Security.

6.4 Infrastructure bottlenecks

The food industry is a significant user of infrastructure for delivery of food, both in Australia and to overseas destinations. While international performance on infrastructure is rated slightly better than regulations, there remains considerable scope for improvement compared with the United States. The Critical Infrastructure Resilience Strategy is expected to improve the capacity of roads, railways, ports and communication and information assets to cope with extreme events. The National Infrastructure Construction Schedule (http://www.nics.gov.au/Project) shows a large number of projects across all states in various stages of development and commitment, which are derived from a National Priority List that has been presented to the Council of Australian Governments (COAG). Three project groups dominate the Australia-wide list of infrastructure projects in the pipeline: the National Broadband Network, hospitals and city infrastructure. Construction has started on the Midlands Irrigation Scheme in Tasmania, but there seems to be scope to include more infrastructure projects to protect and enhance food security, especially with regard to improving roads.

It is recommended that there be a detailed examination of the infrastructure bottlenecks affecting Australian food security, including identification of priorities for development across all states and territories.

6.5 Building skills and capacity

A number of case study respondents indicated that a lack of skills in managing the impact of climate change risks was constraining their capacity to implement an

effective risk management culture, but almost an equal number indicated that their skills were not a constraint to managing this risk. A number of state governments have training programs for agricultural producers to enhance their capacity to adapt to climate change, including improved risk management practices. Some operators of state government programs have indicated they would benefit from further training of their trainers, and at least one indicated that their risk management practices were ineffective. This would be an opportunity to introduced participants to the new standards on risk management, resilience and continuity planning. The shift towards a more holistic approach to risk management is a development requiring extended skills in risk management (see Figure 43 above), which is no longer simply about forward selling or trading swaps, and taking positions in commodity and financial futures markets.

Food security is of such fundamental significance to sustainable development that it would be of value to introduce the topic to the school-age children who will be most affected by how well the current generation of managers and resource users manages the topic. A US study found that food insecurity and insufficiency was associated with adverse health and development outcomes, including poor school performance and depression (Jyoti et al. 2005).

It is recommended that there be further research into the design of a viable risk management training program for trainers (both private and public) in risk management along the food-supply chain (that is, training for producers, processors, storage and transport, etc.), with specific attention to developing skills to comply with the new ISO standards for risk management, resilience and continuity management. In addition, school educators should be encouraged to adopt food security as a topic for primary and secondary education.

6.6 Food-borne infectious diseases

There are many ways in which human health impacts of climate change could affect food production, distribution, product quality and microbiological safety, but many are theoretical and untested. Increased research and development into food-borne infectious diseases would be expected to improve adaptation to climate change impacts and enhance food security. Improved awareness about links between food-borne infectious diseases and climate change would improve preparedness and the speed of response to adverse events. Dengue fever and malaria are spreading south in Australia with changes in average temperatures. Food security is also affected, indirectly, via productivity impacts, when the food labour force is exposed to changes in infectious diseases. Australia has a strong animal and human health system, and it is important not just to preserve this asset, but to exploit its potential fully.

There should be a wide-ranging study on the impact of climate change for the health of food production, distribution, product quality and microbiological safety, ideally with regional impacts considered. It could be integrated with a parallel study on animal health impacts on food security. It could also examine ways of improving awareness about excessive food consumption, which can compromise food security.

6.7 New technologies and innovative work practices

Many respondents agreed strongly or moderately that new technologies and innovative management practices could provide effective solutions for management of climate change impacts. Climate-adapted livestock and plant cultivars are seen as essential or quite important initiatives. In addition, technologies (e.g. remote sensing satellites) that speed up and generate reliable information about emerging climate change events are also rated highly, as are improved management practices (including veterinary, food processing, on-farm), biotechnology and precision agriculture. Innovative food-processing technologies can lead to improved energy efficiency, higher value and new products, and enhanced food safety can enhance access to local and export markets (Versteeg 2008). The PMSEIC Expert Working Group on Australia and Food Security in a Changing World (2010) underlined the importance of innovation and new technologies in protecting food security when making their recommendation to establish an Australian Food Security Agency. This group recommended, among other matters, better engagement of the community and partner organisations to elevate the status of food in Australia and to build cooperative commitment to an improved food value chain.

The reality is that the private sector delivers food security in Australia through partnerships with public agencies, and ideally would remain at the forefront of innovative management practices and adoption of new technologies. Case study respondents for this study mostly favoured their own initiatives to improve capacity to identify, analyse and evaluate risk. This can be achieved, in part, with a market-driven incentive system. In addition, respondents favoured more research and development to reduce the uncertainty of climate change impacts. A large number of respondents also considered that the insurance industry could develop more effective insurance products to enhance control of climate change impact risks.

It is recommended that constraints to private-sector adoption of new technologies and innovative work practices in the whole Australian food-supply chain should be elevated to a policy priority status. Increased R&D and support for extension would be likely to enhance adoption of new technologies and innovative work practices, including, for example, farming carbon in the soil. Opportunities to develop new insurance products for dealing with climate change should be examined further, including encouraging recognition of risk management practices in insurance premiums.

6.8 Low-probability, large-impact policy initiative

As noted in the information review, the UK government (through the Blackett Review) has elevated high-impact, low-probability risks to a new level of policy importance. There would be benefits in having a different risk management approach to the identification, assessment and management of high-impact, low-probability risks, for no other reason than to have a rigorous cross-check on epistemic risk and to minimise the impact of surprises. Several recommendations were made in the Blackett Review to improve the quality of treatment of high-impact, low-probability risks, including greater use of external experts to achieve a more balanced and informed risk management process. The potential for compounding or cascading risks seems to be potentially high for the food industry, due to the close linkages all the way along the supply chain from production through processing and retailing to end-consumers. If this situation is then exposed to a coincidence of diverse risks (for example, climate change, land-use shift, severe drought, adverse investment climate, rapid population growth, economic

downturn, etc.), there would be potential for systemic risk, and from that an adverse impact on food security risk. Systemic risk may also emerge, paradoxically, from wider adoption of improved risk management practices by food organisations, if the constraints to which they are now exposed are not lifted. If they all try to escape the risks to which they are now exposed by running down investment or relocating to another country, local food security may be compromised

It is recommended that, to minimise strategic surprises from high-impact, low-probability risks to the food industry, there should be a Discussion Paper prepared on systemic risk in the Australian food supply and delivery systems. It would examine the impact and preparedness of organisation for a coincidence of shocks that may arise from climate change, normal weather events, government policy, international events and other external influences. It would examine ways of including high-impact, low-probability risks more consistently in policy-making.

6.9 Foreign investment from sovereign governments

Foreign investment has provided a vital, positive and constructive role in the development of an internationally competitive Australian agricultural sector, and in the food processing and retailing sectors. Without the inflow of capital and skills from foreign investment, food security in both Australia and offshore would be compromised. Foreign investment competition with government influence is a relatively new development, and was rated as a likely uncertainty by a number of case study respondents and to have potential for a major impact (either positive or negative) on their performance. While recognising the important role of foreign investment as a conduit to productivity improvement, it is equally important to recognise that competition, transparency and disclosure are vital attributes of an effective and efficient market economy. At the same time, it is important to preserve commercial confidentiality in order to attract investment. Providing competition is preserved, it is quite possible that sovereign foreign investment in Australian agriculture and the food sector generally will add to the diversity of investment, food supply and food security through the same transfer of skills and capital that the commercial foreign investor has undertaken for more than a century.

