NSW GOVERNMENT Industry & Investment

Background Paper
productivity & food security

I&I NSW – PROFITABLE, ADAPTIVE AND SUSTAINABLE PRIMARY INDUSTRIES IN NSW

This paper was prepared by NSW Department of Primary Industries Science & Research Division.

NSW Department of Primary Industries became part of Industry & Investment NSW on 1 July 2009.

Authors

Trevor Gibson

Geoff Allan

Steve Thomas

John Oliver

Deb Hailstones

Peter Parnell

Background Paper - productivity & food security

Summary

NSW has an excellent reputation for producing high quality produce from farming systems and wild fisheries. It currently produces sufficient grains, meat and fibre for domestic needs and for a healthy export trade. However, as global and world demand for such produce is expected to increase, and as food and fibre production faces a complex array of issues associated with climate extremes and variability, increased biosecurity risks, increasing costs of production inputs, declining genetic diversity in primary produce, increased competition for land use, market change and government budgetary pressures on primary industries' R&D capabilities, it seems likely that meeting domestic demand for some products could become a challenge in the future.

NSW is already a net importer of some food products such as seafood and global grain reserves are at a record low. How secure is Australia's continued access to food that is currently imported?

Production systems must respond to these challenges to ensure domestic and regional food security. They also need to have the productive capacity to maintain current market access and secure new opportunities for market access for primary products in the face of increased international competition in less regulated markets.

NSW DPI needs a strategic approach to ensure adequate R&D capacity and capability, and an appropriate policy framework to respond to these challenges. It also needs to participate in or lead initiatives to influence R&D priorities and to understand industry drivers at a national level.

This paper considers some of the drivers that influence the broad operating environment of primary industry production systems and how food security and productivity are impacted. These drivers include:

- Domestic and export market factors that impact on demand and supply
- Policy and regulatory environment
- Increasing demand for functional foods
- Sustainability of production systems
- Climatic impacts
- New and emerging technologies

There is clear recognition of overlaps with other priority R&D themes for the Science & Research Division. The development of adaptive production systems is critical to enable production system responses to climate change and water limitations, and crop protection systems to enhance productivity link to biosecurity issues. In one sense, each of these themes can be viewed as underpinning the continued delivery of food security and productivity in primary industries.

The discussion paper also identifies some of the key actions required to enable and support the delivery of research outcomes in food security and total factor productivity. They include a need for analyses of the trade and market environment and of impacts of changes in this environment, and to identify the critical areas of investment in NSW DPI capacity and capability in food security and productivity to ensure greatest return. Industry also needs to increase its capacity to adopt R&D innovations, in part through improved integration of R&D with extension delivery in NSW DPI.

NSW DPI already delivers a range of R&D activities that focus on delivering improved productivity outcomes for NSW primary industries. These include R&D

programs in the development of more efficient production systems, post harvest and production chain management, disease and pest management and food with enhanced quality and nutrition. Future R&D priorities for R&D investment need to increase the focus on issues that have a clear linkage to food security and productivity, and in which NSW DPI has leadership and capability. They should also account for R&D gaps that NSW DPI must fill to progress food security and productivity outcomes.

The paper summarises gaps in NSW DPI's current R&D program, but equally recognises that NSW DPI is not necessarily the most appropriate agency to fill those gaps. Gaps are identified in the areas of addressing competing resource use, improvement of plant and animal germplasm, understanding plant and animal physiology, food science and safety, improving production efficiency and market access.

Several key outcomes have been identified in food security and productivity to provide direction for NSW DPI's future R&D investment. They are:

1. Sustainable and Adaptable Primary Industry Production Systems in NSW

1.1 Improved farming systems. There is a need to develop and implement farming systems with increased resilience, productivity and sustainability that protect natural resources (soils, water, native vegetation, biodiversity).

1.2 Genotypes better adapted to climatic extremes (linkages to Climate Change priority area). There is a need to develop and evaluate germplasm with desirable traits to increase productivity over a wider range of environments while also protecting the natural resource base.

1.3 Improved pest and disease management systems. There is a need to develop IPM and IWM strategies to minimise chemical use to reduce contaminants and to identify and develop innovative systems to pest and disease management.

2. A Secure and High Quality Food Supply in NSW

2.1 Increased production (outputs) to meet market requirements. There is a need to develop production technologies to ensure the cost-effective production of high quality food to both satisfy local demand and meet export requirements, thereby keeping domestic prices low and providing security for local industries.

2.2 Optimised resources input to increase productivity. There is a need to develop technologies that reduce and optimise resource inputs to food production systems so as to at least maintain existing levels of productivity.

2.3 Improved food quality and nutritive value. There is a need to identify and enhance attributes of foods and feeds that contribute to the health and wellbeing of humans and animals.

2.4 Improved supply chain management to increase produce availability. There is a need to develop and implement communication strategies through the supply chain to better inform production systems of market requirements

Issue

NSW has an excellent reputation for producing high quality farm produce. It currently produces sufficient grains, meat and fibre for domestic needs and for a healthy export trade. However, as global and world demand for such produce is expected to increase, for some products, meeting domestic demand may become a challenge in the future. NSW is already a net importer of some food products such as seafood. In Australia, imports of edible fisheries products over the last decade have increased in value and volume by 63% and 97% respectively and were valued at $1.18 billion in 2006/07 (ABARE, 2008). In addition, global world grain reserves are at their lowest since 1960 (Cribb 2008).

NSW food and fibre production will face challenges in a future operating environment that features:

- uncertain economic growth,
- changing and increasingly extreme climatic conditions,
- increased biosecurity risks, including major changes to animal and plant pest and pathogen populations
- competition for land and water by other purposes, including biofuel crops and urban encroachment,
- increased market competition in less regulated markets
- continuing changes in market requirements and consumer demands,
- Increased costs of production inputs
- Uncertainty in continued access to food currently imported
- Declining genetic diversity that reduces the resilience of production system
- Declining or stagnating global capture fisheries production (Delgado et al., 2003)
- Budgetary pressures on State and Federal R&D providers for food and fibre industries

Production systems must respond to these challenges through the whole supply chain to ensure domestic and regional food security and also to maintain market access.

