The Australian fertilizer industry -- values and issues

Australian Fertilizer Industry Conference 2010

Fertilizer Industry Federation of Australia

Terry Ryan

Meta Economics Consulting Group

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Abbreviations

ABS Australian Bureau of Statistics

ABARE Australian Bureau of Agricultural and Resource Economics

ACCC Australian Competition and Consumer Commission

CAN Calcium Ammonium Nitrate

CPRS Carbon Pollution Reduction Scheme

CSIRO Commonwealth Scientific and Industrial Research Organisation

DAP Diammonium Phosphate

DSE Dry Sheep Equivalent

FAO Food and Agriculture Organisation

FIFA Fertilizer Industry Federation of Australia

GRDC Grains Research and Development Corporation

IFA International Fertilizer Association

IMF International Monetary Fund

LNG Liquefied Natural Gas

MAP Monammoniumphosphate

MOP Muriate of Potash

NPK Nitrogen, Phosphorus and Potassium Fertilizers

TSP Triple Superphosphate

UAN Urea Ammonium Nitrate

Executive summary

The value of the fertilizer industry to the Australian economy is much greater than its value of output or value-added to the broad economic aggregates. Its downstream contribution to the total economy is magnified by its impact on the productivity and production potential of Australia's agricultural sector.

If there was no chemical fertilizer available for the agricultural sector then:

- the agricultural sector would bear a direct economic cost from reduced production of $12.7 billion;
- the entire economy would be reduced by $40 billion from flow on effects;
- the employment loss in the agricultural sector alone would have totalled 107,000 workers;
- for the economy, it would have been 300,000 jobs; and
- exports from the agricultural sector would have decreased by $9 billion.

The fertilizer industry in Australia has been growing in its own right, and as an increasing input into Australian agriculture, with fluctuations in demand because of seasonal conditions. It is no longer entirely dependent upon imports of products or raw materials and has become an exporter of products in the Australian off-season.

On a world scale, the Australian industry is generally small in nearly all fertilizer products and has no influence on world prices.

There are major challenges for the industry and the agricultural sector in the future. The fertilizer industry in Australia has been a major contributor to our enhanced agricultural productivity for over a century now. An analysis of field trials shows that without fertilizer agricultural production in Australia would decline by approximately 20 percent for the broad acre cropping industries and by two thirds for the grazing industries.

There are signs that productivity improvements in agriculture are on the decline, not just in Australia, but internationally. If this trend continues the importance of getting more out of the existing technologies that we have will rise. A world with a bigger, richer population will require a lot more agricultural production. The role of fertilizers as a crucial technology for increasing agricultural production will rise in importance.

A carbon constrained world will also pose new challenges, not just for the fertilizer industry but also for the agricultural sector generally. If the Carbon Pollution Reduction Scheme was in place, the Australian fertilizer manufacturing industry would face an additional cost impost equivalent to an increased payroll tax of six percentage points.

Chapter 1: Fertilizer Industry Contribution to the Australian Economy

The Australian fertilizer industry has been an unsung hero of the Australian economy. It has been a crucial component in our history for delivering the agricultural production and productivity growth that has helped develop Australia.

Its value is much greater to the economy than the value of its sales alone. Its downstream contribution to the total economy is magnified by its impact on the productivity and production potential of Australia's agricultural sector.

Its current value to the Australian economy is measured in our national statistical accounts, but a truer measure is what would be the impact on the economy if there was no chemical fertilizer industry to supply our agricultural sector.

Important as the industry is now, it will be even more essential for meeting the challenges of the future, not just for Australia, but for the world, in feeding the richer, larger population we will have in 2050 but also in helping combat problems arising from climate change and the continuing likely expansion of biofuels production.

From the various studies provided in this paper a scenario can be developed to show what happens to the agricultural sector, and the economy generally, if there is no fertilizer usage in Australian agriculture. A detailed analysis of the impact on agricultural production of fertilizer is provided in Chapter 4. The analysis presented here is the summary effects from a review of a series of field trials. The impacts are measured primarily on the broadacre industries, as the smaller horticultural industries are highly variable in their response to fertilizer and tend to be located on much better soils. Also the intensive livestock industries will not be directly impacted as they do not use fertilizer. There can be indirect impacts from less feed availability from the broadacre cropping industries but these have not been estimated.

The livestock numbers and values of production have been adjusted to take account of the production from the rangelands of Australia where fertilizer is not generally used. This is a broad approach to provide indicative estimates as there will be areas outside the rangelands that also do not use fertilizer, as well as some areas within them that will have fertilised paddocks. Approximately 12 percent of sheep numbers and 28 percent of cattle numbers are located in the areas defined as rangelands. The values from livestock products serve as the base for assessing the impact of fertilizers and have therefore been adjusted by these percentages.

There is, as noted a lesser effect on the grains, oilseeds and sugar industries from ceasing the use of fertilizer than on the improved pasture lands, which have been generally shown to be highly dependent upon superphosphate use for improved pastures, compared to the native pastures.

As shown in Table 1.1, the direct reduction in the value of production would have been over $15 billion in 2008 -- 09. The actual loss of value added is adjusted to remove the cost of fertilizers which are no longer being used. This was a year when international fertilizer prices were much higher than the average of previous years and the current year. Therefore it is likely that this is an understatement of the true cost to the economy. In 2008 -- 09 the value of fertilizer use by farmers was estimated at $3.2 billion by ABARE. This direct economic cost to the Australian economy from the agricultural sector alone amounts to approximately $12.7 billion.

Table 1.1 Economy wide losses from the non use of fertilizers ($m)

Value of production (with fertilizers)	$45,126
Reduction in value of production (without fertilizers)	$15,467
Agricultural sector net income reduction	$12,693
Economy-wide income reduction	$27,645
Total reduction in income	$40,338

Apart from the direct impact on agriculture there are also economy wide impacts. The income multiplier from the Australian input output tables for agriculture is 2.178. (NSW I and I). Using this multiplier on the reduction in value added from the agricultural sector leads to further gross income foregone in the wider economy of over $27 billion in 2008 -- 09. The reduction in income for the entire economy from an inability to use fertilizers would therefore have totalled over $40 billion in 2008-09.

Assuming a constant ratio of labour to the value of output, then the reduction in the value of output caused by the lack of use of fertilizer will have a proportional impact upon employment in the sector. In 2008-09, there were over 357,000 people employed directly in the agricultural sector and an additional 24,000 people employed in services to agriculture. The proportional reduction in employment from not having fertilizer available would lead to an employment loss in the sector alone of 107,000 people. The flow on effects can be calculated again from the employment multiplier derived from the Australian input output tables. That multiplier is 1.828 which would indicate a further loss of jobs in the economy of 196,000. In total the Australian economy would lose over 300,000 jobs if it was not for the production response from the use of fertilizers.

Table 1.2 Economy wide job losses from the non-use of fertilizers ('000s)

Employment in agriculture and services to agriculture	381
Reduction in agricultural employment	107
Flow on reduction in employment	196
Total employment reduction	303

These numbers will be underestimates of the actual impact on the economy as the production responses of the horticultural crops are not included nor are the direct job losses in the fertilizer industry itself, associated with lower production levels.

