Using Foresighting to Identify R&D Priorities for LWRRDC

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Executive summary

This report evaluates the usefulness of foresighting techniques to improve the information available to the Land and Water Resources Research and Development Corporation (LWRRDC) for planning and managing future expenditures on research and development. LWRRDC intend to use a foresighting process as a management and design aid for four key programs in the areas of national dryland salinity, remnant vegetation, national river health and irrigation.

Review of foresighting techniques

There are a wide variety of foresighting techniques available. They can be identified by the differing reliance on historical data (trend analysis), use of causal relationships (models), and human judgement (expert panels, workshops). The exercises can be reactive such as in the Delphi approach where respondents react to information provided and have to justify their judgements, or interactive, such as in scenario building in a workshop format. The techniques can be oriented toward identifying probable futures, or exploring a diversity of future outcomes considered possible. The product from the foresighting exercise can be the process itself—the information exchanged and the skills developed—or the outcome—the descriptions of the possible or probable futures. Most foresighting exercises involve a number of techniques.

The appropriate techniques for a foresighting exercise depend on the goals of the exercise.

- If the goal is to develop relationships between the people involved with an issue, or the aim is to improve flexibility in thinking then the emphasis should be on the process.
- If the goal is to identify issues, technologies, solutions, applications and the like, then the emphasis should be on the outcomes.

Success in foresighting is not easily evaluated as foresighting is not a forecast of the future that is either right or wrong. One measure of success is whether the exercise induces changes in the way things are done—greater communication, greater diversity of ideas, consideration of new issues, quicker reaction to shocks. The key ingredients for success are:

- commitment by those involved to be open in their thinking but remain focused on the topic; and
- 'ownership' of both the process and the outcomes by those funding the study with a commitment to follow through on the information generated by the exercise.

A foresighting methodology for LWRRDC

LWRRDC has both process and outcome goals.

- LWRRDC wants to pull together the diverse group of stakeholders to improve communication between those charged with finding solutions to the problems of the resource base, and those that can affect institutional change to put some of these solutions into action. Also important is improving communication between researchers on different programs to exploit the overlaps and insights available.
- LWRRDC needs to explore all the possibilities as there is a concern that a focus on current issues may be blinding planners and researchers to issues lurking beneath the surface which would come to dominate over time.

The proposed methodology is to:

- use a workshop approach with a diversity of stakeholders—technical, practical and policy making;
- find a common starting point in terms of the issues, solutions, and implementation regimes involved in the various programs—expert opinion would be required to develop a summary for reaction; and
- use scenario development to explore possible issues that could arise in the future and the solutions that would be required—solutions would involve techniques and implementation plans.

Starting scenarios

Some possible demand projections for Australian agricultural production are considered in the light of supply constraints based on historical production trends. Three scenarios covering the potential range of change in natural resource management are offered as a starting point.

- An economic growth scenario—producers take into account only the environmental costs of land and water degradation on their own land.
- A conservative development scenario—producers are forced to take into account the externalities caused by their actions.
- A post materialist scenario—society places an existence value on the environment and producers are forced to take account of all environmental costs, with environmental sustainability as the bottom line.

CHAPTER ONE
Background

The Land and Water Resources Research and Development Corporation (LWRRDC) intends to use a foresighting process as a management and design aid to four of its key programs:

- the national dryland salinity program;
- the remnant vegetation program;
- the national river health program; and
- the national program for irrigation research and development.

A scoping exercise is required to evaluate the potential contribution that foresighting exercises could make to LWRRDC's overall planning, management and coordination of programs. This exercise includes the development of broad-brush scenarios driven by global economic events and policies and the implications of these for Australian resource management.

This report

In this report we:

- review the application of foresighting techniques;
- recommend appropriate methodologies and processes for the conduct of foresighting to meet the particular objectives of LWRRDC; and
- develop a small number of scenarios covering the potential spectrum of change in natural resource management for incorporation under the foresighting exercise.

Review of application of foresighting technique

The available literature on the use of foresighting techniques concentrates largely on the use of these techniques to make science and technology projections. There is wide use of foresighting in commercial areas to assist management to make planning decisions and to train staff to think in more flexible ways. But little of this is available for public evaluation. Foresighting has also been applied to global climate change, where the use of formal models is invaluable to understanding the complex interactions of nature and man's activities. In Australia the Australian Science and Technology Council has undertaken a number of foresighting exercises, with a range of subjects from health to urban water supply. CSIRO has also been involved in several foresighting exercises, most recently on the future for the rangelands.

From these studies the key ingredients for success are:

- 'ownership' of the foresighting process by those funding the exercises and by those involved in the exercises; and
- a commitment by the owners to follow through with the issues generated in the process.

The main pitfall to be avoided is the loss of focus on the outcomes required—be they process or solution orientated. It is easy for the exercises to degenerate into a 'talkfest', with no agreement on outcomes (this may be a range not a point) or plan for ensuring the work is pursued.

Appropriate methodologies for LWRRDC

A foresighting process may place emphasis on process, or on the information generated by the foresighting process.

Where the emphasis is on process the desired outcomes might be:

- the development of skills to apply more flexible (lateral) thinking towards finding solutions to problems as they arise, and
- to facilitate interaction between different groups involved in the same issue—to promote the flow of ideas and information between the groups.

Where the emphasis is on the information generated by the process the desired outcomes might be:

- a consensus on the issues that are likely to arise in the future, and/or a consensus on solutions where the logical next step would be a plan of action; or
- a range of issues that could possibly arise, and the solutions that could be adopted, where the next step could be to prioritise the issues, or it could be left as the range that needs to be addressed.

The best practice methodology depends on the goals of the foresighting process. LWRRDC has both process and outcome goals.

On the process side it is important to pull together the diverse group of stakeholders to improve communication between those charged with finding solutions to the problems of the resource base, and those that can effect institutional change to put some of these solutions into action. This demands a workshop approach to establish the information flows, though follow up will probably be required to ensure a continued communication between the parties.

On the outcome side LWRRDC needs to explore all the possibilities rather than focus on the most likely. There is a strong concern that a focus on current issues may be blinding planners and researchers to issues lurking beneath the surface which would come to dominate over time.

Scenario development

Scenarios covering the potential range of change in natural resource management are developed. The scenarios are broadly specified to ensure their applicability to the four research and development programs.

The scenarios are driven by:

- global economic events and what these mean for the growth prospects of Australian agriculture;
- the ability of the land and water base to meet these demand projections; and
- the extent to which environmental costs are incorporated in the production decisions.

Three broad scenarios are presented.

- The economic growth scenario where producers take into account only the environmental costs of land and water degradation on their own land.
- The conservative development scenario where producers are forced to take into account the externalities caused by their actions. These externalities range from erosion to salinity to water quality.
- The post materialist scenario where society places an existence value on the environment and producers are forced to take account of all environmental costs, with environmental sustainability as the bottom line.

Where to from here

Both CSIRO and the CIE would be happy to be involved in the application of the foresighting technique to the four programs.

The foresighting exercise would involve the development of an issues paper to summarise the current state of knowledge, and then proceed to the workshop phase. The workshopping of the scenarios should provide:

- a detailed assessment of the range of physical challenges associated with each scenario;
- a list of potential technologies (or existing technologies) that would address these physical challenges;
- a detailed assessment of the gaps in physical knowledge, and in information required to induce change in attitudes to the challenges;
- a range of ways that these gaps might be reduced;
- a list of institutional drivers to affect change—a plan of how to implement known solutions and solutions identified in the future;
- a commitment from the participants to develop an on-going exchange of information; and
- an agreement on the type of information and its presentation that will maximise the usefulness of the research undertaken.

The follow-up work, phase three of the process, would involve a planning decision about which of the gaps to address and how to best ensure the ongoing exchange of information in the most appropriate form to affect solutions.

CHAPTER TWO

Review of foresighting—methodology and practice

The purpose of this section is to analyse what foresighting includes and review how it has been applied to assist long term planning.

What is foresighting?

> *Foresight is a process by which one comes to a fuller understanding of the forces shaping the long-term future which should be taken into account in policy formulation, planning and decision making...Foresighting involves qualitative and quantitative means for monitoring clues and indicators of evolving trends and developments and is best and most useful when directly linked to the analysis of policy implications...Foresighting is not planning—merely a step in planning. (Martin and Irvine 1989)*

The Australian Science and Technology Council (ASTEC), as part of their program on matching science and technology to future needs, undertook a review of foresighting techniques in a number of OECD countries (ASTEC 1994). More recently Battelle Seattle Research Center completed a review of seven 'best in kind' foresighting programs (Battelle 1997). The evaluation of foresighting techniques draws on these two reviews, as well as some recent foresighting exercises conducted by ASTEC partnerships and CSIRO in Australia.

The foresighting exercise is a process to develop a picture or pictures of the future. The picture can focus on details such as likely developments in science and technology, or can be broader based and encompass social, economic and ecological outcomes. The former is more likely to be supply driven, with an emphasis on factors that change inputs and outputs, while the latter is more likely to be demand driven, with an emphasis on what society's requirements in the future will be. Foresighting exercises by firms and industries will focus on their product, while those by government may have a narrow focus (for example, the US Critical Technologies Panel), or a very broad focus (for example, the Australian Matching Science and Technology to Future Needs program).

Foresighting is not designed to deliver one 'best bet' picture rather, it delivers a range of possible future outcomes. Foresighting gives explicit recognition to the uncertainty of the future. It is seen as an ongoing process, where the pictures of the future will change over time, partly in response to changes that may be in response to the foresighting outcomes, and partly due to the inherent dynamic and chaotic nature of the future which brings new information.

Both the process and the outcome—the picture or pictures of the future—are the products of the foresighting process.

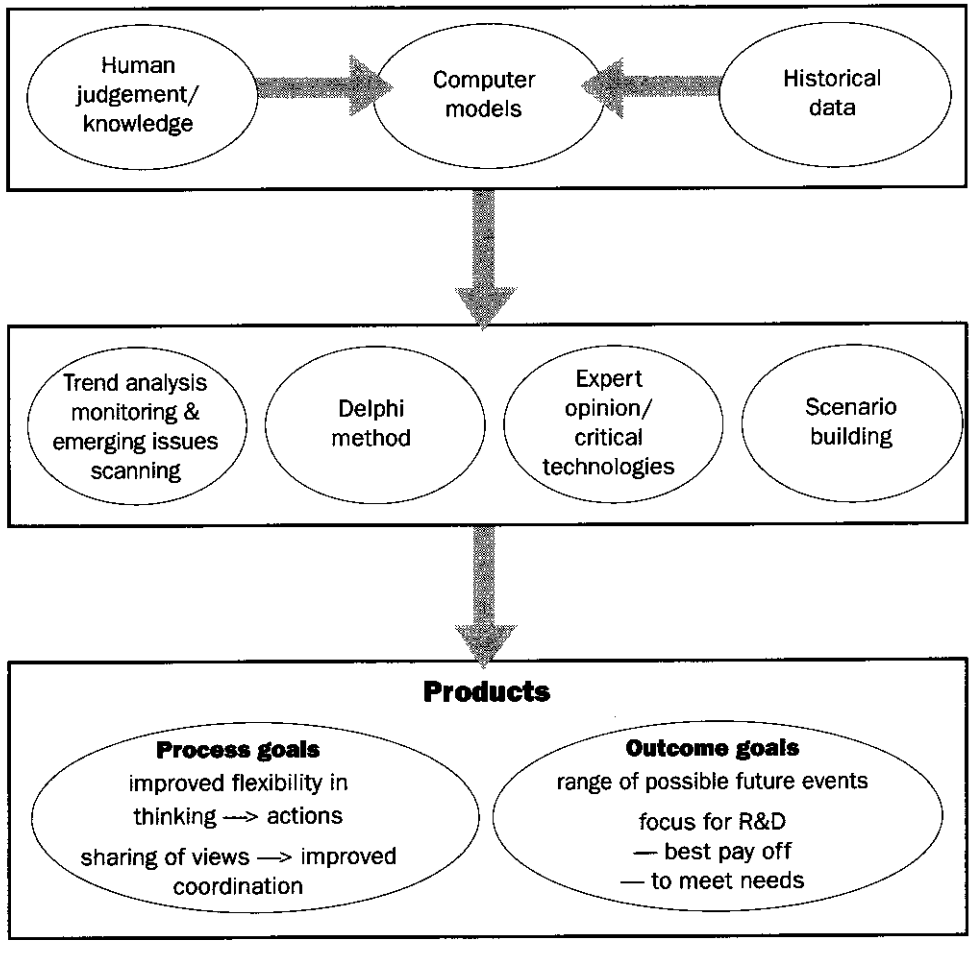
- The process of developing and achieving ownership of the outcome develops flexibility in thinking that can translate into greater creativity. It also improves understanding between different divisions of a firm or between workers working on different sections of a broader project, or between different sectors of industry or government.
- The outcome of the process is a number of descriptions of the future. These provide information that can be used for planning production, investment, training and research and development. The focus might be commercial—maximising the expected return, looking for the best pay-off based on some weighted sum—or it might be on public policy—how to best meet the needs that are most likely to arise.

Figure 1 provides a summary of the foresighting exercise. The main inputs to the process are human judgement and knowledge. This can be formalised in terms of computer models which add insight to human judgement and add to knowledge. Historical data is the feedstock for both the computer models and the knowledge base. Compilation of information and formalisation of relationships in models are important planning tools, but the foresighting technique combines these with the human factor using a variety of methodologies.

There are four main methodologies, relying in varying degrees on the inputs of judgement, knowledge, models and historical information.

- Analyses that rely on historical data tend to have a short run perspective. Trend analysis relies heavily on historical data, but may use computer models to assist in organising the information. Human judgement comes into developing the trend models which can be complex. Scanning and monitoring for emerging issues rely equally on historical data and the human input to judge what is an 'emerging' issue. Expert panels are often used in these exercises.

Figure 1
Summary of the foresighting exercise



- Expert panels may be used in a variety of ways, but the predominant use is in the development of lists of issues and outcomes thought likely to arise in the future. In particular this approach is used to compile lists of 'critical technologies', those seen as essential drivers of broader technological development. The lists rely on the knowledge and judgement of the experts and may or may not place priorities or probabilities on the items in the lists.
- The Delphi method usually takes a survey approach which maintains anonymity of the contributors, although it can be conducted in workshops or with panels of experts. Generally a cross-disciplinary approach is taken with experts from a number of areas included in the group. This method seeks a consensus view, built though an iterative process to achieve agreement. Dissent from the median view is reflected by statistical measures. The Delphi method relies mainly on human knowledge and judgement, although computer models can be used to organise the survey responses and provide the statistics. The lists from expert panels are a common starting point for constructing the survey questions used by the Delphi method.
- Scenario building is the development of a range of pictures of the future through a logical process of cause and effect. It is usually conducted with a diverse group of stakeholders in a workshop format rather than a panel of experts. The aim is to build up a picture of a range of possible outcomes. Consensus on the most likely outcome is not required, but probabilities can be assigned through various methods. Expert panels and consultants may be used to develop a set of initial scenarios. Scenarios developed with computer models to provide internal consistency often provide the starting point for the workshop activities. Computer models can be used to run simulations to generate well defined outcomes under a number of different initial conditions (including behavioural relationships and policies).

  A related method to scenario building is relevance trees which start at one or several outcomes for the future and examine what changes are likely to produce such an outcome.

Many foresighting exercises combine a number of these methods. Where the goal of the foresighting exercise is on the process the emphasis is more likely to be on scenario building, than where information on the future is the goal. But the various approaches complement each other and the appropriate mix is task dependent.

The focus of the foresighting exercise can be on the supply side, the demand side, or a combination of both, taking into account interactions between the two. The focus chosen is determined by the goals of the foresighting exercise. If the goals are product orientated—for example identifying technological developments for R&D investment planning—the supply focus is more appropriate. If the outcome goal is more policy formation orientated—for example identifying what the needs of a particular group will be—then the demand focus is more relevant.

Another way to think about foresighting is that it can provide pictures of preferred futures, pictures of expected futures, and pictures of possible futures.

- Preferred futures are defined by ASTEC as "those we want as a community to achieve—individual values, strategies of corporations and community organisations, and government policies" (ASTEC 1996).
- Expected futures are analyses of experts based on current trends and extrapolations (ASTEC 1996). These may differ from a forecast which describes a single future which is believed to have the highest probability of arising.
- Possible futures are a range of pictures, which attempt to take account of critical uncertainties and trend breakers (ASTEC 1996).

How has foresighting been applied?

The picture of the future is a description of outcomes or processes. The main outcomes of interest have been the level of science and technology (S&T), the state of the environment (SOE), and the standard of living (SOL). Under each of these a number of topics have been examined in depth using foresighting techniques.

The S&T area has received the most attention. A sample of the programs are given below.

- The Japanese have been the most active in undertaking foresighting exercises focusing on S&T. The Science and Technology Agency (STA) has employed the National Institute of Science and Technology Policy (NISTEP) to conduct regular foresighting exercises since 1971.
- In Germany the Fraunhofer Institute for Systems and Innovation Research (ISI) was commissioned by the Federal Ministry for Science and Technology (BMFT) to adopt the NISTEP approach to focus on future S&T developments in 1992.
- In the United States, the Critical Technologies Institute (CTI) was established in 1992 to identify technologies that were 'critical' in the sense that they were state of the art, in the national interest, having specific applications, or could be regarded as generic and pre-competitive.
- Also in the United States the Department of Defence and the Department of Commerce conduct programs to identify 'emerging' technologies.
- The EU's Institute for Prospective Technological Studies (PROMPT) established in 1989, monitors new developments in S&T and undertakes strategic analyses of new areas.
- The Ministry for Economic Affairs in the Netherlands have undertaken a foresighting process since 1989 to set priorities for government support for competing research projects.
- In the UK, the Office of Science and Technology (OST) has developed a three phase approach suggested by Martin and Irvine (1989). The focus is on realising the potential for S&T through providing guidance to government departments who fund R&D projects.
- The Advisory Council on Science and Technology (ACOST) in the UK set up an Emerging Technologies Committee to identify areas of S&T development. Individual projects then focused in the different areas.

Some of the S&T programs incorporate outcomes for the environment and the SOL.

- The Royal Dutch/Shell company based in the Netherlands pioneered foresighting techniques at the company level. While they have a strong interest in commercial applications of S&T, they are also affected by changes in environmental and social trends. A number of other private companies have also implemented foresighting programs (Phillips, Sony).
- The EU set up the Forecasting and Assessment in Science and Technology (FAST) program in 1978. It assesses the impact of S&T on the environment and the SOL, and regional implications.
- The Netherlands established an independent Foresight Steering Committee (OVC) in 1992, which aims to link the potential developments in S&T to society's needs for those developments.
- The Fraunhofer ISI in Germany focused more on how to achieve preferred futures in terms of SOL and SOE in its 21st Century study completed in 1993.
- The ASTEC program in Australia takes explicit account of the SOE and SOL effects in its foresighting exercises, although the focus is on identifying the outcomes for S&T.

Less work has been done focusing specifically on the environment or the SOL.

- The US Army Environmental Policy Institute (AEPI) uses foresighting to identify potential environmental issues that might face the Army.
- The integrated modelling of global climate change (IMAGE 2.0) uses computer simulations to provide global projections of the future state of the climate and consequent land use. (Alcamo 1994). Complex models rely on computing power to provide internally consistent scenarios of a highly complex nature.
- The Millennium Project is a multinational project conducted by the American Council for the United Nations University (AC/UNU). A main aim is the provide information that could help bridge the gap between expected futures and desirable futures. It acts to link various foresighting and futurist programs around the world, to improve methodologies available, and to promote a globally cooperative futures program.

The foresighting exercise does not need to stop at the picture of the future in terms of outcomes. A variety of actions can be proposed and their expected outcomes assessed using foresighting techniques. Foresighting provides valuable input into policy making and strategic planning. It can be used to identify the levers or the drivers of change, and to identify possible actions to pull these levers. It does not, however, make any choices over actions, this is the role of the policy maker.

Figure 2 outlines the different possible foci of foresighting exercises and shows how they feed into strategic planning and policy development.

Trend analysis , monitoring, and emerging issues scanning

Trend analysis, monitoring, and emerging issues scanning all initially rely on historical data. The data must be collected, screened and evaluated. One or all of these approaches are often part of a broader foresighting approach, or in the terminology employed by Martin and Irvine (1989) the pre-foresighting phase.

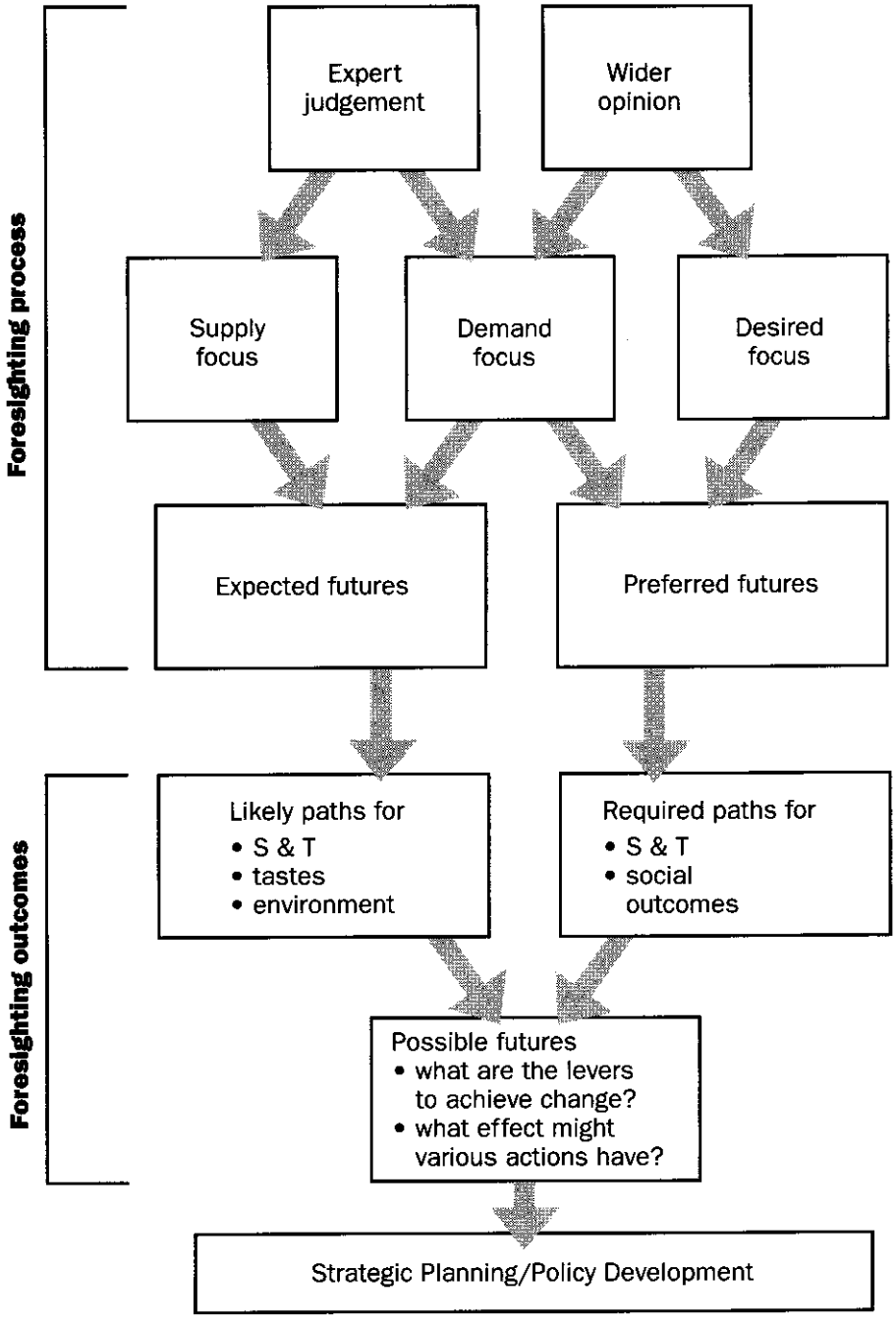
- Trend analysis is based on the assumption that historical patterns will be repeated or that causally understood patterns will continue. It ranges from simple linear extrapolation to multiple non-linear regression models.
- Monitoring examines the data and looks for a critical mass or threshold that has been determined from historical experience or identified by theory. The idea behind critical mass or thresholds is that certain events are expected to act as leading indicators for what will happen in the future. For example, an increase in applications for patents in the field of semi-conductors or the accumulation of a certain body of knowledge might indicate a future boom in communication technology.
- Emerging issues scanning is similar to monitoring, but the focus is on the issues themselves rather than indicators. For example an increase in the number of patents for communications equipment indicates a boom in communication related technology.

Japan's Ministry of International Trade and Industry (MITI) conducts regular patent and literature searches to identify trends in technology. The BMFT in Germany has recently adopted the same approach.

The Department of Defence, the Department of Commerce and the CTI in the US has made extensive use of this sort of approach. Emerging technologies were defined by US Department of Commerce to arise where:

> *"research has progressed far enough to indicate a high probability of technical success for new products and applications that might have substantial markets within approximately ten years".*

Figure 2
Different foci of foresighting



The main advantage of these historical approaches, being based on recent developments, is that the uncertainty is much lower than with human judgement on developments yet to occur. The focus of this approach is on short term developments and if used for this purpose the approach is reasonably robust. Concentration of effort can speed investment increasing the pace of development in the areas identified.

However, there is a danger with extrapolating current trends especially into the medium and long term. History has often demonstrated that history does not repeat itself. Another major problem is that the focus on the outcomes from the historical based exercise might limit the range of activities taking place and become self fulfilling at the expense of better unconsidered alternatives.

Expert panels

Expert panels are convened by the group conducting the foresighting exercise. They may consist of experts from a variety of disciplines or from the same discipline. In some ways these panels provide a historical based approach, but they incorporate human judgement to a much greater degree.

Expert panels may be used for morphological analysis. This approach encourages lateral thinking in terms of new applications for existing technologies and products. The technology or product is described in terms of its physical characteristics rather than its function and the game is to think of alternative uses where these characteristics might be applied.

In the United States expert panels have been used by the Department of Commerce and the Department of Defence to draw up lists of 'critical' or 'emerging' technologies. These lists have been provided as a source of information, but have not been identified as exhaustive or lists that the government considers to be 'best bet'.

The Fraunhofer ISI in Germany used relevance trees to develop a set of critical issues for the 21st Century. They used expert opinion to assess the technological change required to address these issues.

ASTEC in its Matching Science and Technology to Future Needs 2010 (ASTEC 1996) drew on experts first through a consultative process to draw up a list of issues, and then through a series of round tables to further discuss and fully identify the issues. They then went on to take a scenario approach.

The strength of expert panels lies in the nature of the expertise. The members should be the best judges of likely developments in their fields. However, this can create problems as pointed out by Schnaars (1989). Experts tend to be overly optimistic about technological developments in their own area. This was confirmed in the evaluation of the 1971 foresighting exercise conducted in Japan by NISTEP. There is also a problem of 'Zeitgeist'—'there is a characteristic spirit of the times marked by a predominant feature that characterises the intellectual, political and social trends of that era' (Schnaars 1989 p 63). As each era has its own important issues experts (and others) tend to be blinkered about alternatives, that is, they can only see the issues of the times in which they live.

One problem with expert panels is that they can be dominated by a few forceful personalities. A second problem is that, although they can to some extent be cross-disciplinary, they are less likely and less able to take areas where they are not experts into account. For example, a panel of scientists is less likely to incorporate social and economic outcomes into their evaluation.

The Delphi method

The Delphi method is an iterative process whereby individuals, often experts, are surveyed for their opinion on a set of issues or questions. They are asked to make judgements on the likelihood of certain events occurring or issues arising, and the likely timing of such events and issues. The classical Delphi method starts with a 'blank page'—a set of unstructured questions on a topic—in order to fully access the depth of knowledge of the experts. However, this first round is often replaced by having a list of issues and events prepared by an expert panel. The survey provides a list of issues and asks for the participant's judgement as to the timing of events. The results are compiled to provide the median and first and third quartile judgements and the individual respondents are supplied with this information. They are then asked to revise their opinions and, if they are one of the outliers (in the first of fourth quartile), to explain why their views differ. Successive rounds may occur, repeating the exercise until a consensus is reached.

The survey may provide a broader context in terms of the economic, social and political environment as a frame for the issues of interest. This has the advantage of forcing the respondents to think about these issues and provide their responses within a common framework. However, if the environment described is wrong then the outcomes of the process will also be wrong. Differing views on the broader environment are also ignored.

NISTEP in Japan use the Delphi method to develop a consensus on the developments in science and technology likely to occur over the following 30 years. These surveys are undertaken every five years. The surveys are broad based, going across all areas of science, and they force the expert respondents to take into account social and economic needs. However, the incorporation of such issues has been difficult given the long time frame. Assessment of the program which began in 1971 shows that the interdisciplinary nature of the expert groups surveyed improved predictive capability, and that more basic research topics tend to be predicted more accurately.

Germany has adopted the NISTEP program, with ISI conducting the exercise for the BMFT. The first survey was conducted in 1992. A comparison of the German and Japanese results showed similar realisation time for S&T breakthrough, but some difference in the areas of S&T felt to be important. The Germans put more emphasis on energy and environmental breakthroughs while the Japanese stressed cancer and communications breakthroughs (Cuhls and Kawahara 1994). This sharing of a common approach has advantages not only in cost saving but in the ability to compare results from different areas, and highlights the importance of regional effects on the more subjective elements of the survey.

The value of this use of the Delphi method lies in both process and outcome. Exposure to process promotes a more holistic approach to scientific development by the individual participants who are forced to defend differing opinions and to take account of arguments raised from other sides of the issues. The publication of the median outcomes (often timing projections) and the range of outcomes for projected directions for science and technology is useful in R&D development and/or formulation of business plans.

While the Delphi method avoids some of the problems that arise with the workshop or panel approach to extracting ideas from a group of experts, unless run as an interactive process, it does not necessarily improve communication between the different parties to an issue. It may promote understanding as the reasons for dissenting opinions are expressed, but there is no mechanism for on-going communication.

The method has several drawbacks for exercises that want to focus more on the preferred future or draw social policy implications from the expected future. The first problem is that consensus drives out the less conventional ideas which may be more relevant to social and environmental policy than S&T policy. The second occurs if the time frame is too long—'experts' are often unwilling to commit themselves to a view on the economic and social outcomes which are perhaps more uncertain than the scientific outcomes.

As with expert panels, 'Zeitgeist' is a problem for the Delphi method. The less diverse the survey respondents the greater this problem and the problem of over optimism are likely to be.

Scenario building

The scenario building approach sets up a set of different pictures of the future. These pictures must be internally consistent, and ideally represent a wide variety of possible future outcomes. The focus may be narrow, say on a firm's likely range of products, or broad, say on the health profile of a population. Whatever the focus, the scenario must provide a background picture of the broader economy, environment and society as well as the more detailed picture of outcomes of interest to the group conducting the exercise.

The starting point is usually a set of scenarios constructed by experts, or an existing set used in previous exercises. A workshop with all relevant stakeholders is convened with all participants having been informed about the starting set of scenarios. The workshop process is designed to develop the scenarios, to ensure internal consistency and to gain agreement that the each scenario is plausible. It does not have to be thought likely, but must be considered possible. Some exercises may end at this point, others may go on to:

- place probability estimates on the various scenarios;
- develop a set of actions and discuss their possible impacts; and/or
- make recommendations for actions (policy making and strategic planning).

Many private companies that engage in foresighting use the scenario building approach. Shell is a leader in applying this approach. They adopt the scenario building approach as they are interested more in the process than the outcomes. The process has been found to improve the flexibility of thinking of management, improving their ability to respond to changes in the market on either the demand or supply side. Departments in Shell that had adopted the approach performed much better in responding to the oil crises of the 1970s than departments that did not adopt the approach (Battelle 1997).

An example of scenario building in Australia is the ASTEC foresighting exercise on urban water systems (ASTEC 1995b). After conducting interviews with a range of experts to develop the issues, they turned to scenario building as the main foresighting tool. The main reason was that the Delphi method was considered to be likely to concentrate too much on the conventional issues associated with water supply. A secondary reason was the emphasis on the process rather than the outcome, and the interactive workshop format was felt to provide a better environment for exchange of ideas and development of informal and formal contacts between the diverse expert participants.

An important finding of the program, which had as one of it's aims the development of the foresighting process, was that with scenario building the national scenarios need to be modified to take account of regional issues. This needs to be done at the regional level to provide the appropriate expertise. Other findings were that the time frame for foresighting needs to be beyond the 'business as usual' time horizon, and there must be a user and community context to the study. Other findings were that evaluation of the outcomes and usefulness of such studies is required and that the exercises should be repeated rather than performed as stand alone studies.

The CSIRO conducted a foresighting exercise on the future for the Australian rangelands by 2010 at the Australian Rangeland Society's Ninth Biennial Conference in September 1996. The starting point for the scenarios was a combination of economic, technological, ecological and social conditions. The five starting scenarios were reduced to four in the process and actions associated with each scenario to capture benefits and avoid costs were developed. An assessment of the likelihood of each scenario was also undertaken. The regional differences were accommodated by explicit consideration of five regions characterised by vegetation (Mulga, Chenopod, Mitchell Grass, Northern, and Spinifex).

The emphasis of the foresighting exercise appears from the preliminary report to be on the actions rather than the process. While groups not normally well represented at the ARS conferences were encouraged to attend, the actions suggested appear to reflect a predominant influence of current land holders. This may have been because of dominant numbers or a perception among all participants that the current land holders had the main stake. The emphasis on this exercise seems to have been on the outcomes for policy making rather than the process.

The main advantage of the scenario building approach is that it brings together a relevant set of experts and promotes interaction that may lead to more productive long term relationships between those parties involved in an issue. Thus, where the emphasis is on process, scenario building is the preferred technique.

However, there are a number of problems faced by all interactive methods. As with expert panels the scenario building workshops can be dominated by a few forceful individuals. Minority views may get greater weight placed on them simply because their proponents are more vocal. The issues may be changed to reflect an agenda of part of the group rather than take a 'blank page' approach. This is a particular problem where the process is extended to developing actions.

CHAPTER THREE

How might foresighting benefit LWRRDC?

The purpose of this section is to consider the usefulness of the foresighting technique to improving the planning of research and development activities undertaken by LWRRDC.

Usefulness of the foresighting exercise for LWRRDC

Foresighting is a tool to assist organisations in long term planning decisions by providing pictures of the range of possible futures that could arise. Planning may be positioning current investment in capital, R&D or marketing to best position the organisation to take advantage of events that might arise in an uncertain future. Alternatively current investments may be directed at long term outcomes because of a long life in capital assets, the R&D focus, or the creation of brand loyalty.

LWRRDC's R&D program has long term implications—solutions found now will prevent problems arising. Given scarce resources for R&D, it needs to be targeted to the major problems that are likely to arise in natural resource management Some problems are well known but there could easily be other problems yet to be commonly identified that could come to dominate the resource management agenda. Different foresighting techniques provide ideal ways of seeking out the poorly identified issues (for example, scenario building), or developing consensus on the appropriate focus of R&D activity (for example, Delphi).

A foresighting exercise can also be regarded as a training tool, exposing members of the organisation to a greater variety of ideas, and introducing greater flexibility in thinking and approaches to problem solving. It is also a method for improving communication between different parts of an organisation or between the organisation and its clients. LWRRDC may also want involve policy makers in the exercise to impress on them the need for adoption of solutions to problems already identified and well understood.

LWRRDC has four programs focused on different parts of the natural resource. The R&D in the different programs may have some overlap and techniques applied in one program could have lessons for the other programs. While there is the scientific exchange of ideas through journals and internal papers, foresighting may improve the flow of information by bringing researchers together to develop informal contacts through which much information is often exchanged. This would be particularly beneficial where R&D activities are contracted out to disparate organisations. Expert panels and the Delphi method both facilitate such exchanges of ideas, the latter in a more formal way that generally precludes ongoing relationships forming.

Similarly, to bring the researchers together with the resource users can stimulate new ways of addressing problems. Foresighting techniques force those with different views to articulate these views and force others to listen to and address these views. This assists in providing foresighting outcomes that are not tied to the 'current thoughts of the day' and are more diverse and creative. Scenario building leads to a wider variety of ideas being developed, while Delphi provides a more rigorous account of dissenting views.

The ideal methodology for LWRRDC will depends on its goals, but it is clear that foresighting can assists LWRRDC's management through both the process and the provision of outcomes for input into strategic planning.

What should LWRRDC expect from a foresighting exercise?

The products of a foresighting exercise should be:

- greater understanding and communication between the expert researchers involved in the four different projects as to how the R&D outcomes may complement each other;
- greater understanding and communication between those responsible for implementing the technologies developed and those doing the development on what is likely to be needed and what is feasible;
- a base for an going view of the possible futures which can be updated and the implications for the R&D programs examined;
- a set of possible futures and the associated set of possible future needs which current R&D programs should be geared to provide; and
- a set of possible technologies and their likely ability to fulfil the needs that might arise.

LWRRDC's four programs are:

- the national dryland salinity program;
- the remnant vegetation program;
- the national river health program; and
- the national program for irrigation research and development.

The desired outcome of a foresighting exercise is a range of pictures of the state of the resource base at some time in the future. These pictures would, at the specified time, describe:

- the characteristics of the soil and topography and the associated land use;
- the quality and quantity of water and its allocation;
- the agricultural yield from the land and water use;
- the other inputs into agricultural production, including technologically derived inputs;
- the rate of change in the yield; and
- the rate of change in the quality of the soil and water.

Associated with each of the physical descriptions is a list of the challenges that arise. To each of these challenges there is a technical solution to be developed and the implementation of this solution. For example; the soil might be subject to increasing acidification under the picture, so the 'need' is for a solution—a regime of use, or application of lime—that would prevent this and a way of putting the solution in place. 'Needs' also include the assumption about technology, for example if the picture included a drought resistant hybrid wheat, the 'needs' would include the development of this input.

It is the list of possible needs identified by the pictures that provide the input for R&D planning. Foresighting exercises can also assist in prioritising the possible needs once identified, and in suggesting R&D approaches that might provide solutions to the needs.