Market forces dictate how land and water are used (e.g. urban and industrial development versus agricultural production). Where land is used for agriculture, market forces also dictate what products will be farmed and into which markets they will be sold (e.g. grains for biofuels, grapes for wine). There is a role for NSW DPI in policy debate to help determine how land is used. Regardless of what is grown on available land the quest for increasing productivity to make the best use of scarce resources is a priority.

NSW DPI needs a strategic approach to ensure adequate R&D capacity and an appropriate policy framework to respond to these challenges. NSW DPI's R&D investment is currently under review. It is critical that R&D resources are directed at the highest priority issues and, just as importantly, to identify those activities currently supported that could be discontinued. NSW DPI needs to participate in or lead national initiatives to influence R&D priorities and understand industry drivers. The current discussions within the PISC R&D Sub-Committee to rationalise and coordinate state R&D investment are an example.

This paper outlines the research priorities for NSWNSW DPI to ensure future food security industries and total factor productivity for both food and fibre production industries. This is one of four R&D priorities themes identified by the NSW DPI S&R

Board of Management (the others are biosecurity, water management and climate change)[1].

Background

Food security has rarely been an issue for Australia since the early days of colonisation. It can be defined as access at all times to sufficient food for an active and healthy life (NSW Health)[2]. While Australia as a nation is regarded as being food secure, it does contain pockets of food insecurity (NSW Department of Health 2003) and there is recognition that future scenarios could impact on food security. For example, a Senate inquiry commenced in July 2008 to examine how Australia can produce enough food for itself in a sustainable manner and maintain its major export capacity in the face of global warming. Much of the debate within Australia has been about global food security issues rather than domestic concerns. Nonetheless the linkage between food production, energy production and climate change, and the ability of Australian to export much of its food produce means food security issues can be connected to Australia's trade, humanitarian aid and defence policies.

The Commonwealth has also established the Food Chain Assurance Advisory Group to assess food safety and security issues and preparedness in the event of deliberate acts of contamination of the food supply or disruption of major infrastructure. This aspect of food security is beyond the scope of this discussion paper and more information is available at http://www.daff.gov.au/agriculture-food/food/safety-security/national.

The need for safe food is also a consideration in the support of locally or nationally-grown product. Food contamination by foreign bodies and outbreaks of food poisoning are still serious health issues. Food production, storage, handling and processing must ensure contamination is minimised at all stages. The cost of failure is high and can seriously affect brand value and customer loyalty domestically and internationally. Audited systems that demonstrate that risks of contamination have been minimised, and quality assurance systems that demonstrate traceability of product along the processing chain are now expectations of the consumers. To ensure food security, food safety must be at the highest level.

There are several intervention options to influence food security, including strategies for increased production and those that improve food distribution and availability. Agencies such as NSW DPI have a clear role in the development of technologies to:

- improve productivity and hence the production of food, and
- to improve food quality and nutritive value through the production chain

The NSW primary industries food and fibre sector[3] has a gross value of production of $8.5 billion and contributes over $5 billion (or 30%) to NSW export revenue. With multipliers considered, the estimated value of the sector to the NSW economy is $18.5 billion, contributing significantly to the State's economic wellbeing.

---

[1] Responses to the priorities present a degree of overlap. These will be highlighted in the report and other priority action papers referred to where appropriate.

[2] Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle. World Food Summit 1996

[3] Including fisheries production

Primary industries have a history of achievement in improved productivity. For example, at 2.5% per annum, the broadacre agriculture sector has had one of the highest rates of productivity growth of any sector in the Australian economy, though from the mid-1990's this rate has slowed to less than 1.5% (Mullen 2007). Much of productivity growth (50% in NSW) has been driven by the development and adoption of scientific innovations supported by a system of industry and public co-investment embodied in the Rural Research and Development Corporations and Co-operative Research Centres (Mullen 2007). A recent review has found that there is an eleven-fold return on R&D investment in primary industries, with approximately 50% identified as public benefit (Rural R&D Corporations 2008).

With the future challenges facing food and fibre producers in Australia, the development of the tools and capacity to continue to increase total factor productivity (production with fewer inputs) is critical to maintain food security and sustainable industries. The determination of total factor productivity must also account for the characteristic lag phase from initial investment in technology development, technology delivery to and adoption by food and fibre producers and ultimately, the impact of the technology on productivity.

Continued improvements in productivity are essential for viable and sustainable Australian food and fibre industries that are competitive on export markets. This requires continued investment in R&D to develop and deliver innovations and new technologies.

Components of food security and productivity have potential to improve human health and wellbeing and so also have indirect economic benefit. Local production of perishable foods ensures that consumers have access to a reliable, affordable and diverse supply of fresh produce.

This paper focuses on RD&E priorities for the major food and fibre production sectors in which NSW DPI has a significant RD&E role. These priorities are developed within the context of two key R&D themes pertinent to food security and productivity. These are:

1. Sustainable and adaptive production systems in NSW, and
2. A secure and high quality food and fibre supply in NSW

The major food and fibre production sectors in which NSW DPI has a significant role are listed in Table 1, as are the value of the sectors to the State and national economies in terms of production and export. In 2006/2007 the total value of food and fishery production nationally was $30.2 billion, a decrease from previous years because of the impact from drought on broadacre crop production (DAFF 2008). Food production employed over 90,000 people in NSW in 2006/2007, and 321,000 nationally. Australia is a net exporter of food products, with exports in 2006/2007 of 23.3 billion, exceeding imports by $15.1 billion. This gives some sense of the importance of food production and export to the Australian economic and societal wellbeing. Discussion on specific industries within the sector will be informed by outcomes of the current discussions by the PISC R&D Sub-Committee and development of PISC sector papers.