It would be unfortunate if another ad hoc policy was introduced to block sovereign foreign investment on the grounds of national interest, and without having regard to food security. It is important to not simply shift perceptions of a food security problem to another country – especially a country with a large number of more vulnerable people. This study points to growing uncertainties emerging ahead for Australian food security. Careless interventions to block foreign investment can obscure perceptions of risk and actually amplify risk if, for example, the blocked foreign investment would increase productivity and the productive capacity of the food-supply chain.

In the case of investment from China, it has been observed that the national interest of Australia may well be served in a positive way because it provides linkages to markets (Henry 2012) and low-cost capital (Michelmore 2012). These attributes need to be recognised because Australia has a demand for imported capital and China has a capital surplus for foreign investment. China needs reliable supplies of food, and Australia needs reliable markets for food exports. China is also now seeking to switch foreign investment into areas outside minerals. To some extent, domestic tensions about capital investment in Australian farmland are fuelled by concerns about the lack

of control and information about the investing organisations. There is an opportunity to improve significantly the level and quality of communications between the two countries on food security and the drivers of it. At a recent public forum on China's Global Investment (East Asian Bureau of Economic Research 2012), it was suggested that there be improved quality about the debate on China's investment in Australia, improved transparency of investment activity, improved governance of investing organisations and improved exchange of information about capital flows between the two countries. This background prompts the recommendation that a forum for dialogue on China and Australia's joint investment in food security be established.

It is recommended that transparency of foreign government investment (direct or indirect) in Australian agricultural and food processing, storage and distribution assets be improved significantly, without diminishing the incentive for foreign investment of all origins in the food sector. Joint ventures and public–private partnerships with sovereign wealth funds could be examined as a way of encouraging improved accountability to domestic stakeholders.

A Joint Australia-China Food Security Forum should be established, to meet annually and commission a series of research papers on matters affecting food security in the two countries, having regard to the national interest of both countries in food security.

6.10 Improved input–output models

There is a significant gap in understanding flows of products and the cascading impact of risks along the Australian food chain from sourcing of supplies through to production, processing, wholesaling, retailing and export markets. It is currently a patchwork of silos, where risks are understood – indeed, often exceptionally well understood – within defined boundaries at an activity or sub-industry level, but not in an integrated way along the whole supply chain. As a result, there is incomplete understanding of the risks to food security for both Australian and international consumers of Australian products. For example, a serious interruption to fuel and energy supplies could have an unforeseen impact on supplies of both local and imported food products, with adverse consequences for food security. An ad hoc intervention in a food export industry could have a serious impact on the capacity of local suppliers to remain competitive, and foreign consumers relying on that product or commodity. The cascading impacts of interruptions to the Australian food-supply chain are not well understood, and there seems to be considerable scope to apply the principles of precision to policy and industry development in the same way that many agricultural producers are doing at an enterprise level.

It is recommended that improved input–output models be developed to enhance understanding of interdependencies and cascading effects from external influences, ad hoc interventions and unforeseen events on food security, having regard to both international and domestic consumers, regional impacts and different categories of influence (e.g. economic, policy, ecological, logistical).

7 Conclusions

Australia enjoys a high level of food security and enhances food security in a large number of countries that depend on external suppliers for food security. The existing evidence points towards Australia having at this time a high level of food security, and it has been that way for more than half a century. That is, 'a large proportion of all people, at all times (recent, at least) in the country have access to sufficient, safe and nutritious food to maintain a healthy and active life'. Food security is driven largely by income, the vitality of a market economy and interventions that resolve market failure and support income. With average GDP/capita of US$51,000 over the five years ended 2011 Australia is ranked in the top ten countries on income levels, ahead of the United States, United Kingdom, Canada and New Zealand (World Bank 2012). While there is a high level of self-sufficiency in food supply in Australia, the more important indicators for food security include access to competitively priced and high-quality food.

Looking further ahead, there are mixed indicators arising from uncertainty about climate change, changing levels of demand and supply, regulatory uncertainty and a range of other uncertainties, including the quality of infrastructure and a tendency for Australians to eat much more than they need. Reduced per capita consumption of food by Australians would help preserve food security and the health of consumers.

By themselves, many of these risks are likely to be manageable by a private sector with significant experience and expertise in handling change. The real risk is from a systemic convergence of negative external shocks – a 'Black Swan' scenario, characterised by low probability with a large impact, which may happen when several of these uncertain events coincide. A 'Black Swan' scenario could feature the following:

- relatively high growth in population to more than 35 million by 2050 in Australia
- a change in the terms of trade, leading to an economic downturn
- continued growth in per capita consumption of food, with growing obesity levels
- emission-reduction commitments and incentives to switch land-use for increased sequestration
- uncertain extreme climatic events becoming reality and coinciding with a cyclical drought
- increasing resource constraints, especially fuel and energy
- increased soil degradation resulting from a drier and warmer climate
- growing biodiversity preservation demands, leading to reduced specialisation of agricultural production
- lower R&D expenditure, arising from government budget constraints
- growing export commitments to help sustain global food security
- ad hoc regulations that diminish capacity and incentives to invest and trade
- incentives to switch land use from food to energy production
- threats of infectious disease outbreaks.

These events are all manageable by an Australian food-supply chain that is nurtured and not burdened to the point where its capacity to adapt is limited and constrained by poor-quality regulations and lack of support, and where markets have gaps in performance. The evidence from this study is that both the private and public sector can improve their performance through effective risk management and need to improve performance to ensure capacity to adapt is at the highest level possible.

There are significant multi-sectoral interdependencies along and across the Australian food chain, and they extend into international markets where inputs are sourced and commodities and food products delivered. These include economic, information, geographical, ecological, health, mechanical, logistical, biosecurity, vulnerable consumers and climatic categories. These interdependencies are not well understood, mapped or monitored. As a consequence, ad hoc interventions take place, with consequences examined after the event. Effective preparedness necessitates solid planning from a multiple decision-making perspective (Haimes 1981). This requires recognition of the multitude of couplings and interdependencies along the food chain, involving deep understanding of the joint and complementary roles of the private and public sectors.

No study on food security can neglect mention of China, with its need for food and surplus of capital for investment, and Australia's need for markets and foreign investment capital. The formation of a forum for dialogue on China and Australia's joint investment in food security would contribute to improved quality of debate on foreign investment.

While recognising the downside risks, it is equally important to recognise that the 'Black Swan' scenario painted above has another 'tail' to it, and food output may grow well beyond expectations while demand grows well below expectations. Growth in productivity is a universal strategy that fits both outcomes, but there is no universal risk management strategy for all organisations. An effective risk management process has to take place at an organisational level because objectives and context differ for everyone.