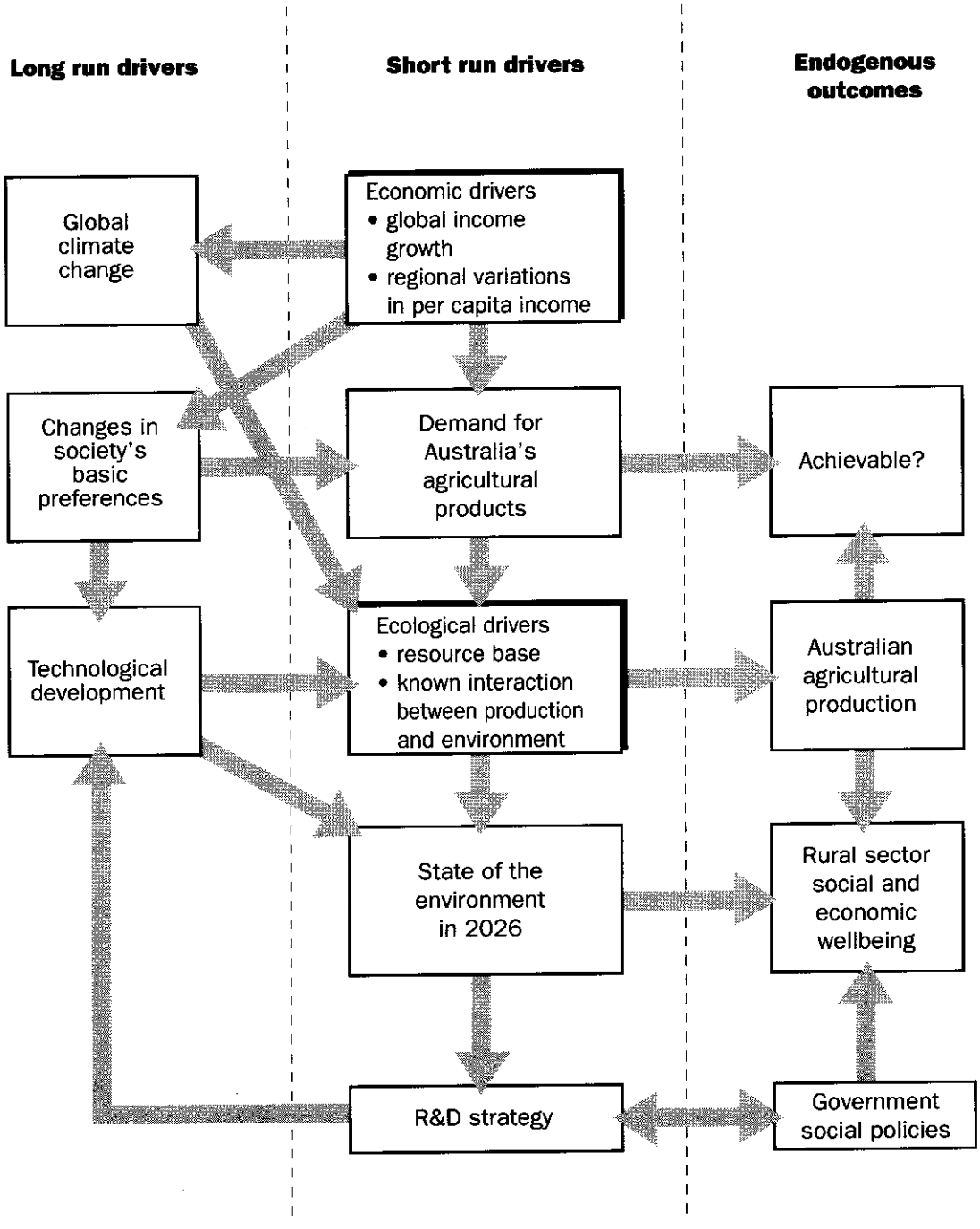
The main drivers for the state of the natural resource base

Figure 3 outlines the main drivers behind the state of the natural resource base. Those developments on the left hand side—society's tastes, global climate change and technology—are labelled as long run drivers. The first two react with a long lag to the changes in the surrounding Australian environment so can be regarded as fixed for the medium term. Technology at the most fundamental level can also be regarded in this light, but innovation, the application of technology, is clearly driven by R&D and the implementation of technology is in turn driven by the social preferences at the time as well as the economic incentives.

The economic drivers and the ecological drivers form the main short run drivers for the state of the natural resource base.

On the right hand side are the endogenous outcomes which stem directly from the state of the natural resource base. The demand for Australian agricultural products is constrained by what can be supplied. The well being of the rural population will depend on what they produce and the government policies in place.

Figure 3
The drivers behind the state of the environment



Long run drivers

Global climate change could bring dramatic changes in the natural resource base for Australia by changing the weather patterns. How soon and exactly what changes are likely to occur is anyone's guess although substantial research has been and is currently being conducted into the subject (see Alcamo 1994 for example). Whether global climate change should be considered as a driver depends on the period for which foresighting is conducted. In a thirty year time horizon it is likely to be irrelevant for most of Australia, although it would feature in a 100 year time frame foresighting exercise.

Changes in society's tastes and preferences are similar to climate change in that they are more likely to act a drivers in the longer term. Schnaars noted in Me*gamistakes* that the forecasters who were more accurate in their predictions of technological change were those who emphasised how slowly new technology is absorbed into society (Schnaars 1989, for example p48–49). The economic and ecological forces also help shape the social outcome in ways reflected in historical trends. As per capita income grows concern for the natural environment also grows. The demand for cleaner air and cleaner water for consumption is well documented, and so to is the growth in an altruistic attitude to protection of the flora, fauna and their homes. But whether extreme swings in attitudes are possible in all but the very long term is highly questionable.

While social changes such as the trend toward ensuring preservation of the natural environment, or the trend toward withdrawal of government services and support for the rural areas and reliance on market forces to correct environmental problems will shape the future they are minor influences in comparison to the economic and ecological forces. To focus on these sorts of changes as drivers runs the risk of Zeitgeist—a focus on the trends of this era losing sight of other possibilities. It would also risk overvaluing current trends—we forget about the moderating influences on today's trends. In any case the continuation of such trends depends more on the economic and environmental condition arising in the future than on unseen forces or animal spirits.

However, massive swings in social attitudes while unlikely would, climate change and nuclear war aside, be the main driver for very big changes in use of the resource base.

Short run drivers

The main economic driver is what agricultural production is demanded of the resource base. This is the demand driver, and depends on world demand for agricultural products rather than Australian demand. Australia is a price taker in almost every agricultural market, so the decision criterion for whether to produce simply depends on whether the cost of production is lower than the world price.

The cost of production will depend on the productivity of the land and water base and the other inputs into production. There are unlikely to be other constraints on production than the state of the land and water base as labour is not in short supply and capital would be available as long as the return on agriculture is competitive.

Niche markets for some specialist Australian products are, and will continue to, develop. For these products Australia is able to exert some control over the price. However, production volumes are generally small. It would be a mistake to assume that this trend toward high value niche Australian products would accelerate sufficiently to replace the current predominance of the broadacre industry in terms of land use. What matters for how much Australia will produce is how much it can produce at world prices.

The key drivers are:

- world per capita income growth and the distribution of income;
- changes in tastes independent of income growth; and
- world supply capabilities.

The other short run driver is on the supply side. The land and water base in Australia are not static. Many experts believe that current agricultural practices are having a generally negative impact on land productivity. In the past yields have been sustained by increased inputs of fertiliser and technological developments such as improved genetics. However, as with niche markets it would be a mistake to accelerate these trends into the future.

Chapter 5 develops three scenarios for the production required from the Australian resource base and the consequent environmental problems that arise. These scenarios are driven by the demand for Australian agricultural products, the supply capabilities of the land, and the social decisions about which environmental costs are included in production decisions.

CHAPTER FOUR

A foresighting methodology for LWRRDC

The purpose of this section is to outline the most relevant approach to apply foresighting to assist LWRRDC's planning.

A foresighting methodology for LWRRDC

The requirements as we see them for a foresighting exercise for LWRRDC are:

- a workshop approach to promote interaction—as process is as important as outcome;
- several phases starting with pre-foresighting by workshops of experts to compile lists of possible problems, and possible breakthroughs in land and water management—this would promote interaction and provide a well informed starting point;
- the main foresighting exercise workshop to consist of a diverse group of participants including some 'blue skies' people—all stakeholders, and future stakeholders should be represented to bring as many views as possible to the table;
- regional perspective's be taken within a national perspective framework, ideally in regional workshops—as the future is likely to differ substantially across regions, and solutions are likely to be regionally dependent;
- the description of the changes in the land and water system in the future must be clear and accepted by the stakeholders as possible outcomes—the problems that may possibly arise are agreed and the needs identified, priorities may be useful;
- the possible technologies required to address these problems must be well defined and agreed upon as appropriate—an assessment of their likelihood of being able to be developed and address the problems might be undertaken; and
- a mechanism for evaluating the foresighting exercise—in terms of process and outcomes—must be developed. Periodic reviews and an on-going program are suggested to ensure management has the information to update planning to unforeseen changes in technology or economic and environmental conditions.

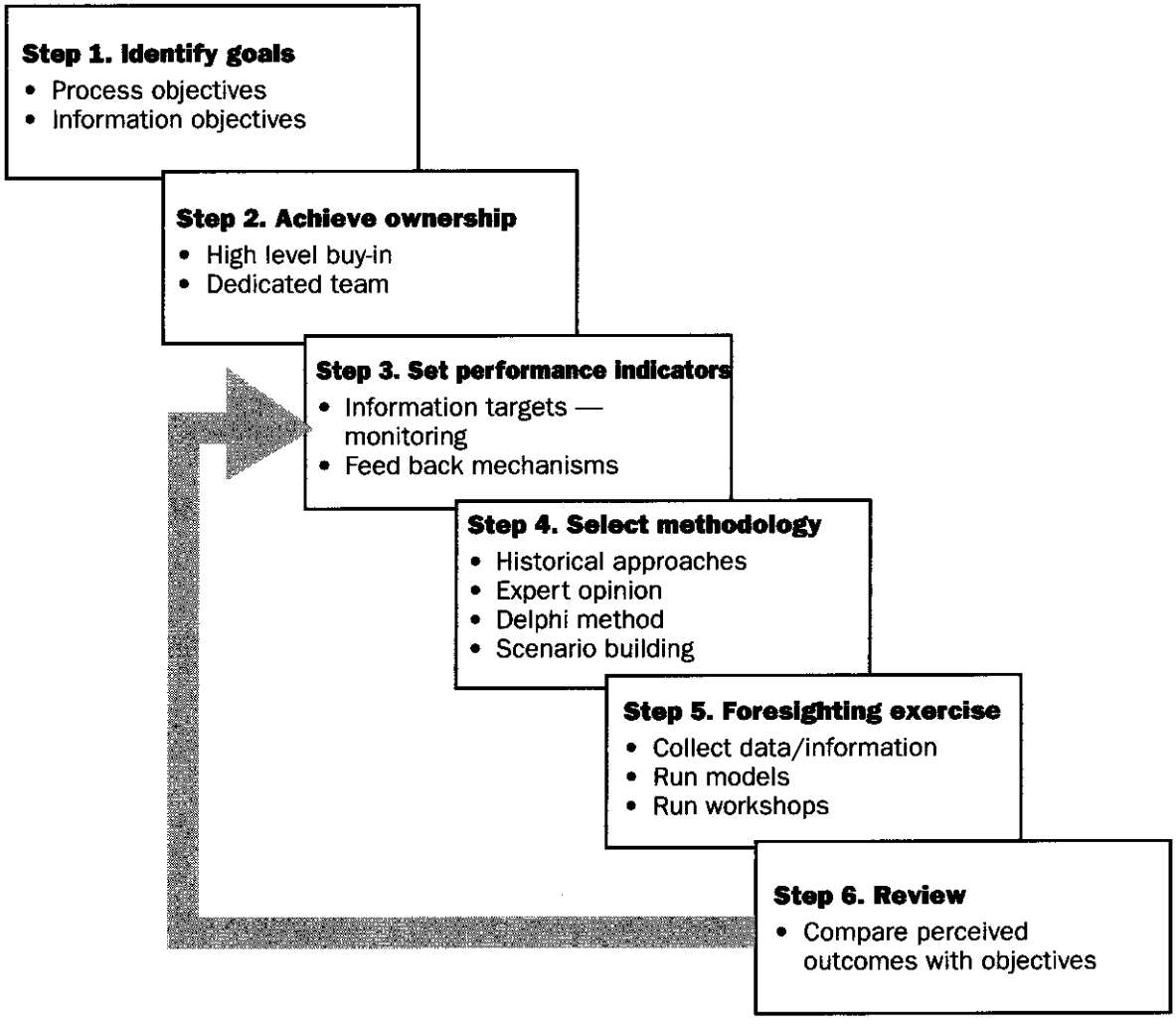
There would be considerable value to whole of sector planning for the LWRRDC foresighting exercise to feed into a broader exercise involving the other R&D organisations such as RIRDC, and the various agricultural industry councils. Such an exercise would be best conducted under a partnership arrangement with ASTEC.

Six steps in a foresighting exercise are developed in Figure 4.

Step 1: identify goals

The goals for LWRRDC are in terms of both process and outcome. While technical research can be funded, issues identified and solutions generated, there is a major problem with implementation of the solutions. LWRRDC sees its role not only as finding the solutions but ensuring that they are affected. Thus the foresighting exercise is as much aimed at planning and management to assist implementation of solutions as it is for more technologically orientated research.

Figure 4
Steps in a foresighting exercise



Process

The main process goals for LWRRDC are:

- to educate researchers, policy makers and practitioners about the R&D program;
- to disseminate information about what problems and solutions are known;
- to get ownership of the problems and a commitment to act on the solutions; and
- to develop information flows that will update the knowledge—of what problems are identified, of what solutions are developed, of what has been implemented, and of how it has worked.

Outcomes

The main outcome goals for LWRRDC are:

- a range of descriptions of the resource base, that is, the range of states of the environment that could eventuate by 2026;
- an identification of the physical challenges that would be likely to arise under each of these descriptions;
- the gaps in knowledge of the physical outcomes under the challenges;
- a range of possible solutions to each of the physical challenges;

- the gaps in the technological solutions; and
- an identification of areas and issues that are currently not on the agenda which could have large impacts under any of the scenarios.

Step 2: achieve ownership

Successful foresighting programs often stem from a single individual's enthusiasm, but they must be supported by the powers 'high-up'. However, for LWRRDC the most important group to get to 'buy-in' is the people in positions of affecting change. These are:

- policy makers in State government—the advisers rather than the people at the top;
- policy makers in Federal government;
- policy makers in the agri-political institutions;
- policy makers and information providers in farmer and agricultural representative organisations; and
- the controllers of information dissemination in the agricultural research and development corporations.

Step 3: set performance indicators

Performance of long term outcome projections is almost impossible to judge until the end of the foresighting horizon arrives, and consequently are not reasonable measures of performance.

Process can be observed and some judgement made as the success or otherwise of the exercise. ASTEC judge the foresighting exercise as successful if it induces change.

For LWRRDC the success or failure of the foresighting process can be judged by:

- the outcomes from the workshops in terms of concrete descriptions, challenges, solutions, and levers to get solutions in place;
- the outcomes from the workshop in terms of gaps and how they might be filled;
- well defined information needs, and the exchange of this information;
- change in policy and advice provided by the various government and nongovernment institutions; and
- observed change in 'on the ground' practices in response to the advice or policies.

Step 4: select methodology

Scenario building should deliver more interaction particularly with accessing a more diverse range of opinions than other foresighting methods. Experts could be used in a pre-foresighting phase to begin the interaction process between people working on different facets of the same big picture.

Setting the scenarios—developing an issues paper

This pre-workshop phase would define the current state of knowledge. The pre-workshop phase would also expose the current researchers and associated experts to the process of foresighting to ensure that they are willing to promote the exercise. Without their support the scenario building exercise is unlikely to bring useful products either from the process or the outcomes of the exercise.

A detailed set of scenarios developed by a panel of experts is an ideal way to begin the foresighting process. This report provides a broad set of scenarios to form a unifying link between the scenario setting of the different program foresighting exercises. The detailed scenarios would take greater consideration of the outcomes for the resources of concern to the specific program, the solutions to these concerns and the levers to get the solutions put in place. They would be the stepping stones required to focus attention on the potential issues and to stimulate interaction, thinking and ideas. The range of possible outcomes should be canvassed to ensure that events with a low probability but a potentially high impact are not ignored.

The set of scenarios could be developed in a workshop involving a diverse group of stakeholders. Agreement on the internal consistency of the scenarios would be required and probabilities of scenarios or components of scenarios arising could be formed based on group consensus.

The detailed scenarios could be developed separately for each program drawing on specialist expertise. These scenarios would form the basis of an issues paper for each program to be provided to workshop participants in advance of the workshop. A common starting point for each program in the scenario development would be the broad scenarios in this report. Any addition or modification to the broad scenarios would need to be addressed before the development of the program scenarios.

Workshopping the scenarios

The workshop should allow sufficient time to conduct the exercise, and facilitate the informal contacts and discussions which are essential components of an effective foresighting exercise where process is important. In this manner lateral thought would be encouraged in a small group setting.

The first step is to ensure agreement on the program scenarios at the program group level. These scenarios include a description of the range of physical challenges likely to be associated with the scenario. The aim is develop a fully articulated set of scenarios that give a range of possible outcomes with the required focus for each program.

The second step is to develop strategies or solutions appropriate to each of the sets of physical challenges. This requires agreement on a set of goals for the outcome in terms of the resource base and use under each of the scenarios.

If there is a common goal under each scenario this could be set up as a target outcome.

If interactions between the different foresighting exercises is desired, the program scenarios could be introduced to the participants from all programs. The aim of this would be to identify overlaps and cross-over effects that might have been omitted from program scenarios due to their particular focus.

Setting probabilities

There are a number of ways to go about identifying the most likely of the scenarios. The Delphi method provides one approach. The participants could be asked to estimate the likelihood of various parts of the scenarios arising in several different time frames. These results would be collated by the workshop organisers.

The median and range of time frames for the possible outcomes in the scenarios could be discussed in later sessions and possibly a second round of projections made.

Step 5: foresighting exercise

In setting up starting scenarios it is important to be aware of the relevant time frame for the foresighting exercise. The divergence from a 'business as usual' will be much greater the longer the time horizon.

LWRRDC has four areas in which it wishes to conduct a foresighting exercise. While each exercise focuses on a particular aspect of the resource base there are a number of common elements. These are:

- examination of likely scenarios for the outcomes of the resource base or use—provision of detail under a broader set of scenarios already developed for LWRRDC;
- identification of future management and R&D strategies;
- improvement in planning and management frameworks to implement the strategies, including identifying information needs; and
- identification of appropriate R&D priorities to be supported under the relevant programs.

While each program could develop its own foresighting exercise, there are considerable benefits to a coordinated approach. These flow from overflows of R&D in one program into the other programs, and from common implementation points. There may be:

- interactions between the program's physical challenges;
- the opportunity for more creative R&D approaches through interaction between people working in different areas; and
- people whose responsibility for policy making and information provision overlaps into several, or all, of the four program areas.

We suggests, therefore, that the four exercises be conducted together so as to promote interaction in the development of the four programs—by exposing experts to other areas, bringing to the fore the current and potential interactions of the four program's aims, techniques and outcomes, and selecting policy makers with overlapping responsibilities as well as those who target a single issue.

Step 6: report and review

The reports on the foresighting exercises should cover the information outcomes and the gaps identified in the outcome goals. The reports should also suggest ways to update the exercise either through a formal mechanism where additional foresighting exercises are scheduled for the future, or through an informal internal process.

Each program group's discussion would be reported on by the expert or experts involved in initial issues paper. Ideally a summary of the outcomes would be added to the experts report. These reports would be circulated to all participants for comment. A final report to LWRRDC should include all the expert reports and if interaction between the foresighting exercises is required, an evaluation of the foresighting exercise for each program relative to the goals of the broader foresighting exercise.

LWRRDC may wish to provide a copy of the final report to all participants. Direct contact between the participants could be encouraged by on-going reports of who is doing what.

CHAPTER FIVE

Starting scenarios for the foresighting process

The purpose of this section is to:

- identify the range of physical challenges to the agricultural land and water resource base likely to emerge over the next 30 years; and
- provide guidance on the institutional drivers required to overcome these challenges.

We first develop a set of priorities for Australia's agricultural production. These are driven by a range of views on global economic growth—which in turn influence the demand for agricultural products. The results from these projections are used to establish the land and water use problems likely to arise from meeting these demands and the nature and size of the technical and institutional challenges to over come them.

We then develop three scenarios. These scenarios are differentiated according to social values—in particular the extent to which producers internalise the environmental costs associated with meeting the agricultural production outcomes from the global economic growth projections.

The scenarios are intended to be developed further during the workshop foresighting exercise. To encourage debate and to stimulate the type of thought required for such workshops to be successful a fully defined set of scenarios—where social and policy changes assumed to occur are consistent with the physical outcomes, and the technological developments—is provided in appendix D. This chapter provides the bare bones of these scenarios.

The development of the scenarios

There are three main drivers for the basic scenarios:

- the projections of demand for Australian agricultural production which are based on global income growth projections;
- the physical constraints on agricultural production which is the availability of land and water, and the potential improvement in yields which depends on the trade-off between the rate of deterioration in the resource base and improvement in technology and other inputs; and
- which environmental costs are factored into production decisions. These costs range from the cost of lower yields on the producer's own land, to the existence value of bio diversity.

Figure 5 summarises these drivers and the range of scenarios that emerge. In this section we discuss the three drivers—global demand, physical constraints, and the extent to which costs are included in production decisions. We also look at the assumptions behind the demand projections and the supply constraints. The scenarios are described in the following section.

The range of demand projections

The relative demand for nine commodities in 2026 under the three different global economic growth projections are demonstrated in Figure 6. The figure shows the index of production in 2026 relative to 1996 production. Table 1 provides the quantities demand by 2026 for each of the commodities under the three global growth projections.

Table 1
World demand for Australian agricultural products by 2026

		Optimistic income	Best bet income	Pessimistic income
Wheat	Kt	29 516	25 247	21 542
Coarse grains	Kt	13 233	12 968	12 816
Rice	kt paddy	1 933	1 853	1 838
Cotton	kt lint	1 650	1 555	1 200
Wool	kt greasy	1 150	1 055	710
Beef & veal	kt cwe	2 682	2 530	2 385
Sheepmeat	kt cwe	791	747	708
Sugar	kt	9 500	8 600	7 700
Horticulture	index of product	513	493	474

Source: CIE estimates.

These demand projections were generated under very different economic growth conditions. But, the results for Australia's rural production look remarkably similar. This is because, excluding nuclear devastation or a climate change catastrophe, long run aggregate economic growth would at most vary in the range between 2.3 per cent and 3.9 per cent a year. While there could be substantial short term variations, long run average growth is driven by population growth, the maximum rate of new technological development and its adoption, and the potential of the developing world to 'catch-up' to the developed countries.

- Population growth has been projected based on the current trends. It is unlikely to vary much from the baseline projection in the next 30 years because the drivers of population—per capita income and female education and empowerment—do not change rapidly on a global scale.
- The maximum rate of technological development at the frontier, even in the golden years, is estimated to average at most 3 per cent a year. The speed of adoption of new technology is the major barrier to more rapid growth and for social and economic reasons these barriers are unlikely to be lowered in the next 30 years.
- The main driver of the different global growth scenarios is the variations in the actual catch-up rate of the developing countries.

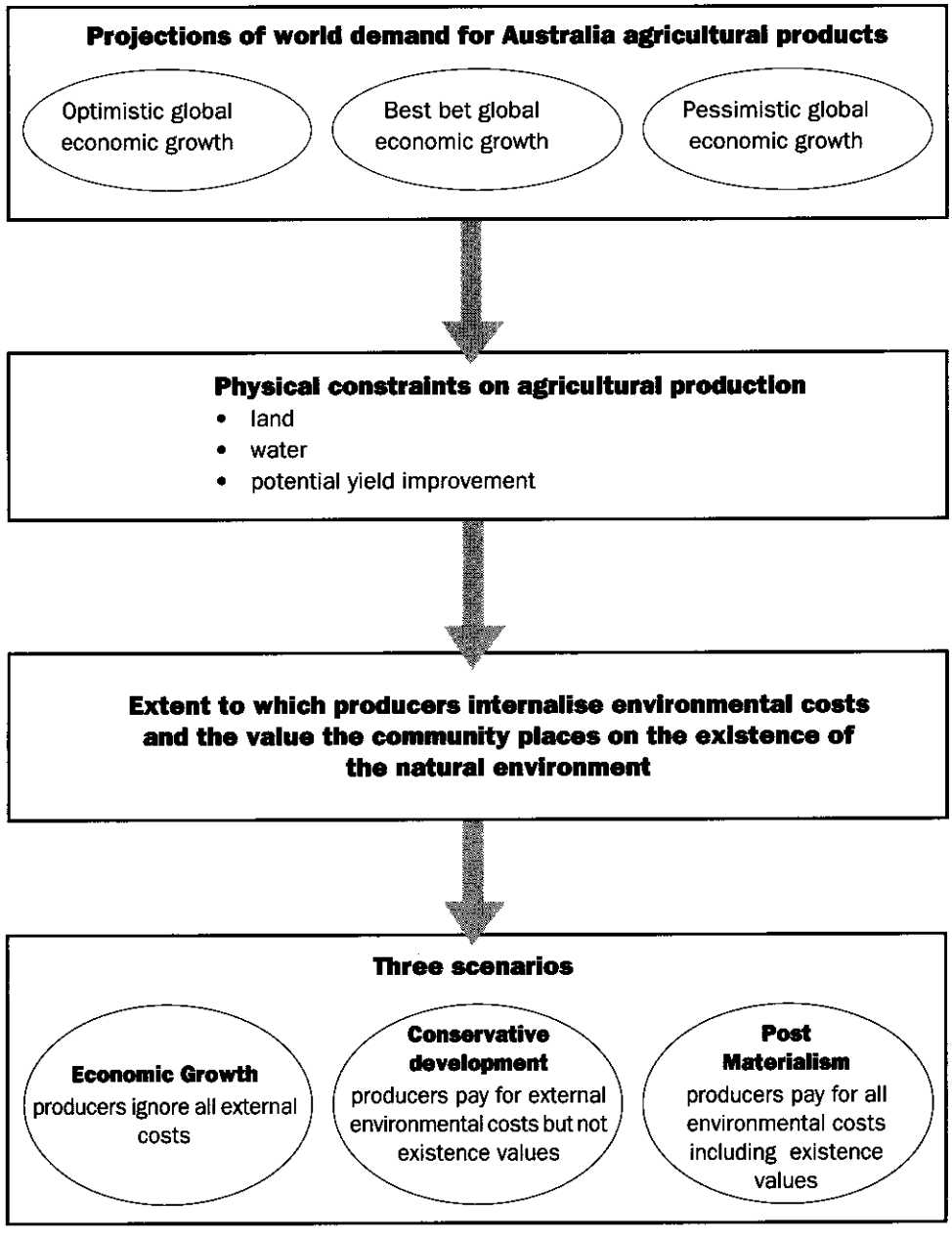
A full description of the demand growth projections and the demand for Australian agricultural production stemming from these income growth projections is provided in appendices A and B.

Optimistic projections of global demand

More countries set out on the catch-up path, and at a faster pace—the main drivers being improvements in government policies in the countries themselves and a reduction in the barriers in the developed countries to both the inflow of goods and services and the outflow of capital and technology.

Growth in demand for food is driven largely by population growth and at low levels of income, income growth. As per capita incomes rise it is the mix of products demanded that changes more than overall demand. In particular the demand for wheat relative to rice and other grains rises and the demand for meat increases. The demand for meat is strongly influenced by cultural factors. Under the optimistic scenario the main growth in demand for agricultural products comes from the growth in the Asian region—due to the large initial population, greatest income growth, and low initial income base.

Figure 5
The range of scenarios



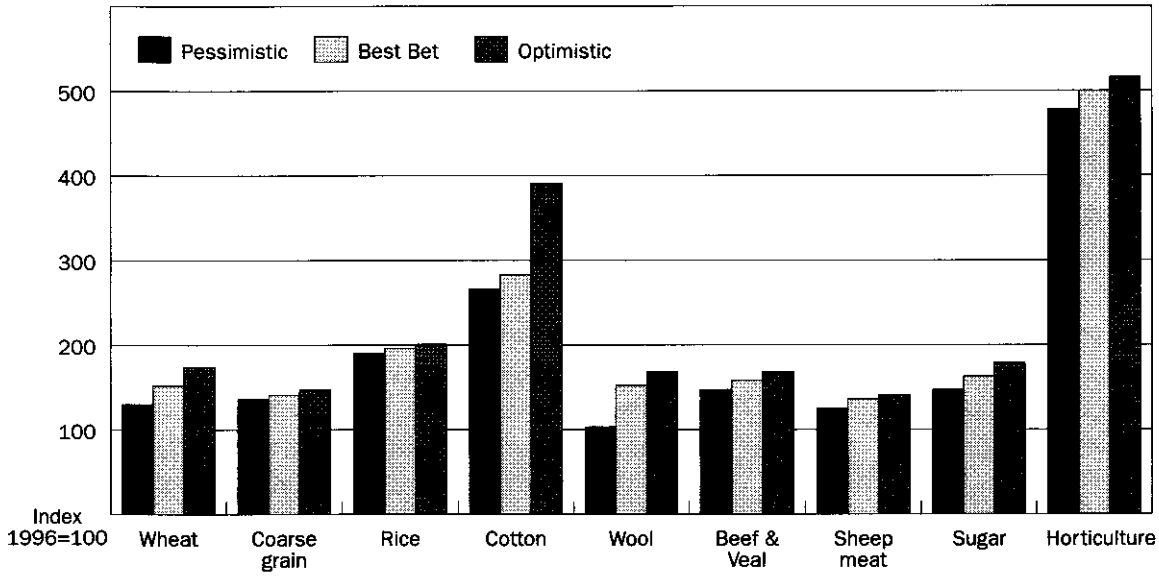
Best bet projections of global demand

The present day trends continue, with the Asian countries following the 'catch-up' path at around the same rates as over the last two decades. Latin America performs better than in the last two decades as government policies improve and scheduled reductions in trade barriers occur. Africa remains a troubled area, though the outlook is to stabilise by the end of the period rather than continuing to go backwards. This is partly because there is not a lot of room to go further in the backwards directions and crisis will force change.

Pessimistic projections of global demand

Africa largely descends into anarchy, a number of Latin American countries revert to the populous policies of the past, and Asia is troubled by regional divisions in China and an abrupt and violent end to the division of North and South Korea.

Figure 6
Index of production at 2026 under the different global economic scenarios



Data source: Tables in appendix B.

While this slows economic growth considerably in certain regions it tends to have positive impacts elsewhere. As agricultural production, particularly for trade is also affected in the countries with slower growth, the net effect on world demand for Australian agricultural products is relatively small. The main change is in the mix of products demanded with a reduction in meat and wheat demand relative to other grains.

Physical constraints on supply

Australia has the physical capability to meet world demand in 2026 under any of the global economic demand projections, but not without a number of tensions arising between land and water use and sustainability. A full evaluation of productive capacity is given in appendix C.

Individual production sectors could meet the production targets in the best bet scenario, if all other production sectors are held more or less constant during that time. However, because of inevitable physical interaction between production sectors, tension will arise if all sectors are expected to grow over the next 30 years. Many of the tensions will be quality ones because of specific timing requirements for advanced production systems. Increasing the quantity and quality of beef and sheepmeats will require irrigated pastures at specific times of the animal feed year. If irrigation water supplies are capped or appropriately priced, then the available water supplies will be used by the cotton, rice and high value horticulture industries. There will be a tension between our expectation of supply, and our ability to physically produce it. If the average farm enterprise moved closer to the capability of the top 10% of farmers the production targets suggested in the optimistic and the best bet scenarios are probably feasible. Production targets in the pessimistic scenario are achievable.

Land

To meet the increase in production of grains an additional 8 million hectares of land would be required for cropping. This land would come from grazing activity. The two main tensions resulting from this increase in land used for cropping are:

- the rotations between cropping and grazing would be reduced increasing the pressure on the land and increasing the rate of deterioration of the soil; and
- the livestock numbers required will be difficult to maintain in periods of drought without a fall in the quality of the product.

There would also be tensions between land use for sugar cane and urban development along the Queensland coast. The ecological balance in the area could be threatened by the clearing of forest for cane fields.

Water

Timely application of water is essential for many products to ensure consistent quality. There would be substantial competition for water under all three of the global economic scenarios, least so under the pessimistic scenario. Unless more frugal irrigation technology is developed and less water intensive varieties are adopted the world demand scenarios cannot be met for all products.

The main loser will be livestock as the area under irrigated pastures declines. An inferior quality product could be supplied utilising marginal land to meet production targets, but the value of production will fall.

While meeting production targets under all three global growth scenarios is possible, unless rescued by a much greater rate of technological advance in crop varieties and irrigation technology than the historical trend, there will be considerable environmental degradation associated with meeting the optimistic and best-bet production levels and possibly even the pessimistic level of demand. Table 2 summarises the tensions for land and water under the world demand projections.

The environmental cost of land and water

The production decisions will depend on the extent to which environmental costs are taken into account by producers. The possibilities range from not at all (flog the land) to meeting only demand consistent with an ecologically sustainable landscape. These two extreme scenarios are called the 'economic growth' scenario and the 'post materialism' scenario. Between the two extremes is the 'conservative development scenario'.

The main economic driver of production decisions behind each of the scenarios is the cost of land and water to the individual producer.

- In the economic growth scenario the cost of land is based only on the future yield of the land. This is less extreme than the 'ignore environmental damage' situation. The external costs would be internalised to some extent if the average size of the land holding became very large. The cost of water to an individual farmer is the opportunity cost of water, that is water is allocated at market prices and goes to the uses with the highest returns. The natural environment under this scenario cannot pay for the water and so receives only the residual.
- In the conservative development scenario the cost of land includes the external costs but very little of the ecological costs. One way to describe this is that ecological costs are included, but the value placed on bio diversity and the like by society is very low. Some institutional mechanism is required to 'internalise' the externalities, and this would most likely fall to government. Similarly, water cost would reflect the costs imposed on downstream users and the costs to adjacent land owners.
- In the post materialism scenario all costs, ecological as well as private and externalities, are recognised and land and water are priced according to the total cost. In this scenario ecological costs are valued against the metric of sustainability—if an activity is unsustainable then it has an infinite ecological cost and so will not proceed.

The interaction of the demand projections, the supply constraints and the incorporation of environmental costs is summarised in Figure 7. The demand projections are summarised by the price that Australia would receive for its agricultural production (the horizontal demand curves in Figure 7). As the prices of agricultural products are unlikely to vary dramatically under any global economic growth projection, these demand curves are close together. This means that the amount of production depends on the cost of production.

Table 2
Possible tensions for commodity groups under the different demand projections leading to the year 2026

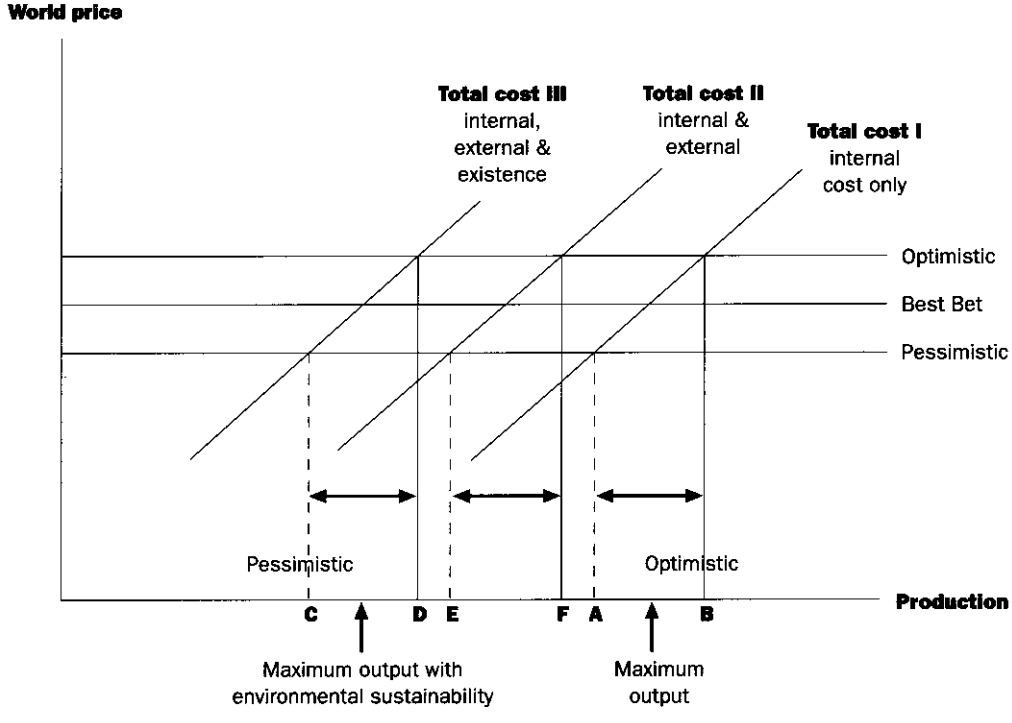
Commodity group	Land tensions	Water tensions	Diffuse Environment tensions
Wheat	Demand for larger planting area will decrease rotational spelling and lead to long term production decline		Expanded area will challenge remnant vegetation areas and bio diversity resources therein
Coarse Grains	Large wheat area will stabilise or decrease the area available for other grains		As above
Rice	Irrigation salinity in the MIA	Competition with Adelaide for urban/industrial use.	
Beef and Veal	High animal numbers will be subject to high environmental scrutiny particularly with reference to drought management	A doubling of feedlot capacity will increase scrutiny for off site pollution effects particularly for stream quality indices and groundwater contamination	Energy audits will reveal feedlotting as a very energy inefficient system
Sheepmeat	Forestry, horticulture and hobby farm expansion will decrease high quality land available for high quality production. Problems of product quality and continuity will ensue.	Less irrigation water to produce timely high quality product such as prime lamb.	
Wool			
Cotton		Will out compete irrigated pastures for water allocation in MDB	
Sugar	Land on tropical coast is relatively scarce and open to high environmental scrutiny	Will compete with urban use and tropical horticulture as sugar move to more marginal rainfall areas	Effect of nutrients and sediments on estuaries and the Great barrier Reef
Horticulture		Will compete head on with sugar in tropical areas, cotton in the MDB and urban use in near coastal areas.	

Source: CSIRO with amendments by CIE.

The cost of production is represented by the supply curves in Figure 7. Cost depends on productivity of the inputs—land, water, fertiliser and pest control, technology and management skill. The cost of land and water are the focus of this exercise—total costs may include the internal costs (net changes to future yield), the external costs imposed due to environmental degradation, and the ecological costs due to loss of bio diversity, and other existence values.