Table 1: Major Food Production Sectors in NSW (2005/2006)

Sector	Production ($ billion)		Export ($billion)		
	NSW	Australia	NSW	Australia	Trend (cf1996/97)
Horticulture	1.08	6.21		0.80	Increase
Beef and Sheep Meat	2.08	9.80	0.85 (beef)	4.27 (beef)	Increase
Wool	0.73	2.09	0.84	2.54	Decrease
Broadacre Crops*	2.00	7.26	1.07 (wheat only)	3.36 (wheat only	Static
Aquaculture**	0.046	0.793			
Dairy products	0.42	3.34		2.57	Static
Intensive Animal Industries***	0.41 (poultry only)	2.12		0.18	Decrease

DAFF (2008) http://www.daff.gov.au/__data/assets/pdf_file/0003/680745/foodstats2007.pdf
* Wheat, rice, barley, canola
**2006/2007 figures
*** pigs, poultry

Inevitably, discussion on R&D priorities for food security and productivity will overlap other R&D priority themes recently identified announced by NSW DPI. For example, climate change is likely to deliver both threats and opportunities for agricultural production and require adaptive responses in plant and animal production systems. Climate change also has the potential to change the distribution of pests and diseases both domestically and internationally with consequent impacts on productivity and market access. Notably, the agriculture sector is currently omitted from the proposed carbon trading scheme recently announced by the Rudd Government, which will impact on investment decisions in the sector. Changes in the availability of water and the regulatory environment for water management will also influence the distribution and production potential of cropping systems. These are discussed in the strategic issues papers relating to these R&D priority themes.

There are several considerations in the broad operating environment that inform any discussion on food security and productivity:

Domestic and export market factors that impact on demand and supply
Demand for and supply of food and fibre products are affected by export and domestic market forces such as:

- International changes in dietary preferences and demand. For example, current trends include increasing consumption of meat at the expense of legumes for protein in developing countries, and an increasing consumption of “healthy” fish protein in the west (countered by associated reductions of wild fish stocks). An increasing demand for meat and fish protein in turn significantly increases demand for feed grains that can compete with grain for human food.

- Increasing costs of inputs and strengthening of the Australian dollar impact on competitiveness, reflected as increased food prices and lower demand for Australian export commodities. Farmer input costs are also increasing faster than the CPI.
- Increased competition by other Southern Hemisphere producers for counter-seasonal export markets in the Northern Hemisphere. Many of these competitors have labour cost advantages, increasing the pressure for Australian exports to rely on quality and biosecurity factors to retain market share.
- Increased market demand for Australian grains in 2020 has been estimated to be as much as 200% over 2000 levels (Benjamin and Pocknee 2004), a level that Australian producers will have difficulty to supply.
- Government trade policy can produce trade-distorting barriers by artificially inflating export commodity prices or reducing production. Market access agreements that can influence these policies are complex, commonly involving protracted discussions on issues with little dependence on science-based data. Biosecurity issues are often the centre of both international and domestic market access. For example, restrictions are placed on the international and domestic trade in horticultural produce because of fruit fly.

Climatic Impacts

One of several emerging sustainability issues for production systems is the potential impact of climate change and variability on productivity and the need for industry to adapt to these impacts. Recent years of adverse weather conditions such as drought have disrupted production in a number of significant food growing and exporting regions. For example, compared with 2004, the production of coarse grains and wheat in 2006 fell by 52% and 33% respectively in Australia (Stoeckel 2008). The potential for increased atmospheric CO_2 and temperatures to promote plant growth may be countered by increased impacts on production by changing pest and disease pressures.

Climate change scenarios also predict an increased frequency and severity of adverse weather events such as cyclones and these would significantly affect horticultural production. Cyclone Larry famously flattened banana plantations in 2006 and bananas became scarce and expensive. Fortunately, the impact was short-lived because of the rapid regeneration potential of banana plants. However, the effect on perennial plantings such as citrus or macadamia trees would have been devastating, given the time of these trees to maturation. Extreme weather events would also impact heavily on the integrity of greenhouses, expected to become an increasingly common means of horticultural production in the face of climate change.

Another issue is variable weather patterns. Australian winter cropping varieties have been developed to take advantage of autumn rains for germination, winter rains or stored ground moisture for crop growth, flowering to avoid late winter frosts, and accessing moisture during grain filling to maximise yield. Variations within seasons that affect these conditions will negatively impact on crop growth. A more variable climate as predicted by some climate change models will therefore create considerable variation in supply which will affect food security. Traditionally Australia does not carry forward large stocks between seasons.

Prolonged adverse climatic conditions such as droughts can have long-term impact on livestock production systems as herds and flocks may take several years to re-build to re-drought levels. Consequently, reduced availability of livestock products (meat, dairy, wool) can continue for several months (or years) following extreme climatic periods.

Climate change and reduced water availability are expected to reduce production of freshwater fish species (especially trout) but improve conditions for culture of most other species. Predicted impacts of increased CO_2 concentration in ocean waters may affect larval performance and settlement of wild and cultured mollusc species.

There is also an increased focus upon carbon footprints and the concept of food miles as policies on climate change responses are developed. Industries will need to respond to these policies and develop strategies to reduce emissions and or increase carbon sequestration as part of proposed carbon trading schemes. These issues are considered in the Climate Change R&D priority theme paper being developed separately.

Sustainability issues for production systems

The focus of production systems has traditionally been on productivity and profitability. These are still relevant in the context of increased costs of production inputs, competition from overseas competitors with access to low cost inputs and of the need to provide incentive for continued and increased investment in primary industry production. Responses to these pressures have included increased mechanisation of crop management and harvesting, development of technologies to reduce input costs (such as for aquaculture feed) and the greater focus on economies of scale though managed investment schemes.

More recently, this focus has broadened to include environmental outcomes and system fit with natural resource management. This recognises the high percentage of the landmass under the management of primary producers (80% in NSW) and the important role of primary producers as custodians of this land. Thus, the development and adoption of integrated pest and disease management (IPM) systems have improved the environmental performance of many agricultural crops. Improved irrigation and nutrient supply management have reduced nutrient leakage into the environment and improved water use efficiency, as has the resource reuse potential of protected cropping systems. Increasing the output per unit of water (eg using irrigation water for aquaculture before use on crops) is a priority.