As the industries identified in this study are export industries, there will be a direct flow on in the reduction of the value of exports by the same factor. It is realistic to assume this as domestic production will be first utilised by the domestic market and only the residual will be exported. The value of agricultural exports in 2008 -- 09 was $32 billion, the potential export losses are of the order of $9 billion. This is over 3 percent of the total value of exports of all goods and services in that year.

Without fertilizer there would be major readjustments in the Australian economy and regional areas and towns would be very severely impacted.

Chapter 2: The Fertilizer Industry in Australian History

The value of fertilizer has long been recognised in agriculture and one of the earliest non manure sources was guano, which was extracted from South American deposits primarily.

In Australia the first mining of guano started in 1850 in Western Australia. This can be said to be the start of the fertilizer industry in Australia.

The major advance for the industry was when the impact of phosphate on agricultural productivity was recognised by farmers. The first imports of phosphate rock occurred in 1905. The increasing demand led to organisations such as the Pivot Phosphate Cooperative being formed in 1919.

The fertilizer industry has continued to expand and diversify its product range to meet the needs of Australian agriculture. Superphosphate was the first major fertilizer product found necessary for Australian soils. Agriculture has diversified from a very heavy dependence on the products of the pastoral industries to a more mixed base with an expanded cropping focus. The mix of products for maintaining the nutrient balance of the soils has changed in line with this, with a greater reliance on high analysis nitrogen and phosphorus compounds and straight nitrogenous fertilizers.

The fertilizer industry has played a vital role in Australia’s economic and agricultural success as Australia has always been classified as a "continent of soils with a low plant nutrient supply" (Smith 2000). Combating this problem has required a major research effort over our history. Today all farming systems know the value of fertilizer in enhancing productivity, and agronomic practices have evolved to deliver the most efficient means of determining how much fertilizer to apply and how and when to apply it.

The use of fertilizers has delivered major improvements to the agricultural environment of Australia. As the Bureau of Rural Resources (1992) in an audit of our agricultural systems comment

"… it is pertinent to indicate that some soil properties, including levels of phosphorus and beneficial trace elements, have been markedly improved over millions of hectares in the last 200 years".

Without this fertilizer input our agriculture would not have been able to deliver the development of Australia as the native grasses of Australia evolved under conditions of low nutrient levels and generally do not

"… have the capacity to give large growth responses to high levels of nutrients". (BRR)

From the 1930s the introduction of subterranean clover to pasture systems and the use of phosphate fertilizers was attributed as increasing the carrying capacity from around 2 to at least 10 dry sheep equivalents per hectare over significant parts of the continent (Smith).

Early trials showed the benefits that could be derived from the use of subterranean clover and superphosphate. An example in South Australia showed that unfertilized padlocks could only carry 2.8 dry sheep equivalents but with the application of superphosphate to improve pasture, that carrying capacity could rise to 12.6 DSE per hectare (Kybybolite Research Station).

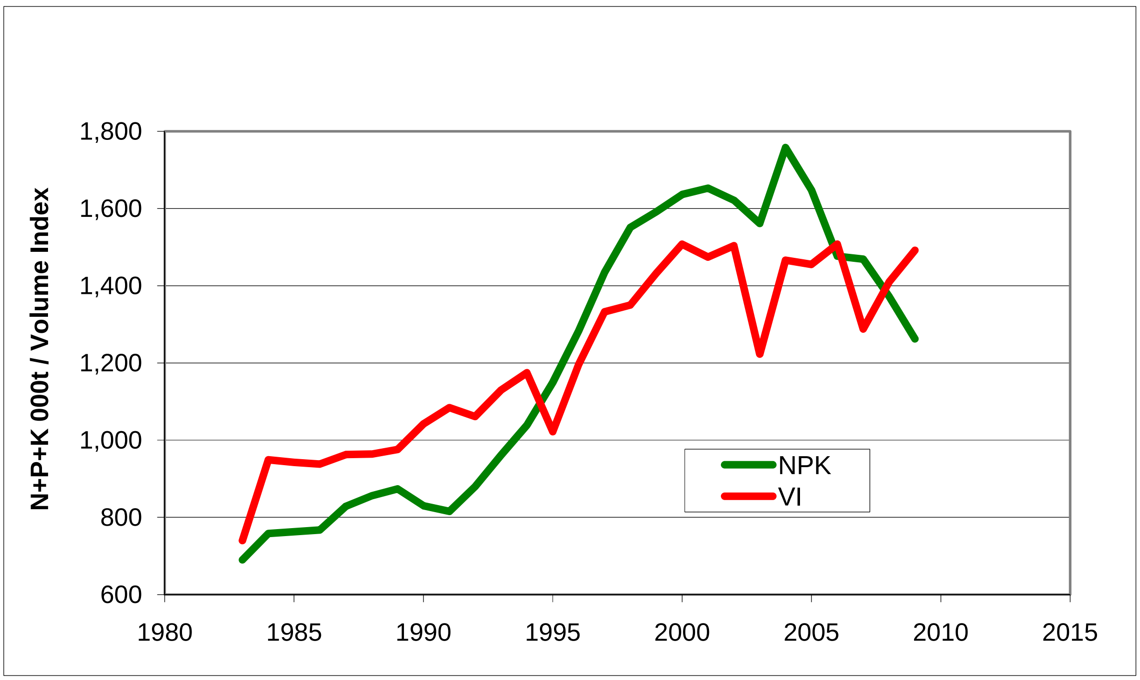
Australia's agricultural production capacity depended upon the establishment of improved pasture species, which depended upon fertilizer inputs to deliver huge increments in productivity. There were also a series of other technological developments such as better machinery to spread the superphosphate on the paddocks. It was the combination of seeds, super and spreaders that helped in this first Australian agricultural technological revolution.

As the Australian agricultural sector diversified away from the grazing industries to cropping and horticulture, the mix of fertilizers used in Australia switched away from reliance on single superphosphate to include fertilizers with a much greater proportion of nitrogen. The cropping industries, and sugar in particular, as they expanded from the 1960s led this surge for additional nitrogen in the broadacre industries. A review of nitrogen fertilizer research for the sugar industry commented:

"The Australian sugar industry has a history of high N fertiliser usage, with applications increasing from the 1960s." (Thorburn)

The importance of fertilizers in delivering the productivity and production levels in Australian agriculture are still recognised in today's technological world. Figure 2.1 demonstrates the rise in agricultural production over the last three decades and the increasing use of fertilizer inputs (ie. nitrogen, phosphorous and potassium shorthanded as 'NPK') to achieve that level of real production. This Figure provides an indication of the enhancements in production due to fertilizer, whilst acknowledging that other factors such as better herbicides and insecticides are also making a contribution.

Figure 2.1: Fertilizer use and agricultural production: Australia



Source: ABS 2010b, FIFA

The importance of fertilizers for Australian agriculture has long been recognised. Subsidies were introduced for their consumption in the 1930s. Payments were made to Australian manufacturers of eligible phosphatic and nitrogenous fertilizers, on the condition that they passed on the subsidy to users by charging lower fertilizer prices. The subsidies were eventually removed in the 1980s after a number of public inquiries and along with progressive reductions in tariffs on manufactured items.