The three scenarios developed for the foresighting exercise reflect three different attitudes to the cost of land and water. At one extreme only internal environmental costs are taken into account (total cost I resulting in a production range AB in Figure 7). At the other extreme all environmental costs, including existence values are taken into account (total cost III, resulting in production range for current commodities of CD). In between is a scenario where external costs as well as internal costs are included by the ecological existence costs are not (total cost II resulting in production range EF in Figure 7).

Figure 7
A representation



Data source: CIE.

The capacity of the resource base to meet demand under each of these scenarios is also represented in Figure 7. While it was judged that there is the capacity to supply the best bet demand projections if only internal costs are taken into account, there is some concern that the optimistic demand could not be satisfied. Determining the exact location of the other supply constraint points would require considerably more research, but a guess is that output under sustainability will be well below that of maximum output.

Assumptions behind the scenarios

The global demand projections for the different commodities are based on a number of assumptions.

- Population growth and distribution is assumed to be the same for all scenarios and is based on the United Nations populations projections model. Justifications for this assumption are given in appendix A.
- There are no world wide catastrophes—nuclear war, massive volcanic eruptions, meteor collision—wars are localised.
- The real price of energy rises slowly if at all. The sharp rise in energy prices in the 1970s and 1980s was partly catch-up in price and partly monopoly power. The rapid expansion in oil producing capacity of non-OPEC countries and the substitution of alternatives soon brought prices back down. In terms of income growth, while some countries experienced severe declines in response to the higher energy prices the effect was short lived and the average growth rates over a decade were unaffected.

Energy prices may rise due to a carbon tax being instituted to assist control of greenhouse gas emissions. However, the impact of such a tax on the growth of GDP is very small. Estimates by McKibbin, Pearce and Stoeckel (1994) found that the cost to the Australian economy of a carbon tax sufficient to reduce emissions to 1990 levels is less than one per cent of GDP over the fifteen years following the imposition of the tax. This implies that on average the tax lowers growth by 0.066 per cent a year.

- Consumer tastes are assumed to remain relatively unchanged, precluding a major shift in consumption patterns toward nontraditional products.
- Long run supply elasticities in the rest of the world do not change dramatically so Australia's position as a price taker for most agricultural commodities does not change.
- While trade policies differ for the different commodities under the three projections the policy outcomes are consistent with the growth rates and the general policy stance of the country. In terms of general agricultural policy the world remains reliant on trade in food—no major block of countries pursues self sufficiency in food as a policy goal. The pessimistic income projections result in greater protection for all industries including agriculture but the impact is relatively small.

The physical constraints on supply are estimated by CSIRO based on the past production capabilities and trend productivity growth (see appendix B). This approach aims to identify tensions in terms of competing uses for land and water rather than provide a detailed account of the land and water degradation outcomes. The main assumptions are as follows.

- Productivity growth in the traditional products is assumed to follow either a historical (linear) trend, or a logarithmic trend. In the latter case the growth in productivity falls over time making the tensions between competing land and water uses greater than under the linear trend.
- There is no increase in the rate of land degradation—the historical rate of degradation is partly built into the productivity growth assumptions, although so to is the increasing use of marginal land for grain and improved pasture for livestock.
- Urban demands for land and water are not taken into account as a competing force.
- The current water requirement figures are used to identify water 'tensions'. The likelihood of more efficient use of water is not addressed in the physical constraints section.

Combining the demand projections and the supply constraints shows that the optimistic demand projections could not be met without a decline in the quality of some of the products, in particular livestock, due to the competition for water. The pessimistic growth demand projections would be able to be met if historical productivity trends could be achieved. The 'best bet' growth and demand projections fall somewhere between the two, and tensions between land and water uses would increase substantially.

These outcomes say nothing about future changes in the rate of degradation of land and water. They simply demonstrate that, if historical productivity trends continue, it is quite likely that Australian production will be insufficient to meet the global demands placed on it and the areas most affected will be irrigated pastures for livestock.

The three scenarios

The development of technology aimed at improving crop yields, developing new varieties, and solving environmental problems depends on the effort put into research and development in these areas. Such research can be privately or publicly funded, developed in Australia or imported from other countries.

The adoption of such technologies depends on market opportunities—which determine the profitability of adoption—and on other forms of encouragement or penalties imposed for lack of adoption. The predominant driver of rates of adoption depends on the institutional system. In a society where private ownership predominates and government is not involved in agriculture the market incentives for adoption will be the main drivers. In a system where government has been assigned the role of ensuring externalities are internalised they may use market incentives (taxes or subsidies) or regulations (quotas and fines) or direct action to achieve the desired adoption. And, in a system where sustainability is required, strict regulation and or a change in ownership would be needed to ensure responsibility is allocated for meeting sustainability targets.

For each of the scenarios a variety of technological solutions and institutional levers are possible to deal with the issues that arise. There are, however, some features that are tied to the scenario and these should be taken as given when developing the range of technical and institutional solutions for each scenario.

Table 3 gives the social and economic characteristics consistent with each scenario. Where a number of alternatives are consistent with the scenario it is labelled 'various'. The first column is not exhaustive but is a good list of the features that will impact on the eventual land and water use. Technology is not included in the table as a wide variety of technologies are possible under each scenario.

The economic growth scenario

Principles

These physical outcomes might be expected when society is focused solely on economic growth. The scenario denies the significance of any reputed decline in levels of concern for and cooperation with others (the sociopathy problem) and asserts that increasing socioeconomic inequality will decline as a problem if the material well being of the poorest in society is lifted, by higher economic growth, in an absolute (not relative) sense. Declining environmental quality is seen as a problem, but one that would be largely resolved by establishing a comprehensive system of property rights over those resources whose management largely determines environmental quality.

Table 3
Some characteristics of the institutional environment under each scenario

	Economic growth scenario	Conservative development scenario	Post materialism scenario
Size and structure of government	Not involved in agriculture	Various	Large but maximally decentralised to regional & local level
Regulation of markets	Regulated only to enforce contracts	Market failures must be corrected eg. externalised production costs, non market costs must be paid	Output mix can be managed if considered socially beneficial eg. regional specialisation, a degree of local self-sufficiency
Property rights	All land freehold with comprehensive rights attached. Access to surface and groundwater on a user pays basis	Property rights much as at present. Water available through transferable quotas	All land effectively converted to leasehold and subject to binding covenants. Minimal interbasin transfer of water. Use rights subject to regional
Environmental	None	Regulations, some public works quality control and economic instruments used for achieving high environment quality	Regulation, incentivation and community controlled catchment/region management
Taxation	Similar to other countries	Various	Total tax take well above present levels. Tax land, excess profits and capital gains heavily. Tax externalities.
Investment in agriculture	Unregulated	Unregulated	Subject to social and environmental impact assessment
Investment support	None	Loans for improving environment and product quality when there are net social benefits	Various government support
Values to be encouraged	None	Moral suasion to encourage land stewardship	Educate children to value land stewardship, cooperation and altruism
Research support	All research privately funded	Publicly subsidised support for technology development and public interest research	Publicly funded support for public interest research eg. environmental remediation; residue reducing technologies
Infrastructure provision	Minimal government provision, maximal private provision	Transport, communication and utilities infrastructure provided collectively	Transport, communications and utilities infrastructure provided collectively. Decoupling from networks encouraged
Services provision	Minimal government provision, maximal private provision	Health, education services provided to national standards	Health, education services provided to high national standards
Community support	None	Various	Fund employment of regional and local government staff on environmental quality programs

Source: CSIRO with amendments by CIE.

The main principles of such an economic growth strategy would be the deregulation of business and the downsizing of government. The limited functions of a minimalist government are seen as including defence, law and order and the provision of some physical infrastructure. This would have a number of implications for R&D and adoption of technology, leaving the former to the private sector, and the latter driven only by market incentives. A full description of the type of institutional framework where this scenario might arise is given in appendix D.

Issues that evolve

Under this scenario there would be a division of land into primary production and marginal land that is brought into production only in years when world prices are high or good climatic conditions are anticipated.

The land use issues to be contended with under this scenario are:

- how to minimise the declines in yields associated with shorter rotations in cropping and grazing;
- how to raise productivity across the broadacre industry to current 'best practice' levels;
- how to incorporate the externalities associated with the more intensive use of land and water into private costs; and
- how to allocate water between competing productive activities.

On marginal land there would be a series of regional specific issues arising from the on-going rate of degradation of the land and water base.

Tables 4 and 5 summarise the constraints faced under this scenario.

The conservative development scenario

Principles

The institutional framework recognises the effectiveness and right of government to intervene strongly to achieve social and environmental goals. It recognises unemployment as the major cause of socioeconomic inequality. It focuses on achieving a high rate of economic growth but only to the extent that this does not detract from achieving major improvements in environmental quality and social equality. This strategy does not regard sociopathy as a problem warranting a policy response.

The main principles of a conservative development strategy are:

- to establish, for individuals and organisations, a system of behaviour rewards and punishments (eg. incentives and regulations) that promotes improved environmental quality; and
- to establish employment-creation programs centred on increasing tax revenues and using these to finance jobs directed towards environmental protection-enhancement.

Issues that evolve

Under this scenario the government is provided with a mandate to deal with the externalities from primary production. However, sustainability and preservation of the environment for their own right are the preserve of private individuals and groups who value these things. Our assessment is that under this scenario Australia would be unable to meet the global demands for its products under the optimistic and best bet growth projections.

Table 4
Some product mix implications and tensions arising under the 'economic growth' scenario of supply

Commodity	Murray–Darling Basin	Other wheat–sheep	High rainfall zone	Northern Australia
Wheat	Corporate ownership of best soils and the processing and associated transport and infrastructure. Intensive 'best practice' on superior soils	Retraction of permanent production from problem soils, but retain ability for large scale production to meet spot markets in some years		
Coarse grains	As above	As above		Some increase as virgin soils become developed
Rice	Corporate rice moves from MIA as irrigation salinity bites			Major increase on virgin soils as technical problems are overcome
Beef and veal	Large increase of feedlotting and vertical integration with lower quality grain production	Large increase in breeding herd required to supply animals for finishing	Retraction as urban requirements, forestry and horticulture take over higher quality soils	Steady increase of live cattle trade based on best soils with more integrated finishing on The Ord. Spotty production and retraction from marginal areas
Sheepmeat	Demand can be met, but with problems of quality and continuity because water has gone to cotton and horticulture	Live sheep trade is good in some years and flocks exist to supply young stock for further finishing		
Wool	Challenge to maintain supply and quality in face of flat real prices	Supply and quality problems	Competition for land from urban, forestry and horticulture	
Cotton	Major expansion on good cotton soils and ownership in perpetuity of water rights			Limited expansion with transgenic cotton able to deal with cost/pest problems
Sugar			Retraction in northern NSW and south-east Queensland due to urban expansion and competition for water	Expansion along the tropical coast and in more marginal rainfall areas that require additional water rights for irrigation.
Horticulture	Major expansion in high quality horticulture. Water rights come from rice and animal industries	Niche expansion but full market opportunities limited by water quality and other environmental problems	Urban and industrial demand for water limits expansion in many coastal areas	Tropical horticulture expands, but competes with sugar and urban for land and water, particularly in Queensland

Source: Appendix D.

Table 5
Some environmental tensions arising under the 'economic growth' scenario of supply

Commodity	Murray–Darling Basin	Other wheat–sheep	High rainfall zone	Northern Australia
Wheat	Emphasis on intensive production methods leads to shorter rotations, more chemical fertilisers and tensions with long term productive capacity of best soils	Continued decline in all attributes of soil function on poorer soils as agriculture acquires only the best soils. Marginal soils are left to care for themselves		
Coarse grains	As above	As above		
Rice	Rising water table and irrigation salinity			Irrigation salinity problems
Beef and veal	Effluent from feedlots affecting surface and groundwaters	Drought years and high cattle numbers lead to overgrazing of marginal lands		Drought years and high cattle numbers lead to overgrazing of marginal lands
Sheepmeat		Drought years and overgrazing because of high flock numbers required to supply stock for meat trade		
Wool		Drought years and overgrazing		
Cotton	Acquisition of water rights lead to low environmental flows and continual quality problems in inland river systems			
Sugar				Expansion of supply leads to further clearing of coastal vegetation, and increased effect on coastal waters and The Great Barrier Reef. Extra demand requires more dams and less environmental flows
Horticulture	Water rights lead to low environmental flows on all river systems. Shifting irrigation footprint leaves salinised soils and underground floods	Over-exploitation of groundwaters, nitrate pollution, etc.	Over-exploitation of groundwaters, nitrate pollution, etc.	Over-exploitation of groundwaters, nitrate pollution, etc.

Source: Appendix D.

The main issues in this scenario are:

- how big the externalities are—in both a physical and value sense;
- how much of world demand would be met, and in what products—the livestock is expected to be downsized but by how much; and
- how the government would go about managing the externalities;

The outcomes for the land and water base lie between those for the economic growth and the post materialism scenarios.

There are a number of ways the government could go about dealing with the externalities. One institutional framework is described in detail in appendix D. Tables 6 and 7 summarise the constraints faced under this scenario.

The post materialism scenario

Principles

The strategy behind the scenario is primarily concerned with the three problems of socioeconomic inequality, environmental quality and sociopathy (as evidenced, for example, by declining concern for others, declining interpersonal goodwill, declining participation in civic affairs). While this strategy accepts the importance of maintaining a vigorous economy and is not explicitly against economic growth, it requires that all development proposals be subject to environmental and social impact assessment.

As a starting point, a post materialism strategy accepts the principles of a conservative development strategy as outlined above. There are two additional principles as follows:

- to downsize material consumption and use the resources so released to invest heavily in social development including educating people in the importance of concern for and cooperation with others and the development of an enforceable, enhanced social contract between government and citizens; and
- To promote the development of an ecologically-sophisticated society. Following Capra (1995), the principles governing such a society include:
  - maximum recycling;
  - maximum use of solar energy;
  - maximum resilience under perturbation;
  - optimal diversity; and
  - optimal balance between the use of competitive and cooperative processes.

A full description of the scenario under a set of institutions that would provide for these sets of values is given in appendix D.

Issues that evolve

Under this scenario sustainability is required in all agricultural production and other activities.

The physical issues are:

- the yield of the current agricultural products when grown under sustainable conditions;
- the potential for other products and new products to be grown—the technical feasibility and the market feasibility; and
- the sustainability of land returned to an uncultivated state—management necessary to achieve sustainability.

The physical outcomes under this scenario are given in Table 8.

Table 6
Some product mix implications and tensions arising under the 'conservative development' scenario of supply

Commodity	Murray–Darling Basin	Other wheat–sheep	High rainfall zone	Northern Australia
Wheat	Reduced production because of 'forced' set aside of large areas of agriculturally marginal or high conservation value land	As for MDB, but more set aside for salinity and biodiversity concerns. Possible increase in production later due to soil conservation measures		
Coarse grains	As above, probable increase in average yields due to withdrawal from marginal land	As for MDB, but more restrictive expansion environment		
Rice	Much lower production than at present			Some localised expansion, but recognition of looming problems
Beef and veal	Reduction in stocking rates, but production systems similar to current ones	Similar to MDB	Retraction by regulation. Forestry and horticulture take over higher quality soils	Large scale retraction from marginal areas following government buy back and land rights schemes
Sheepmeat	Emphasis on higher quality from reduced numbers	Much lower than present		
Wool	Wool markets do not pay enough for adequate environmental protection	Supply and quality problems	Not seen as major here	
Cotton	Water rights, with strong environmental regulation permit limited expansion			Limited expansion with transgenic cotton able to deal with cost/pest problems
Sugar			Retraction due to environmental controls and competition for water	Limited expansion in more marginal rainfall areas permitted by water rights, under strong environmental control
Horticulture	Expansion of high quality horticulture due to water rights system	Similar to MDB, but distance from markets and lack of water limits development	Actively promoted as high value, highly regulated industry. Water rights permit substantial growth	Significant expansion as in high rainfall zone

Source: Appendix D.

Table 7
Some environmental tensions arising under the 'conservative development' scenario of supply

Commodity	Murray–Darling Basin	Other wheat–sheep	High rainfall zone	Northern Australia
Wheat	Ongoing degradation processes will be unable to be met even by increased research and lower production stresses	As for MDB, perhaps worse. Amelioration strategies may improve situation in the long term		
Coarse grains	As above	As above		
Rice	Continued rising water table and irrigation salinity, although research has assisted			Irrigation salinity problems still present. Research shows withdrawal is only long term option
Beef and veal	Land degradation issues remain, although covenants are helping	Overgrazing of marginal lands still a problem	Feedlotting increased, although under massive regulatory restrictions	Rapid changes in land tenure system leave unclear environmental future despite destocking
Sheepmeat	Despite lower stocking rates and other measures, degradation still occurring	As for MDB		
Wool		Prices insufficient to pay for environmental costs		
Cotton	Strong regulation lowers stress from industry, assisted by water rights			
Sugar				Restriction on further clearing of coastal vegetation and concerns about coastal water quality restrict development, but problems with land and water still persist
Horticulture	Bigger industry places more stress on available resources, although regulation restricts over-exploitation	As for MDB	Very strong regulation to restrict nutrient and pesticide pollution	As for high rainfall zone

Source: Appendix D.

Table 8
Production changes under a post materialist agricultural strategy

	Northern Australia	Murray-Darling Basin	Other Wheat-Sheep	High Rainfall
Wheat	Severe decline	50 per cent of present area, same output	60 per cent of present area and output	Some niche production
Coarse grains	Sorghum, kenaf in north	Same as wheat	Same as wheat	Same as wheat
Sugar	Stabilised at 1990s output	na	na	Little, no new expansion
Sheepmeat	na	Half present levels, replaced by native animals	20 per cent of present levels, replaced by native animals	na
Wool	na	Half present output, high quality	Less than half present output, high quality	na
Beef & Veal	Less than half present stock, present output	Small, replace by natives	Small	Some feedlotting, little expansion
Rice	Most production closed	Niche production only	na	Only for local consumption
Cotton	Little	Double output	na	na
Horticulture & other	Massive increase, particularly in bush foods	Massive increase, very diverse	Massive increase, particularly wild flowers and tree crops	Dominant agriculture, extremely diverse

na—Not applicable as not grown in region.

Source: Appendix D.

APPENDIX A

Outlook for economic growth

Three scenarios for global economic growth out to 2026 are proposed.

- The baseline scenario is our best bet on what will happen over the next 30 years—world economic growth averages 3.1 per cent a year.
- A pessimistic scenario which is driven by poor government policy decisions in both developed and developing countries, lower rates of technological growth, and consequent disruption of economic activity in a number of countries—world economic growth averages 2.3 per cent a year.
- An optimistic scenario where government policy in the countries where reform is lagging behind improves dramatically, and technological change enters another 'golden era'—world economic growth averages 3.9 per cent a year.

The average growth rates for the world hide a great deal of regional variation in per capita income growth. It is this regional variation rather than the overall growth rates of the world economy that drive the demand for Australian agricultural products. Per capita income growth has important implications for the combination of food products in the diet—the share of human consumption of grains falls as income rises and meat consumption increases. Differences across countries in tastes means regional variations in growth also influence the relative demand for the different agricultural products.

The next section sets out the assumptions behind the per capita income projections under each scenario. Per capita income growth rates (and levels) are projected for 34 countries and regions. Detail on the Asian region is included as this region is central for demand for Australian agricultural products.

The following section applies these income growth projections to forecast the world demand and demand for Australian agricultural products. CIE global models are used to generate demand projections for:

- meat—beef, sheepmeat, and other meat;
- grains—wheat, coarse grains for human consumption and coarse grains for livestock, and rice;
- sugar;
- wool;
- cotton; and
- other agriculture—fruit, other horticulture.

Explicit (exogenous) assumptions are made about the yields of these products in Australia, but the relative contributions of land, other inputs, and productivity growth is not explicitly modelled. Part of the project is to compare the exogenous yield assumptions with the CSIRO endogenous yield estimates to see if Australia is constrained in delivering the demand estimates for Australian agricultural production.

Per capita income growth projections

The starting point for the projections is the population projections made by the United Nations for population growth out to 2050. The same population projections are used for all three economic growth scenarios as, while per capita income and government policy (particularly with respect to the education and employment opportunities for women) do affect fertility, the lag between the changes and effect is around 20 to 30 years.

- It takes at least ten years before policy and income changes have a significant impact on women's fertility decisions.
- As the high fertility cohort is the 20 to 30 age group there is a natural lag before the second round effects (less women having less babies), which are the main source of declining population growth, take effect.

Table 9 gives the population growth projections for 1996 to 2026 for five year intervals. It also shows the share of the world's population living in each of the 34 countries or regions in 1996 and the expected share in 2026.

The long term growth model

The starting point for the long term growth model is the Solow growth model, where growth in output depends on the growth in labour, capital and total factor productivity, and their relative contributions to growth. These relative contributions of labour and capital growth have been shown empirically to vary across countries in different states of development—in the early stages of development labour growth contributes relatively more to output growth than in later stages, while the reverse is true for capital growth. Growth in total factor productivity (TFP) allows output to grow faster than inputs. For developing countries, fast growth is achieved more through growth in TFP than through growth in capital or labour.

There are two sources of TFP growth—improvement in efficiency and improvement in technology. Efficiency improves if more output is produced from the same level of inputs at a given level of technology. Countries that have government policies that distort price signals such as credit restrictions, price subsidies and tariffs, can improve efficiency by removing the distortions from price signals which will improve the allocation of resources.

Improving efficiency moves a country toward their production possibility frontier. Growth in technology shifts the production possibility frontier outwards allowing more output for the same inputs of capital and labour with additional technology. Technology growth is not confined to bigger better machines but includes improvements in technical skills, management, and lowering of transactions costs such as communication speed and clarity. Countries that start well behind on technology can grow rapidly as they can adopt existing technology instead of developing new technology. How fast they can 'catch-up' depends on the education level of the labour force, and other government policies.

Government policies have a major role in determining the rate of growth of technology. The extent to which markets are open is a major determinant of how much technology can be imported from abroad. Labour market policies and health and education policies govern the acquisition of skills to apply and the flexibility to implement new ideas. At the most fundamental level, government funding of basic research and development impacts on the rate of growth of innovation, but for most developing countries the ability to import technology is more important than original R&D. Improvements in technology are often embodied in new capital, and to a lesser extent in new labour.

Government policy is also a major determinant of growth in capital stock. Access to capital and the expected return on investment drive the level of investment. Countries with open capital markets are not capital constrained as they have access to world capital markets, although government policies, particularly fiscal prudence, will influence the cost of capital from international sources. Countries with closed or highly restricted capital markets must rely on domestic savings as the main source of capital. Again, where governments distort incentives to save through social security schemes, or where they call heavily on domestic savings to finance budget deficits, the higher domestic cost of capital reduces the accumulation of capital, slowing growth.

The CIE long term growth model takes population and labour force growth as exogenous. However, the education and health level of the labour force can vary over the projection period depending on government policy. Growth in the capital stock in a country depends on the cost of capital which in turn depends on the risk premium on international borrowing and on the level of domestic saving. Both of these are influenced by government policies, so projections are based on the expected path of government policy as well as other determinants such as the nature of resource endowments and the demographic structure of the population. There is an adding up constraint in the model where total world wide investment cannot exceed the total world wide saving—for closed economies this is applied at the national level, allowing for aid.

New capital stock can also embody new technology. A faster growing capital stock will embody more new technology than a slow growing capital stock. The same government policies that drive the pace of total factor productivity will influence the extent to which new capital embodies new technology.

The projections of the growth rate of total factor productivity are the most sensitive element in the growth projections. They are very dependent on the assumptions made about government policy. The potential rate of growth can be estimated based on the assumption of free trade in good, services and capital, and how far the countries lag behind, with due allowance for structural differences. This assumes that countries, if given a chance, will converge in terms of income per capita. Observation suggests that while some countries have converged, others have shown little sign of convergence. Closer examination finds that government policies, including political uncertainty and disruption, are almost always to blame.

The scenarios: government policy driven

In the baseline we assume that governments which have recently committed to following more prudent and stable fiscal and monetary policies and increasingly open their economies to trade and capital will continue on this course. For some this path for policy has been mandated by the IMF as a condition for financial assistance, others have realised that these policies form the best path to economic growth. The developed countries also hold to a conservative fiscal and cautious monetary stance. Unemployment is increasingly viewed as permanent and polices designed to ease the social burden. The developed countries maintain their Uruguay round (WTO) commitments to lower existing levels of protection. Capital flows are increasingly international. Environmental protection is viewed as the country's responsibility and increases with income levels within countries.

The pessimistic scenario makes the assumption that some of the major countries who have embarked on reform reverse their stance. Pressures from groups who lose under the new system results either in complete economic disruption (as recently in Albania) or abandonment of reform. In the developed countries slower growth in technology results as the communications revolution does not live up to its promise to lower transactions costs. The outcome of higher unemployment in the developed countries lead them to adopt a more protectionist stance to protect jobs. Reliance on sanctions based on human rights and environmental abuses mean the burden falls disproportionately on the countries at lower levels of development. Increasing attention paid to environmental protection in the developing countries to avoid restrictions slows the economic rate of growth in these countries.

Table 9
Population growth projections and world share of population

	Population shares 1996	Population share 2026	Population growth projections					
			1996–2001	2001–06	2006–11	2011–16	2016–21	2021–26
	%	%	%	%	%	%	%	%
United States	4.58	3.97	0.86	0.79	0.77	0.77	0.72	0.60
Japan	2.16	1.45	0.21	0.10	–0.05	–0.22	–0.33	–0.40
Australia	0.32	0.30	1.19	1.08	1.03	1.00	0.98	0.81
New Zealand	0.06	0.05	0.96	0.76	0.60	0.57	0.55	0.48
Canada	0.51	0.46	1.02	0.92	0.87	0.85	0.81	0.66
Economic Union	6.04	4.11	0.14	0.01	–0.07	–0.12	–0.15	–0.19
Other Western Europe	0.59	0.44	0.47	0.29	0.18	0.18	0.17	0.11
Singapore	0.05	0.04	0.77	0.60	0.52	0.49	0.43	0.34
Taiwan	0.36	0.24	0.21	0.10	–0.05	–0.22	–0.33	–0.40
South Korea	0.78	0.65	0.92	0.79	0.63	0.50	0.45	0.41
Malaysia	0.35	0.38	1.99	1.71	1.47	1.27	1.26	1.15
Thailand		0.88	1.02	0.85	0.72	0.64	0.60	0.59
Indonesia	3.47	3.33	1.46	1.27	1.05	1.01	0.92	0.84
Philippines	1.19	1.26	1.95	1.75	1.54	1.28	1.03	1.04
China (including Hong Kong)	20.99	18.12	0.99	0.79	0.76	0.74	0.63	0.49
Vietnam	1.31	1.43	2.05	1.84	1.60	1.33	1.13	1.13
India	16.41	16.77	1.75	1.58	1.40	1.17	0.97	0.95
Pakistan	2.49	3.45	2.85	2.69	2.53	2.32	2.01	1.60
Other south Asia	3.51	4.08	2.48	2.03	1.80	1.54	1.33	1.26
Cambodia	0.18	0.24	2.50	2.31	2.25	2.19	2.01	1.71
North Korea	0.42	0.40	1.59	1.20	1.00	0.94	0.93	0.85
Laos	0.09	0.12	2.75	2.57	2.42	2.25	1.99	1.59
Myanmar	0.82	0.91	2.04	1.85	1.68	1.53	1.35	1.15
Eastern Europe	2.01	1.44	0.15	0.09	0.14	0.10	0.07	0.05
Argentina	0.60	0.55	1.16	1.10	1.00	0.89	0.80	0.75
Brazil	2.83	2.77	1.53	1.37	1.21	1.06	0.93	0.84
Uruguay	0.06	0.04	0.55	0.54	0.50	0.47	0.44	0.42
Mexico	1.64	1.65	1.74	1.46	1.24	1.07	0.98	0.90
Other South America	3.30	3.52	1.80	1.66	1.52	1.38	1.24	1.10
CIS	5.14	3.85	0.25	0.29	0.33	0.29	0.20	0.21
Middle East	3.85	4.91	2.42	2.39	2.19	1.99	1.79	1.55
North Africa	2.82	3.24	2.09	1.94	1.75	1.54	1.49	1.38
Sub-Saharan Africa	9.32	14.10	2.88	2.79	2.73	2.64	2.49	2.28
South Africa	0.73	0.86	2.18	2.06	1.90	1.71	1.50	1.28
World			1.48	1.36	1.28	1.19	1.08	0.99

Source: United Nations population projections 1996.

The optimistic scenario assumes that many countries currently slow to embrace reform do so much more rapidly and completely. In addition, the response of the developed countries is to support this by leaving their markets open and promoting free trade and stable capital flows. In this scenario the developed countries are happy to do so as there is also a second 'golden' age of technology as the communications revolution lowers transactions costs and improves labour productivity.

In all the scenarios the projected growth rates for the developed countries and the more advanced developing countries vary only slightly, where the big differences occur are in the less developed countries. It is in these countries, many populous, that big variations in economic performance are most likely. Each scenario is discussed in detail and per capita income growth rates projected for five year periods from 1996 to 2026.

The best bet scenario

Table 10 gives the projected GDP growth rates for the 34 countries or regions in the CIE long term growth model. Table 11 gives per capita growth rates and compares estimated income levels in 1996 and 2026.

The developed countries

Currently the developed countries are struggling to bring budget deficits under control. This trend is expected to continue across the board, and social welfare provisions are likely to become less generous which will slowly stimulate saving rates in these countries. Monetary policy has followed a conservative trend which is likely to continue in the foreseeable future as the benefits of a less inflationary environment pay off. The open market of international capital markets will remain and this provides a strong discipline on central bankers to keep control of money supply growth.

- The United States remains the technological leader and its rate of growth depends very much on the rate of expansion of technological frontier. No booms are foreseen in the next three decades but the next decade will experience slightly faster growth due to the better exploitation of desk top computers and communications technology. Government fiscal policy and monetary policy remain restrained.
- Japan is going through a transition period to a post industrial economy. Financial fragility will be dealt with slowly as the financial system restructures. Growth will remain slow but steady relative to the last decade. Declining population will result in higher per capita incomes only part of which will be transferred through to purchasing power.
- Australia will grow at a rate slightly above that of the United States partly due to higher labour force growth. The influence of the dependence on commodity production and the more cyclical economic performance reduces the stability of government policy and while Australian per capita income will rise they will not converge to those of the US in the next three decades. Microeconomic reform brings some gains in the next decade but are limited by commitment to social equity.
- New Zealand experiences similar problems with a commodity based economy but has the added disadvantage of a small size. Reforms will ensure continued growth but at a slowing rate over the next decade. Growth will be slightly below that of Australia.
- Canada is heavily influenced by the United States. In the near term growth will be constrained by fiscal difficulties and the Quebec issue. Improved growth is projected for the medium term as Canada better exploits the NAFTA agreement, but long run growth is determined by US growth.
- The Economic Union (EC12) is forced by the criteria for a common currency to curb government spending and follow conservative monetary policy. This has a stabilising influence on economic growth which in the long run is of benefit, allowing steady per capita growth at close to the same rate as the United States.
- Other Western Europe faces similar influences to the EU but they have less discipline on government spending in the next few years, which results in higher short run growth at a cost of lower growth in the future.

Table 10
GDP growth projections: best bet scenario

	Actual	Projected					
	1980–93	1996–2001	2001–06	2006–11	2011–16	2016–21	2021–26
	%	%	%	%	%	%	%
United States	2.7	2.8	2.6	2.5	2.4	2.3	2.2
Japan	4	2.2	2.0	1.8	1.7	1.6	1.4
Australia	3.1	2.9	2.8	2.6	2.5	2.4	2.3
New Zealand	1.5	3.0	2.8	2.6	2.5	2.3	2.2
Canada	2.6	2.5	2.3	2.4	2.5	2.4	2.3
Economic Union		2.3	2.0	1.8	1.8	1.7	1.6
Other Western Europe		2.5	2.2	2.1	1.9	1.8	1.7
Singapore	6.9	4.0	4.0	3.0	3.0	2.5	2.0
Taiwan	8	5.0	4.5	4.0	3.5	2.8	2.5
South Korea	9.1	6.9	5.5	5.0	4.0	3.0	2.8
Malaysia	6.2	9.0	7.5	6.5	6.0	5.0	4.5
Thailand	8.2	8.5	7.8	7.0	6.5	6.0	5.0
Indonesia	5.8	8.0	9.0	8.0	7.0	6.5	6.0
Philippines	1.4	4.2	4.6	5.9	6.5	6.0	5.0
China (including Hong Kong)	9.6	10.0	9.0	8.0	7.0	7.0	6.5
Vietnam		8.4	9.5	9.0	8.0	8.0	7.0
India	5.2	6.0	7.0	7.0	7.0	8.0	8.0
Pakistan	6	5.0	6.0	6.0	6.0	6.0	6.0
Other south Asia	5.2	5.0	6.0	7.0	7.0	7.0	7.0
Cambodia		3.0	3.5	4.0	4.0	4.0	4.0
North Korea		.0	.0	2.5	2.7	2.5	2.8
Laos	4.8	5.4	4.5	4.0	4.0	4.0	4.0
Myanmar	0.8	3.0	3.5	4.0	4.0	4.0	4.0
Eastern Europe		3.5	5.0	5.0	5.0	4.0	4.0
Argentina	0.8	4.0	3.5	3.0	3.0	3.0	2.8
Brazil	2.1	5.0	6.0	6.0	4.0	5.0	5.0
Uruguay	1.3	3.0	3.0	2.5	2.5	2.5	2.5
Mexico	1.6	4.0	6.0	5.0	4.0	4.0	4.0
Other South America	1.9	4.0	5.0	5.0	5.0	5.0	5.0
CIS		.0	2.0	3.0	5.0	5.0	5.0
Middle East	2.9	3.0	2.8	2.8	2.5	2.3	2.0
North Africa		1.5	1.8	2.0	1.7	2.0	2.0
Sub-Saharan Africa	1.6	2.2	2.8	3.0	3.2	3.0	3.0
South Africa	0.9	3.5	2.5	4.0	4.0	3.0	3.0
World		3.1	3.1	3.1	3.1	3.2	3.2

Source: actual data: World Bank Development Report 1995, 1996; CIE projections.

Table 11
Per capita income growth projections: best bet scenario

	Per capita income levels		Projected					
	1996	2026	1996–2001	2001–06	2006–11	2011–16	2016–21	2021–26
	1994US$	1994US$	%pa	%pa	%pa	%pa	%pa	%pa
United States	26 926	44 685	1.9	1.8	1.7	1.6	1.6	1.6
Japan	35 585	62 617	2.0	1.9	1.9	1.9	1.9	1.8
Australia	18 718	29 714	1.7	1.7	1.6	1.5	1.4	1.5
New Zealand	13 776	24 241	2.0	2.0	2.0	1.9	1.7	1.7
Canada	20 251	31 962	1.5	1.4	1.5	1.6	1.6	1.6
Economic Union	21 061	37 379	2.2	2.0	1.9	1.9	1.9	1.8
Other Western Europe	18 941	32 302	2.0	1.9	1.9	1.7	1.6	1.6
Singapore	23 658	50 227	3.2	3.4	2.5	2.5	2.1	1.7
Taiwan	10 975	33 928	4.8	4.4	4.1	3.7	3.1	2.9
South Korea	9 277	29 086	5.9	4.7	4.3	3.5	2.5	2.4
Malaysia	3 848	15 983	6.9	5.7	5.0	4.7	3.7	3.3
Thailand	2 702	15 574	7.4	6.9	6.2	5.8	5.4	4.4
Indonesia	996	6 139	6.4	7.6	6.9	5.9	5.5	5.1
Philippines	1 024	3 205	2.2	2.8	4.3	5.2	4.9	3.9
China (including Hong Kong)	651	5 130	8.9	8.1	7.2	6.2	6.3	6.0
Vietnam	232	1 622	6.2	7.5	7.3	6.6	6.8	5.8
India	340	1 839	4.2	5.3	5.5	5.8	7.0	7.0
Pakistan	830	2 274	2.1	3.2	3.4	3.6	3.9	4.3
Other south Asia	329	1 297	2.5	3.9	5.1	5.4	5.6	5.7
Cambodia	205	325	.5	1.2	1.7	1.8	2.0	2.2
North Korea	193	234	–1.6	–1.2	1.5	1.7	1.6	1.9
Laos	320	582	2.6	1.9	1.5	1.7	2.0	2.4
Myanmar	689	1 292	.9	1.6	2.3	2.4	2.6	2.8
Eastern Europe	2 586	9 172	3.3	4.9	4.9	4.9	3.9	3.9
Argentina	8 404	16 358	2.8	2.4	2.0	2.1	2.2	2.0
Brazil	3 050	9 786	3.4	4.6	4.7	2.9	4.0	4.1
Uruguay	4 839	9 214	2.4	2.4	2.0	2.0	2.1	2.1
Mexico	4 267	11 058	2.2	4.5	3.7	2.9	3.0	3.1
Other South America	1 968	5 262	2.2	3.3	3.4	3.6	3.7	3.9
CIS	1 938	4 771	–.3	1.7	2.7	4.7	4.8	4.8
Middle East	2 939	3 414	.6	.4	.6	.5	.5	.4
North Africa	978	1 018	–.6	–.1	.2	.2	.5	.6
Sub-Saharan Africa	328	351	–.7	.0	.3	.5	.5	.7
South Africa	3 116	4 918	1.3	.4	2.1	2.3	1.5	1.7
World	4 622	8 085	1.6	1.8	1.8	1.9	2.1	2.2
Combined Koreas	6 107	18 089	5.6	4.5	4.2	3.3	2.4	2.2

Note: per capita income levels are indicative only.

Source: actual data: World Bank Development Report 1995, 1996; CIE projections.

Asia

Asian countries excluding Japan can be classified into three groups based on the stability of their projected growth paths rather than the actual levels of per capita GDP, although these reflect growth trends.

The 'converging' group—Singapore, Hong Kong, Taiwan, South Korea, Malaysia, Thailand and Indonesia—are currently enjoying high growth rates, are clearly on a convergence path and are experiencing, or will experience, a slow down in growth rates as per capita income levels reach developed country levels. These countries have made commitments to increasingly open their already relatively open economies, and to pursue sound fiscal and monetary policies.

The 'emerging' group—China, Vietnam, Philippines, and India—are also currently experiencing moderate to high growth rates but from a very low income base, and are undergoing reforms that should improve growth prospects.

The 'dissenting' group—Cambodia, Laos, North Korea, Myanmar, Pakistan, and other South East Asia (Sri Lanka, Bangladesh, Butan, Afghanistan, and the Maldives)—which, while some are experiencing moderate growth rates are troubled by internal unrest, lack of firm government control and hence a highly unstable policy environment.