There is a much greater understanding of the need for healthy soil and water resources for sustainability and some industries have increased their use of organic soil amendments such as mulch and are beneficially using waste products such as animal effluents and manures. Where food production areas are near or within population centres, transport and storage costs are reduced and product freshness is improved, benefits acknowledged through concepts such as eco-labelling. However, once-productive agricultural land is increasingly suffering under peri-urban encroachment and rezoning.

Another relevant issue for aquaculture production systems is their potential role in replacing wild-caught fish from fisheries that are considered to be at maximum sustainable yields. Aquaculture is the only way to meet increasing global and demand for seafood (per capita consumption has doubled since the 1970's) (Delgado, et al., 2003). Seafood consumption continues to increase in Australia (now approximately 15 kg/capita/yr; Ruello, 1999) up from approximately 5 kg/capita/yr in the 1950's. Hatchery produced fish can also be the source of fingerlings for fish restocking programs. Fishmeal substitution in fish feeds contributes towards conserving lower value fish resources that are used for fishmeal.

New and Emerging Technologies and Market Trends

Crop breeders have always used advances in science and technology to improve rates of genetic gain, with continual developments in physiology, biometry, computer simulation, engineering, end-use quality assessment and robotics. More recently, molecular biology has offered breeders the tools to select elite individuals based on their genotype rather than, or in addition to, their phenotype. Improvements in genomic profiling is moving at such a rapid rate that instruments that can sequence complete genomes within a matter of weeks are very close to commercial release.

The capability to transfer genes between species is also available. To date commercial crops have been developed with resistance to herbicides and incorporation of a gene that codes for the *Bacillus thuringiensis* (Bt) toxin, protecting plants from insect pests. Now there is serious research into development of crops with other traits. Dupont is targeting a 40 percent increase in yields from both its soybean and corn seed products in the next 10 years (DuPont, June 11, 2008). Evaluation is occurring of second generation transgenic crops with improved drought tolerance (Bartels and Hussain 2008), improved N use efficiency (Good, *et al.* 2007), improved boron tolerance (OGTR website) and for improved dough making and nutritional properties (OGTR website).

Development of an Australian Sheep Genetics Database is also expected to improve the rate of genetic gain by enabling all sheep producers to compare sheep from different flocks on genetic merit.

The development and adoption of new technologies can have an impact beyond productivity alone. New breeding and hatchery technologies for faster growing, disease resistant Sydney rock oysters developed by NSW DPI over the past decade has transformed a $35 million industry that faced decimation from QX disease and that relied on methods that had changed little in the last century. New technology for farming non-oyster molluscs and finfish is being adopted slowly by farmers. New or emerging industries require greater initial support, at least until the private sector is able to provide technical and extension services to assist farmers.

Remote sensing utilising spectral images from satellites to monitor changes at the earth's surface coupled with geographic information systems provide a range of multidimensional information. Applications are already being evaluated in forest management and canopy growth in rice. Equipment is being developed to use various spectral measurements at close to ground level to monitor physical and physiological effects on crops. GPS systems are enabling accurate inter-row spacing, differential application of fertilisers and production of yield maps to assist farm management. Such applications will be refined as software and electronics develop to permit more targeted management of resources. Introduction of carbon trading and emission accounting schemes are likely to be drivers in the adoption of such technologies to justify use of fertiliser inputs and demonstrate minimal environmental impact. Subject to an appropriate return on the capital investment in the equipment such systems offer the opportunity to improve farm productivity by lowering input costs.

The high cost of petroleum fuels delivered and used on-farm may well drive development of on-farm management of energy through exploitation of solar, wind or on-farm generation of biofuels. This too, subject to the return on the capital investment being acceptable, could improve productivity.

The value of a balanced diet in preserving human health is widely acknowledged. Research has identified plant metabolites, such as lycopene and sulforaphane, that have chemoprotective effects but opportunities to identify or develop plant varieties enriched for particular metabolites have so far been limited. Horticulture Australia's VitalVeg project will shortly release its first product ("Booster" broccoli), though it is unclear whether this will increase the overall consumption of broccoli in Australia.

The organic sector is portrayed as the fastest growing food sector with claims of global increases of between 10 and 30% per annum. This trend appears to be similar in Australia such that the organic food sector now occupies 1-2% of food sales. (*Organic Food Products Directory*, Regional Development Victoria, 2007). While there are claims of organic foods containing beneficial compounds backed by research (University of Newcastle, LowInputFood Project 2008), there are also claims that such food, particularly vegetables, might be more prone to contamination with enteric bacteria due to the use of manures (University of Newcastle, LowInputFood Project 2007).

Cereals as "functional food" have a mixed reputation. Although many cereal based foods are perceived as fattening or "unhealthy", whole grain equivalents are considered "healthy" and are promoted to form a significant part of the diet. Similarly, starch from cereal foods on one hand is denounced as a significant contributor to undesirable glycaemic loads and glycaemic indices that increase the risk of the "lifestyle diseases" (diabetes, obesity and cardiovascular). Conversely, starch is commended as a contributor to fibre and "resistant starch" which offsets the lifestyle diseases and is implicated in lowering the risk of certain cancers. The community is expecting foods that permit healthy living in spite of overindulgence and minimal regular exercise. Cereal foods, particularly flour, bread and breakfast cereals, are regularly utilised as the carriers of fortifications to correct community-wide dietary deficiencies

The increasing awareness of the importance of omega 3 (ω-3) fatty acids, particularly the long chain ω-3 fatty acids from seafood products, will continue to drive increased demand for seafood and the incorporation of these compounds into other foods.

Policy and Regulatory Environment

New public management paradigms are focussed on the justification of public spending to deliver outcomes of public value. Market based structures are increasingly being utilised to identify activities that deliver private value, especially those delivering an acceptable return on investment and differentiating these activities from areas of market failure. In addressing market failures, Agencies are required to ensure that private investment is in line with the value delivered. However, this expectation raises significant tensions, given that the delivery of public value, especially within primary industries, almost inevitably generates valuable outcomes for the private sector regardless of their input.