In preserving food security in Australia, it remains important not to have policies that focus simply on local food security at the expense of food security in other countries – especially countries with large numbers of poor and vulnerable people. With 3.4% of the world's arable land and 0.3% of the world's population, it is important for Australia to recognise its position in relation to global food security.

Finally, the authors recognise that this project was always going to be challenging, and that it is perhaps too large in scope. A study of food security along the whole food chain in the context of a rapidly changing environment (not just climatic categories), new developments in risk management procedures and with a diversity of interdependent public and private organisations made the project more challenging. With the benefit of hindsight, some things could have been done differently, including:

- *Format for collection of data from public and private organisations*. Similar questions were asked of public and private organisations. In practice, these organisations think about risk and talk about risk in totally different ways. For the future, it may be better to have different questioning and interviews for private-sector and public-sector firms. In a similar vein, there are vast differences in the way small and large organisations think about risk management, and the ways in which they use formal and informal approaches.

- *Case study approach.* The case study approach is a powerful method for dealing with complex subjects, and for communicating with commercial organisations and public-sector decision-makers. This study uses a large number of case studies – possibly too many – and some readers may believe more attention should have been given to establishing statistically reliable relationships between the variables of interest with a view to removing the bias that is ever-present in case studies. In response, the authors confirm that the study is directed mainly to users of the results, and commercial users in particular are responsive to case study material. Researchers may, however, pick up on the recommendations for further investigation.
- *'Black Swan' as a measurable concept.* The project started with reference to Taleb's 'Black Swan' concept. The concept seems to have captured readers' attention. At the completion of the study, it might have been better to have given slightly more attention to resilience as a measure of how well food organisations are responding to extreme events. That would mean identifying and measuring organisational resilience along the food-supply chain.
- *Issues beyond the scope of the study*. A number of matters affecting food security were beyond the scope of the study. These include water use, urban land expansion and mining expansion, including coal-seam gas exploration and production. While beyond the scope of this project, their coverage and role in food security are very important – especially in the case of water.
- *Climate change and contradictory responses.* The project had insufficient resources to follow up on some seemingly contradictory responses in the case study interviews. For example, nearly 40% of respondents indicated that climate change impacts had not been identified as a source of risk to their organization, but a large proportion identified lack of good-quality information about climate change as a constraint to their risk management effectiveness.
- *Aggregation of different respondents.* Case studies are not typically analysed in an aggregated way. In this study, the respondents were aggregated for the purpose of simplification, but aggregation bias is obviously present in the averages. Elimination of aggregation bias could be achieved with a large sample, but the resources required would be significant to cover the food chain across the categories examined in this study. The study makes reference to the need to conduct risk assessments at an individual enterprise level, and for this reason large numbers do not necessarily resolve this matter.

8 Glossary

Accountability: The obligation of individuals or organisations to account for their activities, accept responsibility for them and disclose the results in a transparent manner (http://www.businessdictionary.com/aboutus.php).

Adaptations: Actions taken to help communities and ecosystems cope with, moderate or take advantage of current or future changes in climate conditions. Alternatively, they are practical steps to protect communities from damage and disruption associated with climate change.

Adaptive capacity: The ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour, and resources and technologies (IPCC).

Anthropogenic: Resulting from or produced by human beings (IPCC).

Bayesian method: A method by which a statistical analysis of an unknown or uncertain quantity is carried out in two stages. First, a prior probability distribution is formulated on the basis of existing knowledge (either by eliciting expert opinion or by using existing data and studies). At this first stage, an element of subjectivity may influence the choice, but in many cases the prior probability distribution is chosen as neutrally as possible, in order not to influence the final outcome of the analysis. In the second step, newly acquired data are introduced, using a theorem formulated by and named after the British mathematician Bayes (1702–61), to update the prior distribution into a posterior distribution (IPCC).

Business Continuity Planning: Planning that identifies the organisation's exposure to internal and external threats and synthesises hard and soft assets to provide effective prevention and recovery for the organisation, while maintaining competitive advantage and value system integrity (Elliot et al. 1999).

Epistemic risk: The risk of being wrong about an area of accumulated knowledge that is based on verifiable evidence. (*Note:* Popper (1934) warned about the risk of mistakes when all accepted scientific evidence is based simply on empirical evidence. He developed the idea of falsifiability of claims to encourage risk-taking and boldness in research.

Extreme event: An infrequent event at the high and low end of the range of values of a particular variable.[21] Extreme weather and climate events include: (a) an increased probability of extreme warm days and decreased probability of extreme cold days; and (b) an increased chance of drought during summer with increasing CO_2 and increased chance of rain and flood.

Climate: Refers to weather averaged over time (usually 30 years) (NCCARF terminology).

[21] Arriving at a suitable quantitative measure of an extreme event is complex, and depends largely on the purpose of the measure. In this study, the definition is kept relatively simple to facilitate communication with survey respondents. Some measures are based on the number of events above the long-term 95th percentile (referred to as extreme frequency, while others are based on the average intensity of rain falling in the highest events, referred to as the *extreme intensity*; and the proportion of total rainfall falling in the highest events, referred to as the *extreme percent*. (Nicholls 2008).

Climate change: (Using IPCC glossary) Refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external influences, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.[22]

Climate variability: Refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC). Examples of climate variability include conditions resulting from periodic El Niño and La Niña events, and extended drought and floods (NCCARF terminology).

Critical systems: Systems whose failure can have a major or catastrophic impact on life, the environment and/or functionality of assets. Measurement indicators include reliability, safety, availability, security and functionality.

Drought: In general terms, a 'prolonged absence or marked deficiency of precipitation', a 'deficiency that results in water shortage for some activity or for some group' or a 'period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance' (IPCC).

Extreme event: From a weather perspective, an extreme weather event is an event that is rare within its statistical reference distribution at a particular place (IPCC) – that is, rarer than the 10th or 90th percentile.

Food industry: Defined by the Australian Bureau of Statistics (ABS), using the Australian and New Zealand Standard Industrial Classification (ANZSIC), 1993 edition, and includes agriculture, forestry and fishing production; services to agriculture; commercial fishing; food and beverage manufacturing; and food wholesale and trade. In addition, food retailing is included within the scope of this project, and includes supermarket and grocery stores and other specialised food retailing. Cafes, restaurants and takeaway food services are technically within the scope of the project.

Food security: Defined by the FAO as a situation that exists when all people at all times have physical, social and economic access to safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Food-supply chain: Comprises the following stages: agricultural production, food processing, food wholesaling, food retailing and food catering.[23]

Governance: Refers to the actual behaviour of corporations, as measured by performance, efficiency, growth, financial structure, and treatment of shareholders and other stakeholders. It also includes the rules under which firms operate, with the rules coming from such sources as the legal system, financial markets and factor (labor) markets (Claessens and Yurtoglu 2012).

Holocene: Geological term for the last 12,000 years of the earth's history.
Land use and land use change: Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions) (IPCC).

[22] http://www.ipcc.ch/ipccreports/tar/wg1/518.htm.