The baseline takes a fairly positive view for all the Asian countries because of the spill-over effects of the converging country's growth in the region. Not only is demand for regional goods and services stimulated and transactions costs of doing business in the region lowered, but a good example is set by countries with some what similar attributes. Under the baseline even the dissenting group post reasonable growth performances particularly in the longer term.

- Growth in the converging group of countries varies according to the stage of development of the country. Growth is slowest in the highly developed economies of Singapore and maturing economies of Taiwan and South Korea who are moving toward the high technology end of manufacturing and over the period will become service dominated economies. Malaysia, Thailand and Indonesia will see strong growth over the next decade. Malaysian per capita growth is likely to slow first although output growth will remain stronger due to high labour force growth. Thailand may experience some difficulties in the next decade with inadequate infrastructure slowing potential growth although they should recover lost ground later in the period. Indonesia may also have some problems in the near term with political unrest and succession but should resume a strong growth path by the end of the decade. Firm government commitment to opening their economies and the importing technology through both direct and indirect foreign investment should ensure these countries stay on a converging path.
- The emerging group of countries rely on good government policies to sustain and improve the growth rates over the projection horizon. The high growth rates of China and Vietnam can only be sustained by the continued adoption of market reform, particularly of state owned enterprises and a commitment to open their economies. The pressures from the growing middle class in these countries is assumed to be sufficient to attain these goals. India has been slow to implement the reform package announced several years ago. Progress is likely to be slow but steady, although here too, the state owned enterprises remain an issue. The baseline assumes that these problems take several decades to solve fully. For the Philippines the situation is slightly different but firm commitment to stable fiscal and monetary policy should work wonders for improving the investment environment in the Philippines. The assumption is that political stability allows this to develop by the next decade resulting in a good base for growth in the following two decades.

- The dissenting group of countries should, with the exception of North Korea achieve moderate growth over most of the forecast horizon. The outlook should improve toward the end of the period as political problems in Pakistan, Cambodia and Myanmar are assumed to be resolved so more stable and beneficial policies pursued. Laos suffers from a landlocked position with a high cost to infrastructure development which constrains growth to lower rates than other countries in the region. North Korea is unlikely to survive to the end of the forecast horizon as a separate country. The assumption is that it merges with South Korea in the 2006–2016 period. There is a cost to South Korea's growth rate at the time of transition, but growth in the following decade will be higher as North Korean resources are utilised. A comparatively smooth transition is assumed to be achieved.

Other developing countries

The cost of capital is likely to rise over the first half of the projection period due to the strong Asian demand for capital and the lags in bringing the developed countries budget deficits down combined with the slow rate of increase in savings rates in these countries. These higher demands for capital relative to supply will impact unevenly on the global economy due to the perception of some regions as higher risk areas. It is likely that relative risk premiums will rise for some countries despite their adoption of more stable economic policies because of the competition for global capital. The best prospects for growth are in Eastern Europe and Latin America. Africa, the Middle East and the Commonwealth of Independent States (CIS) have less rosy growth prospects over the projection period.

- Eastern European economies have started to respond to the massive policy reforms of the late 1980s and early 1990s. Growth rates over the next decade are expected to be relatively high as these countries recover lost ground. Entry into the Economic Union is inevitable for most of this group and by the end of the forecast period these countries will largely resemble the other EU countries.
- Latin America has experienced a roller coaster ride with growth rates over the last 30 years. Once viewed as a dynamic region growth slumped in the late 1970s and 1980s as the debt overhang was exposed. The root of the problem was earlier in poor government fiscal controls and distortionary microeconomic policies. Along with political reform the 1990s has seem substantial policy reform in a number of countries in the region, some such a Chile with notable success. The region is still haunted by past performances and capital remains highly sensitive to signs of policy weakness. This raises the cost of capital slowing economic growth in the region. Social policy also is a concern in the region with a growing disparity in incomes. The baseline projections allow for the higher cost of capital but assume that social reforms are pursued to ensure political stability in the region. This is a requirement for continued move to more stable fiscal and monetary policies and improving openness in the region. The extension of NAFTA within the next two decades boosts growth in the later part of the forecast period.
- The outlook for Sub-saharan Africa is for slow positive growth as some countries exploit political stability to improve macroeconomic policies (for example, Zimbabwe). However, a number of countries are likely to remain in a state of considerable political uncertainty precluding policy reform. High population growth in the region will ensure that per capita income growth remains very low. However, per capita income growth is expected to be positive on average rather than the falling incomes of the last two decades.
- North Africa is expected to slowly emerge from the poverty trap. Real per capita income gains are not expected to be large and funding for investment will still depend largely on aid, restricting the potential for economic growth.

- The Middle East is unlikely to capture high growth due to the very slow ability to restructure their economies. Such moves are hampered by the oil income which is projected to remain too high to promote a favourable terms of trade for alternative product development, and too low to provide a substantial increase in growth.
- The CIS growth outcome is dominated by Russia. While improvement is expected in the next decade it will not be until the second decade that output is likely to pick up substantially. A lot could still go wrong in this area.

The optimistic scenario

There are two main drivers behind the optimistic scenario.

- A higher rate of technological growth in the United States results from the lowering of transactions costs due to improvements in communications and desktop computing. This adds around half a percentage point to growth in real GDP in the United States, an effect that flows through to the rest of the world with a lag.
- Improved government stability allows for sound monetary and fiscal policy to be adopted in Africa, and the dissenting group of Asian countries. Reforms are accelerated in the CIS countries, India, the Philippines, Latin America and Eastern Europe. This adds anything from 1 to 3 percentage points to the growth rates in the next decade in these countries. For the more advanced countries growth rates remain higher for the next two decades but at a declining margin on the baseline rates of growth.

Table 12 summarises the per capita income projections.

The developed countries

The United States remains the technological leader so there is a lag of a decade before the other developed countries fully adjust growth to the higher US rates. This lag is partly due to strong protection of intellectual property rights slowing technology transfer, but in part due to less flexible labour markets in the European countries and in Australia which slows the up-take of technology and the adjustment working hours.

The revolution in technology improves the demand for labour rather than reducing it as it facilitates part time and shorter working hours lowering pressure for protection caused by unemployment. As a result the developed countries are more willing to lower remaining trade barriers particularly in manufactured goods. This improved openness benefits the developing countries.

The improved per capita income growth combined with labour market adjustment that reduces unemployment facilitates, and is facilitated by, a change in social policies. Greater emphasis is placed on self funded retirement raising saving rates in the developed countries.

Asia

The more developed countries—the converging group—experience roughly the same impact as the developed countries. For Korea, and Taiwan, the changing industrial structure means that there will be no major additional benefit flowing from the reduction in protection. Those countries in this group still focused on manufacturing exports benefit more from the lowering of protection so growth rates in Indonesia and Malaysia are expected to rise more than growth rates of the other countries in this group.

The impact of the advancement of the technological frontier has little direct impact on growth for the less developed but 'emerging' Asian countries. One reason is that their growth is driven by adoption of existing technology and advancement at the cutting edge makes less of a contribution. A second reason is that these countries lack the infrastructure to make full use of the evolving technology. The effect improves over the period as these countries develop the communications infrastructure that allows more use to be made of the improvements in communication technology. The benefits in terms of higher growth in the second half of the projection period. These countries are operating close to maximum potential and there is little scope for substantially increased growth rates.

Table 12
Per capita income growth projections: optimistic scenario

	Per capita income levels		Projected					
	Baseline 1994US$ 2026	Optimistic 1994US$ 2026	1996–2001 %pa	2001–06 %pa	2006–11 %pa	2011–16 %pa	2016–21 %pa	2021–26 %pa
United States	44 685	51 711	2.4	2.3	2.2	2.1	2.1	2.1
Japan	62 617	69 072	2.3	2.2	2.2	2.2	2.3	2.2
Australia	29 714	33 884	2.1	2.1	2.0	2.0	1.9	2.0
New Zealand	24 241	27 644	2.4	2.4	2.4	2.4	2.2	2.2
Canada	31 962	36 812	1.9	1.9	2.0	2.1	2.1	2.1
Economic Union	37 379	42 665	2.6	2.4	2.3	2.4	2.4	2.3
Other Western Europe	32 302	36 862	2.4	2.3	2.3	2.2	2.1	2.1
Singapore	50 227	51 215	3.2	3.4	2.6	2.6	2.2	1.8
Taiwan	33 928	38 091	5.0	4.7	4.5	4.2	3.6	3.4
South Korea	29 086	32 631	6.1	5.0	4.7	4.0	3.0	2.9
Malaysia	15 983	17 895	7.1	6.0	5.4	5.2	4.2	3.8
Thailand	15 574	17 428	7.6	7.2	6.6	6.3	5.9	4.9
Indonesia	6 139	7 533	6.6	8.1	7.6	6.9	6.5	6.1
Philippines	3 205	5 134	4.2	5.7	6.3	6.1	5.9	4.9
China (including Hong Kong)	5 130	6 291	9.1	8.6	7.9	7.2	7.3	7.0
Vietnam	1 622	1 986	6.4	8.0	8.0	7.6	7.8	6.8
India	1 839	3 130	6.1	7.3	8.5	8.2	8.0	8.0
Pakistan	2 274	3 894	4.0	5.2	6.3	6.0	4.9	5.3
Other south Asia	1 297	2 163	4.4	5.9	8.1	7.3	6.6	6.7
Cambodia	325	489	2.4	3.1	3.2	2.8	2.9	3.2
North Korea	234	1 158	5.4	5.8	7.2	7.1	6.0	5.4
Laos	582	872	4.5	3.8	3.0	2.7	3.0	3.4
Myanmar	1 292	1 940	2.9	3.6	3.8	3.4	3.6	3.8
Eastern Europe	9 172	16 570	6.3	7.9	7.4	6.9	4.9	4.9
Argentina	16 358	19 742	3.8	3.2	2.6	2.6	2.7	2.5
Brazil	9 786	14 274	4.4	6.0	6.7	4.4	5.0	5.1
Uruguay	9 214	12 323	3.4	3.4	3.0	3.0	3.1	3.1
Mexico	11 058	17 349	4.2	6.4	5.7	4.4	4.0	4.1
Other South America	5 262	9 277	4.1	5.3	5.4	5.5	5.7	5.8
CIS	4 771	7 721	1.7	3.7	4.7	6.7	5.8	5.8
Middle East	3 414	3 894	1.0	.8	1.0	1.0	1.0	.9
North Africa	1 018	2 318	1.4	2.8	3.2	3.1	3.5	3.6
Sub-Saharan Africa	351	792	1.3	2.9	3.2	3.5	3.4	3.6
South Africa	4 918	9 609	3.3	3.4	5.0	4.2	3.4	3.7
World	8 085	10 170	2.2	2.4	2.6	2.8	2.9	3.1
Combined Koreas	18 089	20 304	5.7	4.8	4.6	3.8	2.9	2.7

Source: CIE income projection model.

The exception in the 'emerging' group are the Philippines and India. These countries have embarked on reforms but under this scenario the reform programs are accelerated. Along with the 'dissenting' group improved political stability is the key to improving government policy making and low stable rates of money growth, and government focus on core business and reduction of deficits result. In addition these countries open both capital and goods markets to trade. The international capital market accepts the improvement in stability as permanent and risk premiums fall.

North Korea and South Korea merge in the next five years without any dissent. The average growth rate for the combined Koreas slows but recovers over the projection period.

Other developing countries

All countries benefit from the increasing openness of trade, and the lower real cost of capital as saving rates rise in the developed countries. The big gains come from improving political stability and policy reform.

The Eastern European countries experience a boost in growth as the improved conditions in Europe encourage acceptance of these countries into the Economic Union. Their governments are required to meet the Mastritch criteria ensuring rapid policy reform in those countries lagging behind. There is considerable trade creation that benefits these countries in the early part of the projection horizon. Growth rates are assumed to be up to 3 per cent age points higher in the first decade than under the baseline.

The CIS countries also benefit from the improved performance in the region as demand for their products—particularly commodities—rises. The big gain comes from Russia taking the lead on economic reform and being pro-active to promote reform in the other CIS countries. Growth rates are 2 percentage points higher than under the base line for the first two decades. The lower boost to growth than for Eastern Europe is a result of the reliance on commodity production of a number of the CIS countries which will experience less of a boost in demand than manufacturing based economies.

Mexico and the other South American countries group benefit most from the increasing openness and the lower cost of capital. Political stability also plays a part in bringing better policies. Argentina responds least to the improvements although more than the developed country group.

The Middle East improvement in growth is expected to be similar to that in the developing countries. This is driven mainly by increased demand for power and hence oil as incomes rise.

Africa posts the biggest gains in growth rates under the optimistic scenario. This is the most optimistic part of the scenario as it makes the heroic assumption of political stability across the African region and good government policy. The economies are able to make the most of the change in the policy environment as the world environment of open markets is highly supportive and willing to purchase African goods and services, as well as invest in the countries. Under this scenario Africa starts to play the role of the cheap labour resource for light manufacturing that Asia has so successfully pursued. The addition to growth of 3 percentage points brings African GDP growth rates to up to 6 per cent by the middle of the forecast horizon. They are unlikely to reach the heights of the Asian growth rates even under the most optimistic scenario due to the problems of lower levels of education and health in the region, the absence of land reform in many of the countries, and the natural resource endowments that will hinder manufacturing development through competition for capital.

The pessimistic scenario

The pessimistic scenario is really the reverse of the optimistic scenario in terms of the main drivers.

- Technological growth slows as the communications revolution does not bring any benefits.
- Political instability worsens in the areas were it is starting to improve with the resulting disruption to economic growth and bad government policies. In particular, China experiences instability as does India and Pakistan which destabilise the Asian region. The Korean Peninsular erupts in the next five years disrupting growth in South Korea. Although the Koreas do merge the cost to economic growth is high. In Latin America there is a back sliding in commitment to stable sensible government policies in response to populous pressures arising from the increasingly divergent distribution of income.

Table 13 summarises the per capita income projections.

The developed countries

As the expected growth in per capita incomes is not delivered labour market reform and micro economic reform does not occur. Unemployment remains a problem and the developed countries respond by adopting more protectionist policies. While the impact on their growth rates is small these policies flow through to impact negatively on the rest of the world.

Saving rates are unlikely to rise under this scenario and the governments seek reelection by promising tax cuts and end up running increasing budget deficits. Social welfare provisions are largely unchanged and with the aging demographic profile savings rates decline, reducing the supply of capital to the world market.

Growth rates are assumed to be around half a percentage point lower than the baseline growth rates.

Asia

The Asian economies are quite negatively impacted by the protectionist stance of the developed countries and by the increase in the cost of capital. The 'dissenting' group of countries are particularly affected by the latter problem. Less prosperous economic conditions fuel political unrest in countries such as Indonesia and Malaysia, which while not serious contributes to slower growth rates. Growth in the countries without any major unrest is reduced by around 1 percentage point a year in the first decade and half this in the following two decades.

The Philippines is not assumed to experience any major political instability but the threat results in more populous policies that see reform take the back seat and along with the higher cost of capital and the protectionist stance of the developed countries growth in the Philippines falls by 2 percentage points in the first half of the forecast period recovering somewhat in the latter half. Some unrest as a result of religious and other ethnic divisions India, Pakistan and the other South Asian countries. The government response in these countries is assumed to be a major slow down in economic reforms and an expansion of state owned enterprises to provide employment—a return to the inward looking policies of the 1970s. As a result growth rates fall by up to 3 percentage points for much of the forecast horizon. The fall is greater in India that Pakistan because of the baseline assumption of faster reform in India.

Major unrest occurs in Korea, and China. For Korea the adjustment period of the next decade sees growth fall by 2 percentage points, with no growth in the North Korean economy. Transition over the following two decades sees growth rates recover towards the baseline rates. China sees a dramatic fall in GDP growth due to political turmoil in the struggle for succession. The hard liners are assumed to win out and growth drops by 4 to 5 percentage points in the first half of the projection period.

Table 13
Per capita income growth projections: pessimistic scenario

	Per capita income levels		Projected					
	Baseline 1994US$ 2026	Pessimistic 1994US$ 2026	1996–2001 %pa	2001–06 %pa	2006–11 %pa	2011–16 %pa	2016–21 %pa	2021–26 %pa
United States	44 685	38 586	1.4	1.3	1.2	1.1	1.1	1.1
Japan	62 617	54 017	1.5	1.4	1.4	1.4	1.4	1.3
Australia	29 714	25 662	1.2	1.2	1.1	1.0	.9	1.0
New Zealand	24 241	20 935	1.5	1.5	1.5	1.4	1.2	1.2
Canada	31 962	27 597	1.0	.9	1.0	1.1	1.1	1.1
Economic Union	37 379	32 250	1.7	1.5	1.4	1.4	1.4	1.3
Other Western Europe	32 302	27 876	1.5	1.4	1.4	1.2	1.1	1.1
Singapore	50 227	37 491	2.2	2.4	1.5	1.5	1.1	.7
Taiwan	33 928	26 646	3.8	2.4	3.6	3.2	2.6	2.4
South Korea	29 086	25 247	3.9	2.7	3.8	4.0	3.0	2.9
Malaysia	15 983	13 246	5.9	4.7	4.5	4.2	3.2	2.8
Thailand	15 574	12 913	6.4	5.9	5.7	5.3	4.9	3.9
Indonesia	6 139	5 095	5.5	6.6	6.4	5.4	5.0	4.6
Philippines	3 205	2 184	.2	.8	2.3	4.2	4.4	3.4
China (including Hong Kong)	5 130	2 205	4.0	4.2	3.2	3.2	5.3	5.0
Vietnam	1 622	1 348	5.2	6.5	6.8	6.1	6.3	5.3
India	1 839	823	2.2	2.4	2.6	2.8	4.0	4.0
Pakistan	2 274	1 165	1.1	.3	.9	1.1	1.5	1.9
Other south Asia	1 297	636	1.5	1.9	2.2	2.4	2.6	2.7
Cambodia	325	255	.0	.7	.7	.8	1.0	1.3
North Korea	234	140	–1.6	–1.2	–1.0	–.9	–.9	–.8
Laos	582	436	1.6	.9	.6	.7	1.0	1.4
Myanmar	1 292	1 014	.5	1.1	1.3	1.5	1.6	1.8
Eastern Europe	9 172	7 213	2.3	3.9	3.9	3.9	3.4	3.4
Argentina	16 358	13 470	1.8	1.4	1.5	1.6	1.7	1.5
Brazil	9 786	8 087	2.4	3.6	4.2	2.4	3.5	3.6
Uruguay	9 214	7 958	1.9	1.9	1.5	1.5	1.6	1.6
Mexico	11 058	8 490	1.2	3.5	2.7	1.9	2.0	2.6
Other South America	5 262	4 559	1.7	2.8	2.9	3.1	3.2	3.4
CIS	4 771	2 934	–1.3	.7	.7	2.7	2.8	2.8
Middle East	3 414	2 949	.1	–.1	.1	.0	.0	.0
North Africa	1 018	878	–1.1	–.6	–.2	–.3	.0	.1
Sub-Saharan Africa	351	303	–1.1	–.5	–.2	.1	.0	.2
South Africa	4 918	4 252	.8	–.1	1.6	1.8	1.0	1.2
World	8 085	6 284	.8	.9	1.0	1.0	1.2	1.3
Combined Koreas	18 089	15 677	3.7	2.5	3.7	3.8	2.8	2.7

Source: CIE income projection model.

Other developing countries

The impact on the other developing countries comes mainly through the higher cost of capital and the reduction in the openness of trade. These impact differentially because some countries had more to gain from trade than others.

Least affected is the African countries. The baseline allowed for some improvement in growth performance, due largely to better government policies. Many of these would be forced on the countries as loan conditions and cannot be avoided. The assumption is that growth rates are lower than in the baseline by half a percentage point. This is sufficient for many countries to go backwards in terms of per capita income growth.

Latin American countries depend quite heavily on an open global economy for their growth. Growth rates are assumed to fall by around 1 per cent point as a result of the actions of the developed countries and the higher cost of capital. Most, are however, sufficiently along the path to democracy for excessive political instability to be diverted. In addition, the reliance of many of these countries on international capital flows will put some constraints on an overly protective policy response to the downturn in growth.

Eastern Europe is assumed to respond in a similar manner to the Latin American countries. The CIS countries however fair worse, with growth rates falling by 2 percentage points in the middle decade of the forecast horizon. The greater reliance on commodity exports is part of this, as is the likely political instability driven by slower growth and lack of access to western markets.

APPENDIX B

Implications for agricultural production

Agricultural projections

The CIE's global models are used to generate demand projections for:

- beef, sheepmeat, and other meat—the global meat industries model (GMI); and
- wheat, coarse grains for human consumption and coarse grains for livestock, and rice—the world grains market model (WGM).

These models are global in nature—they include all countries explicitly or as part of a region and the demand for and supply of the products included in the models is constrained to add up on an annual basis with due allowance for changes in stocks. The models use a system of elasticities to approximate production and demand relationships. The elasticities used in the model stem from estimates of historical elasticities and judgement by industry experts of likely variations in behavioural and supply relationships. All trade barriers—tariffs, quotas, subsidies, etc.—are explicitly modelled. Time dependent relationships are built into the supply and stock relationships and underlie the range of variables determined outside the model including the policy variables where changes have been timetabled by the WTO. Apart from the elasticities and the base year values of all the endogenous variables (prices, production, consumption and stocks for each country or region) the main exogenous inputs into the models are population and per capita income

The models are partial equilibrium in nature—they focus only on the sectors under consideration. While this allows for rich detail on the sector to be included the cost is that the competition for inputs such as land is not endogenous in the models. It is up to the modeller to impose an adding up constraint on the supply of inputs. For this exercise the important constraint is the availability of land.

Expert opinion based on models, trend analysis, and analysis of demand and supply drivers is used to generate forecasts for:

- sugar;
- cotton; and
- other agriculture—fruit and other horticulture.

The world demand for these commodities is driven by per capita income and population, and by trade policy. Trade policy (and industry policy) have a big impact on the demand for these Australian commodities. Subsidies in other producing countries, and high tariff barriers along with Australian supply productivity are major determinants of Australian production.

The following section applies the per capita income growth and population projections to forecast the world demand and demand for Australian agricultural products. The three income growth scenarios result in three production scenarios.

Implications of best bet scenario for agricultural production

In projecting Australia's future production of agricultural products, it has been assumed that seasonal conditions are normal. In reality, this is not the case with fluctuations between poor and exceptional seasons. (Wheat and coarse grains production are generally affected more.) However, the fluctuations are projected to yield on average, the forecasts shown in Table 14. The crop area in 1996 required to produce 1996 output levels is given in Table 15.

Table 14
Production projections for agricultural products best bet scenario 1996–2026

		1996	2006	2016	2026
Wheat	kt	16 795	20 553	22 886	25 247
Coarse grains	kt	9 612	11 100	11 823	12 968
Rice	kt paddy	951	1 278	1 540	1 853
Beef and veal	kt cwe	1 636	1 953	2 174	2 530
Sheepmeat	kt cwe	554	615	675	747
Wool	kt greasy	697	825	940	1 055
Cotton	kt lint	429	860	1 275	1 555
Sugar	kt	5 300	6 500	7 600	8 600
Horticulture	kt index of product	100	169	303	493

Source: CIE estimates.

Table 15
Crop areas 1996

Crop	Area '000 ha
Wheat	972.1
Coarse grains	527.1
Cotton	303.9
Rice	149.0
Sugar	382.0

Wheat coarse grains and rice

The WGM contains a detailed representation of demand, supply, net trade and stock change for 34 countries and regions throughout the world with prices determined from a market clearing equation. All current grain policies and trade documented reforms are taken into account.

The GMI model is linked to the grains model to provide a basis for forecasting demand for feedgrains into the future. This is crucial to production forecasts with the increasing importance of feedgrains in the expanding pig and poultry industry and, to a lesser extent, the lotfeed beef sector—not only in Australia, but globally.

For grains, the most important factor affecting production are changes in the rate of yield growth. The general consensus is that while yields will continue to increase, the rate of growth will slow. The main sources of yield increases in most countries will be genetic improvements, greater efficiency in input use, improvements in knowledge and management and a greater uptake of new technologies.

The annual growth rates used in the grains model are based on those of Evenson and Rosegrant (1995). The estimates for Australia are contained in Table 16. The annual growth rates in yields used in the estimation are given in Table 17.

Table 16
Annual growth rates in grain yields in Australia

	1985–95	1996–2005	2006–2015	2016–2026
	%	%	%	%
Rice	4.09	1.54	1.29	1.25
Wheat	0.97	0.85	0.80	0.80
Coarse grains	0.54	0.90	0.80	0.80

Source: CIE projections based on personal communication with Rosegrant and adjusted by CIE.

Table 17
Annual per year growth rates in Australia's grain production 1996–2026

	1996–2005	2006–2015	2016–2026
	%	%	%
Rice	2.96	1.87	1.70
Wheat	2.08	1.19	1.10
Coarse grains	1.01	0.69	0.57

Source: CIE projections

- The average rate of growth in all grain production in Australia is projected to slow.
- The most rapid decline in growth is projected in the period 2006–2015 when growth in wheat production will fall from the previous ten year average growth of 2.08 per cent down to 1.19 per cent, rice from 2.96 per cent down to 1.87 per cent and coarse grains down from 1.01 per cent to 0.69. In the period 2016–2026, per year production growth is forecast to be only slightly lower than the rates for 2006–2015.

Beef and veal

- Forecasts for beef and veal were generated using the GMI model.
- Crucial to these forecasts are the exogenous population growth, income projections and relative forecasts of productivity growth for each meat type between Australia and other countries.
- Forecasts for population and income are the same as those used in the grain model detailed earlier.
- For beef and veal, productivity growth in Australia is assumed to be 0.5 per cent per year. This compares with 0.75 per cent for New Zealand and 1 per cent for both Canada and the United States. Other things being equal, the higher the rate of productivity growth in meat production, the lower the increase in meat prices.
- Like most agricultural commodities in Australia, one of the key drivers behind beef production increase is productivity. More beef and veal is now produced per cow than in the past.
- Some of this increase is attributable to higher slaughter weights from more lotfed cattle and better calving rates, particularly in northern Australia.
- Beef and veal production is forecast to increase to 2,140 kt cwe in 2005—on average, a growth rate of 3.3 per cent per year.

- By 2015, the average rate of growth is forecast to slow to 2.1 per cent and yield a beef and veal production level of 2 627 kt cwe.
- By 2026 beef and veal production will slow to an average rate of 1.5 per cent, with production forecast to be 3 050 kt cwe.

Sheepmeat

- The sheepmeat industry in Australia is generally divided into lamb and mutton. The reasons for this is that the lamb industry has traditionally relied on the prices of lamb as the main basis for decisions, while the mutton industry has generally been a byproduct of the wool industry with wool returns driving the decision to slaughter adult sheep.
- For the mutton industry this has recently changed with low wool prices and high mutton returns swinging the balance a little more toward mutton in the decision making process.
- Australia and New Zealand dominate the export of sheepmeat and this is likely to continue well into the next century.
- The sheepmeat forecasts presented in Table 14 were derived from the GMI model and are based on the same assumptions for income and population growth used for beef and grains.
- With a return to better wool prices forecast for the longer term, and the potential for continued strong sheepmeat prices following a permanent demand shift to sheepmeat after the BSE scare in 1996, sheepmeat production is forecast to rise to 670 kt cwe in the year 2005—an average annual growth rate of 2.2 per cent.
- With Australia's competitive advantage in the production of sheepmeats, this average growth rate is forecast to increase to 3.1 per cent to the year 2015 before slowing to 2.6 per cent by 2026. By the year 2026, it is forecast that Australia will be producing 1,176 kt cwe of sheepmeat.

Wool

- Just like crops, one of the biggest determinants of wool production is yield or wool cut per sheep.
- A number of factors affect average cut for sheep. Of course, seasonal conditions are most important along with the proportion of adults shorn. Other factors include: the proportion of merino and British breeds in the national flock; improvement in herd genetics; and, flock management.
- Cut per head in the five year period from 1989–90 to 1994–95 has an average of 4.56 kg per head to 4.50 kg per head. The five year period to 1989–90 was a time of high prices and good seasons while the period following has been one of mixed seasons and falling prices.
- In this period of declining prices, sheep numbers have also been falling. At its peak in March 1990, Australia had a flock of 173.6 million sheep. The flock in March 1996 was down to 126.3 million.
- With expected improvements in wool prices leading into the next century, longer term improvements in genetics and better flock management, wool production is expected to rise not only from increased cuts per head, but also from slightly increased sheep numbers.
- Wool production in 2005 is expected to be 825 kt greasy, up from 697 kt greasy in 1996. This represents a year average growth rate of 1.89 per cent. The average growth rates in the ten year period to 2015 are expected to slow to 1.31 per cent. For the period to 2026, average growth rates are expected to decrease to 1.16 per cent as cuts per head begin to reach biological limits and flock increases are limited by land constraints.

Cotton

- The cotton industry in Australia is heavily reliant on the availability of irrigation water. These levels have been increasing with the construction of new dams and the revitalisation of the of river irrigation area.
- Better varieties have also added to yields and with an emphasis on breeding for disease resistance reductions in spraying for disease are occurring.
- The biggest problem in growing cotton has been the large reliance on spraying for insects and the potential development of resistance to the sprays currently being used. Evidence of this has seen production in Pakistan and China being severely reduced in recent years. The introduction of transgenic cotton will alleviate this problem.
- Areas planted with cotton in Australia are likely to increase at a steady rate to the year 2026 with yields likely to be maintained.
- Lint production is likely to grow at around 8 per cent per year to the year 2005. This means production will double from the current level of 429 kt to 860 kt. Thereafter, land constraints are likely to place pressure on growth. It is likely that average growth will be around 4 per cent by the year 2015 before slowing to 2 per cent by the year 2026.

Sugar

- Australian sugar production has increased by 50 per cent since 1990. Policy changes have removed constraints to expansion and allowed big economies of scale in growing, harvesting, milling and handling to be achieved. Despite historically low international prices, Australia has been highly competitive internationally and now exports over 85 per cent of production. Australia is one of the most efficient sugar producers in the world.
- Australia is likely to continue its rapid expansion at least until 2005 as it adjusts to the more favourable policy environment and takes up land previously precluded from the industry.
- Significant productivity increases are expected to emerge as the full adjustment is made. This will add further to production.
- Opening up of trade access under APEC and WTO is also likely to provide an additional boost to grow in the first decade of the new century. Beyond that, Australia's cutting edge technology is expected to help it sustain strong productivity growth.

Horticulture

- Horticultural production within Australia is experiencing unprecedented growth. For example, in the period 1991–92 to 1994–95, the value of horticultural production rose by more than 18 per cent. Much of this growth is attributable to the rapidly expanding demand for fresh horticultural products in Asia.
- Generally, it is believed that for most horticultural products within Asia, the income elasticity of demand exceeds 1.
- With rapidly rising incomes in most Asian countries, increasing demand for fresh horticultural products is gaining importance.
- Of importance also is the demand for fresh produce in the increasing domestic market where the health benefits of eating horticultural products is gaining importance.

- Unlike other agricultural industries, horticulture—in particular the vegetable industry—is unlikely to face land availability as a constraint to production.
- Production of horticultural products is forecast to increase by an average of 6 per cent per year to the year 2015 before slowing slightly to an average of 5 per cent per year as income growth in some Asian markets begins to taper, leading to a reduction in demand.
- By the year 2026, horticultural production in Australia is forecast to be almost five times the current levels.

Implications of optimistic scenario

Wheat, coarse grains and rice

- Higher income in the Asian countries raises demand for all grains relative to the baseline.
- Wheat consumption experiences the greatest growth from the higher income levels. This is due to income growth in the countries with the highest income elasticity of demand for wheat—Vietnam, China—as people switch out of other grains (especially rice) into wheat.
- The demand for coarse grain is only slightly higher as higher consumption of lot fed beef offsets lower direct consumption.
- Rice is the least income elastic of the grains and consumption rises only slightly relative to the base case in response to higher income.

Beef, veal and sheepmeat

- The consumption of beef and veal is only slightly higher than under the base scenario. The higher growth in income in Asia has little effect because the income elasticity of demand for meat decreases rapidly. The improvement comes mainly from higher consumption in the developed countries, Latin America and to a lesser extent Africa.
- The consumption of sheepmeat follows a similar pattern as that for beef and veal. Asia is not the growth market for this product and the improved performance is driven mainly by the higher incomes in the Middle East and Africa.
- These projections are income driven and do not include any further liberalisation of meat trade than is currently on the agenda.

Wool

- Wool demand is sensitive to economic growth in the major wool consuming and processing countries, but it is also losing market share to other fibres.
- Under the optimistic income growth scenario demand for wool will improve, with a greater proportion of processing capacity shifting to Asian countries. This trend is already established but it would be enhanced. After 2005, Asian exports of woollen textiles will have greater access to markets in the developed countries because of the demise of the Multi-fibre agreement.

Cotton

- Like wool the demand for cotton is responsive to economic activity, and cotton textile processing is tending to relocate from the traditional areas of Japan, the United States and Europe to Asian countries including India and Pakistan. Greater openness in these countries, which is a driver for the higher economic growth, will accelerate this trend.

- In Australia expansion of cotton production has been quite rapid in recent years, and this trend is likely to continue; but production will be constrained by water availability for irrigation.
- The higher income growth under the optimistic scenario is likely to indirectly stimulate production in the other main producing countries like China, India, and Pakistan.
- These forces imply that the increase in production under the optimistic scenario is only slight relative to the base scenario.

Sugar

- As well as an opening up of trade under APEC, an opening up of the Indian sugar market would have a big impact for Australia. The stronger income performance of India is predicated on accelerated free trade and this would have positive implications for the world sugar market. Similarly improved performance in China raises demand for imports of sugar boosting world prices.
- Australia is a low cost producer and land is not seen as a constraint so improvement in world demand flows through into Australian production. Prices and Australian production could be 10 per cent higher than the baseline scenario.

Horticulture

- Production in horticulture is unlikely to face the same potential land constraints as other broadacre agricultural industries.
- It is more likely to be demand driven, with most of this increased demand originating from our close Asian neighbours. The main factor behind demand changes will be the rate of income change.
- Under the optimistic income projections, the countries who experience the greatest increase in income growth are the less developed. Currently, this group represents almost no market for Australian horticultural products. In the short term, the impact on horticultural demand is likely to be small.
- Most other Asian countries' income projections under this scenario are for only a moderate increase in income growth.
- By the year 2026, the overall impact on horticultural production under the optimistic scenario is likely to be around 4 per cent.

Table 18
Australian production projections: optimistic income 1996–2026

		1996	2006	2016	2026
Wheat	kt	16 795	21 329	25 195	29 516
Coarse grains	kt	9 612	11 131	11 908	13 233
Rice	kt paddy	951	1 293	1 580	1 933
Beef and veal	kt cwe	1 636	1 983	2 235	2 682
Sheepmeat	kt cwe	559	629	701	791
Wool	kt greasy	697	875	980	1 150
Cotton	kt lint	429	880	1 350	1 650
Sugar	kt	5 300	7 200	8 400	9 500
Horticulture	kt index of product	100	171	309	513

Source: CIE estimates.

Implications of a pessimistic scenario

Wheat, coarse grains, and rice

- The demand for grains falls relative to the base scenario as per capita incomes are lower. The effect on the demand for Australian production is fairly small relative to the decline in income.
- Wheat is the hardest hit by the fall in incomes as the most income elastic of the grains. The failure of Vietnam and China to perform well has a relatively strong influence on world price due to lower demand.
- Coarse grain consumption falls as the indirect demand for grains as stock feed falls with the lower income. However, part of this fall is off-set by greater consumption of coarse grains relative to wheat.
- Rice consumption falls the least under the lower income scenario. Rice has a higher substitution elasticity relative to wheat than do the other grains for countries in the Asian region.

Beef, veal and sheepmeat

- Even under the pessimistic scenario income growth is sufficient to raise the demand for Australian beef and veal. The main reason for the small difference in the two scenarios is that while Asia is the growth market in terms of increasing consumption per capita, the base consumption in these countries and the level at which per capita consumption peak is very low. It is income and population growth in the developed countries that drives the demand for beef, and income in these countries does not differ greatly in the scenarios.
- Sheepmeat production demonstrates greater sensitivity to the change in income scenario than beef and veal. The relative reduction in production growth is greater due to the very poor performance of some of the main sheepmeat consuming countries under the pessimistic scenario. In particular the poorer performance of the Middle East and former communist bloc countries contribute to the lower consumption demand growth, and hence lower world prices and Australian production.

Wool

- Under the lower income growth scenario confidence in wool production in Australia will continue to decline. This would lead to further contractions in wool production in the medium term as world prices remain low.
- Under the low income growth scenario the focus of the wool industry is likely to be a greater emphasis on quality product for specialised markets rather than the wider market, however, the strong price competition from alternative fibres will keep prices even for high quality wool relatively low.

Cotton

- The demand for cotton, particularly in Australia's main markets in Asia—Japan, Indonesia, and Korea—is likely to be adversely affected by the slower demand for cotton textiles due to lower income growth. While still experiencing strong growth in production relative to other agricultural products (except horticulture), cotton production is significantly lower than in the base scenario.

Sugar

- With much lower growth in both India and China world demand for sugar will be substantially lower than in the base scenario. Australian producers are likely to expand production at a slower rate due to the resulting reduction in world price.
- It is also likely under slower growth that the trade barriers assumed to be withdrawn in the base scenario would not be dismantled at the same rate. This has, perhaps, a bigger negative effect on the growth of production than the world price.
- Brazil has a big incentive to divert sugarcane from ethanol production to sugar production and is likely to do so at a steady rate over the next decade. Opening up of trade under APEC and possibly India will help absorb Brazilian sugar. The failure of either of these events could lower Australian prices and production by around 10 per cent.

Horticulture

- Under the pessimistic scenario, income reductions in some of the current Asian markets for Australian horticulture are in the vicinity of 1–2 per cent in the first decade.
- This tapers off over time but, by the year 2026, is still significant. More significant in this period is the reduction in growth rates on emerging markets.
- In 2005 the horticultural production index is projected to be around 162, down by more than 4 per cent of the best bet scenario.
- This trend continues right through to the year 2026. The production index in 2026 is forecast to be 3.8 per cent below the best bet level.

Table 19
Australian production projections: pessimistic income 1996–2026

		1996	2006	2016	2026
Wheat	kt	16 795	19 496	20 548	21 542
Coarse grains	kt	9 612	10 911	11 712	12 816
Rice	kt paddy	951	1 271	1 537	1 838
Beef and veal	kt cwe	1 636	1 895	2 092	2 385
Sheepmeat	kt cwe	559	607	652	708
Wool	kt greasy	697	650	700	710
Cotton	kt lint	429	750	1 100	1 200
Sugar	kt	5 300	5 900	6 800	7 700
Horticulture	kt index of product	100	162	291	474

Source: CIE estimates.