Water policy in Australia is creating considerable change in agriculture exacerbated by recent years of low rainfall. Community environmental expectations of healthy rivers and waterways and the integration of management of water with other natural resources are creating an unprecedented competition for water. Both Federal and State governments have come under increasing scrutiny to ensure the efficient use of

water. The Water Management Act 2000 is the main piece of water legislation for NSW that governs how water as a resource is provided for the environment and shared between water users.

Changes in wheat marketing in particular, but also in marketing of other cereals is changing the dynamics of grain handling and marketing and permitting the entry of internationally based organisations to manage Australian exports. This has removed export management of Australia's grains one step further from Government control.

Regulation of aquaculture is improving as state wide consultative mechanisms mature and policy makers gain a better understanding of aquaculture. However, resource allocation (water and sites), effluent controls and licensing, and biosecurity management have all been difficult (slow and costly) for aquaculture. They are perceived as barriers to development and contribute to a negative perception among investors about aquaculture in NSW.

Given Australia's history as a major exporter food produce, food security has never been a significant issue for Australians. However, the issues of food, energy and climate change are closely linked and at the global scale the latter two are focussing attention on to future food security.

To some extent there is an expectation that increased agricultural investment and enhanced agricultural productivity can meet future food requirements. However, many projections of future global food security either ignore the impact of climate changes or assume that productivity gains from increased carbon dioxide availability, better targeted fertilisation and the release of new areas suitable for crop production will offset losses.

Australian policy on food security must provide the assurance that Australians have access to food at reasonable costs in the context of climate change impacts, increasing energy costs and increasing farm input costs. Given that Australia exports much of its agricultural produce, at face value this aspect does not appear to be difficult to satisfy. As a consequence the debate on food versus fuel uses of agricultural capability continues.

However it is not quite so obvious that Australia also needs continued access to imported foodstuffs that might become unavailable or more costly due to factors outside Australia's control. This aspect is coupled with trade policies.

Because Australia does have the capability and capacity to produce food in excess of its requirements it can remain a provider of food to the Pacific region and the world at large. This could be for humanitarian reasons to assist the looming world food crisis or for strategic reasons to offset potential regional political instability where food shortages might have military, economic and terrorism consequences.

Policy positions of food retailers, particularly the larger chains, can also impose specific packaging requirements that affect the ability to access local and export markets. Such requirements are not always evidence-based, for example the "food miles" concept introduced in Europe did not withstand scrutiny but successfully reduced the access of foods imported from distant suppliers.

Action Required to Address the Issue

- Analysis of trade and market environment. This needs to include analysis of export and import markets and internal trade. Important components include trends, benchmarking statistics and KPIs. Analyses should be conducted on a short term (5 years) to address immediate requirements and long term (20 years) to anticipate for expectations of initial impacts of climate change.
- Sensitivity analyses in consultation with stakeholders that identify at a high level the impacts of changes in the external and internal environment on food security and productivity
- Determination of consequences of not doing the RD&E through economic analyses of NSW DPI's R&D outcomes from its investment portfolio.
- Analysis of the capacity and capability needs for NSW DPI given the capacity and capability available elsewhere in industry and by other agency R&D providers. This would include identification of the opportunities for collaboration, integration and rationalisation and would map capacity and capability against NSW DPI priorities.
- Identification of where NSW DPI must target its R&D capacity and capabilities, and yet retain the flexibility to respond to changes in the operating environment. This is effectively an R&D priority setting exercise and needs to include consideration of resourcing requirements and constraints to resourcing.
- Work with partners and stakeholders. This involves engaging stakeholders in project development and strategies to influence funding decisions and priority setting.
- Increase industry capacity for innovation adoption through enhanced skills in business analysis, entrepreneurship, communication and leadership.
- Enhance value chain communication and improve efficiency of price transmission through alliances, through-chain partnerships etc
- Improve integration of R&D with extension in NSW DPI and develop improved extension tools and mechanisms. This should include consideration of the government's role in both R&D and in extension delivery for industry groups and of measurable impacts of extension in delivering R&D outcomes
- Quantify the key impacts of R&D in food security and productivity and focus investment upon areas that offer the greatest return.
- Set priorities in consultation with other NSW DPI Divisions

Appropriateness – is it NSW DPI's Role to Research Productivity and Food Security?

NSW DPI co-invests in research in cases of market failure - where insufficient industry funds are available to meet the R&D requirements to support the development of an infant industry, where there are identifiable public good benefits (such as in biosecurity, environment or for regional communities), spill-over benefits to non-contributing sectors (such as food processing industries), or where externalities (adverse impacts) are avoided by the conduct and delivery of the research outcome.

The share of benefits from the delivery of productivity-related research and thus the share of costs for the research will vary. NSW DPI's business model for R&D recognises this and allocates its research investment accordingly.

Work Already Underway

Many past and existing NSW DPI R&D programs have focussed upon delivering improved productivity outcomes for NSW primary industries. Many of these programs have also either directly or indirectly contributed to food security and can provide a framework upon which to develop priorities into the future. Although specific areas of research have evolved according to changes in R&D priorities, currently they can be broadly grouped as:

More efficient and sustainable farming systems

- Generation of science-based data to underpin the development of standards, innovations and guidelines to improve production practices. This R&D includes but is not restricted to nutrient management from nutritional and environmental perspectives, agronomic practices, animal welfare and behaviour studies, animal nutrition technologies and irrigation technologies and practices.

Examples include:
- Assessment of fertigation and development of improved irrigation practices in horticultural crops
- Improved stockfeed technologies and nutrition for animals and fish
- Regulation and management of flowering and cropping for horticultural crops
- Breeding and farming systems for finfish and molluscs
- Improved dryland and irrigated farming practices
- Feedbase management for pasture- and rangeland-based animal production systems
- Improved on-farm yields through genetic and crop management gains
- Evaluation of fertiliser technologies
- Precision management systems to improve farm efficiency -
- Native fish restocking programs and development of underpinning hatchery technologies

- Genetic and biotechnological approaches to improved productivity and efficiency. This involves both conventional plant and animal breeding and evaluation as well as pre-breeding activities. Pre-breeding identifies and characterises novel germplasm, gene identification, pyramiding of alleles and traits of interest into the breeding parental pool, and the development of tools (such as molecular maps and markers, image analysis, near infra-red spectroscopy) to improve breeding efficiency.