Chapter 3: The Fertilizer Industry in Australia

3. 1 Fertilizer manufacturing industry

Since its establishment the fertilizer manufacturing industry in Australia has been growing in importance, in its contribution to the Australian economy. The latest data available from the Australian Bureau of Statistics (ABS 2008 Manufacturing Census 8221.0), states turnover of fertilizer manufacturing in 2007 -- 08 climbed to over $4.3 billion up more than $1 billion on the previous year. ABARE statistics state that only $3 billion of fertilizer was consumed by Australian farmers in that year. The value added in the industry increased from $817 million to $1024 million. As a proportion of the entire manufacturing sector, it has risen to over one percent of in terms of output value and just under one percent in terms of value added. It is a capital intensive industry with wages and salaries in the latest year accounting for 0.63 percent of the total wages and salaries paid in the manufacturing sector.

The importance of the Australian industry has been increasing steadily over time. In 1996 -97 the industry only accounted for 0.52 percent of manufacturing sector turnover and 0.5 percent of the value added. In the same period, direct employment in the fertilizer manufacturing industry has increased from 2300 to 3300.

In 2006-07, the latest year for which ABS has provided statistics, intermediate inputs such as phosphate rock and natural gas into the production of fertilizer accounted for over 70 percent of the value of output. Sales and service income was $888,000 per employee, well ahead of the manufacturing average of $373,000 per employee. The value added per employee in fertilizer manufacturing equates to $247,000 yet for manufacturing as a whole it was only $98,000 per employee.

Manufacturers source raw materials from imports, or from domestic sources, as well as importing finished fertilizer products from international suppliers.

Table 3.1: Fertilizer manufacturing in Australia

	Wages and salaries ($m)		Sales and service income ($m)		Industry value added ($m)	
	2006-07	**2007-08**	**2006-07**	**2007-08**	**2006-07**	**2007-08**
Fertilizer manufacturing	257	331	3,121	4,327	817	1,024
Total manufacturing	50,190	52,745	377,246	395,667	101,815	107,331

Source: ABS 2010a

3.2 Phosphate rock mining

Christmas Island was a major supplier of phosphate rock that was suitable for the production of single superphosphate for Australian usage. Production from this source has declined from 1,000,000 tonnes per year of production 35 years ago to 500,000 tonnes 25 years ago which then declined to zero but has now increased again to approximately 50,000 tonnes per year in recent years.

Phosphate rock mining is undertaken at the Phosphate Hill mine in Queensland. The nature of the deposit is such that it has to be processed and used in high analysis fertilizers, MAP and DAP, and is not generally suitable for conversion into single superphosphate.

Statistics are available for the period 2001- 02 to 2006 - 07 from the ABS. In this period the production of phosphate rock increased in a relatively steady progression from 1.7 million tonnes in 2001- 02 to 2.1 million tonnes in 2006- 07. The ex-mine value of production over the same period declined from $241 million in 2001- 02 to $96 million in 2006 -07. This indicates that the unit price per tonne of phosphate rock mined declined by approximately two-thirds in the same time period.

Table 3.2:Phosphate rock mining production

	$m	tonnes
2001-02	241	1,712,639
2002-03	131	1,910,241
2003-04	129	1,890,519
2004-05	135	1,935,679
2005-06	94	2,083,454
2006-07	96	2,131,046

Source: ABS 2008

3.3 Natural gas

Natural gas is a major input into the production of nitrogenous fertilizers. The price of nitrogenous fertilizers is now very much linked to prices in energy markets especially for natural gas.

Inputs into the production of nitrogenous fertilizers such as the plant, equipment and materials are internationally traded with the exception of natural gas on the eastern seaboard of Australia. With the development of a coal seam methane liquefied natural gas (LNG) industry and terminal in Queensland, the price of natural gas will be set at the international export price. Currently the international export price for LNG from all LNG export terminals in the world is higher than the long-term contract prices that have prevailed for natural gas on the eastern seaboard. Natural gas prices have been able to be lower than export prices in this market because it is what is known in economic terms as a non-traded industry. This does not mean that there is no commercial trading but that there has been no international trading from this market either importing or exporting. Prices were therefore set by domestic demand and supply conditions. The recent growth in the world's LNG industry and its likely establishment on the eastern seaboard will bring international prices to this important input to the fertilizer industry.

Helping to off- set this likely rise in prices for this important input, is the recent technological development, primarily in the United States, allowing the fracturing of rocks and the capture of large amounts of gas from these rocks which previously was not available for production. This technological development has helped lead to a major surge in production of natural gas in North America and its further likely development and implementation in many other countries, including Australia, where the prospective basins and rock seams are accessible.

The gas production response from this technology could be very significant and widespread even though its implementation has been occurring only relatively recently.

3.4 Fertilizer industry downstream contribution

The transport task

The scale of the contribution of the fertilizer industry to the Australian economy can be seen in its role in providing a major market for the transport sector in Australia. The ABS undertook a major survey of the transport task in Australia in the year 2000 - 01 investigating the components and their contribution to the total transport task in Australia. For the road freight industry, 1.63 percent of all the freight carried was chemical fertilizer which accounted for 1.92 percent of the total tonne kilometres of freight carried in Australia. For seaborne freight, chemical fertilizers accounted for 0.99 percent of the total tonnage carried and 1.18 percent of the total tonne kilometres. Overall, the fertilizer industry made up 0.9 percent of the total freight task within Australia for both the volume of freight and the tonne kilometres.

Table 3.3: Australian fertilizer industry freight task 2000-01

	Tonnes ('000)	Tonne kilometres ('000)
Road	9,990	1,693,822
Rail	85	72,017
Sea	469	1,146,754
Total	10,544	2,912,593

Source: ABS (2002)

This is a significant freight task in the overall Australian economy but is being measured alongside such large volume industries as the agricultural and mining sectors.

Policy issue: An Efficient Transport Sector.

The Australian fertilizer industry is highly dependent upon an efficient transport sector especially for road and sea freight. It is a common interest of both the farm sector and the fertilizer industry to ensure open and efficient competitive markets throughout the transport industry both nationally and internationally. Historically, the Australian waterfront and coastal shipping sectors have been well below world's best practice in delivering efficient services. The history of those industries and their institutional structure could lead to a reversion to past practices.

3.5 Distribution services

The fertilizer industry provides its product throughout Australia's agricultural lands. To ensure availability and efficient delivery of product to farmers most major country towns have fertilizer depots to provide local storage and services. These depots are in many cases integral components of businesses that also provide other agricultural services. The provision of fertilizer products is an incremental service in the suite of services provided to farmers and makes a contribution to the overall profitability of the local agricultural service provider.

Spreading services are undertaken by farmers themselves or by specialist contractors. There are estimated to be over 1000 specialised spreading vehicles used by contractors providing this service for farmers.