[23] UK Department of Environment, Food and Rural Affairs (DEFRA 2006).

Likelihood: The likelihood of an occurrence, an outcome or a result, where this can be estimated probabilistically (IPCC).

Monte Carlo: A risk analysis method based on random numbers drawn typically from within specified ranges. Depending on the number of risks of interest and the ranges of possibilities (an input), the Monte Carlo method generates distributions of outcomes.

Principles-based regulation: Regulation based more on desired outcomes, processes and principles than on prescriptive rules.

Projection: A potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from *predictions* in order to emphasise that projections involve assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised, and that therefore are subject to substantial uncertainty.

Radius of stability: Model for computing the stability radius within which robustness is achieved.

Regulatory fatigue: Lack of response to a rule of law that aims to change the activity of a person or organisation by elimination, suppression or redirection of that activity.

Resilience: Refers to the 'adaptive capacity of an organisation in a complex and changing environment' (ISO/IEC Guide 73) or the ability of a system to recover following an emergency (Haines 2009). In more detail, it is defined by the IPCC[24]in the context of food security as including:

- coordinated planning along food-supply chains, sectors and networks
- responsive, flexible and timely recovery measures, and
- the development of an organisational culture that has the ability to provide a minimum level of service during interruptions, emergencies and disasters, and return to full operations quickly.

Risk: Defined (using AS/NZS ISO 31000:2009) as the effect of uncertainty on objectives.

Risk appetite: The amount of risk that an organisation is willing to pursue or retain (ISO Guide 73). (*Note:* definition of risk tolerance is a controversial issue).

Risk criteria: The terms of reference against which the significance of a risk is evaluated (AS/NZS ISO 31000:2009).

Risk management: Defined (AS/NZS ISO 31000:2009) as comprising coordinated activities to direct and control an organisation with regard to risk.

[24] Definition is adapted from the Australian government's *Critical Infrastructure Resilience Strategy* report. See http://www.ag.gov.au/cca.

Risk management framework (AS/NZS ISO 31000:2009): Defined as a set of components that provide the foundations and organisational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organisation.

Risk management policy (AS/NZS ISO 31000:2009): Comprises a statement of the overall intentions and directions of an organisation related to risk management.

Risk owner (AS/NZS ISO 31000:2009): Defined as the person or entity with the accountability and authority to manage a risk.

Risk management process (AS/NZS ISO 31000:2009): The systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analysing, evaluating, treating, monitoring and reviewing risk.

Risk monitoring (AS/NZS ISO 31000:2009): Defined as continually checking, supervising, critically observing or determining the status in order to identify change from the performance level required or expected.

Risk tolerance: An organisation's or stakeholder's readiness to bear risk after risk treatment in order to achieve its objectives (ISO Guide 73). (*Note:* as with risk appetite, the definition of risk tolerance is a controversial issue.)

Risk velocity: Rate and direction of change in a source of risk.

Robust: Refers to the insensitivity of performance to external stresses (Haimes 2009). A product, process, approach or system designed for continuous operation with very low down time, failure rate, variability and very high insensitivity to a continually changing environment (http://www.businessdictionary.com/aboutus.php).

Robust optimisation is an approach in which the best case/worst case performance is defined for decision-making or as a cross-check.

Rules-based regulation: Regulation based around tightly defined legislation and regulations that prescribe what organisations must and must not do in the conduct of their business.

Scenario: Using IPCC terminology, a scenario is described as a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future may unfold.

Sensitivity: Describes the degree to which a system or community is affected, either positively or negatively, by climate variability and climate change. The effect may be direct (decreased crop yields due to declining rainfall) or indirect (increased damages to infrastructure as the frequency of coastal flooding events increases when the sea level rises).

Sequestration: The process of increasing the carbon content of a carbon reservoir other than the atmosphere. Biological approaches to sequestration include direct removal of carbon dioxide from the atmosphere through land-use change, afforestation, reforestation and practices that enhance soil carbon in agriculture.

Systemic risk: Risks affecting the whole system. Applicable to economic, financial, environmental, health and epidemic diseases with knock-on or contagion effects.

Uncertainty: An expression of the degree to which a value (e.g. the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of source, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behavior (IPCC).

Value at risk (VaR): Used to estimate a worst-case scenario, based on a time period, confidence level and loss percentage or amount. Three methods for assessment that are commonly used including historical method, expected value and Monte Carlo method.

Vulnerability to the impacts of climate change: Defined as a function of exposure to climate conditions, sensitivity to those conditions and the ability to adapt to changes. In other words, vulnerability refers to the degree to which a person or a community, or even an ecosystem, is at risk of harm or injury due to exposure to a hazard or stress (such as a tropical cyclone, earthquake or heatwave), and their ability to cope, recover or adapt to the hazard (NCCARF terminology).

Water security: Defined by the FAO as a situation of reliable and secure access to water over time. It does not equate to constant quantity of supply as much as predictability, which enables measures to be taken in times of scarcity to avoid stress.

Water scarcity: Defined by the FAO as a more relative concept, describing the relationship between demand for water and its availability. The demands may vary considerably between different countries and different regions within a given country, depending on the sectoral usage of water. A country with a high level of industrial demand or that depends on large-scale irrigation will therefore be more likely to experience times of scarcity than a country with similar climatic conditions without such demands.

Weather: Defined as the atmospheric condition in a particular location in terms of air temperature, humidity, pressure, precipitation and wind-speed (NCCARF terminology).

Zoonotic: A disease that normally exists in animals but can infect humans.

9 Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABC	Australian Broadcasting Corporation
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACERA	Australian Centre of Excellence for Risk Analysis
ACIAR	Australian Centre for International Agricultural Research
AEMC	Australian Emergency Management Committee
AFGC	Australian Food and Grocery Council
AFSA	Australian Food Security Agency
AGD	Attorney-General's Department
ALGA	Australian Local Government Association (ALGA
ANRA	Australian National Retailers Association
AICFS	Australian International Centre for Food Security
ASX	Australian Stock Exchange
BCM	Business Continuity Management
BCP	Business Continuity Planning
BDH	Beidahuang Nongken Group (China)
BIP	Business Interruption Policies
BOM	Bureau of Meteorology
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
CIAC	Critical Infrastructure Advisory Council
CIP	Critical Infrastructure Protection
CIPMA	Critical Infrastructure Program for Modelling and Analysis
CIR	Critical Infrastructure Resilience
CIRS	Critical Infrastructure Resilience Strategy
CODB	Cost of Doing Business (World Bank)
COFCO	Chinese National Cereals Oil and Foodstuffs Corporation
COSO	Committee of Sponsoring Organisations of the Treadway Commission
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DCCEE	Department of Climate Change and Energy Efficiency
DECC	Department of Energy and Climate Change
DFAT	Department of Foreign Affairs and Trade
DIISR	Department of Innovation, Industry, Science and Research
DoHA	Department of Health and Ageing