Examples include:
- Faster growing Sydney rock oysters through selective breeding
- Germplasm evaluation and screening of perennial tree crops, pastures and field crops for improved performance attributes and quality parameters
- Sourcing and evaluation of plant genetic resources that will underpin germplasm development for hostile environments and other desirable traits
- Molecular markers to select for desirable traits in animal and plant improvement
- Identification and quantification of cultivar x environment x production system interaction to improve crop yield, consistency of supply and quality
- Molecular characterisation of genetic diversity
- Development and adoption of new diagnostics for quality parameters and biosecurity
- Development of biometric tools and databases to assist variety evaluation
- Improved decision support tools for enhancing rates of genetic improvement
- Enhanced understanding of functional biology (proteomics, phenomics, metabolomics etc) and linkages to improved production

- Development of production technologies that improve sustainability and productivity in existing systems, or deliver stepwise system innovations

.

Examples include:
- New hatchery technologies for Sydney rock oysters and finfish
- Automatic milking system development for pasture-based dairy production
- Improved feeds for finfish
- Prediction modelling to assist producers in meeting market specifications and management systems
- Improving productivity on hostile soils (acidic, saline, acid sulfate, sodic)
- Incorporating perennial pasture species into crop rotations
- Conservation farming techniques
- Grazing strategies for dual purpose crops
- Variety specific agronomy packages to optimise yield

Market Access and production chain management

- Supply chain mapping and management for product ripening, quality and nutritional value. This involves identifying the components of a supply chain "paddock to plate" (product maturation, harvest, handling, transport, storage, packaging, promotion) and assessing the impact of each on the final product quality (nutrition, quality, presentation).

Examples include:
- Underpinning meat science contributing to Meat Standards Australia system for describing beef quality
- Processing technologies to enhance quality and consistency of beef and lamb
- Strategies to prevent chemical resistance in grain storage insects
- Development and evaluation of technologies for packaging, transport, storage and presentation of horticultural products
- Assessment of consumer perception and preferences in foodstuffs
- Nutritive evaluation of stock feeds

- Development and evaluation of alternative (non-chemical) postharvest treatments and technologies to support market access of horticultural products

Examples include:
- Cold disinfestation of export fruit
- Use of controlled atmospheres, combination treatments against pests of trade significance in horticultural produce

Disease and pest management (in the context of maximising productivity potential rather that biosecurity)

- Genetic approaches to disease and pest management. This involves the identification of diseases and pathotypes as well as the incorporation of new genetic resistances, and the identification of molecular tools (markers) to assist selection.

Examples include:
- Breeding for QX resistance in Sydney rock oysters
- Germplasm enhancement for improved pest tolerance and disease resistance
- Identification of pathotypes of disease agents

- Integrated pest management, involving the development and validation of pest and disease management practices that reduce or eliminate chemical usage. These often involve a combination of approaches that enhance resistance, encourage natural predators and/or target susceptibility windows and require knowledge of the pest/disease lifecycle and ecological interactions.

Examples include:
- Fruit fly management strategies to improve fruit yield and quality in susceptible hosts
- IPM approaches to insect pest control in crops, including GM crops
- Identification and development of new biocontrol and bioactive agents
- Crop management practices that enhance numbers of beneficial insects
- Development of integrated weed management practises
- Encapsulation technologies for delivery of active ingredients

- Development of diagnostic tests and vaccines to manage diseases. This involves developing, validating and implementing new and existing tests that provide rapid, robust, high throughput identification and differentiation of pests and pathogens, and their application to cost-effective surveillance.

Examples include:
- Development of vaccines to reduce losses from animal diseases
- Molecular screening tests to identify genetic diseases and abnormalities
- Diagnostic technologies to detect new and emerging diseases eg PCR, antibodies
- Development and implementation of molecular tools reflecting validated taxonomy

Food with enhanced quality and nutrition

- Improved levels of bioactive components of functional foods. This involves identification and measurement of bioactive compounds, validation of bioprotective or other beneficial effects, development of plant varieties with improved bioactive properties

Examples include:
- Identification and development of cultivars with enhanced levels of bioactive compounds
- Investigations aimed at improving omega-3 fatty acid levels in beef and lamb
- Enhancing the functional food characteristics of pasta (antioxidants, glycaemic index, resistant starch)
- Development of cost-effective aquaculture diets that ensure human health benefits of seafood (particularly omega – 3 fatty acid content) are maintained or enhanced

Gaps in the Current Work

NSW DPI's current R&D portfolio is broad but cannot cover all aspects of plant and animal research in productivity and food security - nor should it. Some aspects are better done by other agencies, accounting for developments and arrangements under the current PISC RD&E framework now in progress and for our own strategic R&D priorities and capabilities. The following identified gaps in the current R&D are not intended to suggest that NSW DPI needs to fill all. The Department will continue its R&D in priority R&D areas in its current portfolio, withdraw from lower priority areas and redirect investment to new areas to fill key gaps that align with priority R&D directions.