3.6 Fertilizer consumption

Table 2.3 outlines details of fertilizer consumption in Australia for the major products and elements. The most noticeable characteristic is the high degree of variability in consumption between years. Over the period the trend lines for consumption of the different fertilizers are all on the rise but with major downturns in consumption occurring regularly. Nitrogen consumption over the long term has tended to increase but over the most recent decade there has been a minor downward trend due primarily to the poor seasonal conditions. Demand for other fertilizers has also fallen.

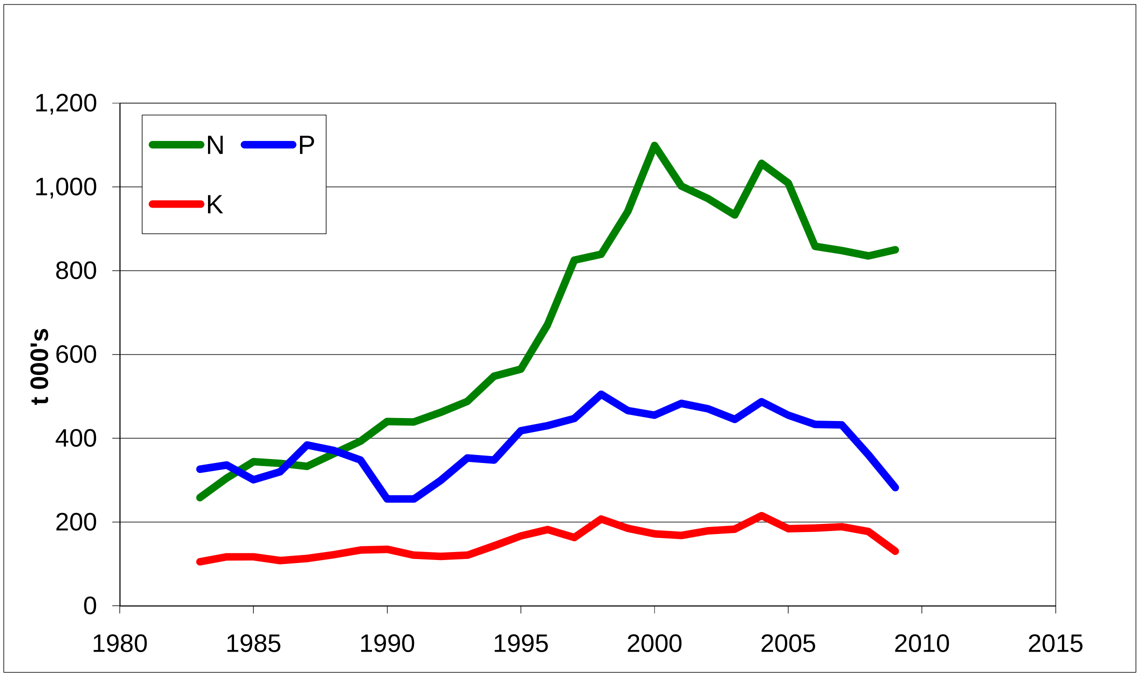
Table 3.4: Fertilizer consumption in Australia: by product and element

	N (t)	P (t P2O5)	K (t K2O)	P	K
	kt	kt	kt	kt	kt
1983	258	741	127	326	105
1984	305	764	141	336	117
1985	344	684	141	301	117
1986	340	727	130	320	108
1987	333	873	136	384	113
1988	363	843	147	371	122
1989	393	791	160	348	133
1990	440	580	163	255	135
1991	439	580	146	255	121
1992	462	680	142	299	118
1993	488	802	146	353	121
1994	548	791	172	348	143
1995	565	950	201	418	167
1996	671	977	219	430	182
1997	825	1,016	196	447	163
1998	839	1,148	249	505	207
1999	941	1,059	223	466	185
2000	1,099	1,034	207	455	172
2001	1,002	1,098	202	483	168
2002	972	1,068	216	470	179
2003	933	1,011	220	445	183
2004	1,056	1,107	259	487	215
2005	1,009	1,034	222	455	184
2006	858	984	224	433	186
2007	848	982	227	432	189
2008	835	818	214	360	177
2009	850	642	157	282	130

Source: FIFA

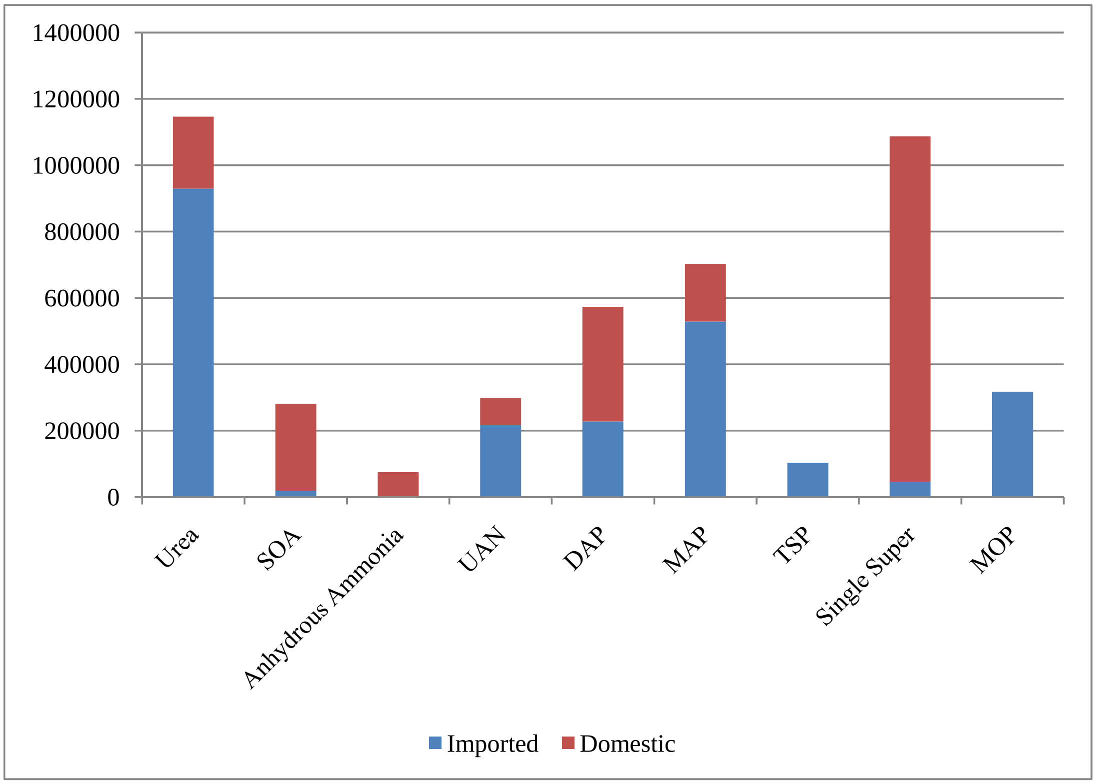
The overall pattern of the consumption of the different elements in Australian agriculture is presented in Figure 3.1.