Other agricultural products

Dairy

Dairy is not included in the demand projections although it is an important agricultural industry in Australia. The main resource for the industry is irrigated pasture and so it would compete mainly with livestock finishing for meat production and to a lesser extent sugar and horticulture.

The industry has experienced substantial productivity growth in recent years. The biggest productivity improvement in the future is likely to come from the adoption of growth hormones currently used in the United States. This type of productivity improvement will reduce land requirements for pasture. There would however, be an increase in demand for grains for feed and hence for land in the grain producing areas.

The domestic market for dairy products is small and unlikely to experience rapid growth in the future. For the developed countries growth prospects are best for the processed products of cheese and butter. The market for these products will also grow with income growth in the Asian region, but the base is very small so the effect on quantities demanded is limited. The big growth market for Australian diary farmers is for whole milk powder.

Currently Australia and New Zealand compete for market share mainly against domestic producers. Over time, as subsidies to dairy farmers are wound back in many markets the United States is likely to become a major competitor. It is not expected that Australia will have any influence over world price and the industry must be kept profitable through productivity improvements.

Farm forestry

Farm forestry is a new product that can both compete with and be complementary to traditional agricultural production. While it competes for land, capital and to a much lesser extent water, yield benefits also can occur. Shade and shelter improve survival rates for livestock and lower calorie requirements. The reduction in wind speed and reduction of the water table assist crops and pasture through lowering soil loss, reducing the salinity threat and reducing wind damage. Even in areas where production of wood is not economic as a single crop, these other benefits can make farm forestry an economic option (RIRDC 1995).

There is huge potential for the expansion of farm forestry in Australia both at the plantation level and as part of an integrated farming system. Whether such an expansion occurs depends largely on government policies and developments in the markets for wood and wood products. Government ownership of much of the plantation industry as well as the native forests has resulted in distorted markets for timber and wood fibre. These distortions will need to be corrected before there are sufficient economic incentives for a large expansion in trees as an agricultural crop.

Other new products

There are a myriad of new products that could be developed over the next 30 years. However, it is difficult to foresee any replacing the traditional land use on a large scale. By definition products aimed at niche markets remain relatively small scale unless the 'niche' becomes a standard.

Over the last 30 years the only major changes in land use in Australia have been the increase in land used for rice production and the growth of cotton from non-existent to over 300 000 hectares. Products that already exist that might expand dramatically are hard to think of although olives for oil and to a lesser extent for consumption might be one candidate.

New products such as alternative meats (kangaroo, venison, emu), oils (teatree, eucalyptus), vegetables and fruits, are unlikely to become major land users. For some, this is because by their nature demand is small. For others, it is because there would need to be a major change in consumer tastes to replace an existing product with the new product.

New products can be explored under the scenario analysis by identifying the product characteristics which are consistent with the scenario. For example, the development of a kangaroo meat industry would not be inconsistent with a focus on environmentally sustainable development. The expansion of organic production is not inconsistent with any of the scenarios developed, though more probable under some than others.

APPENDIX C

The Challenge of World Economic Growth to Australian Agriculture

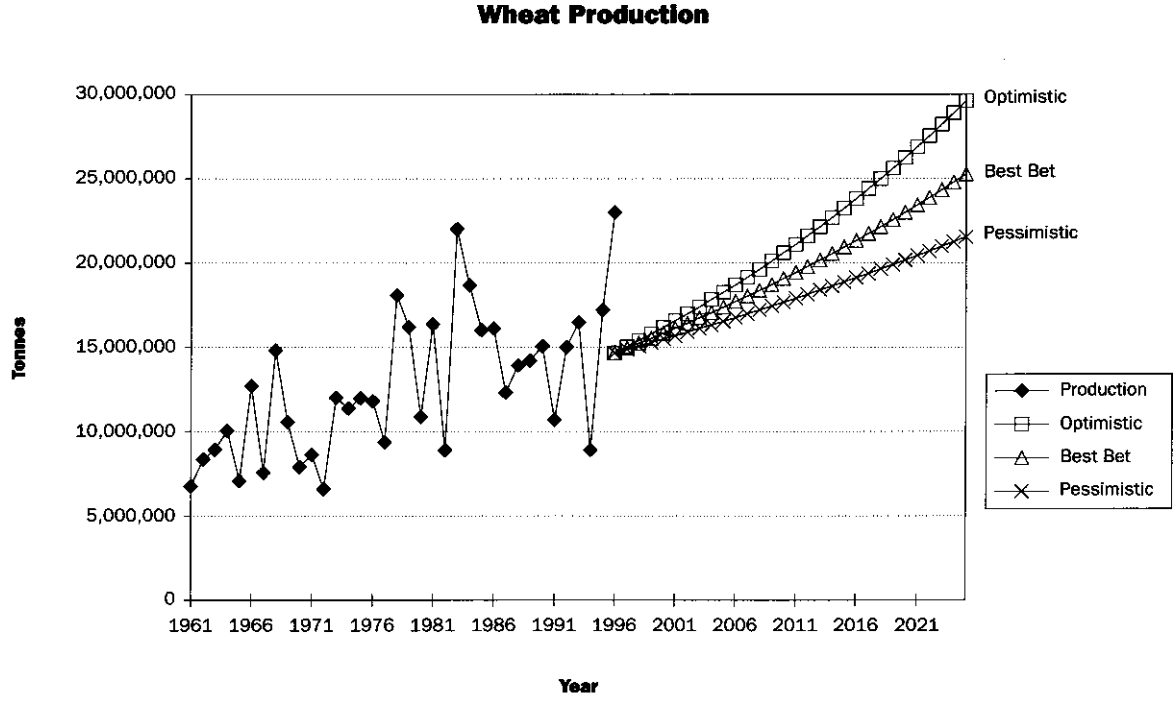
This section outlines some of the implications of past production patterns for different agricultural commodities in Australia. Further, it provides some indication of the possible tonnages and yields which will be required if Australia is to meet world demand, as described earlier in this report.

The two main methods used here to show these implications are:

1. graphs of tonnages of each commodity produced each year since 1960, together with tonnages required by each of the three production projections out to 2025; and
2. graphs of extrapolation of total production and yield, extrapolated to 2025 used two curve fitting methods.

Wheat

Figure 8
Historical wheat production in tonnes to 1996, and three scenarios to 2025.



In 1996/97 the Australian wheat crop has produced more than 22 million tonnes. This has been due to a larger than usual area of planting (greater than 13 million ha) and good seasonal conditions. This level of production has also been achieved historically in the year 1983/84 (Figure 8). This level of production is not typical because market opportunities and climate variability play a key role. Changing market opportunities for Australian wheat mean that less area is planted, and that fertiliser and management inputs are reduced in times when price returns are potentially less. Climatic variability means that in any growth season, at least one of Australia's wheat growing areas can be suffering from a major or minor drought. In order to consistently meet the 2025 targets, it is a reasonable assumption that the area of land planted and the yield per hectare must both increase. There is much scope for improvement in average yields. Australia wide the average wheat yield is currently less that 2 tonnes per hectare, while the best farms consistently record 4–5 tonnes per hectare. Increasing the area of land planted specifically to wheat is easily accommodated in the current arable land stock. Developing new land is also possible. However it is reasonable to assume that most high quality land in zones of rainfall appropriate for cropping, is already under the plough. Reducing climatic variability by irrigation is not feasible for broadacre crops such as wheat, although it is currently used for grain meeting specific market requirements.

Two methods of extrapolation from 30 years of historical wheat production data give a range of total wheat production by 2025 from 17.4 to 24.5 million tonnes per year (Figure 9). Similar trend extrapolation of yield per hectare (Figure 10) give a range of 1.55–2.0 tonnes per hectare. If both of the linear trend indications are met, then the best bet target of 25.25 million tonnes by 2025 can be met within the land stock currently planted in the peak yield years of 1983/84 and 1996/97. The pessimistic scenario will require less land (10.8 million ha) and the optimistic scenario considerably more land (14.8 million ha).

Figure 9
Extrapolation of total wheat production to the year 2025 using an 'linear' and 'log' fit to the historic data from 1961 to 1996.

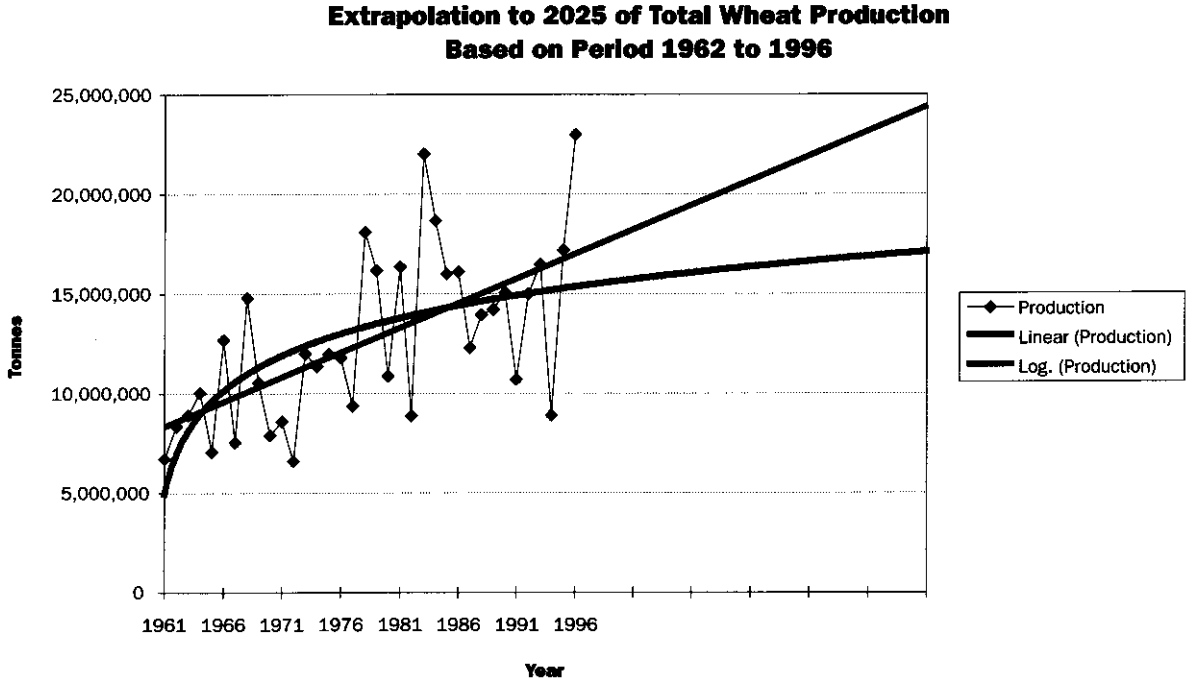
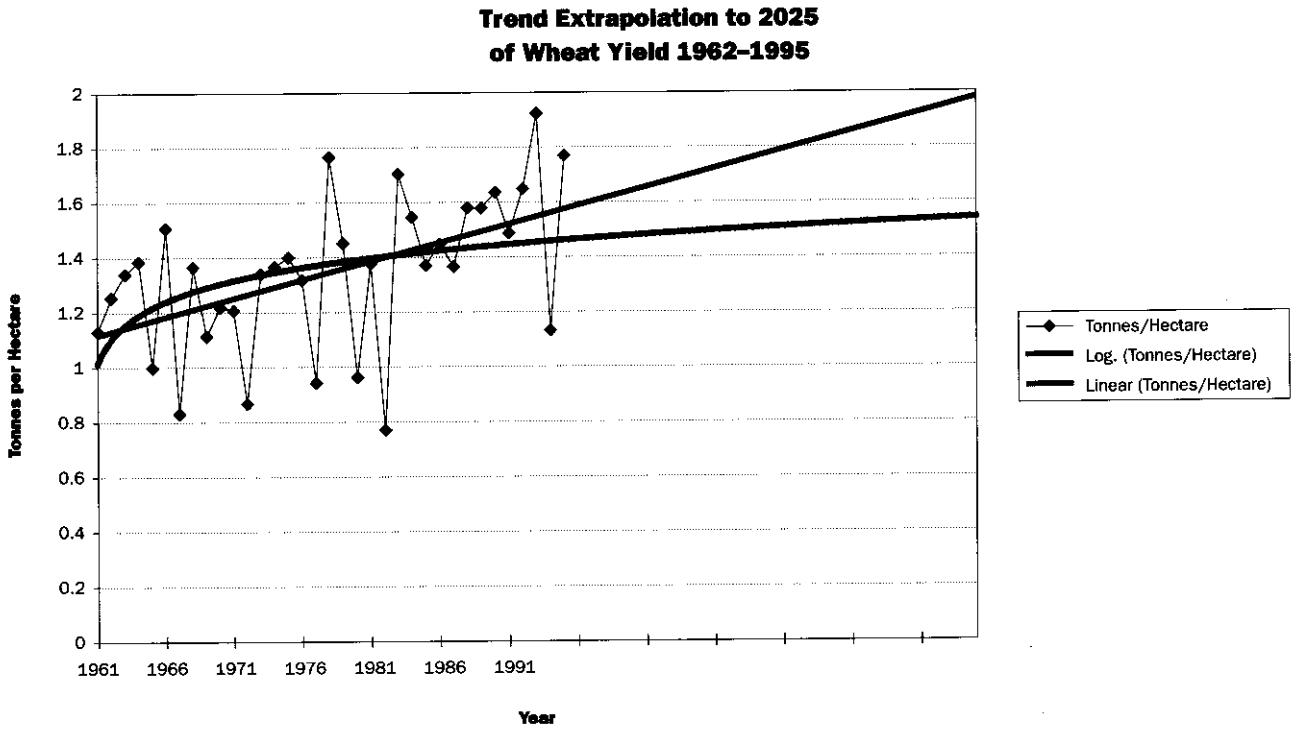


Figure 10
Extrapolation of yield per hectare using same methods and time periods.



Coarse Grains

The production of coarse grains increases from an historic high of 10 million tonnes to a range of 12.8 to 13.2 million tonnes for the three scenarios (Figure 11). In the 30 years of history which we present, coarse grain production has grown in a comparable manner to wheat. While the dips in grain production due to drought have largely coincided, the two high points in wheat production were not matched by the coarse grain sector. While an aggregated sector such as this hides important detail of individual crops such as barley, oats and sorghum, this suggests that wheat takes up most of the residual arable land in times of good climate or optimistic markets. There are many technological opportunities which can change this generalisation, but the comments on the 'average versus the best' also apply to the coarse grains sector.

Two methods of extrapolation from 30 years of historical coarse grain production data give a range of total grain production by 2025 from 9.0 to 14.5 million tonnes per year (Figure 12). Similar trend extrapolation of yield per hectare (Figure 13) gives a range of 1.7 to 2.4 tonnes per hectare. If both of the linear trend indications are met, then the best bet target of 12.9 million tonnes by 2025 can be met within the land stock planted in the peak yield years of 1983 to 1985 and in the current season 1996/97. Both the pessimistic and optimistic scenarios require the same land stock of 5.0 to 5.6 million hectares, and this is considered feasible. In a later section we do discuss the feasibility of growth in all sectors through the scenario period. We note that there are possible tensions.

Figure 11
Historical coarse grain production in tonnes to 1996, and three scenarios to 2025.

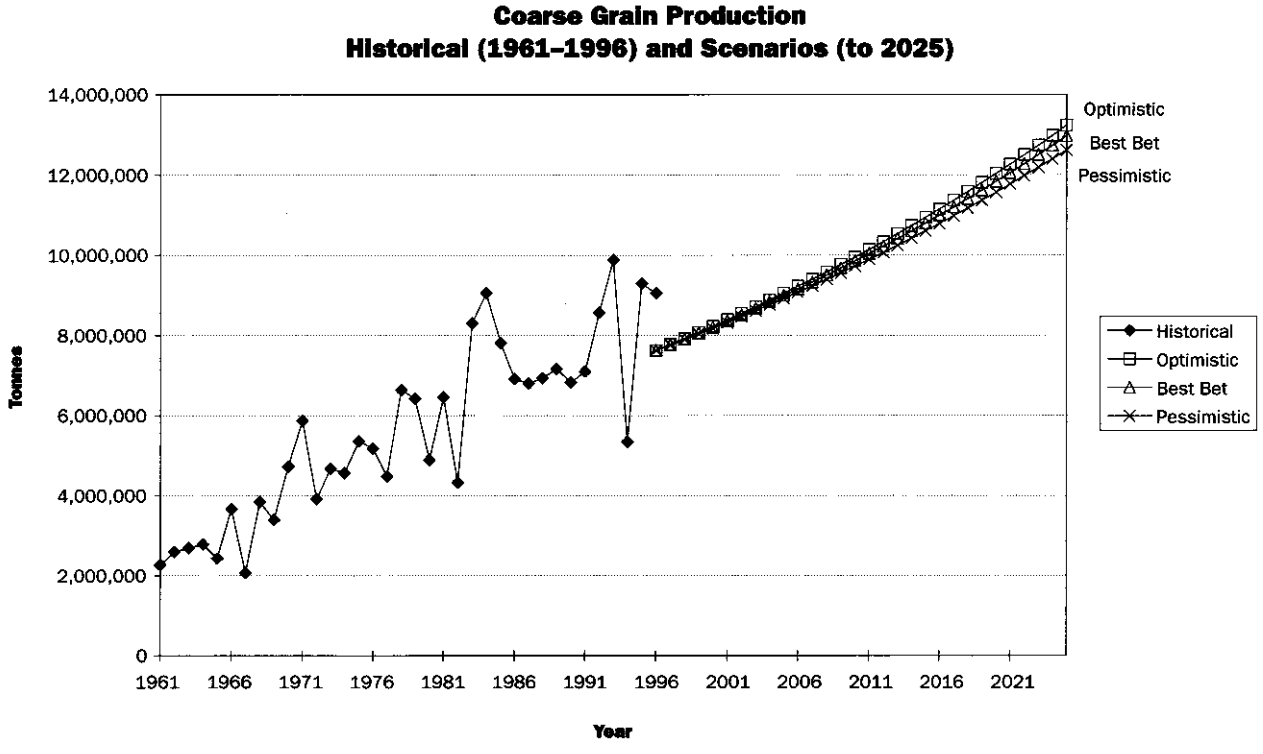


Figure 12
Extrapolation of total coarse grains production to the year 2025 using an 'linear' and 'log' fit to the historic data from 1961 to 1996.

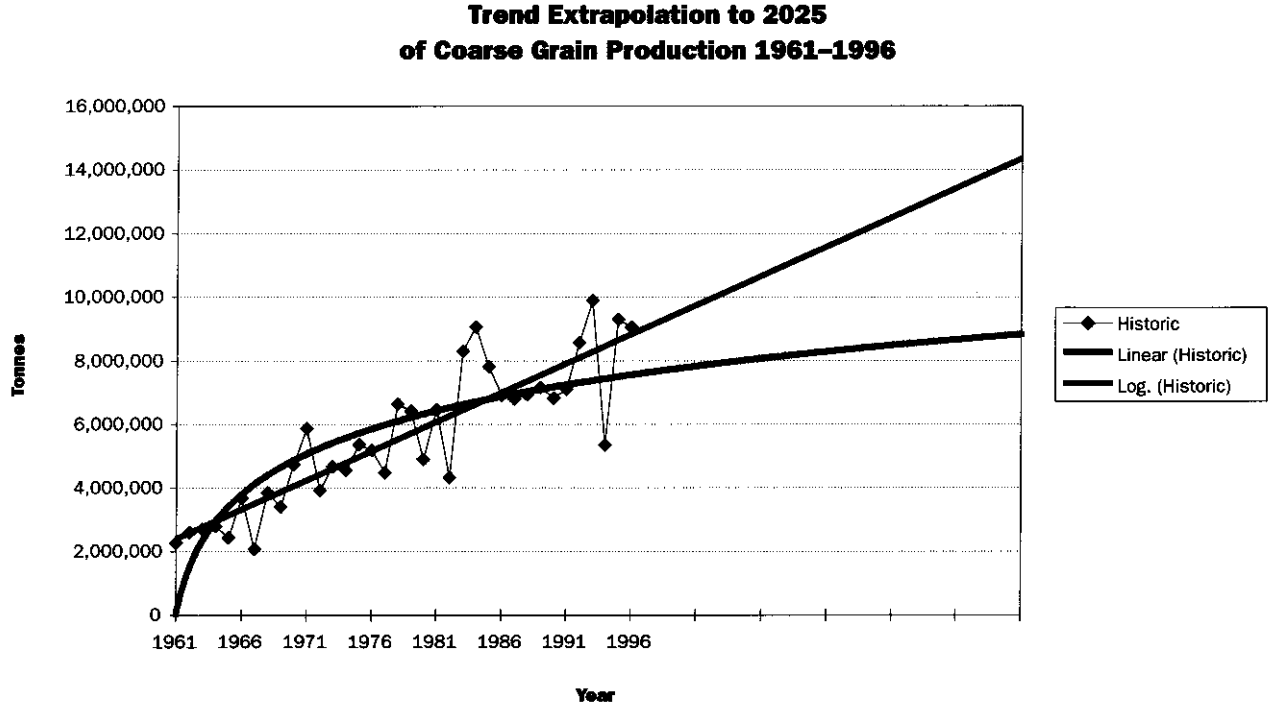
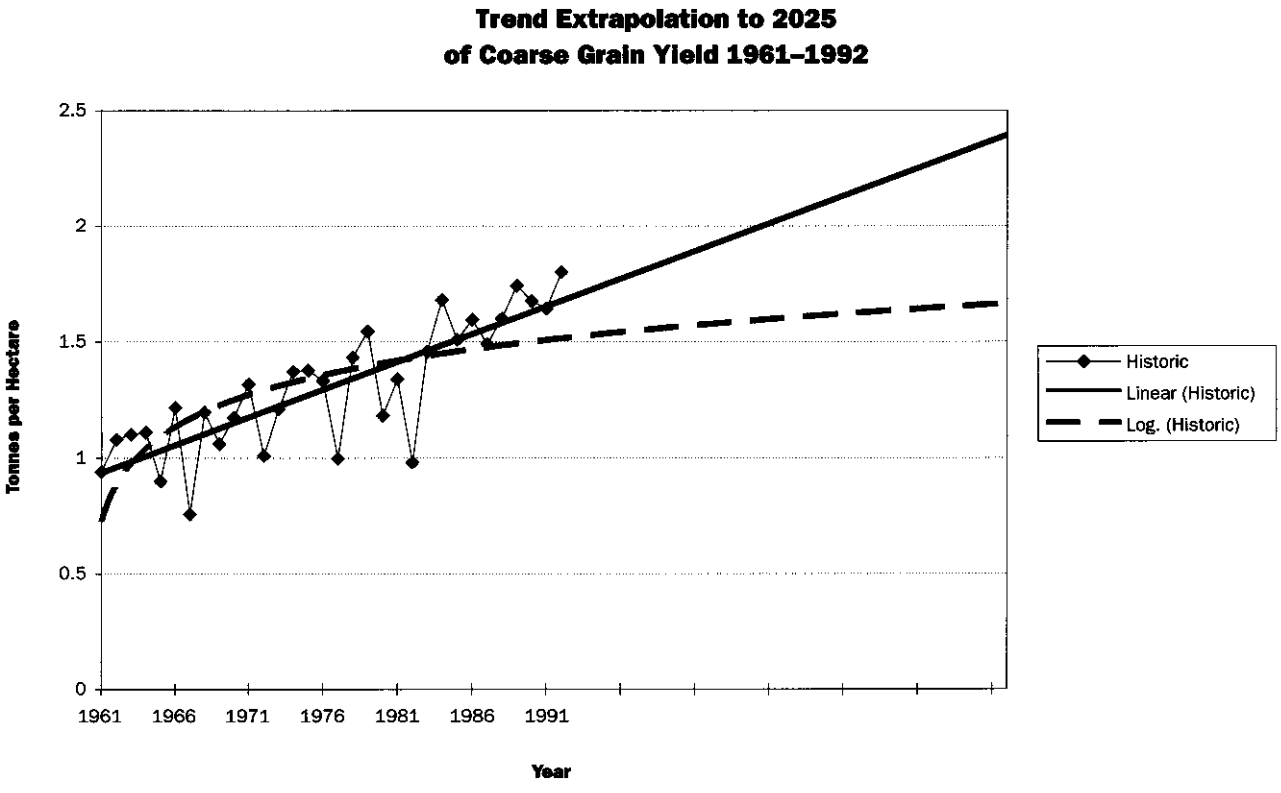


Figure 13
Extrapolation of yield per hectare using the same methods and time periods.



Sugar

The three scenarios suggest a 40–80 % rise in sugar production by the year 2025 (Figure 14). Growth coming from the best bet scenario takes raw sugar production for 5.3 million tonnes in 1996/97 to 8.6 million tonnes by 2025. Industry sources in Queensland (Canegrowers, 1997) note that the industry aims to increase the area under cane by 2.5% annually, and considerable expansion has occurred since 1988.

Two methods of extrapolation from 30 years of historical sugar production data give a range of total raw sugar production by 2025 from 4.2 to 6.5 million tonnes per year (Figure 15). Similar trend extrapolation of yield per hectare (Figure 16) gives a range of 11.5 to 12.0 tonnes of raw sugar per hectare. This is currently being exceed by 1 tonne per hectare and so may be a statistic anomaly.

However as with most crop commodities there is a wide range of yield variation in the historic record, and the production system now faces a range of biophysical and environmental challenges. The linear extrapolation of the historical production record indicate that 6.5 million tonnes may be achieved in 2025, which is well below the targets set in the scenarios. If the linear trend in yield is achieved then the production targets cannot be met without a significant expansion of the stock of sugar land and the supplementary irrigation water needed to give high levels of production. On a future yield of 12 tonnes of raw sugar per hectare, from 640,000 to 800,000 ha may be required. This is a major expansion from the 397,000 ha under production in the current year. Average yield are well below what is technically feasible (NCEA, 1997), and so best practice initiatives have an important part to play.

Figure 14
Historical sugar production in tonnes to 1996, and three scenarios to 2025.

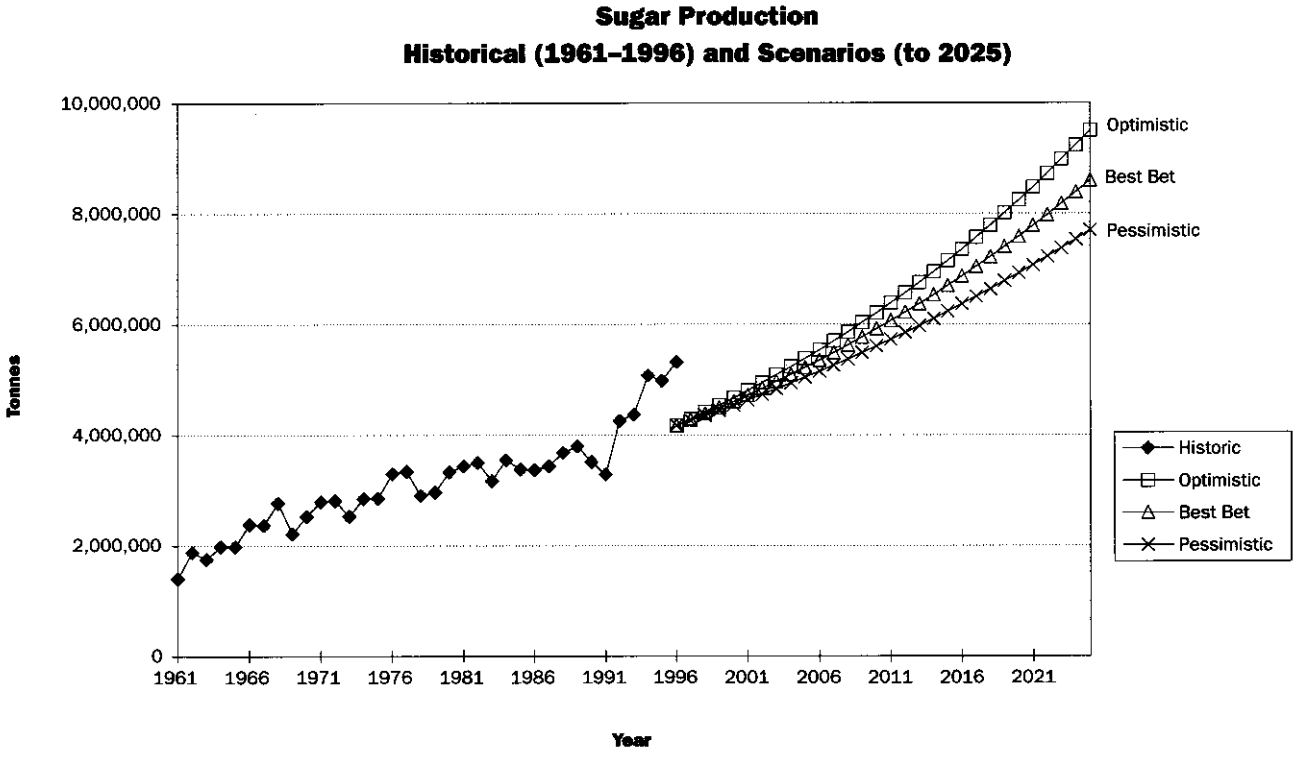


Figure 15
Extrapolation of total sugar production to the year 2025 using an 'linear' and 'log' fit to the historic data from 1961 to 1996.

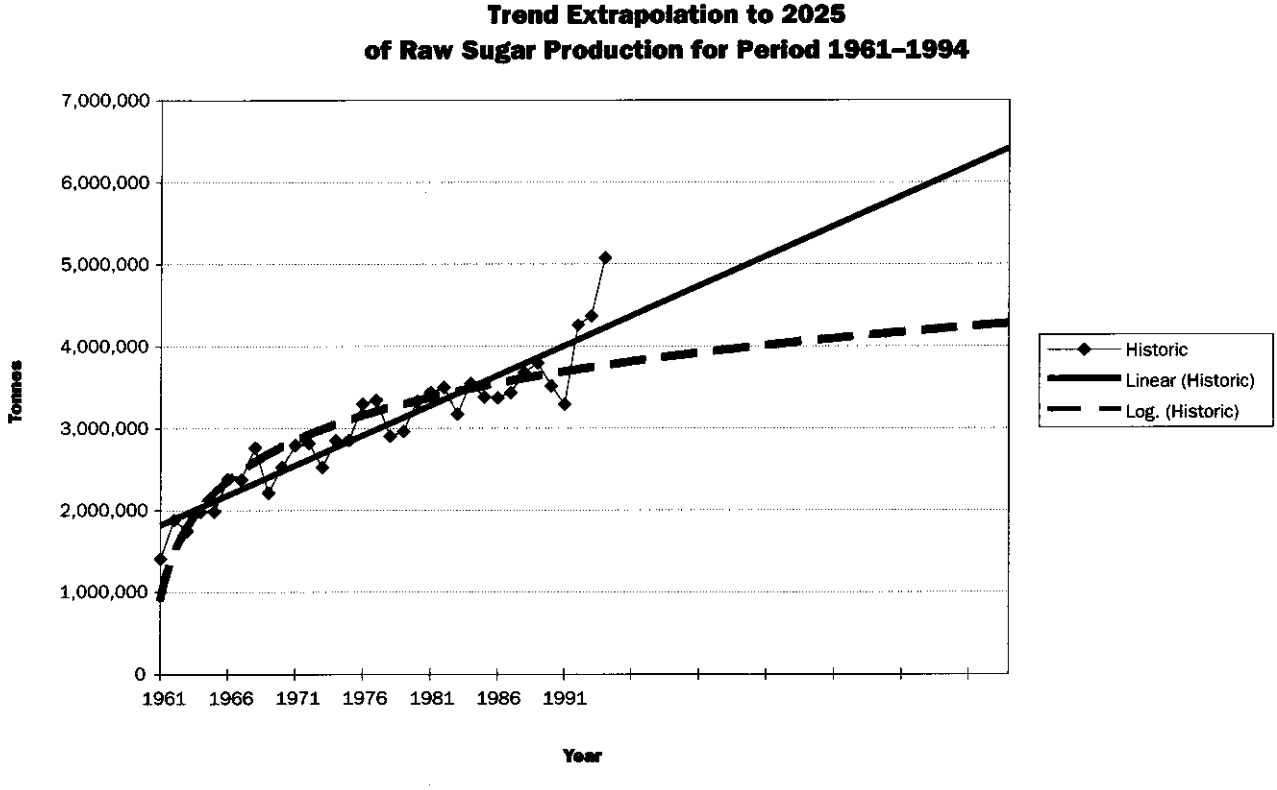
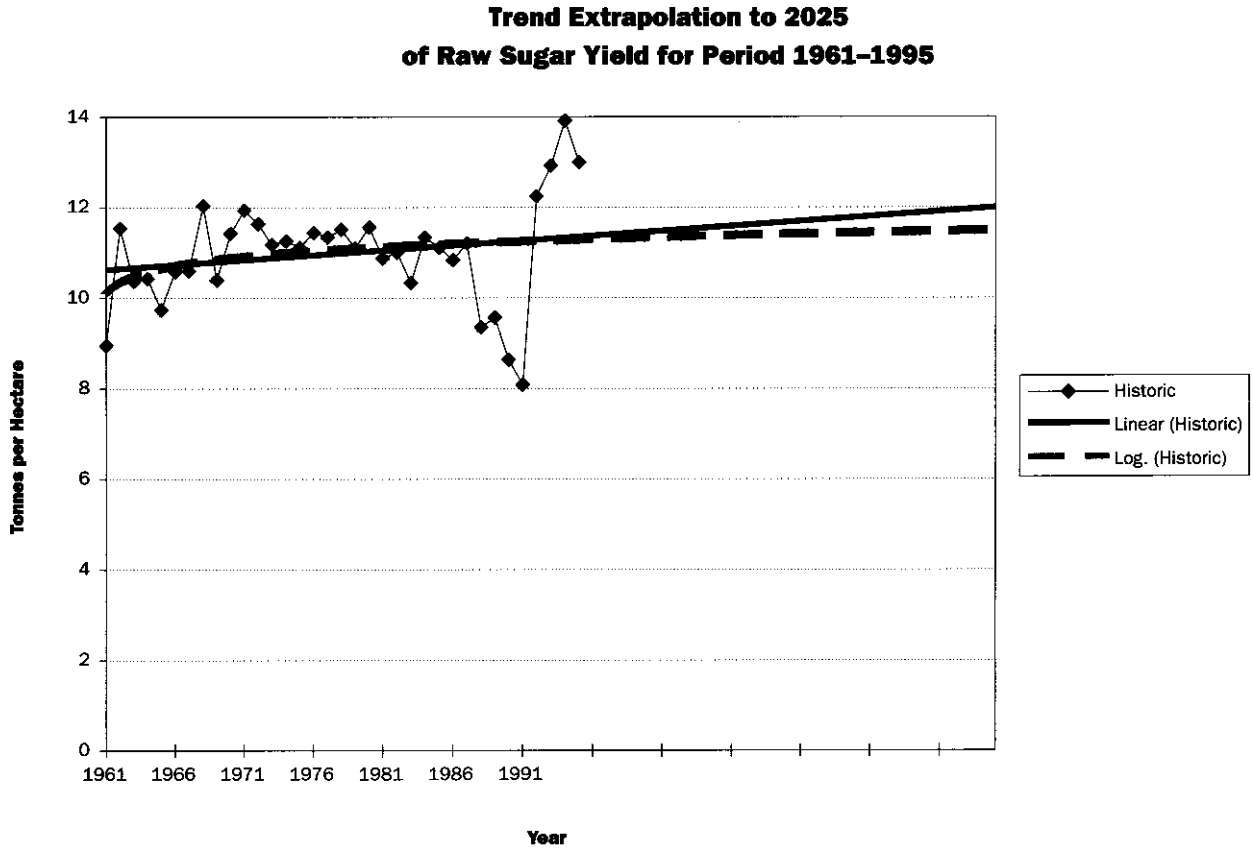


Figure 16
Extrapolation of yield per hectare using the same methods and time periods.



The Ord River will come into production in the 1996–97 season. Although the production of sugar cane is 80% higher there (the sugar content remains the same; ABARE, 1996), the scheme would not be able to make up the balance of new cane land required. Most of that land will come coastal and near coastal areas in Queensland. Around 40% of the sugarcane area is currently irrigated (ABS, 1995), and it is possible that a larger proportion of the expanded crop will have to be irrigated as the industry expands into drier or more marginal areas. The requirement for water will be a developing tension, within the industry and in competition with other water users.

Sheepmeat

Under the three scenarios sheepmeat production is expected to increase from the current level of 548,000 to a range of 708,000 to 791,000 tonnes per year (Figure 17). In 1972 sheepmeat reached an historic peak of 956,000 tonnes on the back of historically high sheep numbers, and what were presumably good market opportunities. It is assumed that the live sheep trade will continue growing parallel to the meat market. Current data indicate that this trade has increased from 4.3m head in 1991 to 5.7 million in 1996.

The aggregated nature of the sheepmeat market as presented undoubtedly hides a range of important subtleties, particularly in the area of product quality and market specifications. Historically it appears that 25% of sheep numbers have been slaughtered annually to give the annual meat production (Figure 18). Relatively small changes in flock composition, higher biological rates, and different turn off strategies could produce the added sheepmeat production suggested without a major increase in sheep numbers, and carrying capacity requirement.

Figure 17
Historical sheepmeat production in tonnes to 1996, and three scenarios to 2025.