Competing Resource Use

- Stockfeeds
    - Development of multipurpose crops
    - Breeding and prebreeding for desirable stockfeed quality parameters

- Biofuels and Biopolymers
    - Identification and development of non-food sources for biofuels
    - Germplasm development for biopolymers that can substitute for oil-derived products
    - Predictive modelling of impacts of biofuel policies on food production

- Fibre Production (are these gaps? Input sought)
    - Improvements in animal and plant fibre quality
    - Precision management for fibre crops to reduce input costs

- Environment
    - Improved use and management of effluent and water
    - Development of sustainable farming systems compatible with
        - the changed climate expected by 2030
        - the introduction of Emissions Trading Scheme
        - peri-urban issues and potential amenity value

Genetic Improvement

- Genetic Modification (GM)
    - Application of GM technologies to improve quality and production characteristics of crops to meet market specifications

- Genomics/Phenomics
    - Genetics of disease resistance and development of resistance molecular markers for breeding programs in horticulture
    - Functional profiling of whole genomes
    - Development of new phenotyping technologies
    - Developing new platforms

- Germplasm Development and Evaluation
    - Assessment of crops with improved thermal tolerance and productivity in water-limited environments
    - Improved methodologies for germplasm development and evaluation
    - Development of pre-commercial germplasm

- Interface with the Environment
    - Understanding interactions of plant and animal genetics with environment and management
    - Germplasm development for improved nutrient productivity in crops to better manage inputs and reduce risk to environment
    - Germplasm development for the environments expected in 2030

Plant and Animal Physiology

- Adaptability
    - Understanding and enhancing plant and animal physiology and biochemical characteristics that favour thermal tolerance and in water-limited environments
    - Root and canopy architecture and linkages to water use efficiencies
    - Improved nutrient scavenging capabilities by plants

- Market interface in beef cattle
    - Phenotypic prediction of end-product performance achieved from specific production systems

- Product Quality and Integrity
    - Seasonal impacts on physiological parameters
    - Supply chain management (harvest to plate) in cereals
    - Assessment of organoleptic characteristics and consumer preferences across horticulture

Human Health and Nutrition

- Food science
    - Broad scale identification and enhancement of bioactive components in primary produce and promotion of functional foods
    - Studies on animal- and plant-based food allergens
    - Nutraceuticals and functional foods

- Food safety
    - Detection and elimination of contaminants in food
    - Contaminant traceability systems to improve food safety

Production Efficiency

- Improved production Systems
    - Development of new platforms and breeding technologies for production and environmental outcomes
    - Management of climate change impacts
    - Determination of farming system carbon footprints
    - Integrated risk management for farming systems

- Feed Efficiency
    - Improved management of the impacts of feed and resource use
    - Cost effective means to identify differences in feed efficiency and greenhouse gas emissions
    - Improved understanding of nutrient availability and delivery systems to meet nutritional requirements

- Animal and Plant Health
    - Better early life measures for improvement of herd and flock fertility and production efficiency
    - Understanding and management of diseases of aquatic animals (to optimise production and manage biosecurity issues)

Market Access and Import Replacement

- Market Intelligence Capabilities
    - Predicting and understanding market needs and capacities
        - Meeting export market requirements
        - Understanding risks to supply of imported products
    - Market failure analysis

- Product Quality and Integrity
    - Improved capacity to enhance product quality and integrity through the detection and elimination of contaminants

- Supply Chain Efficiency
    - Improved supply chain efficiency through packaging technologies, improved environmental footprints, value-based marketing and the development of tools for improved transaction efficiencies

NSW DPI's Capabilities in Addressing these Gaps

Strengths o Highly skilled R&D resource base o Leading skills and expertise in plant and animal physiology, nutrition, genetics, germplasm development and economic assessment o Skills, experience, physical resources and facilities to conduct large scale plant and animal genetics experiments o Well established strategic alliances and co-operative arrangements with other R, D&E providers (including university sector and CSIRO, other state agencies) to leverage innovation investment o Experienced network of extension officers to assist in achieving rapid adoption of R&D outcomes. o	Weaknesses o Declining workforce over time resulting in diminishing capacity for RD&E (note age distribution) o Strong reliance on industry and Commonwealth coinvestment, resulting in reduced capacity to pursue independent RD&E agenda of relevance to NSW o Rapidly increasing age profile of key scientists with challenging environment for appropriate succession planning o High overheads o Slow to respond to change o NSW DPI does not lead any of the key initiatives in the State or Innovation Plans.
Opportunities o New funding sources (climate change) o Potential to focus on high priority areas (and withdraw from lower priority) through PISC R&D framework o Increasing engagement of private sector o	Threats • Loss of capability through unstructured VR program • Capacity to maintain R&D infrastructure • Other agencies preferred to develop and deliver R&D • PISC National R&D Strategy • Non-science pressures on researchers

Priority R&D Outcomes in Productivity and Food Security for NSW DPI

This section identifies priorities for future NSW DPI R&D to achieve key outcomes in total factor productivity and food security. The priorities take into account NSW DPI's existing R&D capabilities and the imperative to improve these capabilities and/or redirect them to higher priority R&D areas. Alignment with the NSW DPI Corporate Plan is shown below.

NSW Corporate Plan

Key Result Area 1	Key Result Area 2
Strong economic performance of primary industries	Appropriate access and wise management of natural resources
Outcome	**Outcome**
Primary industries use innovative technologies and practices	Primary industries achieve improvements in natural resources and environmental management

NSW DPI Research for Action – Productivity and Food Security

Result Area 1	Result Area 2
A secure and high quality food and fibre supply in NSW	Sustainable and adaptive primary industry production systems in NSW
Outcome	**Outcome**
Improved primary industry production systems to secure healthy food for NSW consumers	Primary industries use best management practices that protect natural resources and promote adaptation to climate change

Table: Outcome, Strategies and Research Portfolios for Productivity and Food Security Research in NSW DPI

Result Area 1: A secure and high quality food and fibre supply in NSW		
Outcome: Improved primary industry production systems to secure healthy food for NSW consumers		
Objectives	Strategies	Research Portfolios
To increase production to meet domestic and export market opportunities	• Develop integrated and multi-disciplinary approaches to achieve cost-effective increases in production (through germplasm development and studies in functional biology, genetics, molecular biology, biochemistry, physiology) – P&FS	• •
	• Develop production platforms, and improved breeding technologies and farming systems for aquaculture species – P&FS/AB&MS	•
	• Develop biometric and decision support tools to enhance the rate of genetic gain and increase production - P&FS	•
	• Develop improved feedbase management practices for pasture- and rangeland-based animal production systems consistent with NRM outcomes - P&FS/ AB&MS	•
	• Complete model risk analyses of current and future farming practices to meet production and NRM demands – Econ Unit/SPC/P&FS	•
	• Model the impacts of research outcomes by economic evaluations - Econ Unit/ P&FS	•