Figure 3.1 Major element usage in Australian agriculture (kt) (FIFA 2009)



Fertilizer use in Australia is dependent upon domestic products and imports. Figure 3.2 shows the average composition of the major products used in Australia by the two sources of origin over the period 2002 to 2009. The variability in Australia's climate leads to major variations in demand for fertilizers due to seasonal conditions. The average annual supply over this period is provided as an overall indication of the scale of usage of major fertilizer products in Australian agriculture. UAN is for the latest year only as its widespread use is a relatively new trend in the Australian market.

Figure 3.2: Major products by origin (t) (FIFA 2009)



Apart from the major elements there are secondary elements required to ensure effective plant growth Calcium and magnesium deficiencies can occur on some soil types and are remedied by the application of lime, dolomite or gypsum. Sulphur deficiencies are more widespread. Single superphosphate has been the most common fertilizer used to supply sulphur to pastures although more recently very fine elemental sulphur coated on high analysis phosphorus products has become a common alternative. Sulphate of ammonia is also used in situations where nitrogen is also required.

Gypsum supplies sulphur and calcium, lime provides calcium and dolomite provides calcium and magnesium. Lime and dolomite also act to neutralise soil acidity whilst gypsum provides soluble calcium useful in improving soil structure in sodic soils.

3.7 Trace elements

The trace nutrients necessary for plant growth are boron, cobalt, copper, manganese, molybdenum and zinc but only in very small quantities. Soil and plant tests can show the deficiencies in these trace elements and the industry can blend the appropriate product to make up for the identified deficiencies in the soils of particular paddocks and farms. As an indication of the trace nature of the elements, in 2009 the total amount distributed of all these elements in fertilizer compounds added up to only 9500 tonnes of the over 1.5 million tonnes of fertilizer elements used in Australia that year.

Table 3.5: Trace element usage: Australia (t)

Element	2009	Average usage 2002 - 09
Boron (B)	135	1,667
Cobalt (Co)	0	11
Copper (Cu)	438	1,491
Manganese (Mn)	655	1,165
Molybdenum (Mo)	9	54
Zinc (Zn)	2,247	5,071

Source: FIFA

Trace element requirements can be determined through soil and plant tests and from typical outward symptoms on plants suffering from trace element deficiency.

Box 1: Molybdenum -- the impact of a trace element

Molybdenum (Mo) is one of the six ‘minor’ chemical elements required by green plants. The other five are iron, copper, zinc, manganese and boron. These nutrients are termed ‘trace elements’ because plants need them in only very small amounts. However they are essential for normal growth. Sales of molybdenum by the fertiliser industry have amounted to between nine and 18 tonnes per year over the last three years.

Molybdenum is needed by plants for chemical changes associated with nitrogen nutrition. In non-legumes molybdenum enables the plant to use the nitrates taken up from the soil. Where the plant has insufficient molybdenum the nitrates accumulate in the leaves and the plant cannot use them to make proteins.

In legumes molybdenum serves two functions. The plant needs it to break down any nitrates taken up from the soil—in the same way as non-legumes use molybdenum. It also helps in the fixation of atmospheric nitrogen by the root nodule bacteria. Legumes need more molybdenum to fix nitrogen than to utilise nitrates.

The discovery of the importance of molybdenum to agricultural production in Australia, and its general absence or inaccessibility in many Australian soils was a superb piece of technological development by the Australian agricultural science community. The work started at the Waite Institute in South Australia in 1930s and progress was made such that after World War II it was said "sub, super and ‘moly’ greatly extended the area of highly productive pasture in southern Australia". (Smith 2000). It was noted that:

“Since molybdenum deficiency in Australia was first reported in 1942 ... it has been found in many places throughout southern and eastern Australia." SA DPIR

Molybdenum is provided by the fertilizer industry for the appropriate usage in soils deficient in it. Deficiency is determined by soil and plant tests and applications of it in fertilizer only have to be made every few years based on further testing.

Responses can be quite spectacular, a study in 1942 found that adding a molybdenum compound at the rate of “2 lb per acre was capable of increasing lucerne yields approx. 3-fold over control plots.” This allowed a near trebling of livestock carrying capacity with the consequent productivity and production benefits to the grazing industries of Australia. (Kaiser 2005)

Another early study found that oats suffered a 60percent loss in yield when grown in solution culture without molybdenum. (SA DPIR)

The profitability of agriculture is greatly enhanced where small amounts can be applied at a relatively low price with major increases in production.

3.8 Domestic fertilizer suppliers

To get fertilizers from a port or factory to the end user requires an extensive supply chain. Distributors source fertilizer products from either domestic manufacturers or directly from international suppliers. Many distributors also value add the final product by blending, mixing and coating of finished fertilizer products to suit the specific requirements of individual farmer orders. This allows farmers to match applications to expected crop and soil conditions and application strategies.

Fertilizer agents and dealers receive their supplies from the distributors and are involved in the day-to-day sales of fertilizer to end users. Agents and dealers also value added services by providing a range of complimentary products, advice and services like finance and spreading services.

There are a range of marketing models with some companies involved in only one part of the supply chain and some filling all the links from manufacture to end user.

Following is a list of the major fertilizer suppliers in Australia though there are other independents that will import and distribute from time to time.

- Impact Fertilizers
- Incitec Pivot
- Hi Fert
- Viterra
- Grow Force (Ruralco)
- Megafert
- Summit Fertilizers
- Superfert
- Whitfert
- Ravensdown
- CSBP
- Landmark
- Elders

Recent market entrants include large international firms Koch and Weng-fu.

Many of the companies operate simultaneously through the different levels of the industry. Manufacturers may import product as well as distribute and retail. However a large part of the retail market is made up of small independent businesses.

This should be recognised as a strong signal that the domestic market is highly competitive, as the different firms can compete throughout the value chain offering services that meet their customer requirements and their corporate knowledge. With minimal barriers to imports, domestic producers have little market power to raise prices above world prices. The number of companies involved in the different levels of the fertilizer value adding chain ensures that there are multiple competitive pressures to deliver efficient services at competitive prices. None of the distributors or retailers has market shares that would allow them to exercise market power. On the eastern seaboard of Australia the two largest distributors account for approximately only one quarter of total fertilizer sales.

Apart from the manufacturing plants, the port facilities for imports and the transport services used for both, there are significant other value adding activities in the fertilizer industry chain. These activities include marketing activities such as agronomic advice, blending and on-farm spreading services. This last service is often undertaken by specialist contractors, rather than by farmers. This allows greater specialization in equipment which helps to deliver productivity improvements to the farm sector.

The provision of agronomic advice by the fertilizer industry and other private sector organisations is becoming much more important with the gradual, or in some cases already complete, withdrawal of State Government Departments of Agriculture from the provision of extension services. This withdrawal has been occurring since 1996 when the South Australian government announced that it was going to withdraw from the provision of agricultural extension advice, which includes advice on appropriate fertilizer usage and applications. Other states have followed the South Australian precedent at varying degrees of speed. The reduction in State Government extension services has become a major policy issue being investigated as part of the current Productivity Commission Inquiry into the Rural Research and Development Corporations. It has been raised as an issue in a number of submissions to the Inquiry. As noted by the multi-industry submission (which included industry organisations representing the majority of Australian agricultural production):

"State government agencies previously had a major role in rural extension, this is changing quickly as the States reduce rural sector funding and personnel."