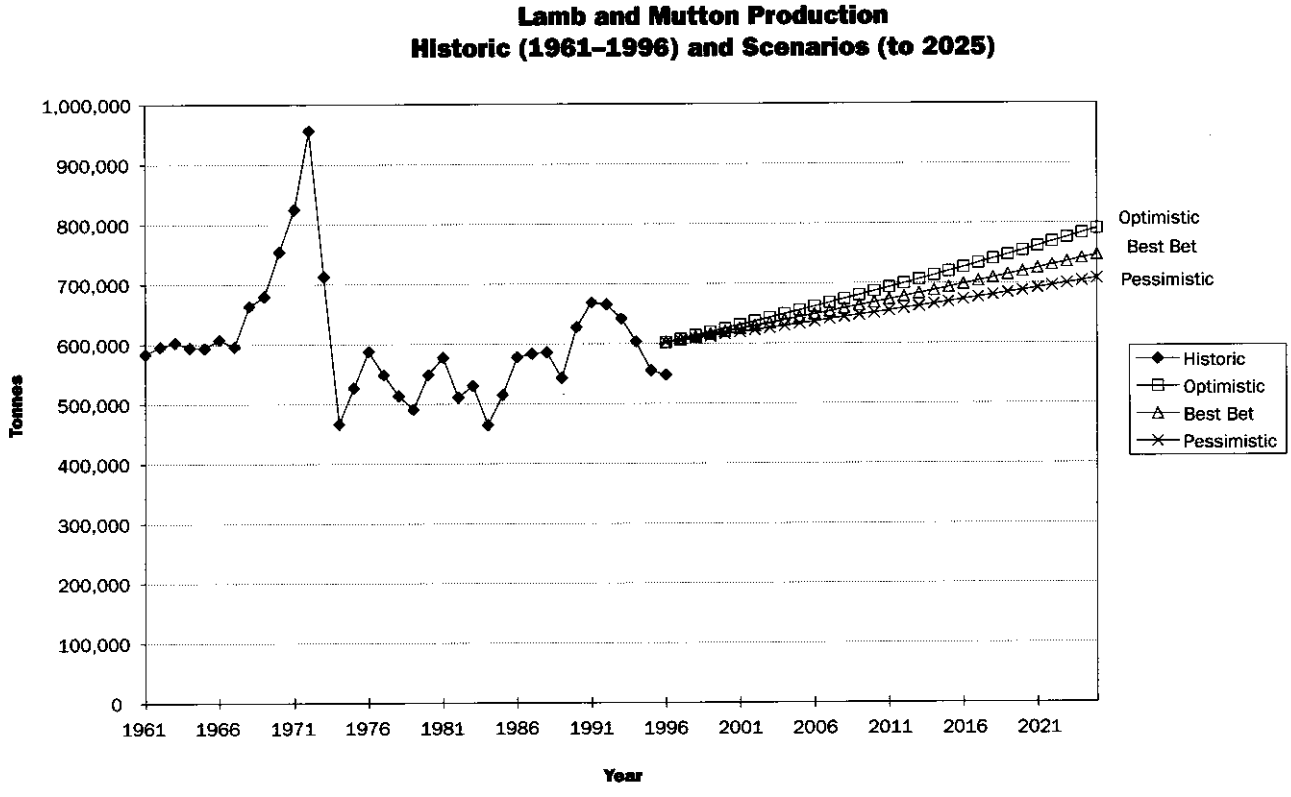
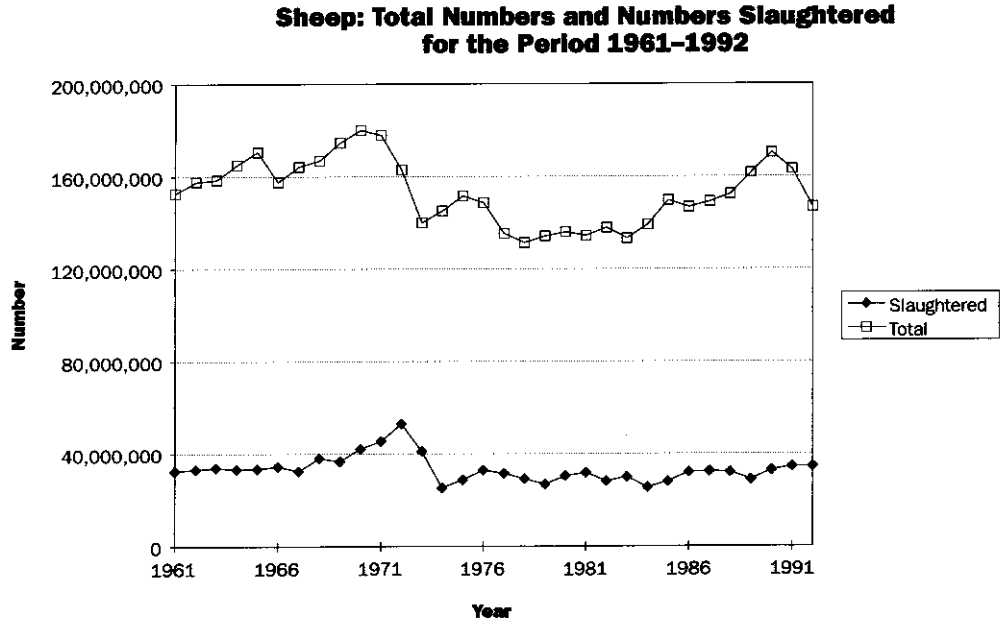


Figure 18
Total sheep numbers and numbers slaughtered for the period 1961 to 1992.

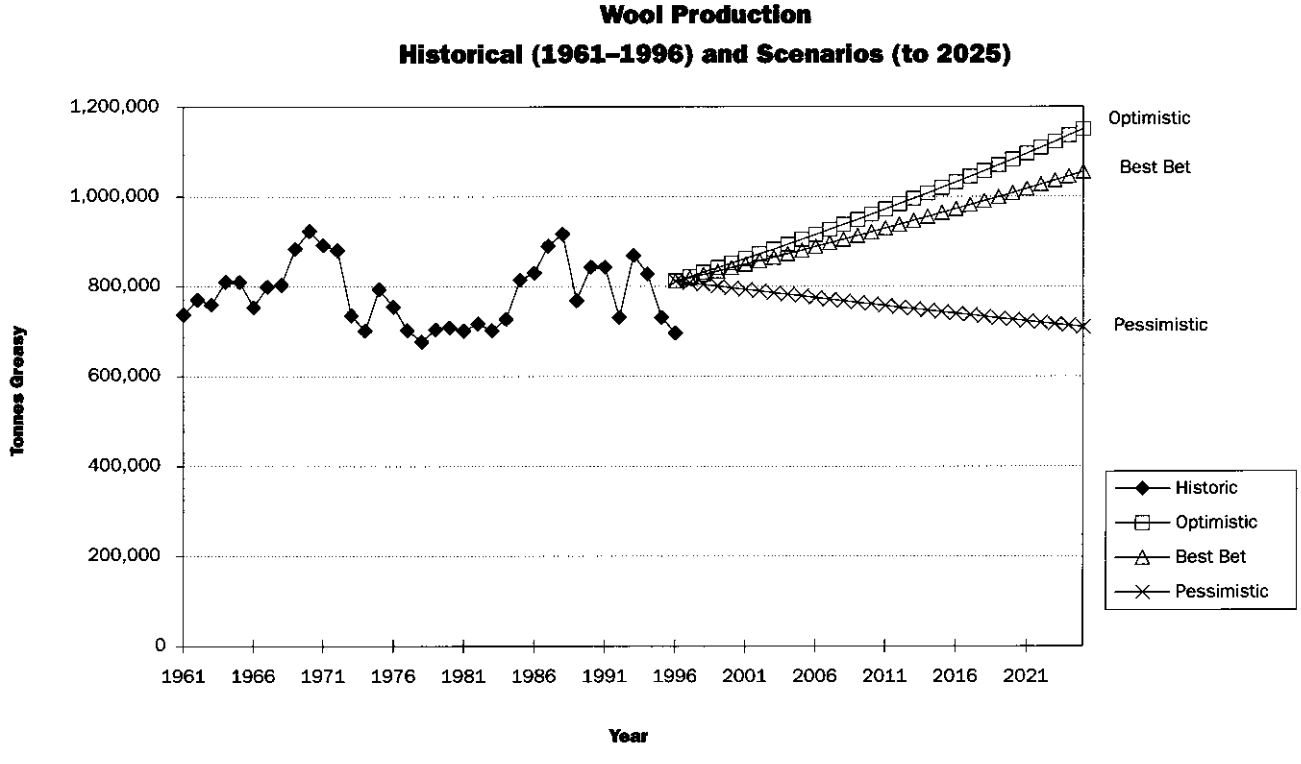


In 1996 23% of the sheep flock of were slaughtered to produce 577,000 tonnes of sheepmeat. If 30% of the same flock size were slaughtered in 2025, then the best bet target of 747,000 tonnes could be met. Structural changes of this nature are normal across whole regions, and are thus feasible across the national flock without increases in total numbers. Some tensions may arise between product quality, size and quality of the wool clip and competition for irrigation water.

Wool

It is anticipated that wool production will increase from the current level of 679,000 tonnes per year to 1,055,000 1,150,000 and 710,000 for the best bet, optimistic, and pessimistic scenarios respectively (Figure 19). In the 30 years of historic record present, Australian wool production has peaked at about 920,000 tonnes in two periods, and the higher production levels are obviously physically feasible. However at the time when these peaks occurred the size of the other production sectors was much smaller, and the agricultural workforce was larger. A steady or even rapid change in the relative prices for wool could see this level of production achieved again in as little as five years and sheep numbers would have to approach their historic high of 180 million again (Figure 18). Depending on the mix of breeds and the production systems that develop in any revamped sheep and wool industry, this would also help the higher production levels foreseen in the sheepmeats sector.

Figure 19
Historical wool production in tonnes to 1996, and three scenarios to 2025.



There may however be some tensions with the beef and veal sector, particularly if the cropped area for wheat and coarse grains are increasing. The area of arable increase would inevitably encroach onto the 'sown pastures and grasses' stock of higher quality land. Climatic variability will give an added tension. It is relatively easy to design a livestock feeding system which can double forage yields under a stable and foreseeable climatic regime. However the frequency of droughts in Australia will not decline.

Increasing sheep numbers by at least 50% at the same time that most arable sections are increasing, as well as the demand for irrigation water will lead to a series of livestock feeding challenges. Once again the production increase in this sector is feasible by itself, but climatic variability, competition for irrigation water and a limited stock of high carrying capacity land may restrict the best bet and optimistic production targets being reached.

Beef and Veal

The production of beef and veal is anticipated to rise from the current 1.7 million tonnes to 2.5, 2.9 and 2.4 million tonnes in the best bet, optimistic and pessimistic scenarios respectively (Figure 20). The peak production in the last 30 years was 2.2 million tonnes in 1978. The total herd then was 33.4 million compared to 27.5 million today. This includes the dairy herd which eventually ends up as beef product. Slaughtering rates in the last ten years usually vary from 35–40% (Figure 22) and it is difficult to think how this could be increased by much, except if there is a significant move to feedlot production. Such a move is expected in the industry and in time, it is expected that the national beef herd is predominantly breeders and all yearling cattle would be turned off to feedlots. In this way the production levels in the scenarios are then feasible without increasing the total numbers in the herd. This would use more of the grain being produced, and this is a logical development of the way in which the industry has been restructured in the last decade. The feedlot capacity in Australia is currently around 800,000 cattle and this would allow the turn off to slaughter of 5 million yearlings if they were lot fed for two months each. This lot feeding capacity would have to be at least doubled to deal with the 11 million yearlings which would come from a national herd stabilised at the current levels of 27.5 million being turned off at a yearly rate of 40%. Keeping the predominantly grass fed industry, then total numbers would have to stabilise around 34 million, which is 24 greater than current numbers. This is feasible with technology and management which we have now. However the same caveats noted with the sheepmeat and wool industries apply here. If grain areas expand into the higher quality grazing land, and irrigation water is allocated from pasture to cotton, horticulture, environmental flows and urban/industrial use, there may be problems with the supply, timing and continuity of quality product.

Two methods of extrapolation from 30 years of historical beef and veal production data give a range of total production by 2025 from 2.0 to 2.7 million tonnes per year (Figure 21). If the two trend extrapolations bracket the plausible future, and remembering that 2.2 million tonnes has been produced relatively recently, then the beef and veal sector can plausibly meet the three scenario targets, but with some tension with the other sectors.

Rice

Rice production is expected to rise from the current levels of 1.45 million tonnes to between 1.8 and 1.9 million tonnes in 2025 under the three scenarios (Figure 23). Under the simple extrapolation methods we have used, this would appear to be feasible (Figure 24 and 25). We have assumed that rice land is not limiting and that the financial returns for rice will enable it to acquire the 12 megalitres of water per hectare per year required for its production. The Murrumbidgee Irrigation Area where most of Australia's rice is produced, does have a number of looming environmental challenges including irrigation salinity. If this challenge is not equalled, then under a number of the agro-ecosystem scenarios that follow, it is possible that the rice industry re-locate to other areas of suitable soil type if irrigation salinity and rising water tables start to limit production.

Figure 20
Historical beef and veal production in tonnes to 1996, and three scenarios to 2025.

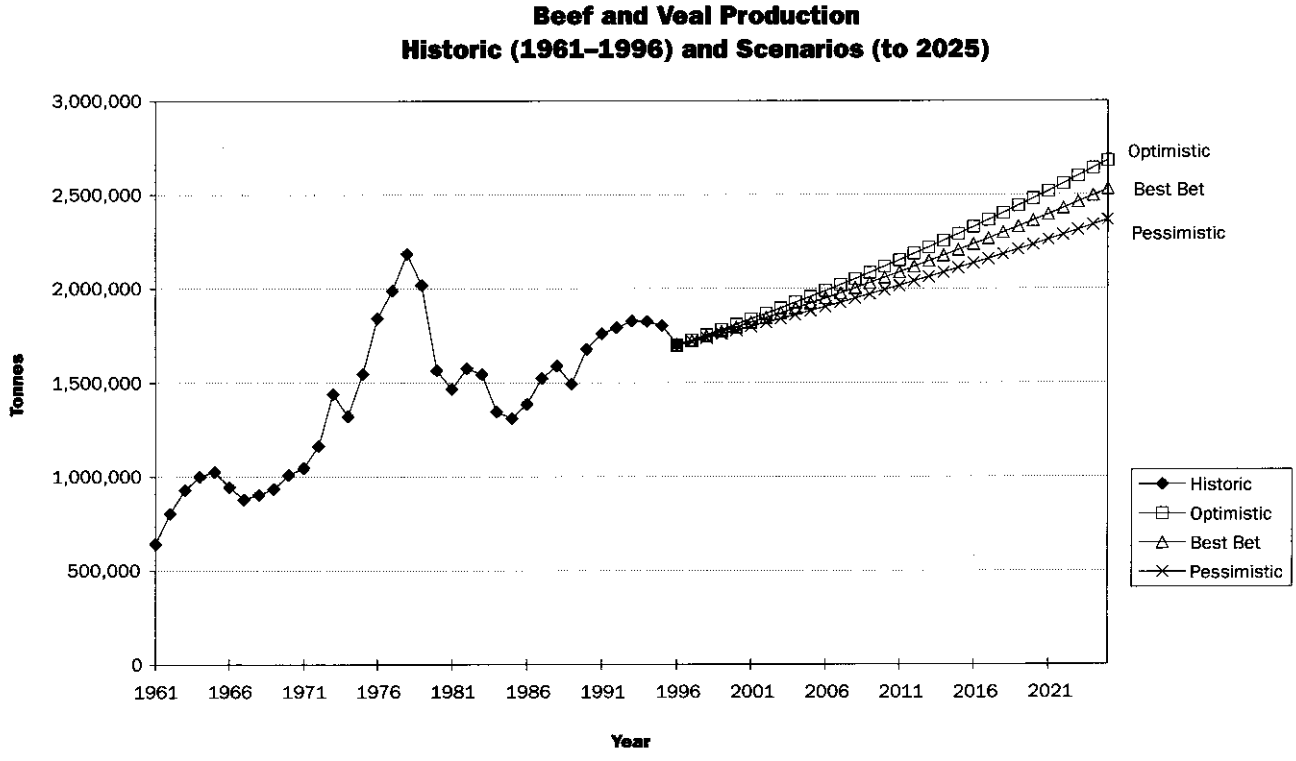


Figure 21
Extrapolation of total beef and veal production to the year 2025 using an 'linear' and 'log' fit to the historic data from 1961 to 1996.

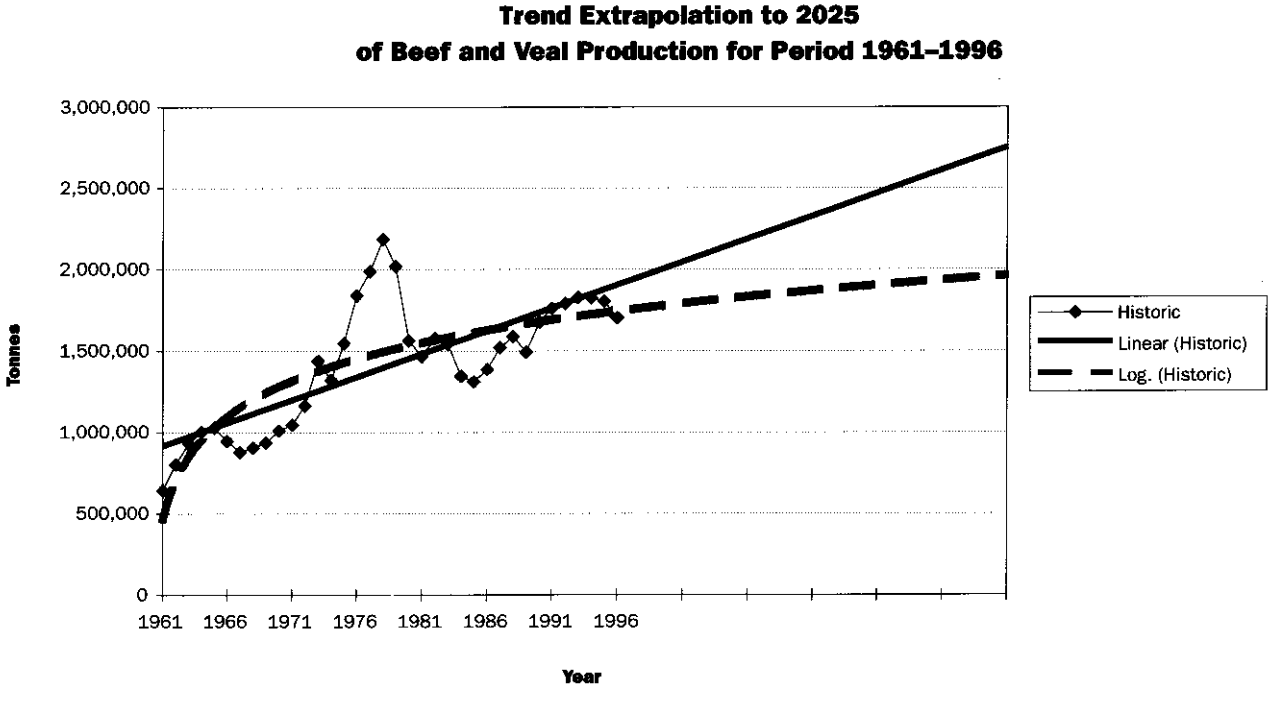


Figure 22
Total numbers of cattle and numbers slaughtered for the period 1961 to 1992.

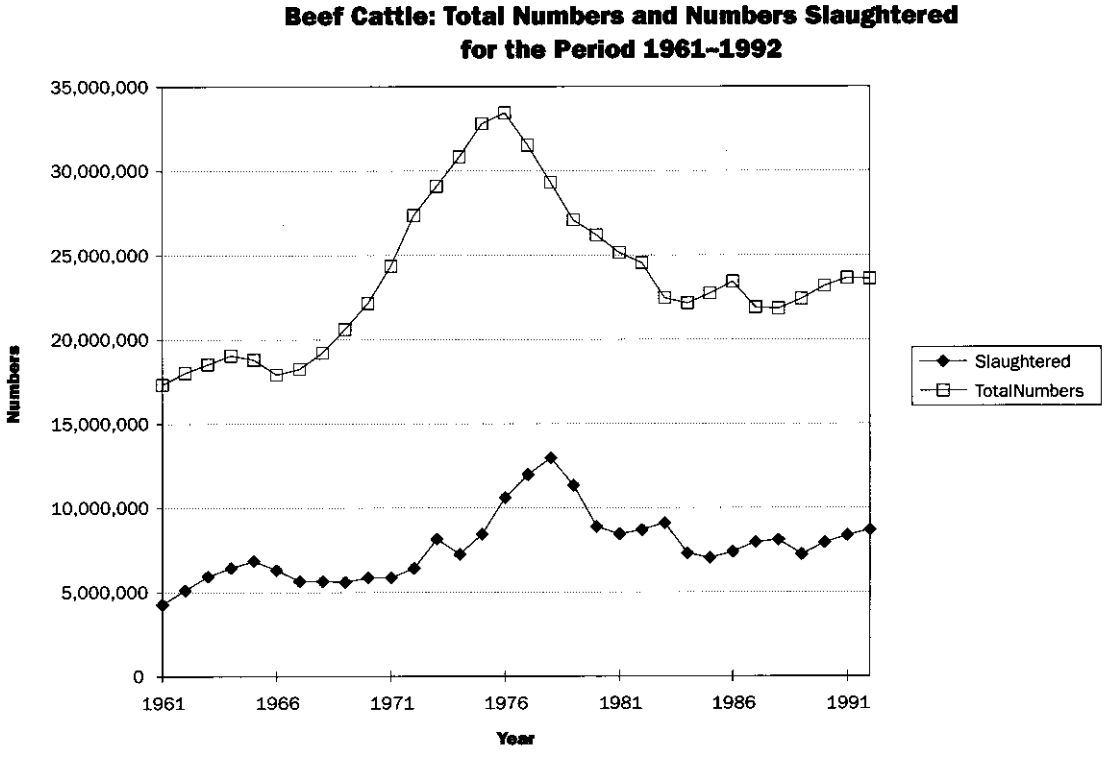


Figure 23
Historical rice production in tonnes to 1996, and three scenarios to 2025.

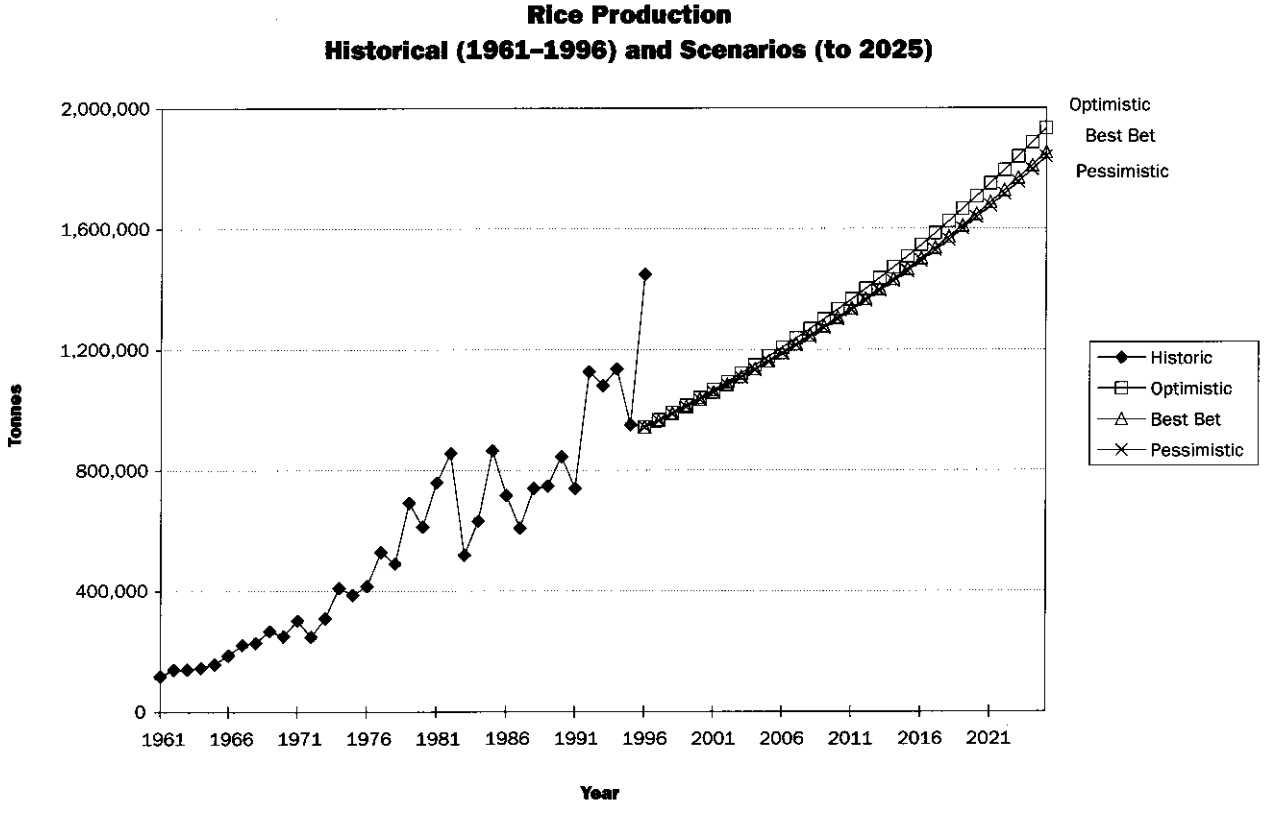


Figure 24
Extrapolation of total rice production to the year 2025 using an 'linear' and 'log' fit to the historic data from 1961 to 1996.

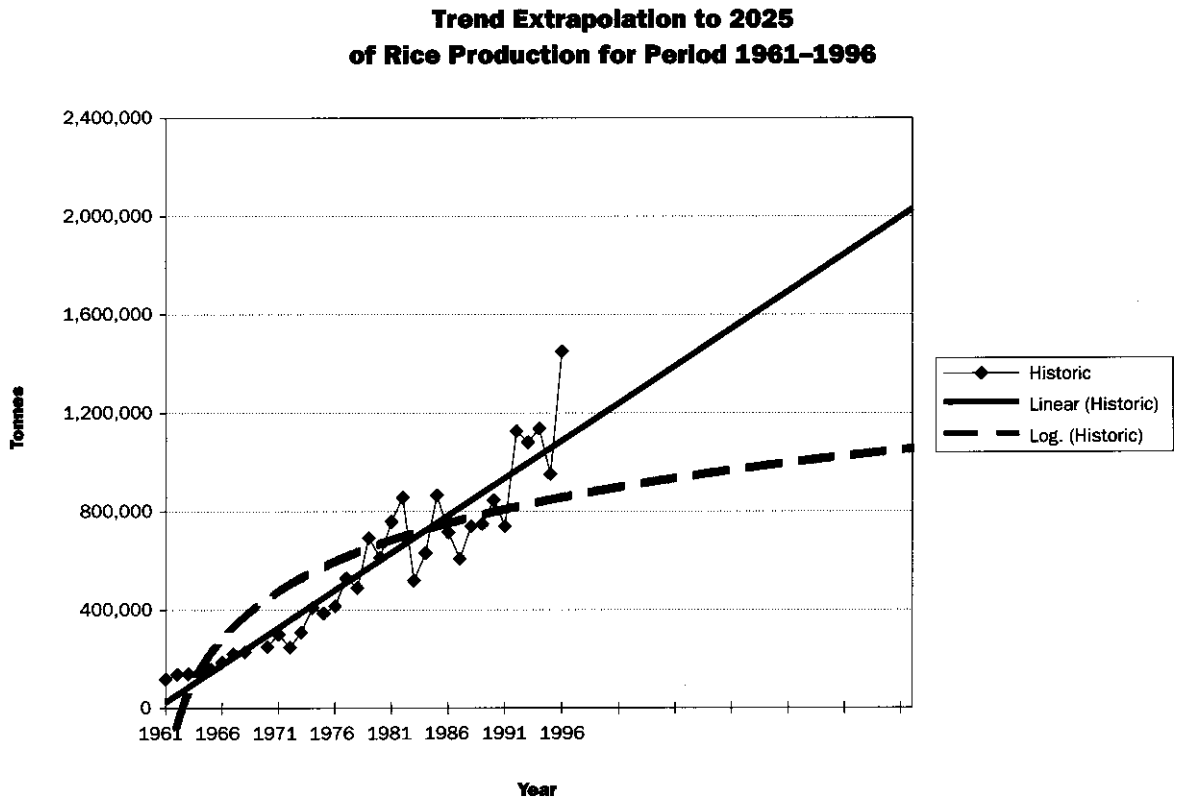
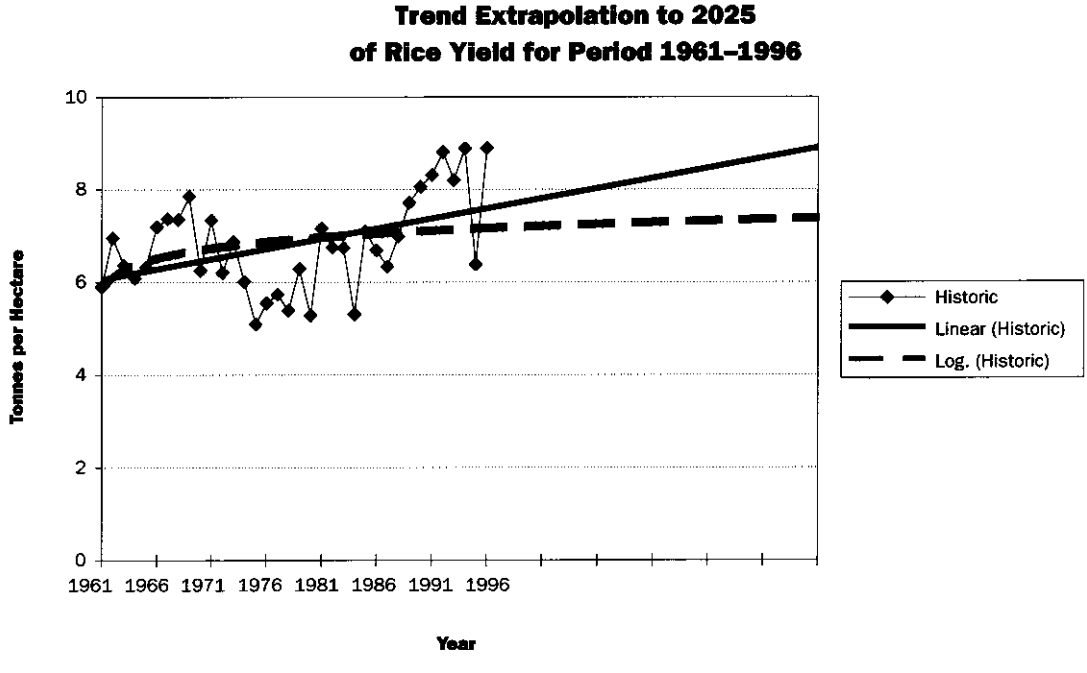


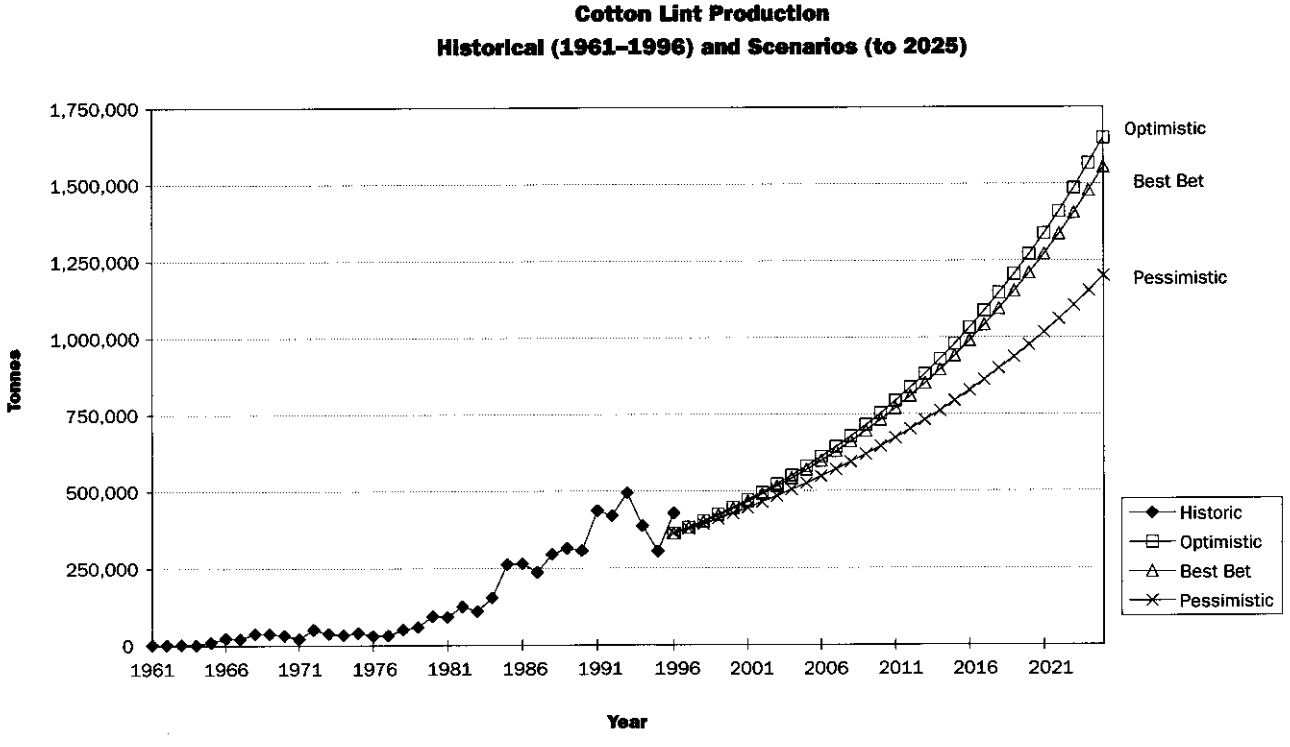
Figure 25
Extrapolation of yield per hectare using the same methods and time periods.



Cotton

Cotton lint production is expected to increase from the current level of 480,000 tonnes grown on 371,000 hectares in 1996, to 1.55, 1.65 and 1.20 million tonnes in the year 2025 for the best bet, optimistic and pessimistic scenarios respectively. If yield of lint follows the linear extrapolation to 2.7 tonnes per hectare by 2025 (Figure 28), this would require a little over 600, 000 hectares of cotton soils and 5.4 million megalitres of irrigation water. While this require more investigation, we assume that the area of cotton soils is not limiting along the main inland river systems of eastern Australia. To give an estimate of the irrigation water required, this increase would require 88% of the 6.2 million megalitres of surface irrigation water consumed in the New South Wales portion of the Murray–Darling Basin in the period 1989–1993 (MDB, 1995).

Figure 26
Historical cotton lint production in tonnes to 1996, and three scenarios to 2025.



Expansion of this nature would not occur without considerable structural change within the rest of the agricultural industries which use irrigation water. Cotton is set to return to the Ord River with 25,000 hectares of irrigated land and a potential increase of cotton production of 40,000 tonnes of lint per year (ABARE, 1996). The growing of transgenic cotton varieties in winter when insect pressure is least will allow this. Although this will be an important development, we would assume that most of the cotton expansion will occur where the industry is located now.

Horticulture and Other

The scenario expect that the aggregated index of production for the horticulture sector will rise by at least 300 %. This will expand the production of fruit from the current 2.5 million tonnes to 12 million tonnes, and the production of vegetables (excluding tubers) from the current 1.5 million tonnes to 6 million tonnes. Once again we assume that land is not limiting for this production expansion.

Figure 27
Extrapolation of total cotton lint production to the year 2025 using an 'linear' and 'log' fit to the historic data from 1961 to 1996.