To optimise resource input to increase productivity.	• Develop integrated risk management strategies for farming systems that incorporate the impacts of genetic/environmental/management (GxExM) interactions – P&FS/ABMS	•
	• Undertake risk assessments of climate change-induced changes to biotic and abiotic impacts to provide the basis of farm management packages - P&FS/C&W/ AB&MS	•
	• Develop genetic tools and technologies for livestock industries that enable rapid rates of genetic improvement in production efficiency and improve the feed quality of crops and pastures - P&FS/ABMS	•
	• Develop improved hatchery and diet technologies, and husbandry practices for aquaculture species - P&FS	•
	• Develop variety-specific agronomic packages and conservation farming technologies - P&FS/ABMS	•
	• Develop innovative practices that improve fertiliser efficiency and effectiveness in cropping and pasture systems - P&FS/ABMS	•
	• Develop multi-purpose crops and identify alternative crops, plants and production systems for fuels and biofuels - P&FS/ABMS	•
	• Develop technologies to improve the quality of supplementary stockfeeds - P&FS/ABMS	•

To optimise the quality and nutritive value of food produced in NSW	• Determine the impact of GxExM interactions on food quality attributes, particularly in relation to climate variability - P&FS	•
	• Develop functional foods and food-based nutriceuticals that reduce the risk of lifestyle diseases (Link only)	•
	• Develop production and traceback systems that ensure produce meet quality standards and consumer expectations for safe food – AB&MS/P&FS	•
	• Develop and adopt innovative diagnostics for quality and nutritive attributes of agricultural produce (P&FS)	•
To improve supply chain management to increase availability of high quality produce	• Develop and implement supply chain communication strategies to better inform production systems of market requirements - AB&MS/P&FS	• •

Result Area 2: Sustainable and adaptive primary industry production systems in NSW		
Outcome: Primary industries use best management practices that protect natural resources and promote adaptation to climate change		
Objectives	Strategies	Research Portfolios
To develop and implement farming systems with increased resilience, productivity and sustainability that protect natural resources	• Identify and implement best management practices for plant- and animal production systems under climate change and increasing climate variability – P&FS/AB&MS	•
	• Develop integrated approaches to modelling effects on productivity of climate variability (C&W/P&FS/Econ Unit)	•
	• Develop germplasm for efficient nutrient and water cycling - P&FS	•
	• Develop production systems that enhance NRM outcomes – P&FS/C&W/	
To develop genotypes and phenotypes that are better adapted to climatic extremes	• Identify genetic traits and develop new animal and plant germplasm to increase productivity over a wider range of environments – P&FS	•
	• Identify and develop better adapted livestock phenotypes and breeding systems that utilise adaptive characteristics of particular breeds, bloodlines and individuals - P&FS	•

To develop innovative approaches to improve pest and disease management that increase productivity and reduce contaminants	• Develop germplasm for resistance breeding for endogenous and exotic diseases - P&FS	•
	• Develop capability to anticipate impacts of climate change on the effectiveness of chemicals used in primary industries – C&W/P&FS	•
	• Identify and develop new biocontrol agents and integrate them into production systems – BR/P&FS	•
	• Develop crop management systems, including the evaluation of transgenic technologies, that enhance numbers of beneficial organisms – P&FS/BR	•
	• Develop improved weed management practices, including the evaluation of transgenic technologies - BR/P&FS	•
	• Develop and apply innovative diagnostic technologies for pests and diseases - BR/P&FS	•

References

ABARE, (2008). Australian Fisheries Statistics 2007. Australian Bureau of Agricultural and Resource Economics, Canberra. 86pp

Aldous, E.E. (2007) Social, environmental, economic and health benefits of green spaces. *Acta Horticulturae* 762:171-185

Bartels D and Hussain S S. (2008) CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 2008, 3, No. 020, 17 pp.

Benjamin, C. and Pocknee, G. (2004). Grains Industry Strategy. Report for Grains Research and Development Corporation. Pocknee and Associates Consulting.

Cribb, J. (2008). Tackling the global farming crisis. Agri-Food National Conference. Agri-food Industry Skills Council. 25-26 September 2008, Melbourne\

DAFF (2008) Australian Food Statistics 2007. Department of Agriculture, Food and Forestry
http://www.daff.gov.au/__data/assets/pdf_file/0003/680745/foodstats2007.pdf

Delgado, C.C., Wada, N., Rosegrant, M.W., Meijer, S., Ahmed, M., (2003). Outlook for Fish to 2020: Meeting Global Demand. International Food Policy Research Institute and World Fish Centre, Malaysia, 36 pp.

Good, A.G., Johnson, S.J., De Pauw, M., Carroll, R.T., Savidov, N., Vidmar, J., Lu, Z,, Taylor, G., and Stroeher, V.(2007) Canadian Journal of Botany, Volume 85, Number 3, 1 March 2007 , pp. 252-262.

Mullen, J.D. (2007). Productivity growth and the returns from public investment in R&D in Australian broadacre agriculture. Australian Journal of Agricultural and Resource Economics 51: 359-384.

NSW Department of Health (2003). Food Security Options Paper: A planning framework and menu of options for policy and proactive interventions..
http://www.health.nsw.gov.au/pubs/2003/pdf/food_security.pdf

OGTR website: http://www.maps.ogtr.gov.au/jsp/statesearch.jsp

Ruello & Associates, (1999). A study of the retail sale and consumption of seafood in Sydney. Volume 1. Fisheries R & D Corporation Project Report 98/345. 173pp. Fisheries Research & Development Corporation, Canberra.

Rural R&D Corporations (2008). Measuring ecomonic, environemtna and social returns from Rural Research and Development Corporations investment. www.ruralrdc.com.au.

Stoekel, A. (2008). High Food prices. Causes, implications and solutions. RIRDC Publication No 08/100