DRARDLG	Department of Regional Australia, Regional Development and Local Government
DRET	Department of Resources, Energy and Tourism
EMA	Emergency Management Australia
ERM	Enterprise Risk management
FAO	Food and Agriculture Organisation of the United Nations
FCSG	Food Chain Sector Group
FSANZ	Food Standards Australia and New Zealand
GIS	Geographical Information Systems
GMO	Genetically modified organism
GPS	Global Positioning System
GRC	Governance, risk management and compliance
HACCP	Hazard analysis and critical control points
HAZOP	Hazard and operability
HHM	Hierarchical Holographic Modelling
HSEC	Health/safety/environment/community
ICA	Insurance Council of Australia
IFC	International Finance Corporation
IGT	Information gap decision theory
IPCC	Intergovernmental Panel on Climate Change
ISPA	International Society for Precision Agriculture
ISPOR	International Society for Pharmocoeconomics and Outcomes Research
LPI	Logistics Performance Index
LTCM	Long-term capital management
MCDM	Multiple-criteria decision-making
NCCARF	National Climate Change Adaptation Research Facility
NCCIP	National Committee on Critical Infrastructure Protection
NEMC	National Emergency Management Committee
NHMRC	National Health and Medical Research Council
ORACBA	Office of Risk Assessment and Cost-Benefit Analysis
OTGR	Office of the Gene Technology Regulator
PA	Precision agriculture
PBR	Principle-based regulation
PM&C	Department of the Prime Minister and Cabinet
PMRM	Partitioned Multi-objective Risk Method
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
RBR	Rules-based regulation
RMIA	Risk management Institution of Australia
TISN	Trusted information-sharing network
UN	United Nations
UNDP	United Nations Development Programme

VaR	Value at risk
VCCAR	Victorian Centre for Climate Change Adaptation Research
VRT	Variable rate technology
WEF	World Economic Forum
WHO	World Health Organization

10 References

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Appendix 1: Primary data questions on food security

Data were collected from 50 organisations operating in the Australian food-supply chain as either direct line operators providing good and services or providers of support services including regulatory support. The collection format included a combination of interviews (both face-to-face and telephone), automated online response to questions and hard-copy responses to questions.

The interviews collected the following data:

1. Location of all operations of the respondent across eight states and regions.
2. Industry classification with thirteen options and the main focus only selected.
3. Annual turnover (average) over the last three years.
4. Number of employees (average) over the last three years.
5. Use of formal or informal risk management framework identifying, measuring, monitoring and reporting on risk for use in making decisions.
6. Effectiveness (self rated) of risk management framework in terms of helping the organisation achieve objectives and adding value.
7. Components included in risk management program selected from twelve possibilities including business partner's supplier training through to alerts about new and emerging risk.
8. How often does your organisation perform due diligence into the risk of suppliers, etc.?
9. How is due diligence conducted in your organisation?
10. Which of the following systems is your organisation developing further to enhance capacity to deal with the impacts of climate change?
11. How would you rate the commitment of management at your organisation to effective risk management?
12. How frequently are risk management topics (e.g. risk identification, analysis, evaluation etc) raised at your board and management meetings?
13. How traceable are your risk management activities? That is, how easy and secure is it to store information about risk management activities and retrieve risk related information?
14. Does your organisation have an alert system for high risk events?
15. Thinking about integration of your risk management into different decision-making levels of the organisation, what proportion of decision-making employees have consideration of risk as a stated condition of their job functions?
16. To what extent does your organisation meet the ISO Standard 310000 on risk management principles and guidelines?

17. We protect and create value out of uncertainty because we have a good understanding of risk and that it has potential for good and bad results. (Agree or disagree?)
18. We can gain a competitive edge out of our expertise in risk management through lower costs, better marketing and more precise timing of our activities. (Agree or disagree?)
19. We continually review the risks to which we are exposed so that at any one time all significant risks are considered when we make a decision. (Agree or disagree?)
20. Risk is considered in all of our management processes and decision-making at an operational and strategic level. (Agree or disagree?)
21. Have climate change impacts been identified as a source of risk to your organisation?
22. If you answered yes to the previous question how would you rank the following methods for handling extreme climate events?
23. The following table lists a number of risks that may or may not be applicable to your organisation. For each risk there is an indicator of how likely you judge that risk will become reality over the next ten years. For each risk, please tick just one box which best indicates your judgment of likelihood for that event.
24. Using the same risk identified in the table above, please rate the potential consequences of that event on your organisation's value, should it become reality over the next ten years.
25. What information sources do you use to identify and rank risks from climate change impacts?
26. What impact has the announced carbon tax for Australia and other policies (e.g. carbon farming initiative) had on your risk management policies, procedures and practices?
27. Our obligations to supply international customers are just as important as our obligations to supply Australian customers. (Agree or disagree?)
28. Retailer's house brands are more resilient to climate change impacts than manufacturer's brand. (Agree or disagree?)
29. Increased vertical integration would improve our capacity to cope with impacts of climate change. (Agree or disagree?)
30. Communication of our risk management processes is a high and ongoing priority in our aim to create an effective, open and transparent risk management culture in our workplace. (Agree or disagree?)
31. New technologies and innovative management practices can provide effective solutions for the management of most risks from climate change. (Agree or disagree?)

32. Please indicate for each of the following (fourteen) new technologies, practices and investment products your organisation's view on their importance for managing climate change risks.
33. The following table lists a number of items that may be constraining your capacity to implement an effective risk management culture for dealing with climate change impacts. Please indicate how important each constraint is to your situation.
34. For each intervention listed below, please indicate your judgement about how useful that intervention would be in overcoming constraints to management of climate change impacts.
35. How confident are you in your organisation's capacity to deal with risks to which it is exposed?

Appendix 2: Summary of case study responses

A1 Location of responding case studies

Location	Response %	Response count
Queensland	38.5	20
New South Wales	61.5	32
Victoria	44.2	23
Tasmania	19.2	10
Northern Territory and north-west Western Australia	19.2	10
South West of Western Australia	30.8	16
South Australia & southern Western Australia except south-west Western Australia	36.5	19
Murray Darling Basin	26.9	14
Other (please specify)		7
Answered question		**52**
Skipped question		**0**

A2 Main focus of industry operations of case studies

Industry category	Response %	Response count
Primary production – extensive (grain, livestock)	25.0	13
Primary production – intensive (irrigation, sugar, feedlots, intensive animal production etc.)	5.8	3
Farm input supplier – merchandise and materials (incl. fertiliser, chemicals, fuel, oil etc.)	1.9	1
Farm input supplier – credit, insurance, banking and other professional services	5.8	3
Health services	0.0	0
Education services	3.8	2
Infrastructure supplier – roads, railways, ports, airports, health facilities, education facilities	5.8	3
Food processor	15.4	8
Transport and storage provider	1.9	1
Food wholesaler (including food importers)	7.7	4
Food retailer	3.8	2
Regulator of food or agricultural production or services	7.7	4
Other (please specify)	15.4	8
Answered question		**52**
Skipped question		**0**

A3 Annual turnover of case study organisations (average last three years)