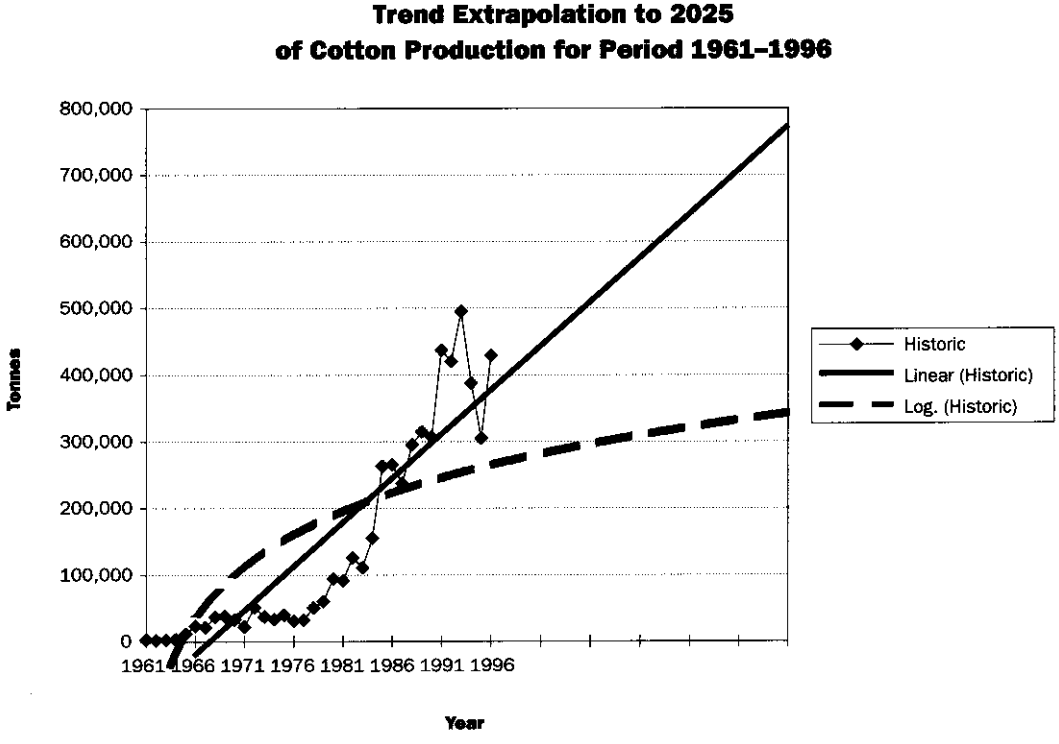
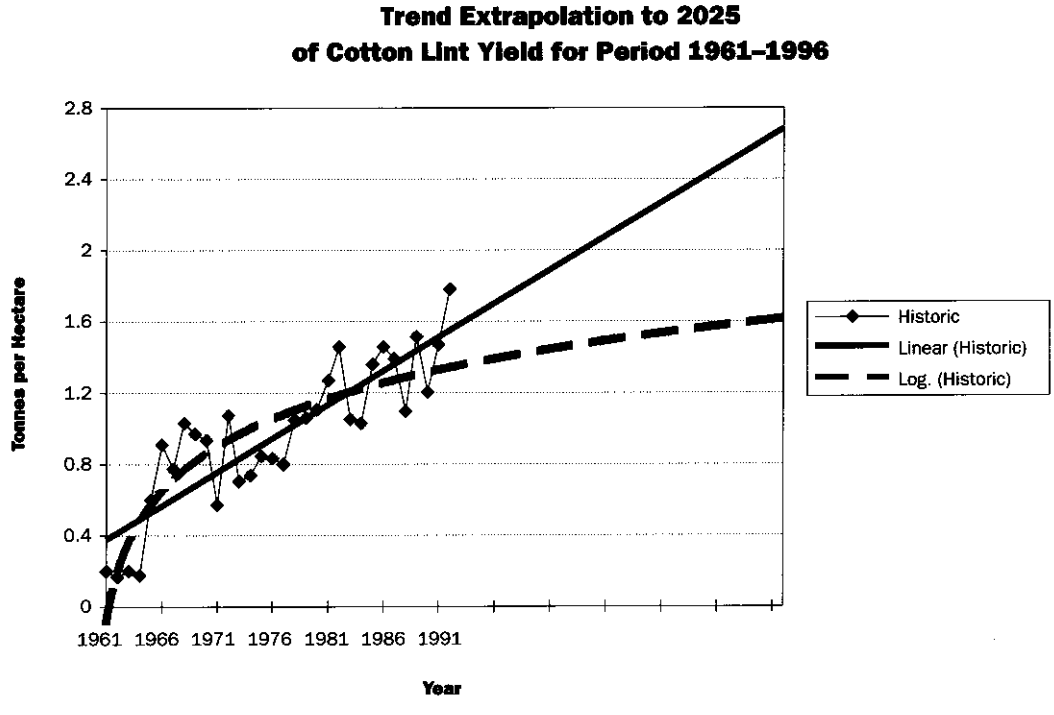
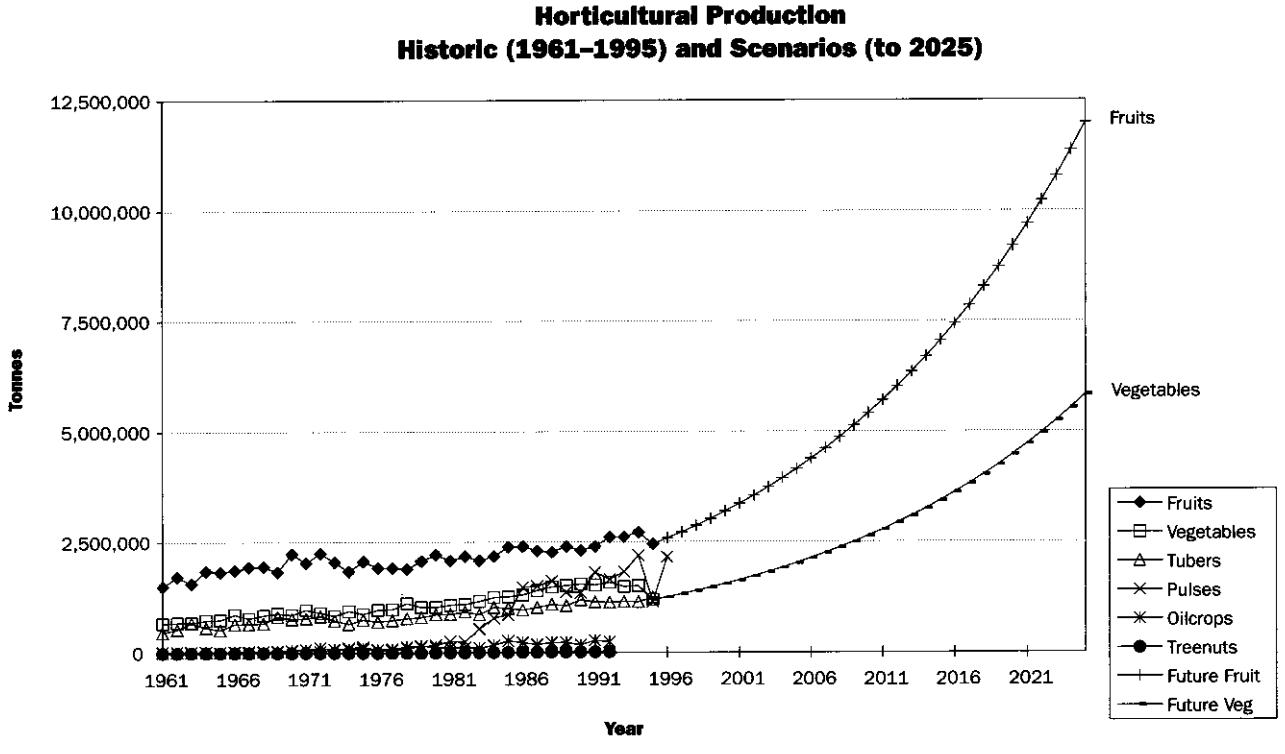


Figure 28
Extrapolation of yield per hectare using the same methods and time periods.



For intensive industries such as horticulture, technology, management and human inventiveness can deal with the expected production increase. We expect though that there will be tensions in water availability. If we accept the same water use requirements we show for grapes in a later section, (1,000 litres of water per litre of wine produced), the extra 8 million tonnes of fruit and vegetable will require 18 million megalitres. This is 70% more than the total irrigation water currently diverted in the whole Murray–Darling Basin (10.7 million megalitres). Given that the total stock of water in Australia is much larger than the Murray–Darling Basin stock, and given that real water pricing will speed and ease allocation of water, this water requirement will produce considerable tension with other production sectors across all production demand scenarios.

Figure 29
Historical horticulture and other crop production in tonnes to 1996, and three scenarios to 2025.



Potential Production and 2025

Wheat, coarse grains, sheepmeat, wool and rice have all been within 80% of the production targets set in the best bet scenario for 2025. Sugar and beef are in the 60–70% range while cotton is still at around 30% of the 2025 market potential (Table 20).

Some of the production peaks are recent (this year for rice and wheat) while wool, sheepmeats and beef occurred in the 1970s. Of all the production targets we would suggest that the beef and veal one is the most difficult to achieve. Finishing 50% more animals to the specifications of discerning markets in 2025 could produce tensions in both northern and southern Australia.

While in northern Australia the more arid and more monsoonal country could produce adequate numbers of store stock to be finished, the higher rainfall country (and the Ord Irrigation Area) could be concentrating on sugar and tropical horticulture. In southern Australia high quality grazing land will be taken back into arable use, water for irrigation will be priced competitively and therefore out of reach of pastoral industries and the wool and sheepmeat industries may be more flexible and able to respond to rapidly changing market situations.

Table 20
Fraction of the production target expected in each scenario that the peak historic production for each commodity represents (historic as a percentage of 2025 expectation).

Crop	Year in which Peak Historic Production Occurred	Optimistic Scenario (Historic Peak as % of 2025 target)	Best Bet Scenario (Historic Peak as % of 2025 target)	Pessimistic Scenario (Historic Peak as % of 2025 target)
Wheat	22 million tonnes in 1983/84 and 23 million tonnes in 1996/97	75%	87%	102%
Coarse Grains	9.9 million tonnes in 1993/94	75%	76%	79%
Sugar	5.3 million tonnes in 1996/97	55%	62%	69%
Sheepmeat	956 000 tonnes in 1972/73	121%	128%	135%
Wool	923 000 tonnes in 1970/71 and 916 000 tonnes in 1988/89	80%	87%	130%
Beef and Veal	2.2 million tonnes in 1978/79	82%	87%%	92%
Rice	1.4 million tonnes in 1996/97	72%	76%	76%
Cotton	495 000 tonnes in 1993/94	30%	32%	41%

The Question of Land

In 1994 there were 18 million hectares in crop (16 m in grain crops) and 30 million hectares in sown pastures and grasses. (ABS 1996). Excluding the pastoral industries, the least optimistic of the yield per hectare projections for the main crop types requires an expansion of the cropped area to around 26 million hectares, an increase of 8 million hectares or 45% (See Table 21). While it requires further analysis, we assume that there is sufficient land stock of a suitable type in the sown pastures category to supply the 8 million hectares needed. While improvements in technology and management could supply the production increases needed, we accept that there are good reasons embedded in our past and current physical and social function why this has not happened already. Climate variability, poor parent material and soils derived therefrom, and declining terms of trade for our farm sector are some of the most important factors. The first two are permanent facts of life for Australia which market reform and government policy will never change. There is some expectation that globalisation and free markets will help with the third and related factors. The promise of increased net returns to the farm sector, will allow available technology and knowledge to be applied.

If arable land is excised from the sown pasture component of land use, this could produce two important tensions. Within the cereal sheep zone the proportion of land under some form of pasture rotation may gradually decrease, possibly destabilising the longer term resilience of the system, while short term needs are meet by increasing energy and fertiliser inputs.

The second tension could result from less higher quality land for the grazing components of the farm system. This could go two ways. Animal numbers may be maintained or even increase, perhaps during a series of good rainfall years and good market prospects. The inevitable drought will increase economic tension within the system, and perhaps even harm the biological system which underpins farm production. This will reduce physical and economic prospects of meeting the animal production goals in the three global scenarios. The second option is that animal numbers may decline with the increase in arable land, and scenario production targets will not be met. A more stable animal system may ensue, and economic returns may equal the old system if 'non commodity' markets can be developed which emphasise product quality.

Table 21
Hectares of land needed under two projections of yield per hectare, needed to supply total production for each demand scenario in the year 2025.

Crop	Extrapolation of historic yield per hectare to 2025	Optimistic Scenario	Best Bet Scenario	Pessimistic Scenario
Wheat	Linear (2.0)	14 760 000	12 623 000	10 771 000
	Log (1.55)	19 042 000	16 288 000	13 898 000
Coarse Grains	Linear (2.4)	5 513 000	5 403 000	5 340 000
	Log (1.7)	7 784 000	7 628 000	7 538 000
Raw Sugar	Linear (12.0)	792 000	717 000	642 000
	Log (11.6)	819 000	741 000	664 000
Paddy Rice	Linear (9.0)	215 000	206 000	204 000
	Log (7.5)	258 000	247 000	245 000
Cotton Lint	Linear (2.75)	600 000	565 000	436 000
	Log (1.6)	1 031 000	972 000	750 000

The Question of Water

While the previous section noted that land was generally not limiting for most production sectors that is not the case for water. The most important asset of water is that it allows the production of the appropriate quality of product at the time required by the market and by the consumer. This is critical in a market place that is already national wide, and is rapidly becoming global wide.

The use of water for irrigation in most established agricultural areas is constrained by both management and the environment. Many rivers in the Murray–Darling Basin have more than 50% of their annual flows diverted into irrigation and this is now recognised as having the potential to cause long term decline in the quality of the water resource in both the surface and underground systems (ABS, 1996).

As proper water pricing comes into play, the market will ensure that water is allocated to the most financially attractive sectors. Examples are given in Table 22 of the 'water cost' of a kilogram weight of market product. It can bee seen that the animal products are an order of magnitude higher than the vegetable products. Thus in 'water' terms, a kilogram of beef should bring 25 times the dollar returns that a kilogram of rice brings to a grower. A kilogram of butter should bring 18 times the return of a kilogram or a litre of wine.

In 1994 total area of irrigated land was 2,4 million hectares of which pastures were 136,000 ha, cereals 354,000 ha, vegetables 96,000 ha, fruits 144,000 ha, sugar 168,000 ha and other products 275,000 ha. The sources of this water was 46% from state run irrigation schemes , 31% from streams and farm dams and 16% from underground aquifers. On average each hectare of irrigated land receives about 4,250,000 litres (4.25 megalitres) of irrigation water. If cotton is to expand to 600,000 or even 1,000,000 ha, then each hectare added to the current stock of cotton land will require the withdrawal of two 'average' irrigated hectares from our currently exceeded irrigation potential. This will probably impact first on the sheepmeat and the beef and veal sector. Their potential expansion will therefore be truncated because they are unable to supply quality product at the appropriate time. They may be able to expand low quality product on marginal land to meet the scenario objectives, but this will probably conflict with some assumptions of market attractiveness and return, which assume that a product, if produced, will be cleared somehow in the international marketplace.

Table 22
Water demand for irrigated crops in south eastern Australia (after Meyer, 1997)

Crop	Yield per Hectare in kilograms	Irrigation Water per Hectare per Year in litres	Water per Kilogram of Market Product
Rice	9 000 paddy rice 5 850 white rice	12 000 000	2 000 litres per kilogram of white rice
Wheat	5 000 grain 3 750 flour	5 000 000	1 300 litres per kilogram of flour
Cotton	3 000 with seed 1 700 as lint	9 000 000	5 300 litres per kilogram of cotton lint
Maize	13 800	7 000 000	500 litres per kilogram of maize
Wine Grapes	9 300	8 000 000	1 000 litres per litre of wine
Dairy Pasture	830 butter fat	15 000 000	18 000 litres per kilogram of butter
Beef Pasture	300 steak	15 000 000	50 000 litres per kilogram of steak
Wool Pasture	88 clean wool	15 000 000	170 000 litres per kilogram of wool

Interactions and Tensions

Wheat

Most wheat in Australia is grown within a farming system that relies on managing a physical and economic balance between animal and crop enterprises. A pasture ley for five out of every ten years is the key to balancing soil fertility (particularly nitrogen) and soil structure with a range of linked environmental variables. The rotation period can be reduced, and industrial nitrogen supplied to the system, but these will eventually to lower production rates over a time scale of decades (or a range of increased environmental costs). In the short term therefore there is ample opportunity to double or triple the area sown to wheat, but this will destroy the economic and biological balance of an integrated farming system which has developed over the last 100 years.

Coarse Grains

As well as being important commercial products in their own right, the coarse grain commodities also double as important animal feeds at particular times of year (oats fed as green feed crop) or as components for the animal feeding industry of pigs, poultry and feedlot cattle.

If the production increase in the best bet scenario comes from an increase in land area while other commodity groups are being held constant in output, then it is easily feasible in its own right. However when it is combined with production increases in wheat, wool, sheepmeat and beef/veal then in a time scale of decades there are a number of tensions which must be resolved. It is feasible to hold the stock of more intensively used land constant and increase the productivity per unit of land area, per unit of fertiliser and water input and per unit of energy input. However that will require the average farm productivity in physical and economic terms to move considerably closer to the performance shown by the top 5–10% of farm enterprises.

Sugar

Meeting the best bet production scenario for sugar requires an approximate doubling of land area from the present 365,000 ha (ABS, 1996a) to over 700,000 ha. While this is feasible in its own right there are a number of strong resource and social interactions which may limit this expansion. Both land and water demands of an expanded sugar industry will limit expansion of tropical beef and horticulture industries. Tourism and population growth due to internal migration will expand demand for high quality land and water supplies in those same areas where sugar homes to expand.

The proximity of the sugar industry to coasts, estuaries and The Great Barrier Reef will continue to cause environmental concerns, whether those concerns are justified or not. Continued clearance of coastal forest to allow expansion of the sugar industry will probably be judged and environmental bad.

Sheepmeat

The supply of wheat, coarse grains, beef and veal, wool and sheepmeat all interact within the same production system. While 81% of the 2025 best bet scenario was produced 25 years ago, this was on the back of high sheep numbers and a differently structured economy from the one we have today. Working forward from 1997, a large increase in the supply of quality product at the right time would give production tensions in the beef and veal sector and the wool sector. The nutritional requirements for spring lamb production can only be met in a sustained manner in a limited number of pasture production systems in eastern Australia. This would limit pasture availability for the beef and veal sector at that time of year, and require irrigation water also needed by the rice, cotton and horticulture sectors. The type of sheep breeds required to give efficient sheepmeat production would eventually change the quality characteristics of the wool sector.

Wool

Scenarios for wool production are feasible in the best bet scenario. Major tensions will arise, particularly in drought years, with the beef and veal and coarse grains sector.

Beef and Veal

The additional 50% increase in beef and veal production will require a 40% increase in cattle numbers assuming that breeding, nutritional and health technologies continue to develop on a reasonable trajectory. The extra carrying capacity required will produce many tensions within the overall agricultural system particularly in the years of high stress caused by price instability and drought. While high quality land, improved production systems and irrigated pastures could supply the carrying capacity, the land, water and inputs required will probably be allocated first to agricultural systems with a higher return. If the current trends to feedlots continue then there will be increased demand for coarse grains and increased environmental tensions.

Table 23
Possible tensions for commodity groups under the different demand scenarios leading to the year 2025.

Commodity group	Land tensions	Water tensions	Diffuse Environment tensions
Wheat	Demand for larger planting area will decrease rotational spelling and lead to long term production decline		Expanded area will challenge remnant vegetation areas and bio diversity resources therein
Coarse Grains	Large wheat area will stabilise or decrease the area available for other grains		As above
Rice	Irrigation salinity in the MIA	Competition with Adelaide for urban/industrial use.	
Beef and Veal	High animal numbers will be subject to high environmental scrutiny particularly with reference to drought management	A doubling of feedlot capacity will increase scrutiny for off site pollution effects particularly for stream quality indices and groundwater contamination	Energy audits will reveal feedlotting as a very energy inefficient system
Sheepmeat	Forestry, horticulture and hobby farm expansion will decrease high quality land available for high quality production. Problems of product quality and continuity will ensue.	Less irrigation water to produce timely high quality product such as prime lamb.	
Wool			
Cotton		Will out compete irrigated pastures for water allocation in MDB	
Sugar	Land on tropical coast is relatively scarce and open to high environmental scrutiny	Will compete with urban use and tropical horticulture as sugar move to more marginal rainfall areas	Effect of nutrients and sediments on estuaries and the Great barrier Reef
Horticulture		Will compete head on with sugar in tropical areas, cotton in the MDB and urban use in near coastal areas.	

Rice

Rice will compete for water with environmental flows. urban Australia, cotton, irrigated pastures and high value horticulture such as wine. The long term effect of rising watertables and subsequent irrigation salinity will force rice to develop new production technologies and find more land.

Cotton

Cotton will compete with most sectors for water, but will probably not be limited by the availability of suitable land and soil.

Horticulture, Vegetables and Other

Horticulture, particularly high quality and high return sectors such as wine, will compete with most other sectors for water. All animal production systems which rely wholly or in part on irrigated pastures will decline or move to less favoured areas.

Global Environmental Change: Potential Impacts

There is little doubt that components of environmental change, such as the Greenhouse Effect, could have significant effects on Australian agricultural systems. As yet, the magnitude of the potential impacts are unclear. Climate models are so far unable to provide consistent predictions of changes in rainfall and temperature for regions within Australia. Analyses performed by the IMAGE research group in the Netherlands show that global environmental change is likely to be higher in the coming decades than before or after, a very sobering thought.

In Australia, studies are only now beginning to be undertaken into the effects of global change on environmental and production systems, so it will be some years before any clear results will be available. However, this simply places more emphasis on our ability to adapt rapidly to these results when they are available. Foresighting studies such as this one assist this process.

Conclusion: Quality versus Quantity

Throughout all of the production systems in Australia there will continue to be a tension between product quantity and product quality. The 'agricultural system' scenarios which sit under these three global economic driving scenarios will explore a number of obvious strategies to resolve this tension. As noted above, each individual production sector alone can probably expand to meet the production targets set by the global drivers. Another option would be to cap production at 1995 levels and to develop an increased dollar return per unit of physical output. Thus the assumptions are turned around. We have a proven physical feasibility because it has been done. The question then is what market and quality characteristics are required to produce ever rising financial returns while keeping physical outputs the same.

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APPENDIX D
Scenarios

Scenario 1: Economic growth

Australian Agriculture under the Economic Growth Scenario

Introduction

The adoption of the economic growth scenario has meant that the full efficiencies and opportunities offered by economic growth and market deregulation become available. Corporate conglomerates are bigger, stronger and more vertically integrated. Companies compete against each other in a global market and nation states are irrelevant in financial affairs. Government exist to help the way of business in a competitive world and government agencies have evolved into small policy bureaus. The technical work of government and business has been outsourced, and the resulting Australia is a nation of small businesses. Most employees effectively work for themselves and restrictive work practices are non existent. Education, health, social security are all privatised and there is a small safety net for the bottom 10% of citizens.

The demand scenarios (optimistic, best bet, pessimistic) are feasible in this world of economic growth. A key factor is the management and ownership of all the best arable soils by a number of agricultural conglomerates. Wheat and coarse grains therefore yield at least 5 tonnes per hectare, and grain production comes from 40–50% of the arable area used in the year 2000. The previously arable land has been stocked by breeding flocks needed to maintain meat production from the beef and sheepmeat sectors. Market animals are finished in feedlots and on limited areas of irrigated pastures, again operating to top technical capacity.

Corporate agriculture has long since retracted from the more marginal arable soil types and salinised irrigated areas. These areas are owned by a second tier agriculture, of semi-subsistence farming families who are employed part time in other industries. The marginal areas are able to swing back into production under contract farming when global market models indicate years of higher demand. Production is of lower quality, but suitable for feed grains and for human consumption in poorer countries. Corporate conglomerates have moved production areas to virgin soil types as genetically engineered crops have broadened production options (Table 24).

The complete move to corporate agriculture has provided a flood of small business opportunities, as all crop management, harvesting, value adding and product sale is outsourced. Farmers whose enterprises were marginalised by soil quality problems and poor financial returns have found many options for employment, and are able to retain their land but a very minimal production base. As full globalisation of world markets became reality, these part time farmers found many niches for small production runs of highly specialised food products.

One unforeseen impact of the rapid demise of government agencies is that Australia lacks a strong quarantine capability, as well as lacking the ability to implement protocols which deal with the introduction of new plants and genetically engineered organisms. Corporate agriculture has responded by bulking up its production areas, excluding small parcels of land and enforcing strict boundary control. Property rights allow this, and new plant and animal lines are always ahead of any disease scare anyway. Marginal farm areas suffer many disease problems and plant invasions, which in turn increase their marginality.

Table 24
Some product mix implications and tensions arising from the product by region interactions of meeting the three demand scenarios under the 'economic growth' scenario of supply.

Commodity	Murray–Darling Basin	Other wheat–sheep	High rainfall zone	Northern Australia
Wheat	Corporate ownership of best soils and the processing and associated transport and infrastructure. Intensive 'best practice' on superior soils	Retraction of permanent production from problem soils, but retain ability for large scale production to meet spot markets in some years		
Coarse grains	As above	As above		Some increase as virgin soils become developed
Rice	Corporate rice moves from MIA as irrigation salinity bites			Major increase on virgin soils as technical problems are overcome
Beef and veal	Large increase of feedlotting and vertical integration with lower quality grain production through to overseas restaurant chains	Large increase in breeding herd required to supply animals for finishing	Retraction as urban requirements, forestry and horticulture take over higher quality soils	Steady increase of live cattle trade based on best soils with more integrated finishing on The Ord. Spotty production and retraction from marginal areas
Sheepmeat	Demand can be met, but with problems of quality and continuity because water has gone to cotton and horticulture	Live sheep trade is good in some years and flocks exist to supply young stock for further finishing		
Wool	Challenge to maintain supply and quality in face of flat real prices	Supply and quality problems	Competition for land from urban, forestry and horticulture	
Cotton	Major expansion on good cotton soils and ownership in perpetuity of water rights			Limited expansion with transgenic cotton able to deal with cost/pest problems
Sugar			Retraction in northern NSW and south-east Queensland due to urban expansion and competition for water	Expansion along the tropical coast and in more marginal rainfall areas that require additional water rights for irrigation.
Horticulture	Major expansion in high quality horticulture. Water rights come from rice and animal industries	Niche expansion but full market opportunities limited by water quality and other environmental problems	Urban and industrial demand for water limits expansion in many coastal areas	Tropical horticulture expands, but competes with sugar and urban for land and water, particularly in Queensland

Table 25
Some environmental tensions arising from the product by region interactions of meeting the three product demand scenarios under the 'economic growth' scenario of supply.

Commodity	Murray–Darling Basin	Other wheat–sheep	High rainfall zone	Northern Australia
Wheat	Emphasis on intensive production methods leads to shorter rotations, more chemical fertilisers and tensions with long term productive capacity of best soils	Continued decline in all attributes of soil function on poorer soils as agriculture acquires only the best soils. Marginal soils are left to care for themselves		
Coarse grains	As above	As above		
Rice	Rising water table and irrigation salinity			Irrigation salinity problems
Beef and veal	Effluent from feedlots affecting surface and groundwaters	Drought years and high cattle numbers lead to overgrazing of marginal lands		Drought years and high cattle numbers lead to overgrazing of marginal lands
Sheepmeat		Drought years and overgrazing because of high flock numbers required to supply stock for meat trade		
Wool		Drought years and overgrazing		
Cotton	Acquisition of water rights lead to low environmental flows and continual quality problems in inland river systems			
Sugar				Expansion of supply leads to further clearing of coastal vegetation, and increased effect on coastal waters and The Great Barrier Reef. Extra demand requires more dams and less environmental flows
Horticulture	Water rights lead to low environmental flows on all river systems. Shifting irrigation footprint leaves salinised soils and underground floods	Over-exploitation of groundwaters, nitrate pollution, etc.	Over-exploitation of groundwaters, nitrate pollution, etc.	Over-exploitation of groundwaters, nitrate pollution, etc.

Because of the strong and quick management ethic of corporate agriculture, production and quality is never affected by the breakdowns in quarantine. It feels no need to spread its technical abilities outside its boundaries, except when a possible production opportunity (eg. access to extra breeding stock or land for spot crops) might be forestalled.

Where the rights to surface water are owned by corporate agriculture, the whole system is managed well and water quality maintained. Underground water however belongs to whoever owns the land. Because much of the land is used for the second tier of agriculture, most enterprises struggle for survival. Over-pumping and aquifer pollution are widespread and typical of marginalised lands left to exist and persist in a different world.

The demand for high quality land in the arable and horticulture industries has inevitably claimed the best soil types. Since most land and national parks are under private ownership, the presence of remnant vegetation or threatened species has had little effect on this outcome. If the land is available at a price, then it can be brought. Private conservation foundations are particularly effective in purchasing and retaining parcels of land that are near to, and attractive to, the predominantly urban populace. Most farming zones are profit driven and the obvious link of local production, local jobs and per capita affluence are usually enough to roll over any local resistance to further development. Rangelands vegetation is generally improving with destocking under a carbon credits scheme, except in areas where water is hard to control and feral animals are out of control.

Australian corporate agriculture has finally became efficient in world terms, and productivity indices are always within 80% of what is technically feasible.

The effect of implementation of the economic growth scenario is not been without its social costs. The family farm has been replaced by the agricultural conglomerate in most productive parts of Australia. Thus the farm ethos has disappeared and replaced by industrial food production, the character of which is indistinguishable from any other OECD country. In fact, globalisation ensures that a consumer is never quite sure of where a product is sourced, only that it meets the quality and price parameters embedded in its brand name. The lower tier of Australian land use is seldom seen, but sometimes noticed when a back road takes the driver through the marginalised and degraded lands that are economically beyond repair, and thus left to subsist at continuing environmental and social costs.

This scenario finally allows Australian export market requirements to be seamlessly linked with agricultural production technologies. The political power of farming organisations is broken and subservient, tightly defined market specifications are always met and delivered in the quantities which the market requires.

Details of Key Facets of the Economic Growth Scenario

Size and Structure of Government

Government is small in size and very centralised. It is efficient in managing large information flows and producing distilled views of Australia's key performance attributes. This ability allows rapid policy changes, particularly for forward market opportunities. Government still retains the management of external relations, defence, corporate standards and so on. Most other areas such as health, education, social welfare etc. have long since been privatised.

Most information and management requirements are outsourced, which has produced a wide range of nimble and efficient firms who trade in key information flows and data sources. The firms keep national and regional statistics and retain a number of pricing tiers which reflect the timeliness and accuracy of the information that they sell many times to different clients. Information is the most valuable commodity in a trading nation. There is no in-built assumption that access to information is a right. However, information technology has managed to jump the 'ownership' issue, and once information is available in a digital form, it is quickly organised and distributed to a wide range of clients (paying and non-paying) by a wide range of data agencies.

Regulation of Markets

The effect of the economic growth scenario is to allow the full potential of market reform to diffuse through all economic sectors. Fast information flows and sophisticated performance auditing are keys to the success of the scenario. Corporate cowboys can be dealt with quickly in the corporate legal system. Suspension of share trading and closure of lucrative market opportunities are further threats, but are rarely used in an overt way.

The problems of externalities is dealt with corporately by a full system of tradeable permits. Government performs an auditing role which is in turn audited by international trade bodies. Non-compliance to agreed international standards has an instant feedback of penalties which restrict trade access to the markets of the all important trading blocks. In the agricultural and land use sector, the permit system has been designed to be extremely effective for water quality and land quality issues in the corporately held high quality production zones. On marginal lands and damaged lands the philosophy of 'low value—low scrutiny' applies.

Property Rights

All land is held as private tenure except large parts of northern Australia which are either Aboriginal land or defence training areas. The right to treat land, biodiversity and water resources as one's private fiefdom has been upheld in the courts many times. Productive zones are well managed by the linked interests of corporations who control access to water rights and the commodity sectors which use that water. The problems of marginal lands or damaged lands are ignored, except if they impact on key sectoral interests such as water quality or production. This impact is dealt with by acquisition, retirement and if necessary engineering solutions which seal off the problem rather than fix it.

National parks in the main have been privatised, and are now run as business ventures which attract their clientele on the basis of their environmental resources and quality. The market determines what is attractive, rather than any pseudo-scientific ideals of original biodiversity, threatened species and so on. Rights to clean air, clean water, access to semi-natural landscapes and so on are dealt with primarily by market mechanisms. There are two obvious options. 'Clip-on' technology will result in solution of water and water problems, and even access to semi-natural landscapes if you buy an appropriate piece of real estate. Alternatively, you can move to a location which has all three in semi-natural abundance, and then keep on moving by trading upwards or sideways if that is required. Communications technology has effectively decoupled workplace location from workplace location. You no longer have to be in Collins Street to be the CEO of a large corporation.

Environmental Quality Control

There are few controls on environmental quality, but this is balanced by a corporate environmental ethos which gains international market position through the quality of the food and fibre products. Food contamination problems are an anathema to whole agriculture industry because of the stigma attached to it. Quality problems cause quick runs on share prices, ensuring that the brightest and best managers are sought for the most important corporate positions.

The unhindered evolution of the economic growth scenario has allowed two production worlds to evolve in terms of environmental quality. The first world developed as agricultural conglomerates quickly acquired 'greenfield' locations of best soil quality, least historic problems and highest water quality. Their corporate ethos then ensured that all links in their production chain maintained the highest standards of environmental management, and quality product therefrom. The second world evolved in the older agricultural areas where farm enterprises declined as the full implications of dryland salinity, acidification, irrigation salinity and poor soil structure became obvious.

The production systems linger on, however, and are able to respond to spot markets for average and lower quality product. Much of this lower quality product goes to non-food industrial uses or to poorer markets in Asia and Africa. Trade is undertaken by a wide range of independent trading firms who will sell anything to anyone for a specific need and at a specified price. The major conglomerates are shielded from any implication in this lower quality trade, simply because they are not implicated in it. Australian 'farm sweatshops' in this context are merely the land equivalent of many manufacturing companies in any city anywhere in the world.

Land and water are now quickly traded items, sold on quality and price. There is no social value attached to a parcel of salinised farm land. It is judged to be a piece of machinery that has worn out, to be replaced. There is an eager (waste management) industry which takes on 'used' land at the right price, since there are a wide range of crops which have been developed to produce some product, again at the right price. Chief amongst these are range of cellulose producing plants which are used to produce liquid fuels and as feedstock for plastic industries.

The potential of river systems such as the Murray–Darling to be brine and effluent streams has been effectively dealt with because all water rights are now in the hands of a few big companies who specialise in delivering the correct quantity and quality of water at the correct time. They are closely linked to the agricultural conglomerates who own the high quality land, and have management rights to the key water catchments. The management systems needed to bring this into place, and the new infrastructure required, has meant much higher water prices. Old inefficient irrigation practices have long since disappeared. All urban areas pay high prices for town and industrial water , and are heavily penalised for effluent, phosphorus and salt loadings which are in excess of the water delivered.

Much of the lower quality grazing land is now used for carbon offset arrangements, a good source of cash flow to large pastoral companies who retained their extensive land holdings from the late 1990s. Land cover is increasing on these large holdings, and original environmental problems such as woody weed encroachment are now seen as a plus in the world of carbon offsets. Many of the pastoral smaller holdings, which were economically marginal in the 1990s were purchased en masse by carbon offset brokers on the world market. Feral animals are controlled primarily by management of waters but uncontrolled river frontages in many areas continue to maintain many environmental sores. Periodic harvesting of multiple protein sources (rabbits, goats, cattle, horses, kangaroos etc.) does produce periodic cash flow, but the rangelands are seen as a 'wild' resource which looks after itself. The environmental quality of the rangelands and marginal pastoral lands is thus internalised, with no national or corporate responsibility taken.

Taxation of Farm Businesses

Taxes will remain at low levels under an economic growth scenario, but tax auditing will ensure that all production sectors of the economy are treated equally. There are no 'sweetheart deals' for structural change or investing in biological capital.

Vertical integration and a large degree of overseas ownership of the agricultural conglomerates has encouraged the development of many legal loopholes: where pricing schemes allow a low local price to be paid, good returns can be made on sales in foreign markets. These schemes further reduces the tax 'take' within Australia. Profits may be repatriated back to Australia for re-investment in agricultural industries, but not necessarily in the production sector from which the products were sourced. Alternatively, the profits can flow to production sectors in other countries where tax breaks are available, or where cost structures allow the chance of higher profits.

Investment in Agriculture

Investment closely follows the demand requirements of the 'optimistic', 'best bet' and 'pessimistic' scenarios, leading to land and water rights for cotton, and a newly developed high quality horticulture (eg. wine) sector. Animal industries will be at a price and timing disadvantage for irrigation water, particularly in summer, initiating dis-investment in cattle and sheep grazed on irrigated pastures. Commodity value arable crops will boom and bust with world market cycles, perhaps accentuated by increased climatic variability and lowered resilience of agroecosystems under production and environmental stresses.

In real terms under an economic growth scenario, agricultural commodity prices are expected to remain relatively flat for the next 25 years. Agriculture will probably come a poor sixth behind other major sectors of the economy which grow rapidly as the world economy grows. The presence of countries with either overt or covert agricultural subsidies will ensure the continuance of fairly flat investment in Australian agriculture. This will diminish as highly efficient commodity firms begin to compete equally on a world market, although these firms even if they are 'Australian', will source their product wherever the supply, quality and product is right.

Depending on the availability of suitable feedstock, there is focused investment on the production of synthetic food products from vat fermentation and other bio-industrial processes. For particular products (eg. milk, cheese, butter), these synthetic factory products produced at or near the location of the market, tend to marginalise the original form of product (from irrigated pastures and dairy cows). The relocation of capital from old sources of product to new synthetic forms is swift and eager, since there is little love of the 'old ways' in a the forward looking and thrusting economic growth scenario.

Investment Support

Large crossholdings are common in companies that have inter-relations in the agricultural production sector. This ensures access to the specialist services of key production, transport and processing capability. Thus super conglomerates may develop linked investments in water, transport and port facilities merely to ensure access at key times, should resource quality or quantity become a problem. This is the alternative to the large vertically integrated company which owns and controls all aspects of the production chain. The latter system is more difficult to do in agriculture (compared with, perhaps, petroleum) because of the vast range of produce, its biological nature, and its relatively short shelf life.

Other countries will buy full production capability within Australia to ensure food security for a key number of product lines. The present trend to the overseas ownership of key processing capability will extend from plough to plate.

Values to be Encouraged

- Speed of delivery of appropriate quality product, at the right price, to globalised markets.
- Accuracy and speed of information flows, with good look-ahead capability
- Imagination to define and develop a never-ending array of products and market niches.
- Responsiveness to the whims of the market, no matter how strange or difficult.
- Continuity of supply and the ability to make up shortfalls from anywhere in the globe
- Technical ability to make every by-product a saleable commodity for some market, some where.
- Maintenance of corporate trust and quality standards.
- High level of linked trading ability throughout the agricultural production sector so that a manager is able to relate changes in product quality and time of supply, to quality of inputs (eg. water quality) and subsequent environmental charges (nationally or internationally).

Research Support

In some areas of research, Australia has maintained and expanded its capability, and it is still an important node for privately owned agricultural research. Some key breakthroughs for integrated farming systems under saline and acidified soils have maintained a competitive advantage, although that information is not used in Australian production systems.

All new crop systems used in Australia now come from a limited number of genetic engineering laboratories in Switzerland, the USA and Japan. It is not even necessary to test varieties locally since the physical, chemical and hydrological properties of the worlds landscapes and soils are well known. New highly engineered crop and pasture varieties are regularly dispatched from these central labs to the individual countries for propagation and distribution. Mismatches with environmental requirements are quickly rectified, and escape of weedy plants is regulated by an encoded five year destruct mechanism.

Animal research is likewise not needed since highly adapted 'product line' animals are regularly flown in from the overseas research labs, multiplied and run into the particular conglomerates food production chain.

There exists a grass roots research capability within Australia which thrives through the excellent communications technologies which all but the very poor have at their disposal. The individual wealth generated by rapid economic growth has given a significant minority the access to land not acquired by the agricultural conglomerates. While not really a counter culture movement, this research is competent, practical and regionally diversified and easily accessible. It serves as an ongoing buffer, and an alternative source of specialised product when overseas market demands.

Infrastructure Provision

Many key networks for transport, energy, urban water and so on have long since been privatised. In general, higher quality service and lower prices have resulted. With no limitation for maximum ownership levels, some utilities have crept back into control by very narrow power bases. For agriculture, much of the ownership and function of key infrastructure has been determined by its age and state of repair in the first decade of the new century. Old dams and well established irrigation schemes with environmental problems were left to wither. The resident populations and their traditional industries maintained a lower quality of life, with occasional upturns when their product mix was again demanded.

The agricultural conglomerates have shifted to newer areas with high quality water, soil and new infrastructure. Northern Australia in particular has benefited from some of these shifts where the water-soil-product mix was right. In southern Australia, new land is accessible through a combination of new water rights and new irrigation technologies. New global forecasting tools allow the conglomerates 1–2 years planning time in advance, enabling rapid responses to global food opportunities. Shifting cultivation is practiced in a highly organised way, but with little regard to land and water requirements. In years when opportunity is large, whole regions are ploughed from fenceline to fenceline.

Transport infrastructure has been retained and developed to service the conglomerate dominance of the agricultural areas. Key railway trunk lines are owned by linked sets of companies and serve them first. Rapid advances in pipeline and conveyor technology allow many traditional modes of transport and handling to be bypassed.

Precise definition of market volume and requirements, and Australia's increased value adding capability has meant that absolute volumes of material are greatly reduced. Increased volumes of by-product and effluent has to be dealt with locally, which in turn has increased (by several orders of magnitude) the infrastructural needs for waste treatment.

Services Provision

Since a high quality and 'constantly learning' workforce is seen as the key to even higher levels of economic growth, the private education system has grown to dominate the education sector. For agriculture, this has meant that the agricultural universities and faculties are now owned by the main agricultural conglomerates, and are now tightly focused. Some are focused on regions where integrated production is important (eg. grain, forage and cattle and feedlots) while others are focused on particular products (eg. wine, cotton, rice).