And the implications for this are:

"The rural extension system plays a critical role in encouraging the adoption of new technologies, and is therefore a fundamental element in terms of the success of a national

rural R&D system. The withdrawal or downscaling of rural extension services by State Governments will impact on adoption rates and ultimately productivity growth in the rural sector ..." (PC submission 2010)

This traditional service provided by state governments to farmers is expected to continue to decline. This service is still needed by farmers and is now being provided by other sources such as the fertilizer industry and private consultants.

As a guide to the level of investment by the industry in providing advisory services, almost 1000 people have completed the Fertcare training program for advisors with nearly 2500 trained across all levels of the program which includes training for sales and logistics staff as well as advisors.

3.9 International trade

The Australian fertilizer industry is an importing and exporting industry, primarily of nitrogenous fertilizers and ammonium phosphates. However, all potassium-based fertilizers and some other products such as triple superphosphate are all imported. Australia lacks any operating mines of the feedstock to make potassium-based fertilizers.

Australia also imports rock phosphate, which is used to manufacture single superphosphate.

The Australian fertilizer industry has reduced the dependence upon imports of manufactured products through increasing production and consequent exports of nitrogen fertilizers and ammonium phosphates. The increase of production and consequent exports in the off-season for Australian fertilizer demand has reduced the net imports required of these fertilizers and thus helped ensure a better security of supply in case of potentially adverse impacts on security of supply due to actions by overseas producers or Governments.

Details of the trade position for all the major chemical fertilizers are provided in Table 3.6.

Table 3.6: Net trade in fertilizer products

	Imports							Exports		Net exports	
	TSP	DAP	MAP	Ammonium fertilizers			K	Nitrogen fertilizer	MAP/ DAP	Nitrogen fertilizer	MAP/ DAP
				Sulphate	Nitrate	Urea					
	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt
2003-04	163.5	211.6	740.5	8.3	8.3	1, 156.6	447.0	135.7	264.6	1, 083.0	687.6
2004-05	231.8	286.7	926.3	4.9	4.9	1, 288.6	496.7	205.5	313.5	1, 263.3	899.5
2005-06	310.3	202.5	528.2	8.8	8.8	1, 056.1	403.7	186.6	312.3	1, 013.9	418.4
2006-07	165.6	83.0	443.1	8.6	8.6	794.6	306.1	269.4	154.9	633.1	371.3
2007-08	106.8	312.8	582.5	10.4	10.4	1, 032.5	465.0	310.8	237.0	835.2	658.4
2008-09	107.3	214.0	455.3	78.7	78.7	884.8	331.2	398.6	480.8	714.3	188.5

Source: ABARE

3.10 Fertilizer usage in Australia - problems with statistics

The ABS conducted a major survey in 2007 -- 08 investigating farm usage of various fertilizers. The Fertilizer Industry Federation of Australia maintains a database of sales of the various fertilizer products based on member data. There is not a direct concordance between the two series in terms of product classifications and many of the major products can be relatively easily cross classified. Unfortunately there are major discrepancies between the two data sources. Details of these discrepancies are presented in Table 3.7 and the percentage differences between the claimed usage and the actual sales of the various fertilizer products.

The Fertilizer Industry Federation data is on a calendar year basis whereas the ABS data is on a financial year basis and therefore there will be some discrepancies arising from the different time periods.

The overall usage of fertilizers is similar between the two data sources. However, at individual product level these divergences can be quite large. Although discrepancies can arise from farmers buying fertilizer and not utilising it in that particular year, the scale of these divergences for some products is well beyond farmers carrying forward their own stockpiles of fertilizer.

Table 3.7: Fertilizer sales and claimed usage

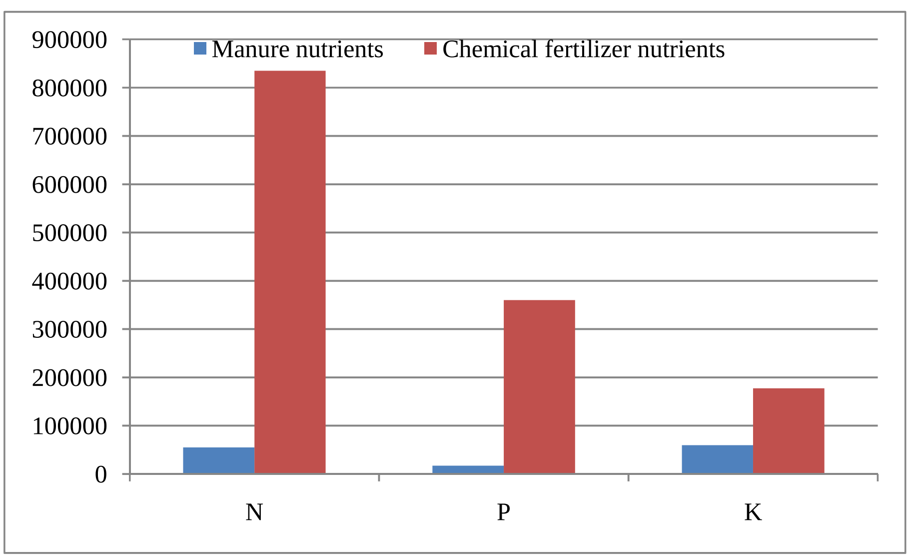
	ABS	FIFA	Percentage difference
Urea - Tonnes applied (t)	816,232	1,042,980	22
Ammonium sulphate - Tonnes applied (t)	166,176	263,616	37
Single superphosphate - Tonnes applied (t)	866,199	1,031,937	16
Double or triple superphosphate - Tonnes applied (t)	217,868	78,521	177
Muriate of potash or sulphate of potash - Tonnes applied (t)	168,809	259,683	35
Ammonium phosphates - Tonnes applied (t)	875,231	1,117,114	22
Other fertilizers	248,610		
Total fertilizer use	4,336,082	3,868,963	12

Source: FIFA, ABS 2009

Apart from the discrepancies at the individual product level, the claimed usage by farmers of all chemical fertilizers is above that for sales by the industry. This is not made up by the usage of animal manure which has been specifically excluded from the statistics presented here.

The only issue to note from these discrepancies is to always be aware of the differences that people claim and the actual hard data of physical sales.

Policy issue: the divergence between the different statistical sources and the inaccuracies from the farm survey information could lead to public and policy misconceptions of the actual state of affairs and possible outcomes from alternative policy proposals.



900000
800000
700000
600000
500000
400000
300000
200000
100000
0
Manure nutrients
Chemical fertilizer nutrients
N
P
K

Chapter 4: The contribution of fertilizer to agricultural productivity

The productivity enhancements in agriculture have come from a combination of factors working together. For example, better varieties of crops that are more disease resistant or efficient, combined with better chemicals that target specific pests, and more advanced machinery ensuring better applications of the technologies that are available. It is difficult to separate any one aspect from the other factors because they are usually adopted together and deliver a combined productivity effect.