Annual turnover (average over last 3 years)		
Answer Options	**Response %**	**Response count**
Up to $5m/year	25.0	13
$5m, up to $50m/year	25.0	13
$50m, up to $250m/year	9.6	5
$250m, up to $750m/year	1.9	1
More than $750m/year	23.1	12
Not relevant (not for profit or regulatory or government agency)	15.4	8
answered question		**52**
skipped question		**0**

A4 Employee numbers of case study organisations (average over last three years)

Answer Options	**Response %**	**Response count**
Up to 25 full-time employees	42.3	22
25, up to 200 employees	19.2	10
200, up to 1000 employees	3.8	2
1000, up to 5000 employees	25.0	13
More than 5000 employees	9.6	5
answered question		**52**
skipped question		**0**

A5 Formal framework for identifying, measuring, monitoring and reporting on risk

Answer Options	**Response %**	**Response count**
No	44.2	23
Yes	55.8	29
answered question		**52**
skipped question		**0**

A6 Self-rated effectiveness of formal risk management frameworks

Answer Options	**Response %**	**Response count**
Urgent improvement required	4.8	1
Not that good	0.0	0
Unable to judge	9.5	2
Very Good	71.4	15
Excellent	14.3	3
Any comments?		3
answered question		**21**
skipped question		**31**

A7 Components of current risk management programs

	Part of current program	Not in current program but could be in future	Not in current program but will be within next three years	No plans to introduce this
Internal training	21	0	0	0
Business partner/supplier training	13	4	0	2
Risk ranking of business partners/suppliers	10	3	2	4
Business partner/suppler ethical/compliance standards	10	3	0	5
Internal code of conduct	20	1	0	0
Regular automated monitoring of all business partners/suppliers	6	5	3	4
Auditing of compliance activities	17	2	1	0
Due diligence on all new business partners/suppliers	13	3	1	1
Ad hoc due diligence reviews of all existing business partners/suppliers	11	4	1	2
Exposure to climate change impacts	7	6	1	4
Alerts about new and emerging risks	14	3	2	0
Other (please describe under comments)	3	1	0	0
Answered question				***21***
Skipped question				***31***

A8 Performance of due diligence into the risk of key service providers

Provider	Never	Rarely	Sometimes	Usually	Always	Not applicable
Suppliers	2	1	4	4	6	3
Third party agents or consultants	1	2	2	5	7	3
Providers of forecasting and prediction services	1	4	0	4	3	7
Acquisition targets (incl. assets and companies)	3	0	2	0	9	6
Senior level executives/board members	1	0	2	5	7	5
Sales agents	1	0	2	4	6	6
Customers/clients	2	0	4	3	6	4
Others	1	0	0	0	1	6
Answered question						21
Skipped question						31

A9 How is due diligence conducted

Answer options	Response %	Response count
Internally by our own compliance team or myself	89.5	17
Completely outsourced to third party	21.1	4
Partially outsourced to third party	42.1	8
Other (please describe):	0.0	0
Any comments?		3
Answered question		**19**
Skipped question		**33**

A10 Areas being developed further to enhance capacity to deal with climate change

Answer options	Response %	Response count
Human Resource Management	18.8	3
Customer Relationship Management	18.8	3
Provisions and Expense Recognition	18.8	3
Government Risk & Compliance Regulations	43.8	7
Data Collection & Information Management System	37.5	6
Environmental Management System	62.5	10
Quality Management	37.5	6
Enterprise Resource Management	18.8	3
Supplier Relationship Management	31.3	5
Other	12.5	2
Any comments?		2
Answered question		**16**
Skipped question		**36**

A11 Commitment of management to effective risk management

Answer Options	Response %	Response count
Uncommitted	9.5	2
Not that committed	0.0	0
Unable to judge	4.8	1
Quite committed	28.6	6
Highly committed	57.1	12
Any comments?		3
Answered question		**21**
Skipped question		**31**

A12 Frequency with which risk management topics are raised at board and management meetings

Answer Options	Response %	Response count
Continuously (monthly meetings or more frequently)	42.9	9
Quite frequently (every quarterly meeting)	28.6	6
Frequently (six month intervals)	14.3	3
Annually	4.8	1
Not that often	9.5	2

Maybe every couple of years	0.0	0
Any comments?		2
Answered question		**21**
Skipped question		**31**

A13 Traceability of risk management activities

Answer options	**Response %**	**Response count**
Very secure and also easy to access	47.6	10
Quite secure and accessible	33.3	7
Unable to judge	14.3	3
Somewhat easy to access but not secure	4.8	1
Neither secure nor easy to access	0.0	0
Any comments?		0
Answered question		**21**
Skipped question		**31**

A14 Presence of alert system for high-risk events

Answer options	**Response %**	**Response count**
Alert system in place and applies to all identified risk areas	23.8	5
Alert system in place but it only applies to some activities	33.3	7
We do monitor risks quite regularly	9.5	2
We have ad-hoc monitoring of events to which we are exposed	14.3	3
No alert system for high-risk events	19.0	4
Any comments?		1
Answered question		**21**
Skipped question		**31**

A15 Employees with risk integrated into requirements

Answer options	**Response %**	**Response count**
None	9.5	2
Less than 50 of employees with decision-making functions	14.3	3
Risk management is only a requirement for our most senior managers	4.8	1
Unable to answer	19.0	4
At least 50 of employees with decision-making functions	33.3	7
100 . All employees with decision-making functions	19.0	4
Any comments		2
answered question		**21**
skipped question		**31**

A16 Compliance with ISO 31000

Answer options	**Response %**	**Response count**

Comply fully with the principles and guidelines	33.3	7
Comply with most principles and guidelines	19.0	4
Unable to judge	42.9	9
Comply with almost half of principles and guidelines	4.8	1
Very little compliance with principles and guidelines	0.0	0
Any comments?		0
Answered question		**21**
Skipped question		**31**

A17 We protect and create value out of uncertainty because we have a good understanding of risk and that it has potential for good and bad results. (Extent of agreement)

Answer options	**Response %**	**Response count**
Agree strongly	15.0	6
Agree	62.5	25
Not sure, unable to judge	15.0	6
Disagree	7.5	3
Disagree strongly	0.0	0
Answered question		**40**
Skipped question		**12**

A18 We can gain a competitive edge out of our expertise in risk management through lower costs, better marketing and more precise timing of our activities. (Extent of agreement)

Answer options	**Response %**	**Response count**
Agree strongly	27.5	11
Agree moderately	45.0	18
Not sure	7.5	3
Not relevant to us	17.5	7
Disagree slightly	2.5	1
Strongly disagree	0.0	0
Answered question		**40**
Skipped question		**12**

A19 We continually review the risks to which we are exposed so that at any one time all significant risks are considered when we make a decision. (Extent of agreement)

Answer options	**Response %**	**Response count**
Agree strongly	22.5	9
Agree moderately	62.5	25
Not sure	7.5	3
Disagree slightly	7.5	3
Strongly disagree	0.0	0
Answered question		**40**
Skipped question		**12**

A20 Risk is considered in all of our management processes and decision-making at an operational and strategic level. (Extent of agreement)