Health and social welfare provision are again mainly private, and insurance schemes provide well organised and funded service provision. Vertically integrated industries who need to attract and keep important sets of key skills, provide easy access to these services as part of an employment package. Less skilled workers and the unemployed compete for a range of safety net provisions supplied by a much smaller government, and a range of privately funded welfare organisations.

Community Support

The nature of community support for agriculture has changed vastly, and farmers and their families have disappeared from public view. An economically deprived person is just that, whether they are in a city slum, a country town or a distant sheep station.

The brand name of the food conglomerate has replaced the idea of beef farmers, orchardists or shearers. Everyone in the production chain is now an important cog in the wheel, but no particular set of people get special status. The nature of global competition means that quality can be kept high and prices kept low. Successful conglomerates return their profits back to their shareholders, but much primary industry is now overseas owned. This does not mean that profits automatically flow offshore. Rather they are re-invested in the next sets of products that the global market might be needing. This can give big boosts to particular regions and products, and rapid withdrawals from others.

Scenario 2: Conservative Development

The mid-term future of Australian Agriculture under a conservative development scenario

Introduction

This chapter reviews the types of changes that might occur in the agricultural sector of the Australian economy in the event of the electorate moving to strongly support the adoption of a national strategy of conservative development as its preferred avenue to seeking high quality of life for Australians over coming decades. More generally, this is a scenario in which agricultural industry is free to produce what it chooses where it chooses subject to viability and feasibility considerations under:

1. Future market-generated cost-price-technology regimes.
2. A range of direct regulations proscribing nominated products, technologies and locations region-by-region.
3. Changes in cost-price-technology regimes created by government programs, eg. levies, subsidies, property rights markets, research.
4. Self-imposed constraints on production, eg. ethical considerations.

Being an export-oriented price-taking sector, it can be assumed that free market costs, prices and technologies would be similar under the three scenarios being considered for the agricultural sector, namely economic growth, conservative development and post materialism. However, the other factors driving the output level and mix in the agricultural sector—regulations, price-changing interventions and self-imposed constraints—stand to be markedly different under the three scenarios.

The question we ask here is whether, as a result of these differences in output determinants, an Australia committed to conservative development is more (or less) likely to meet the output schedules envisaged for 2025 under the optimistic, best bet and pessimistic scenarios for world growth than under a deregulated market or economic growth strategy for Australia.

The prima facie answer to this question has to be that Australia will choose not to meet the output targets suggested. This is because under a conservative development strategy for agriculture, farmers will be stopped from using land as they wish in many situations, will be excluded from land set aside for conservation purposes and will have to pay higher prices for basic inputs such as water and inputs standing to carry environmental levies such as chemicals.

The possible situation that farmers of 2025 might be facing is well-illustrated by the Natural Resources Management Strategy flagged by the Murray–Darling Basin Ministerial Council in 1989 and incorporating policies such as the following:

- a moratorium on further clearing of native vegetation in the Basin;
- selective re-establishment of trees in areas where this would have maximum effect on the spread of dryland salinisation;
- purchase of cropping rights in marginal areas;
- imposition of erosion-retarding cropping practices;
- transferable water rights;
- a network of evaporation basins;
- water to be sold at full cost including amortisation of headworks;
- no new cities and carefully controlled expansion of existing regional centres;
- detailed environmental impact assessment of all proposed new industrial projects;
- projects involving irreversible devaluation of natural capital to be offset by projects to conserve other natural resources under significant threat;
- a major land allocation exercise covering conservation, recreation, tourism, timber plantations, industrial infrastructure etc.

Every one of these proposals stands to reduce short-term profit maximising possibilities and hence output levels.

Conversely, there are several reasons why output under a conservative development agricultural strategy might tend to be higher than under an economic growth strategy for agriculture:

1. Government funded agricultural research stands to be much greater under a conservative development agricultural strategy than under economic growth. this in turn stands to hold the rate of technical progress, the basic source of productivity increases, at a higher than otherwise level.

2. Product quality might possibly be higher under conservative development leading to higher unit prices for agricultural exports, thus tending to offset lower quantities of exports.

3. Land prices in higher rainfall more-heavily-settled areas may be lower under a conservative development agricultural strategy than under an economic growth scenario because there could be lower population pressure to drive land prices up in peri-urban regions. Lower land prices imply higher profits and greater output. Production in Australia's high-rainfall zones will be critical for meeting nominated output schedules in beef, dairy products, sugar, fruit and vegetables.

4. Land degradation leading to declining productivity and output in some regions may well be dramatically higher under an economic growth strategy for agriculture than under a conservative development strategy.

Other Wheat–Sheep Zones

SOUTHERN AND WESTERN WHEAT–SHEEP ZONES

How might land degradation be higher and output lower in our key agricultural areas? There is little disagreement that the drier parts of the Murray–Darling Basin and the other parts of the wheat–sheep zone in eastern and western Australia are under threat from a range of ongoing land degradation processes (problems of soil salinisation, acidification, compaction etc.). Under current and foreseeable prices for the products of these areas (wheat, oats, barley, oil seeds, lamb, wool) it is extremely doubtful that productivity-conserving land management practices are economically justifiable. This means that, left to market forces, outputs of these products may rise in the short term but fall in the longer term as productivity declines bite.

In contrast, under a conservative development agricultural strategy, production stands to fall somewhat in the short to medium term as conservation measures are implemented and then stabilise at a sustainable level. If this perception is correct, the question of interest is how fast declining productivity might lead to falling output in these areas and what the prospects are for countervailing technology to maintain production. It is not at all impossible that, by 2025, output from the southern and western wheat–sheep zones would be higher under a conservative development agricultural strategy than under an economic growth strategy. However, under either strategy, there is little reason to see production exceeding current levels.

THE MURRAY–DARLING BASIN

Production in this zone could well increase under both an economic growth strategy and a conservative development strategy. There are several reasons. A greater intensity of cropping is possible and the area used for cropping could still expand. Productive soils and the possibility of producing high protein higher valued crops means that soil conservation measures are more likely to be profitable and hence more likely to be implemented under both strategies. The northern third of the Murray–Darling Basin has undergone dramatic changes in land use, in terms of both diversification and intensification, since the second world war. These include steady increases in the production of winter grains, massive increases in summer grains and, more recently, cotton and oilseeds. Total livestock units have increased by perhaps 50%. Increased use of fertilisers and irrigation water have been the driving forces in this transformation. The options of running sheep or cattle and growing summer or winter crops make this the most flexible extensive farming area in the country.

The average wheat yield on the Darling Downs in the north-east of the Basin is nearly five times the national average. The Downs is commonly presented as a highly productive and efficient farming district, yet an average of four to eight mm of rich black earth is lost there each year as a result of soil erosion. At this rate, the fertile topsoil will be exhausted in 30 to 50 years. Over 10,000 ha of this "gem in the crown of Australian agriculture" have already been retired from cropping due to irretrievable erosion damage. Many of the upland farms in the Downs are small and probably only marginally economic. Consequently, farmers find it difficult to afford adequate conservation measures and to avoid cultivating the steeper (erodible) upper slopes. Ignorance and apathy play a part too.

Apart from erosion, which is well recognised, the Upper Darling Basin may be on the verge of experiencing more of the land degradation problems already being experienced further south. The intensification of the last 40 years has opened the way to salinisation, loss of soil structure and soil acidification. The input–output balances of water in the landscape have been massively changed and new equilibria have not been established.

Table 26
Some product mix implications and tensions arising from the product by region interactions of meeting the three demand scenarios under the 'Conservative Development' scenario of supply.

Commodity	Murray-Darling Basin	Other wheat-sheep	High rainfall zone	Northern Australia
Wheat	Reduced production because of 'forced' set aside of large areas of agriculturally marginal or high conservation value land	As for MDB, but more set aside for salinity and biodiversity concerns. Possible increase in production later due to soil conservation measures		
Coarse grains	As above, probable increase in average yields due to withdrawal from marginal land	As for MDB, but more restrictive expansion environment		
Rice	Much lower production than at present			Some localised expansion, but recognition of looming problems
Beef and veal	Reduction in stocking rates, but production systems similar to current ones	Similar to MDB	Retraction by regulation. Forestry and horticulture take over higher quality soils	Large scale retraction from marginal areas following government buy back and land rights schemes
Sheepmeat	Emphasis on higher quality from reduced numbers	Much lower than present		
Wool	Wool markets do not pay enough for adequate environmental protection	Supply and quality problems	Not seen as major here	
Cotton	Water rights, with strong environmental regulation permit limited expansion			Limited expansion with transgenic cotton able to deal with cost/pest problems
Sugar			Retraction due to environmental controls and competition for water	Limited expansion in more marginal rainfall areas permitted by water rights, under strong environmental control
Horticulture	Expansion of high quality horticulture due to water rights system	Similar to MDB, but distance from markets and lack of water limits development	Actively promoted as high value, highly regulated industry. Water rights permit substantial growth	Significant expansion as in high rainfall zone

Table 27
Some environmental tensions arising from the product by region interactions of meeting the three product demand scenarios under the 'Conservative Development' scenario of supply.

Commodity	Murray–Darling Basin	Other wheat–sheep	High rainfall zone	Northern Australia
Wheat	Ongoing degradation processes will be unable to be met even by increased research and lower production stresses	As for MDB, perhaps worse. Amelioration strategies may improve situation in the long term		
Coarse grains	As above	As above		
Rice	Continued rising water table and irrigation salinity, although research has assisted			Irrigation salinity problems still present. Research shows withdrawal is only long term option
Beef and veal	Land degradation issues remain, although covenants are helping	Overgrazing of marginal lands still a problem	Feedlotting increased, although under massive regulatory restrictions	Rapid changes in land tenure system leave unclear environmental future despite destocking
Sheepmeat	Despite lower stocking rates and other measures, degradation still occurring	As for MDB		
Wool		Prices insufficient to pay for environmental costs		
Cotton	Strong regulation lowers stress from industry, assisted by water rights			
Sugar				Restriction on further clearing of coastal vegetation and concerns about coastal water quality restrict development, but problems with land and water still persist
Horticulture	Bigger industry places more stress on available resources, although regulation restricts over-exploitation	As for MDB	Very strong regulation to restrict nutrient and pesticide pollution	As for high rainfall zone

Current interest in the use of effective new arboricides to clear the poplar box woodlands, here and further north, will certainly increase short-term stock-carrying capacity but may also eventually induce extensive dryland salinisation.

CENTRAL AND NORTH-CENTRAL QUEENSLAND

North of the Murray–Darling Basin, and largely in the northern wheat–sheep zone, are the established cropping areas (grains/oilseeds, cotton) of the central highlands and the Dawson–Callide valleys of the Fitzroy Basin, and it is around the margins of these areas (as well as the edges of the Upper Darling Basin) that dramatic increases in crop area have been occurring and could continue to occur. While considerable potential for further westward and northward expansion certainly exists, the rate is likely to be dampened by the problems of developing stable farming systems in these climatically variable areas, the lack of suitable crop varieties and inadequate marketing facilities. Under a conservative development strategy, this potential expansion would be more likely to be held back until stable farming systems were developed to cope particularly with high intensity rainfall. On the other hand, suitable crop varieties and adequate infrastructure are more perhaps likely to eventuate under an interventionist philosophy of government funded research and government funding of infrastructure than under free market conditions, given the considerable uncertainties involved.

Also, throwing emphasis back to livestock farming in this region under an economic growth strategy, is the continuing improvement in the range of pasture species available and the advent of efficient new tree-killing chemicals. There is a danger here. Clearing woodland on low-fertility soils raises its short-term carrying capacity but all too frequently leads to loss of fertility and the invasion of unpalatable species. Thus prospects for an expansion in beef production would appear to be much lower under a conservative development strategy seeking to avoid such outcomes.

The Rangelands

Despite their great area, the rangelands do not and will not contribute greatly to agricultural exports under any scenario. And, with several exceptions, notably the prospects for live young beef exports from several regions, prospects for significantly increased production under either an economic growth or a conservative development strategy are modest. It is doubtful whether even totally unregulated exploitation would increase short-term output significantly and it would certainly reduce long-term output as a result of destruction of perennial vegetation. Under conservative development, very large properties running stock at low densities constitute the most likely scenario. Production might fall somewhat, but, as noted, the impact on national exports would be minor.

The High Rainfall Zone

Agriculturally speaking, the high-rainfall zones, where soil waterlogging is more likely to inhibit plant growth than soil dryness, range from the sugar lands of Cairns to the superfine Merino country of southern Tasmania.

The intensively farmed parts of the Queensland high-rainfall zone comprise the wet tropics of Cairns–Ingham, the Atherton tableland, the Burdekin, Mackay–Proserpine and Bundaberg–Maryborough. Apart from the recently less regulated sugar industry, the backbone of the north Queensland economy, they supply fruit and vegetables to much of eastern Australia, particularly in winter. The range of crops which are beginning to be grown in a small way (eg. coffee and tea) or experimentally is large and prospects for the Queensland high-rainfall zone are excellent. Soil erosion (because of steep slopes and intense rainfall) is a potential problem in large areas and an actual problem in many banana and pineapple plantations, even those on well-structured kraznozem soils with a great capacity to accept water. Returns are such however that production would not be curtailed by the imposition of soil conservation requirements under a conservative development strategy.

Elsewhere in the high-rainfall zone, farming systems are well-established and without the overwhelming problems of so much of Australian agricultural industry. By the same token, prospects for large output increases are not obvious. Winter wheat for grazing and grain on the arable parts (say a third on average) of properties in the high-rainfall zone is an interesting possibility. After all, Tasmania was once the granary of Australia! Livestock production based on productive improved pastures is particularly important. The key to the relatively high standards of land management in the high-rainfall zones is that the land is valuable enough per unit area to warrant expenditure on improvements and, in the face of degradation, preventive and ameliorative measures.

It could be that production and exports from some high rainfall agricultural enterprises might expand under a conservative development strategy relative to an economic growth strategy, eg. wine, tropical fruits, sugar. The reason is that such enterprises are land intensive rather than land extensive and that land is more likely to remain available for agriculture in the wetter settled areas of Australia under a conservative development strategy because of lower competition for land from highly competitive population-driven land uses such as residential development.

Concluding comments

Unlike a post materialism scenario, which envisages massive change in the Australian agricultural production system, the economic growth and conservative development agricultural strategies can readily be seen as variations on the present system with one going further down the deregulation path and the other using the resources and powers of government to implement much of the 'sustainable development' rhetoric that has bombarded Australia in recent years.

The tentative conclusion being suggested here is that a vigorous implementation of the types of protective measures noted would probably reduce production in the northern rangelands and the wheat–sheep zones at least for a period of some years. Subsequently, and it is difficult to suggest just when without further work, production under an economic growth strategy might fall, and continue falling, below that being maintained under a conservative development strategy.

In the high rainfall areas, measures associated with a conservative development strategy are less likely to reduce the output of the more valuable products associated with these areas and indeed may even improve their quality and unit value.

Provided then that world economic growth delivers the opportunity to sell increased quantities of Australia's main agricultural exports, it cannot be taken as given that the best way of meeting that opportunity is to largely deregulate the agricultural sector and let market forces produce those exports.

Scenario 3: Post materialism

An Agricultural Strategy for an Ecologically Sophisticated Society

Introduction

Post materialism is further from current socioeconomic conditions than either the 'economic growth' or 'conservative development' scenarios. It is included in this exercise to show the implications of pursuing a set of social, environmental, and economic goals outside the current paradigm, although addressing the same problems of low economic growth, declining environmental quality, and increasing sociopathy.

A quite different scenario could have been an equally valid choice for this purpose. Post materialism is used here because it suggests a deliberate search for a truly long term ecological and social future for Australia. Some may describe this as 'strong' ecological sustainability. The drivers towards the acceptance of such a scenario come from many quarters, even the farming community itself:

> *"In short, existing systems of food and fibre production are unsustainable. The rural sector is aging, declining, stressed and going broke, and depleting natural and human resources in the process.... More sustainable systems of land use and management are unlikely to be developed or implemented by people preoccupied with short term survival" (Campbell, 1994)*

As outlined in the chapter on three national strategies for Australia, post materialism implies a highly decentralised society with a very strong commitment to ecological integrity and social learning as means of developing and maintaining improved quality of life. Reduction of inequality and sociopathy feature as key social aims under this strategy.

This scenario's impact on the agricultural sector is primarily through the adoption of a set of key principles aimed towards the creation of an ecologically sustainable agricultural system. These maybe defined as (certainly not uniquely, or even originally, being enunciated by the Australian Standing Committee on Agriculture (1991)) inter alia: *the use of farming systems or practices which maintain or enhance*:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems influenced by agricultural practices

These principles are interpreted in a post materialist society as requiring the conversion of freehold land to leasehold with binding covenants, integrated management of real biophysical units such as catchments, a variety of controls on environmental quality, community assessment of new agricultural proposals, and massive innovations in public and private interest research. Also certain is the adoption of new products, technologies, and attitudes, perhaps best characterised by the word 'diversity'. Much greater (and better) use of human capital is assured.

Agriculture in Post Materialist Australia

The Big Picture

Social organisation in a post materialist Australia would be based on about 20 'bioregions', each with its own government. State governments would have a minimal role. Each region would have a degree of self-sufficiency, perhaps within explicit regional population targets or ceilings. Some bioregions might be largely in Aboriginal ownership. The national government would retain strong control over international affairs including defence and trade. Domestically, it would set frameworks and minimum standards in diverse policy areas (eg. in employment, in environmental matters) within which regions would be free to develop autonomously. Encouragement of massive decentralisation would be a national budget priority. Internationally, Australia would actively defend its protective stewardship of a fragile land acknowledged to be a major part of the world's heritage.

In one sense, this is a 'land hungry' scenario in which the per capita demand for land would be high, because each person is placing a large but light footprint on the landscape. For example:

- more wind farms and solar farms
- more timber plantations
- more land devoted to producing renewable substitutes for non-renewable mineral and energy resources
- more native forests committed to light selective logging

- widespread ownership of hobby farms and rural retreats
- more dedicated (single use) water catchments
- more parks, reserves and wilderness areas
- more low-intensity agriculture
- more urban forests and garden cities
- more 'half acre' urban residential blocks supporting low-energy houses, productive gardens and solar, water collecting and sewage composting technologies

The post materialist agricultural landscape is essentially different from anything we have contemplated over the past 200 years. Revegetation of up to half the area of all farms reduces salinity and acidity problems and erosion, provides shelter for native and farm animals, is a source of valuable timber crops, stabilises nutrient flows, maintains water quality, and is seen as just as valuable as other forms of agriculture. Farm level planning continues the bio-regional approach adopted by the state and local communities, using soil type and landscape boundaries, 'keyline' principles, and integrated, diverse production systems. Healthy, functioning, and evolving ecosystems are seen as valuable for their own sake. They are also widely understood to be essential for the maintenance of production systems. Management is focused on the long view, using techniques such as new forms of no tillage farming to actively improve soil condition. Other new features of farming include the dramatic improvement in the knowledge base about our land, and transfer of all sorts of technologies (social, industrial, and agricultural) to regions, local communities, and individuals: "not high tech, not low tech, but just right tech!" (Graetz, 1994). These attitudes are seen as simply essential to future success and well being.

Major changes occur to the nature of food and fibre production systems under this scenario. Animal rearing becomes much more diverse, and includes the farming of native animals such as kangaroo, emu, and wombat. Emphasis is placed on quality and value added production, rather than on volume. Feral pests are a problem of the past because of biological control.

Massive increases in native plant production occur, with bush foods being a major collection of domestic and export niche markets. Pharmaceutical crops have emerged as significant niche export income earners. Seasonal production and consumption patterns are re-adopted. Annual crops are now only seen as part of complex mixed production systems. Pest control by combinations of polycultures and biological control methods has succeeded widespread use of chemicals, although new generations of 'natural' treatments are available. Perennial tree and pasture crops have begun to be seen as not only valuable for soil, salinity, and water management, but also as a way of increasing profits through lowering fuel use. Broadacre grain farming has retreated from all marginal areas, notably closing much of the Western Australian wheat industry. Land thus left vacant is actively returned to native vegetation or grazing.

Local production of alcohol-derived fuels to take advantage of newly available and better utilised biomass has further reduced demand for fossil fuels, and all remote area electric power is produced by solar or wind. A significant source of income for some rural residents is the sale of power from renewable resources to distributors. Sources of biomass are region-dependent, with ligno-cellulosic fermentation of woody natives dominating in drier areas, and hemp, tubers, specialist crops and sugar in more humid ones. Fuel cells driven by methanol (Ruthenium catalyst/semi-permeable membrane cells are currently (1997) in operation) provide reliable electricity and motive power.

Producer cooperatives have replaced centralised organisations in marketing and product distribution, with significantly increased profits and control. These bodies are better able to cope with the diverse niche marketing of the high value products now favoured over the volume of the late 20th century. Vertical integration is highly developed to include initial processing, goods production, and sales. This extends to include the consumer, with rapid and effective feedback to processors and primary producers via advanced telecommunications. Rural communities retain more control over their products, profits, and well-being. Finance by rural credit unions has almost replaced banks, with the strong entrepreneurial spirit of rural Australians being focused on their community's development. Electronic communication, telecommuting, and other forms of decentralised work has increased both the number and diversity of rural populations, stimulating growth of a disparate range of vibrant and healthy communities

The Regions

Northern Australia

> *"These are Australia's most inferior pasture lands, with their extremely low nutritional value in the dry season enforcing a grazing regime characterised by uniquely low stocking densities, usually below two beasts per square kilometre. Cattle are of poor quality, suffering annual nutritional stress, poor weight gain, high mortality and calving rates commonly below 40%" (J. Holmes, 1986)*

The massive areas and distances of northern Australia, coupled with unique climatic, soil, and ecosystem functioning separate this region from the rest of post materialist Australia. Settlements are widely scattered and self sufficient, but thoroughly integrated into the production systems of southern Australia. Stocking rates over the entire region have dropped by 50% or more, with concentration on breeding for fattening in more temperate climates. Tree crops are common substitutes for pasture species. Grazing is restricted to small, highly productive and managed locations with intensive use of tropical legumes, perhaps only 10% of the area of a farm, with the remainder set aside for native drought pasture and other crops. This in turn reduces pressure on biodiversity over large areas.

The wetter areas of the north are now seen as some of the most valuable in Australia, producing a massive range of products from bush plums to termites. The latter, being much more efficient harvesters of dry organic matter than cattle, are now farmed for a range of consumer goods including Termite, the rage replacement for Vegemite. Selection and genetic engineering of native fruits, tubers, and grains to increase desirable characteristics is under way.

The transfer of 'billabong culture' from Aboriginal people to the wider community, when mixed with modern land use management techniques and philosophies, provides a huge range of food commodities to Australian and overseas communities. In north Queensland, sugar production is stabilised at 1990s levels due to competition for land, water pricing, and environmental controls. Demand for traditional sugar crops has stabilised with the decrease in highly processed food and read-to-eat meal production.

More arid regions are seen as seasonal agricultural lands, with little permanent cropping or grazing. Use of highly productive but sporadic native crops such as channel millet (Echinochloa sp.), native sorghums, and various tree crops is dependant on seasonal flooding or rains. The biodiversity conservation and water management value of these inland northern regions takes precedence over production under post materialism.

Large intensive agricultural schemes such as the Ord irrigation system remain highly productive areas, and have provided expertise to new locally developed and smaller cooperatives. These are designed around very high technology irrigation and land management principles. They are often situated to take special advantage of particular local landscape or infrastructure features.

Conservation has been recognised as an important and valid land use in the north. It has displaced pastoralism in many areas, notably the Kimberley, Cape York, and larger parts of the Top End.

Murray–Darling Basin

> *"From the headwaters to the terminal lakes, the salinity of the Murray becomes progressively more influenced by the natural inflow of highly saline groundwater. These natural inflows have been increased and will be increased still further in coming decades as a result of both irrigation and dryland farming practice. Be assured, the Murray–Darling basin is in trouble." (K. D. Cocks, 1992)*

The Murray–Darling basin was the first area which adopted post materialist agriculture, driven by declining social conditions as well as agricultural yields. Its proximity to Australia's major markets assisted the transition. Sheep and wheat still occupy up to half the area previously farmed, but only provide 20% of farm income due to reduced stocking pressure and longer crop rotation cycles. Other income from a diverse range of animals and crops, value adding at local and regional levels, and a constant search for higher quality and small, discriminating new markets have made this region highly profitable again. Population is increasing in rural towns and villages, farm sizes are smaller, and lifestyles and income streams diverse.

Greenhouse-induced climate change has made cotton 30% more efficient in water use, which, when coupled with adoption of advanced semi-dryland cotton farming and precision farming techniques, has nearly doubled production tonnages over 1990s levels while returning more than half its water allocation to the rivers for environmental flows. Much stronger regulation of water extraction and chemical usage have assured Australia's position as the world's leading organic cotton producer.

Rice is no longer grown in large quantities in the Murray–Darling basin, despite pressure from Asian consumers. It is simply regarded as too environmentally damaging and wasteful of water to indulge in here. Instead, niche market high value rice production (jasmine, basmati, etc) is grown in small areas, with an emphasis on companion products such as fish, mud eyes, yabbies, and algae. Multiple use of irrigation water resources is necessary and encouraged by real environmental cost water pricing.

Product diversification in this region includes the massive production of native wildflowers, as well as a wide range of (largely organic) fruits and vegetables. Tree crops, both native and introduced, are also important.

Other Wheat–Sheep Areas

> *"Agriculturally, the region may yet contract as fast as it expanded: dryland salinisation is taking 250 square kilometres a year out of production and the region is earmarked for increasing aridity under greenhouse scenarios... The large Swan and Blackwood rivers, which were once fresh, are now too saline to be dammed for agricultural use or human consumption. This is environmental degradation on a tragic scale". (K. D. Cocks, 1992)*

Australia's humanitarian global support position still requires the production of large tonnages of grain to feed growing populations in Asia, Africa, and South America during their transition to post materialism. This requires the maintenance of wheat production in areas which would otherwise be returned to native vegetation on a massive scale. In total, about 30% to 40% of all wheat–sheep land in production in the 1990s is no longer used for these purposes. Sheep numbers in particular are dramatically down, with all wool production from very high quality, intensively managed flocks in small areas. However, the consumer move away from the 'supermarket culture' towards more personal, meaningful service has provided niche markets for high quality, purpose-built organic grains and flours for pasta, bread, and meat products.

As in the rest of Australia, land is managed from a landscape function perspective. In these fundamentally low productivity regions, nutrient input–output and flow is seen as a key management parameter. Production is therefore tailored spatially and temporally to suit. Cropping cycles are modified and lengthened, sometimes including periods under forest or tree crops. Genetically modified grains are introduced to produce plastics which replace our dependency on petrochemicals. Kangaroos, perhaps genetically engineered so as to not jump 2 metre fences, graze native pasture/woodland regions, and provide a large source of export income.

Climate change has altered the expectations of farmers in these regions. It has closed the northern wheat areas in Queensland, and increased rainfall in Western Australia has worsened the existing salinity problems. However, it is starting to result in a more diversified landscape both naturally and through management strategies.

The High Rainfall Zone

> *"Although Australian cities and towns occupy only 0.01 per cent of the continent, this area is concentrated in our most important catchments and often on high value agricultural land. Urban fringe development and coastal development often compete with agricultural and conservation land uses. The impact of human habitation extends far beyond the area cleared for buildings and infrastructure". (State of the Environment Advisory Council, 1996.)*

Australia's Ecumene, the inhabited areas of eastern and south western Australia, have become even more our residential and conservation centres than in the 1990s. Very high productivity land is still intensively managed, but for a wider range of produce than previously. Integration of a strong conservation reserve ethic with pro-resource management attitudes has created a seamless on- and off farm natural resource management system. Catchment-based government has replaced local councils, bringing urban and rural dwellers closer through systemic management systems.

Production systems in this region are hard to characterise because of the dramatic diversity. Forestry is not seen as simply a single product industry, but is now effectively managed for timber, food, animals, conservation, and recreation. Proximity to markets permits harvesting and sale of very high quality produce to a range of discriminating markets. Cropping regimes in parts of these regions still produce large quantities of oil seeds and specialist grains, but include more regional processing cooperatives. Feedlots are seen as inefficient use of resources and often polluting, and are highly regulated.

High value agriculture such as dairying, horticulture, and a range of small mixed farming systems have been boosted by increased research, community development, and land stewardship. Demonstration communities designed to include varieties of permaculture as well as biodynamic and organic farming methods, mesh neatly with advanced technology industries (including hydroponics, aquaculture, and biotech) and processing, and knowledge-based employment. Ecodesign and studies of industrial (and agricultural) ecology are the norm.

An example of the difference which has been achieved is the Hunter valley, where re-afforestation of 80% of the area has changed local atmospheric conditions, increasing rainfall and productivity. High value horticulture (including grapes, tree crops and vegetables) has increased in area, and salinity has become a problem of the past through effective land management. Proximity to major centres has encouraged rejuvenation of towns and villages in the valley.

The Product Mix in Post Materialist Australia

Diversification, new products, niche marketing, self sufficiency, dramatically improved quality and ecologically sustainable volumes form the core of this agricultural strategy. Recognition of pressing environmental constraints by the Australian community will force the reduction of areas planted to wheat and coarse grains, and stabilisation of the acreage of sugar, rice, and cotton. Animal numbers in traditional farm systems are likely to decline for similar reasons, and because of the change to more diversified systems.

The income gap will be more than filled through three main changes: value adding, quality improvement, and new products. These are all driven by the desire of the community to regain control over their lives and their future. Emphasis on social values which supplement material wealth has reduced demands for more and more production—in fact, dematerialisation of the economy has reduced flows of materials and energy in Australia by 50% since the turn of the century. This has significantly increased quality of life by reducing pollution, energy use, and other attributes of the late 20th century.

Environmental Quality

Maintenance and indeed improvement of environmental quality is one of the key goals of the post materialist world. This implies that policies will be adopted and implemented to achieve these goals, probably at the expense of gross agricultural production (as seen in the previous sections). Such a position is in clear contrast to the other agricultural strategies outlined in this report. While post materialism may be seen as somehow outside the realms of probability, it is included to demonstrate that active and responsible government can improve quality of life as well as improving environmental quality.

Dramatic improvements are likely in biodiversity quality under postmaterialism, simply through effective retreat of grazing and cropping practices from large areas of land. Active rehabilitation of specific habitats also occurs under government and community-sponsored schemes. Water quality remains a problem because of inheritance of historical problems, but is being dealt with by research, revegetation, lower extraction and use, pricing, and massive environmental quality programs. Salinity (dryland and irrigation) is seen as a long term problem which will take generations to combat. Land degradation has largely been overcome through the dramatic changes in agricultural practices, product mixes, revegetation, and retreat from marginal areas. Soil quality on most farms has increased and will continue to do so.

Table 28
Production changes under a Post Materialist agricultural strategy

	Northern Australia	Murray–Darling Basin	Other Wheat–Sheep	High Rainfall
Wheat	Severe decline	50 per cent of present area, same output	60 per cent of present area and output	Some niche production
Coarse grains	Sorghum, kenaf in north	Same as wheat	Same as wheat	Same as wheat
Sugar	Stabilised at 1990s output	na	na	Little, no new expansion
Sheepmeat	na	Half present levels, replaced by native animals	20 per cent of present levels, replaced by native animals	na
Wool	na	Half present output, high quality	Less than half present output, high quality	na
Beef & Veal	Less than half present stock, present output	Small, replace by natives	Small	Some feedlotting, little expansion
Rice	Most production closed	Niche production only	na	Only for local consumption
Cotton	Little	Double output	na	na
Horticulture & other	Massive increase, particularly in bush foods	Massive increase, very diverse	Massive increase, particularly wild flowers and tree crops	Dominant agriculture, extremely diverse

na—Not applicable as not grown in region.

Summary

Post materialism may be considered by some as a utopian world which can never be, or perhaps should never be, achieved. However, an alternative perspective is that without such a transformation, Australian agriculture has little long term future. The scenario presented here is but one of a range of possible ways which deal with the challenges of deliberately maintaining environmental quality.

Two issues become important here: the pathway to achievement of post materialist goals, and the place of post materialist Australia in the world. The first of these issues is highly enigmatic, and until complex models are constructed and built, no answer is possible. Obviously, a key achievement must be the changing of deep and important values held by many groups in society. Community recognition of attributes other than material wealth will require fundamental value shifts. The second issue is of equal difficulty, and has yet to be clearly argued. Post materialism may then be a serious option for Australia.

Summing up: Scenarios for the future of Australian Agriculture

Options and Possibilities

If we do not explore the consequences of our choices, our freedom to choose is an illusion. Exploring consequences requires logic and analysis, and the rigour to follow through the implications of current or perceived future behaviour. There are a large range of forces which play a role in determining our possible futures: the forces of nature, social, political, and economic dynamics, scientific discovery, the development and application of technology, and the fundamental capacity of our resource base. However, with our enormous capacity to alter natural systems, human choice increasingly shapes the future we actually spawn. Futures methods, such as scenarios, systematically explore, create, and test possible futures in this context.

Perhaps the most common use of these ideas is to identify what you don't know, but need to know, to make intelligent and informed decisions. The scenarios outlined in this report have been developed for exactly this purpose. They are simply aids to help us make better decisions today through the construction of plausible images of the future. This exploratory forecasting has been carried out in a quantitative/qualitative combinatorial manner which takes best advantage of available information and expert knowledge to develop three plausible futures. It must be emphasised that the 'word pictures' presented here are only the first step in a complex, multi-stage process of scenario development. An ongoing development and analysis of these broad themes must take place with stakeholders to fully define important implications and key relationships.

Scenarios are narrative descriptions of the future which focus attention on causal processes and decision points (Kahn, 1967). No scenario is ever probable, merely plausible. The scenarios presented here are one variety of the scenarios technique, a 'snapshot' in time of the condition of important variables describing environmental quality under different conditions. Another technique, describing the evolution of the present system to each of the three end points identified here can often be more valuable, describing the causal chain leading to the result. Elements of this technique have been included in the scenarios presented here, but substantially more work is required using this process than was possible in this exercise.

Drivers of the Australian Agricultural System

The three worlds of Economic Growth, Conservative Development, and Post materialism are markedly different interpretations of plausible futures for Australian agriculture. Each contains elements which make it both a desirable and an undesirable future for a range of reasons. Each also appears to be so different that few common elements are visible. However, when distilled to their fundamental components, the essence of all three scenarios presented in this report can be described by combinations and states of three variables:

Retreat: the movement of agricultural production away from economically and ecologically marginal areas;

Intensification: the increase in capital per unit output;

Diversification: the production of a wider range of products at the farm or regional level

Demand for agricultural exports as varied in the three global scenarios (optimistic, best bet and pessimistic) and attitudes to environmental management as varied in the three domestic scenarios (economic growth, conservative development and post materialism) will jointly determine the extent to which Australian agriculture (1) retreats to the better-watered, more fertile areas (2) diversifies and (3) divides into a 'big corporations' segment and a 'family farm' segment. Variations within this family of possibilities are discussed in more detail below.

Retreat

ECONOMIC GROWTH

Under an Economic Growth scenario at home and a best bet scenario for global markets, large areas of land are determined to be of too marginal value to be used for large commercial purposes, becoming 'second tier' subsistence farms or 'wasteland'. The balance between soil quality and rainfall is, as at present, the primary criterion for much of Australia. Freer markets encourage land transfers to the most profitable uses, implying rapid and extensive land use change in the better agricultural areas. In total, however, the area commercially farmed in Australia is perhaps 30% less than is presently used.

CONSERVATIVE DEVELOPMENT

Retreat in a Conservative Development world is carried out through regulation and government buy-back of marginal agricultural and high conservation value land. The rangelands are abandoned in an agricultural sense. Under a best bet global scenario, the degree to which retreat is adopted is higher than in an Economic Growth world, but still uses the profitability of the land as one criterion. Obviously, retreat would be higher again under a pessimistic global scenario and lower under an optimistic scenario.

POST MATERIALISM

Retreat under Post materialism is somewhat different than in the other two scenarios, because of recognition of the inherent value of natural vegetation and landscapes. Even more area is taken out of large scale agricultural production, but it may be used lightly and infrequently. Massive re-afforestation is part of Post Materialist retreat. A drive to preserve rural communities may also serve to maintain agricultural activity in marginal areas.

Intensification

ECONOMIC GROWTH

Intensification in this scenario is characterised by agribusiness-style development, with massive start up capital and the ability to buffer shocks. It represents not only capital intensification, but also of land use and technology, all of which will be more evident under an optimistic global scenario than under a best bet or pessimistic scenario.

CONSERVATIVE DEVELOPMENT

This scenario has a lower degree of capital intensification than Economic Growth, because of the choices made to regulate production and environmental quality and the consequent reduction in the short-term profitability of agriculture. However, a general increase in capital intensity will be needed to improve production from smaller areas under more restrictive conditions, especially under an optimistic global scenario.

POST MATERIALISM

Capital intensification is also present under Post Materialism, but is retarded by policies to maintain the role of labour in agricultural production. Intensification is also spatially much less well distributed than in the other two scenarios.

Diversification

ECONOMIC GROWTH

Depending on world prices for a wide range of products, this is the scenario least characterised by diversification, although it would be more diverse than at present. Concentration of ownership and control by large companies implies a significant reduction of animal and crop varieties, although this is somewhat balanced through the initiation of new agricultural industries.

CONSERVATIVE DEVELOPMENT

Diversity is a little more important in this scenario, with some attempt to maintain and perhaps increase product range and farm types. On the whole however, the strong regulatory environment prevents large change from present positions, and may even restrict options unless world market prices for novel products are optimistically high.

POST MATERIALISM

Post Materialism is characterised by diversification more than retreat or intensification. The production of indigenous or niche crops, highly integrated mixed farms or production industries, a range of social and economic structures, are simply some examples of the variety which is encouraged in a Post Materialist world. It can be assumed that diversification would be encouraged by the principle that bioregions should, within reason, seek self-sufficiency in agricultural products.

Conclusion

The scenarios presented in this report form the basis of a sound foresighting exercise to investigate possible and plausible futures for Australian agriculture out to about 2025. They have not attempted to develop the full implications for Australian agriculture of both global demand scenarios and domestic strategy scenarios and the interactions between these. Nonetheless, sufficient material has been presented to convey a flavour of the multitudinous possible forms that Australian agriculture could take over coming decades. More importantly still, the present exercise has established a framework within which a systematic elaboration of these possibilities should be undertaken. The matrix of possibilities, three economic demand scenarios by three socio-economic supply scenarios, is more than sufficient for more detailed analysis and description.

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