As fertilizers provide the basic building blocks of plant growth and yield, any increase in yield potential is likely to require increased fertilizer to reach full expression.

There are a number of tools that have been developed to help the farmers maximise profitable production while minimising input costs and potential external environmental costs from fertilizer usage such as loss of nutrients in water run-off.

4.1 Fertilizer use modelling

In determining the appropriate amount of fertilizer to apply to farms there are a number of models to assist in decision-making to ensure the most efficient use of fertilizers for the target production levels. These models have been used in Australia for many years, however they are becoming more capable of incorporating more and better quality information to ensure more informed decision making on all aspects of fertilizer usage. As an example the variables that are utilised in some of these decision-making models are provided below. The values for these variables are an input into the model to minimise fertilizer losses from the farm and maximising their use efficiency. As can be noted from the number and type of variables the models are becoming very sophisticated. The variables used in the Farm Nutrient Loss Index model from the Victorian Department of Primary Industries include:

- surplus water
- soil profile
- slope
- land shape

- waterlogged area
- run-off modifiers
- proximity to waterway
- groundcover
- pasture type
- timing of fertilizer application
- rate of fertilizer application
- stocking rate
- groundcover
- soil test

This information can be used by the farmer, often working with an advisor, to help determine the most appropriate fertilizer treatments, taking account of specific characteristics unique to that farm.

The fertilizer industry is also delivering these specific skills and information through their Fertcare program. Fertcare lifts the skills and knowledge of everyone involved in the supply of fertilizer and soil products. The program is designed to ensure that high quality advice is provided to users of fertilizers to allow them to maximise productivity and minimise environmental and food safety risks.

This technological development has helped ensure the fertilizer industry contributes to productivity improvements in the agricultural sector with minimal environmental consequences.

4.2 Soil testing

The efficiency of fertilizer usage has been greatly improved by developments in soil and plant testing which allow the targeting of specific amounts of various elements; both major nutrients and trace elements. This improves the efficiency of usage of fertilizers and minimizes any consequential environmental effects from overusage.

Many farmers at the forefront of this technology are now doing within paddock testing and within paddock distribution of fertilizer. Unfortunately there are still a large number of farmers to take up this productivity enhancing development. As demonstrated in the ABS survey the numbers of farmers using these technologies are a minority.

Table 4.1: Fertilizer application decision making

Activity	Number of farms	Proportion of farms (%)
Soil tests	34,926	24.8
Previous paddock yields	26,965	19.2
Standard annual rate	25,740	18.3
Consultant's recommendations	31,205	22.2
Used as much as could afford	30,553	21.7
Dependant on seasonal conditions	30,572	21.7
Leaf or stem sampling	10,551	7.5
Other/none reported	780	0.6
Agricultural businesses	140,704	

Source: ABS 2010a

4.3 Precision agriculture

The combination of the use of Global Positioning System (GPS) with farm machinery and equipment that can collect more detailed information about inputs and outputs has allowed farmers to target farming practices such as fertilizer application and agricultural chemical use to within paddock farming parameters.

The efficiency of use and application of fertilizers and trace elements is greatly enhanced by this technology. This will provide input cost reductions and enhanced production for the long-term benefit of the agricultural sector.

4.4 Farm budgets

Using information from soil tests, the fertilizer requirements can be determined and incorporated into farm budgets for a particular crop and region. There are numerous examples of farm budgets provided for different regions, different soil types and different crops. These are provided by State Departments of Agriculture and the private sector. They are usually updated regularly. They are comprehensive and detailed tools to provide baseline gross margins analyses for different potential yields and prices.

Farm budgets by their nature relate the likely production outcomes with the costs and potential price benefits. Dealing with the uncertainties of the climate is still the major management tasks of the farmer.

The provision of this information from the models, soil testing and farm budgets help ensure the most efficient use of fertilizers for the prevailing market circumstances. It means that the farmers, the customers of the fertilizer industry, have more information and analyses available to help in decision-making every year. Climatic conditions are still the great unknown but nearly all other aspects of the decision-making process in farming are informed by increasingly sophisticated information.

Increasing the penetration rates of use amongst farmers for existing technologies such as soil testing and precision agriculture can help lift the average productivity of the farm sector in the medium term. However, it will require new technologies to lift the future productivity growth rate of the sector.

4.5 Measuring the contribution of the fertilizer sector to agricultural productivity

The need for fertilizers

Every crop and pasture grown in Australia removes nutrients from the soil. As has been shown in our history many of these nutrients are not readily available in our soils. The addition of these nutrients through fertilizer application has enabled the productivity revolution in Australian agriculture, starting with the addition of superphosphate and trace elements such as molybdenum. The foods we eat or grasses we feed to our livestock all take nutrients out of our soil system that have to be replaced. Examples of the composition of elements in some of our crops that are removed for our benefit are provided in Table 4.2. The examples are indicative and are in kilograms per tonne of dry matter.

Table 4.2: Nutrient removal from soils by various crops (kg per tonne of dry matter)

	Nitrogen	Phosphorus	Potassium	Sulphur	Calcium	Magnesium
Oats	17.0	3.2	4.1	2.3	1.0	1.4
Wheat	22.0	3.8	4.7	2.2	0.4	1.6
Barley	18.0	3.8	4.8	1.7	0.6	1.5
Maize	15.0	2.8	3.6	1.2	0.2	1.6
Sorghum	21.0	3.2	3.9	1.8	0.4	1.4
Lucerne hay	35.0	2.3	17.4	2.0	13.3	1.3
Ryegrass hay	30.0	3.0	20.0	3.0	4.0	3.0
Maize silage	14.4	2.7	9.2	1.2	2.6	2.9
Lupins	51.5	3.0	8.1	2.3	2.2	1.6

Source: NSW DPI 2005

There have been a very large number of field trials conducted in Australia to assess the extent of production improvements for various crops under a range of different levels of fertilizer application, whether by type or amount. These field trials are conducted in a variety of regions and soil types.

Widespread soil testing clearly shows that there is variation in soil fertility within paddocks let alone between farms and regions. This variability in soil nutrient levels mean there is no single measure that could be derived for the increase in production from the application of fertilizer to Australian soils.

A number of field trials have been conducted using control treatments where there has been no fertilizer application tested against other treatments with varying amounts of fertilizer applied. These field trials provide a basis of determining what would happen to agricultural production and productivity if there was no fertilizer applied.

If no fertilizer is applied there will be a gradual diminution back to the pre-fertilizer and improved pasture nature of the Australian rural sector as the previously added nutrients are mined by future agricultural production.

Table 4.3 presents a summary of the carrying capacities, in dry sheep equivalents, for field trials comparing unimproved pastures with improved pastures and the application of fertilizers. There is a great deal of variation in both the carrying capacities for unimproved pastures and improved pastures by region.