Answer options	Response %	Response count
Agree strongly	25.0	10
Agree moderately	60.0	24
Not sure	7.5	3
Disagree slightly	7.5	3
Strongly disagree	0.0	0
Answered question		**40**
Skipped question		**12**

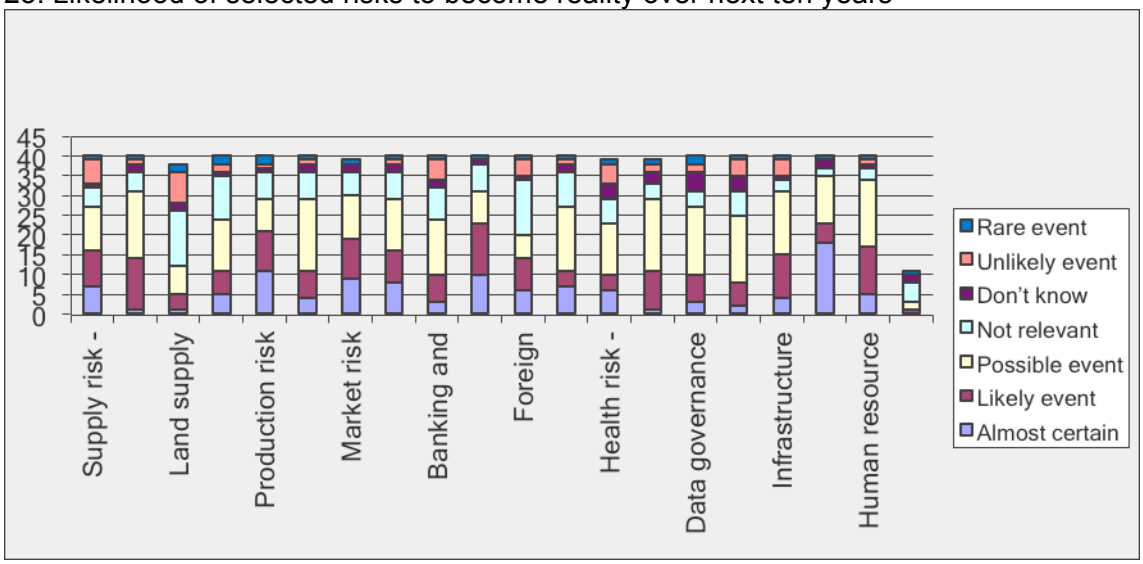
A21 Have climate change impacts been identified as a source of risk to your organisation?

Answer options	Response %	Response count
No	37.5	15
Yes	62.5	25
Answered question		**40**
Skipped question		**12**

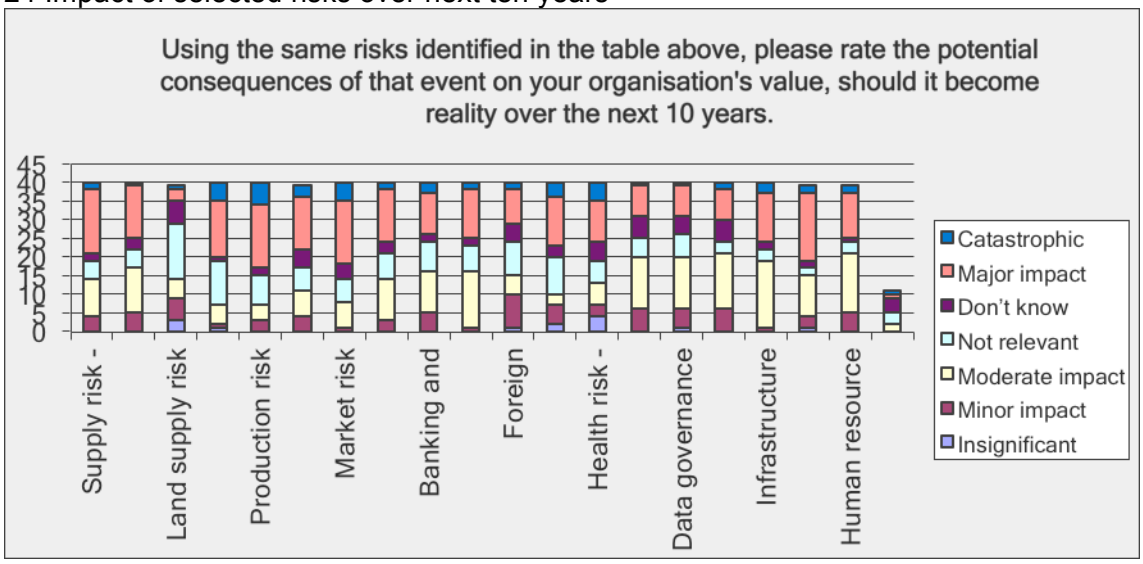
22 Methods for handling extreme climate events

Answer options	Response %	Response count
Treat all risks the same.	12.5	5
Treat risks the same but with exceptions, especially if we had a recent experience.	5.0	2
Treat risk on the basis of expected value. That is, the product of likelihood and damage or value at risk.	32.5	13
As above, treat risk on the basis of expected value but include some other cross checks.	15.0	6
A very different process for dealing with rare events that have high impact.	15.0	6
Other (please specify).	20.0	8
Answered question		**40**
Skipped question		**12**

23. Likelihood of selected risks to become reality over next ten years



24 Impact of selected risks over next ten years



25 Information sources used to identify and rank risks of climate change impacts

Answer options	Response %	Response count
Regional risk data compiled internally.	50.0	20
Subscription to regional climate change impact data supplied by private organisations.	12.5	5
Public information provided by agencies (e.g. Bureau of Meteorology, Climate Kelpie, IPCC, FAO, NOAA, WMO, Worldweather etc).	80.0	32
Climate forecasting apps (various suppliers).	27.5	11
Other (please describe below under comments).	12.5	5
Any comments?		6
Answered question		**40**
Skipped question		**12**

26 Impact of announced carbon tax on risk management

Answer options	Response %	Response count
Zero impact	15.0	6
Minor impact	40.0	16
Moderate impact	27.5	11
Significant impact	17.5	7
Any comments?		5
Answered question		**40**
Skipped question		**12**

27 Our obligations to supply international customers are just as important as our obligations to supply Australian customers (Level of agreement)

Answer options	Response %	Response count
Strongly agree	40.0	10
Agree moderately	28.0	7
Not sure	4.0	1
Disagree slightly	20.0	5
Strongly disagree	8.0	2
Answered question		**25**
Skipped question		**27**

28 Retailer's house brands are more resilient to climate change impacts than manufacturer's brands.

Answer Options	Response %	Response count
Strongly agree	8.0	2
Agree	24.0	6
Not sure	44.0	11
Disagree	16.0	4
Strongly disagree	8.0	2
Any comments?		2
Answered question		**25**
Skipped question		**27**

29 Increased vertical integration would improve capacity to cope with the impacts of climate change (Level of agreement).

Answer Options	Response %	Response count
Strongly agree	24.0	6
Agree moderately	12.0	3
Not sure	20.0	5
Disagree slightly	28.0	7
Strongly disagree	16.0	4
Any comments?		2
Answered question		**25**
Skipped question		**27**

30 Communication of our risk management processes is a high and ongoing priority in our aim to create an effective, open and transparent risk management culture in our workplace (Level of agreement)

Answer Options	Response %	Response count
Strongly agree	28.0	7
Agree moderately	52.0	13
Not sure	8.0	2
Disagree slightly	12.0	3
Strongly disagree	0.0	0
Answered question		**25**
Skipped question		**27**

31 New technologies and innovative management practices can provide effective solutions for the management of most risks from climate change impacts.

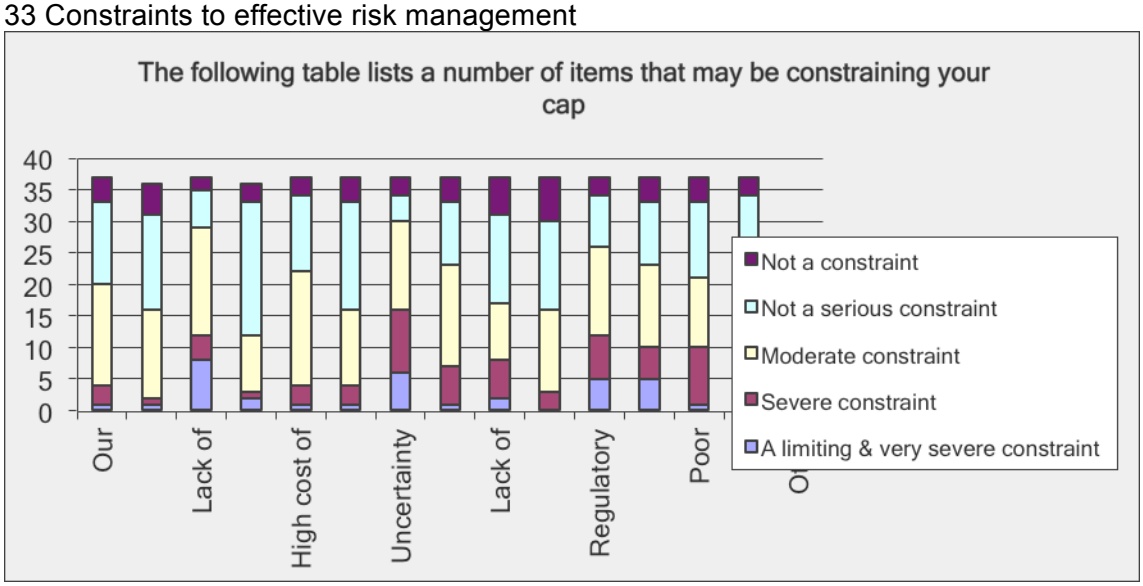
Answer Options	Response %	Response count
Strongly agree	25.0	10
Agree moderately	47.5	19
Not sure	22.5	9
Disagree slightly	5.0	2
Strongly disagree	0.0	0
Answered question		**40**
Skipped question		**12**

32. Importance ranking of new technologies, practices and investment products for handling climate change impact risks

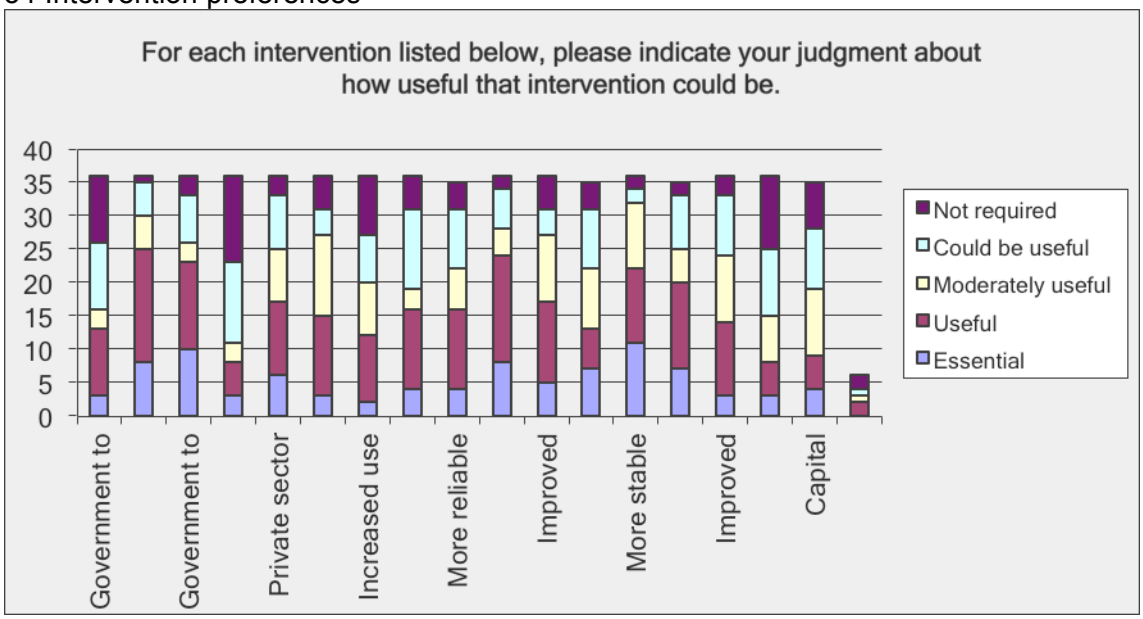
Answer options	Not important	Unable to judge	Quite important	Essential
Technologies (e.g. remote sensing satellites) that speed up and generate reliable information about emerging climate change events.	5	10	10	12
New buildings in climate exposed areas.	12	18	3	4
Buildings with greater resilience to climate events.	9	14	8	6
Real time locating systems for tracking people, equipment & vehicles.	10	12	13	2
Climate adapted livestock and plant cultivars.	3	7	10	17
Improved management practices (incl. veterinary, food processing, on-farm).	2	5	17	13
Improved insurance products.	5	4	24	4
Tailored loans for investment to improve risk management of climate change.	5	14	14	4
Changing land use.	2	5	21	9
Improved environmental	2	7	18	10

Answer options	Not important	Unable to judge	Quite important	Essential
management of assets.				
Improved human health services (for infectious diseases, infrastructure etc).	6	10	15	6
Biotechnology.	2	4	19	12
Precision agriculture (incl. GPS guides, digital farm maps, satellite imagery, vulnerability maps etc).	3	3	19	11
Other	1	5	0	2

33 Constraints to effective risk management

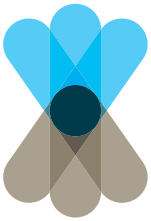


34 Intervention preferences



34 Confidence in capacity to handle risks to which organisations are exposed

Answer options	Response %	Response count
Extremely confident	11.1%	4
Quite confident	61.1%	22
Unable to judge	16.7%	6
Not that confident	11.1%	4
Very unconfident	0.0%	0
answered question		**36**
skipped question		**16**



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