The improved pastures require the addition of phosphorus fertilizer compared to the native grasses that dominated before the introduction of species such as subterranean clover. The improved species and fertilizers are crucial for raising the carrying capacity of our pasture lands, outside the remote grazing areas of inland Australia. Without the combination of the two technologies production from the grazing industries in the higher rainfall regions of Australia of the coast, tablelands and slopes could well decline to only a third of their existing level.

Table 4.3: Production comparisons on field trials with and without fertilizer for the pastoral industry

Location	Unimproved pasture	Improved pasture+ fertilizer	Carrying Capacity- old technology
	DSE	DSE	%
Southern tablelands(NSW)	1	9	11
Northern tablelands(NSW)	3	10	30
Northern slopes(NSW)	2.1	10.3	20
Coastal (NSW)	4.5	19	24
Hunter(NSW)	3	15	20
Gloucester(NSW)	2.3	15	15
NSW	6.3	11.8	53
Bothwell	2.8	3.8	74
Pawtella	3.3	6	55
Nile	2.5	6	42
Average production			34

Source: NSW Agriculture (various), Tasmania DPIW (2006)

An analysis of field trials in the grains industry in a number of regions shows that without the application of fertilizer there is an average reduction in production of around 20 percent. These field trials were conducted in a variety of regions and for a variety of crops with some having multi-year time spans.

Table 4.4: Production comparisons on field trials with and without fertilizer for the grains and oilseeds industry

Location	No fertilizer (kg)	Average with fertilizer (kg)	Average reduction in production (%)
Hart (SA)	2,760	2,869	3.81
Hart(SA)	2,460	2,741	10.27
Riverton(SA)	3,990	4,490	11.14
Minlaton(SA)	3,107	3,520	11.73
Wildeloo(SA)	3,140	3,833	18.08
Willura(SA)	2,088	2,369	11.86
Toodyay(WA)	2,510	3,142	20.11
Salmon Gums(WA)	2,650	3,270	18.96
Northampton(WA)	2,900	3,248	10.72
Frankland(WA)	2,600	3,608	27.94
Gnowerup(WA)	1,150	1,350	14.81
Holt Rock(WA)	2,600	3,517	26.07
New Norcia (WA)	2,000	2,808	28.78
Cuballing(WA)	1,500	2,850	47.37
Dunedoo(NSW)	3,150	3,290	4.26
Nindigully (wheat)(QLD)	2,280	3,140	27.39
Nindigully (barley) QLD)	2,320	3,080	24.68
Nindigully (canola) QLD)	1,180	1,500	21.33
Average reduction			18.85

Source: GRDC (various)

A similar analysis for the sugar industry shows that without the application of nitrogenous fertilizers, over a five-year period, the average yield of sugarcane was only approximately 60 percent of that which could have been obtained with the application of fertilisers (Thorburn).

Aggregating the information from a variety of trials indicates that without the input of the fertilizer industry into agriculture, many agricultural commodities could face reductions in production of the order of one-fifth to two-thirds with consequent loss of productivity and competitiveness on world markets. In the longer term the impact on our ability to help feed the world could be seen as an even more significant impact.

Chapter 5: Productivity improvements in agriculture

Achieving major productivity improvements in agriculture will be essential to meeting the increased production challenges of feeding the world's growing population. Without significant growth in agricultural land, the production challenge becomes much greater and will rely on further intensifying agriculture, primarily through greater use of inputs such as fertilizers.

In an international context, the contribution of fertilizers to increasing agricultural productivity has long been recognised. The Green Revolution in Asia delivered major increases in food production to a significant proportion of the world population and helped avert the threat of starvation that appeared to be looming. Fertilizer was one component along with improved varieties and water usage in helping to more than double world cereal production. Fertilizer was an essential component to ensure all other parts of the Revolution delivered their potential.

As the US Department of Agriculture noted:

"Increased fertilizer use accounted for one-third of the growth in world cereal production in the 1970s and 1980s. Among developing regions, per hectare fertilizer consumption increased most rapidly in land-scarce areas (such as in Asia) and most slowly in Africa.

Plant breeders have succeeded in developing crop varieties with high yields that will produce under particular pest pressures or environmental stresses. To obtain these benefits, however, investments in complementary crop management technologies such as irrigation or fertilizer use may be necessary.

In countries with poor soils and climate, basic inputs such as fertilizer and water are more important than they are in countries that are better endowed." USDA 2003

It is worthwhile reviewing where Australian agriculture has come from in the productivity race to assess what has helped deliver the increased productivity and where we could possibly be heading.

Australian agriculture has long been reliant upon technology and productivity improvements to ensure its long-term viability. There have been many studies looking at the big picture of agricultural productivity improvements in Australia. An analysis of those studies shows a divergence between the analytical studies of the economists and the views of the farmers actually delivering the productivity improvements. Probably the most notable omission from the macro studies on agricultural productivity is any mention of fertilizer contributing to the productivity improvements in Australian agriculture.

This neglect is in the economics literature but in the practical and agricultural understanding of productivity, fertilizer usage is well understood.

Improvements in productivity in agriculture have always been a primary concern of Australian farmers. Australia's long history as a pre-eminent agricultural export nation has been based upon the long tradition of productivity improvements at least matching the long term decline in the terms of trade. This farm level impact has generally been mirrored at a macro level for the Australian economy over most of our history as import prices have tended to rise at a faster rate than our export prices.

Productivity growth has been attributed to changes at the farm level such as structural adjustment, adoption of improved technologies and techniques, better management practices, reduced use of inputs because of greater efficiency improvements and economies of scale. Off farm contributors to productivity have come from the microeconomic reforms undertaken in the Australian economy, improvements in market access and technological developments in other sectors of the economy.

There have been studies trying to determine the sources of productivity growth in Australian agriculture. However none have come to a definitive conclusion on the relative contributions of the different sources. The sources analysed included:

- Improvements in public infrastructure
- Improvements in the education levels of farmers
- Domestic research
- Adaptation of foreign research.

The productivity growth derived from research is generally accepted as the major driver for these improvements. One study attributed almost half the value of agricultural output in 2003 to new technology generated by Australian research since 1953. (Mullen)

The definition and measures of productivity have been well established in the economic literature. The standard definition of productivity is that it reflects the level of production of outputs relative to the level of inputs used. The most common overall measure used is total factor productivity. This measures total productivity by comparing a ratio of total outputs relative to total inputs used in the production of that output.

Productivity trends are measured over time in terms of average annual growth in total factor productivity. A high level of growth is sought after as it reflects either an increase in the level of outputs relative to the resources used or alternatively a reduction in the use of those real resources required to achieve a particular output level. There are also a number of other productivity measures which are of a partial nature such as the measurement of outputs relative to the amount of specific resources such as labour used in the creation of those outputs. This is called labour productivity. It does not take account of changes in the amounts of capital, for example, that are used in boosting the level of outputs.

There have been a large number of studies undertaken in Australia looking at changes in total factor productivity for agriculture. Many of these have been undertaken using the databases from ABARE farm surveys. Total factor productivity is usually measured over long time spans as short term deviations in production and use of inputs can disguise the overall improvements in productivity that are occurring over the long term. This is primarily because of the impacts of varying climatic conditions on production between seasons.

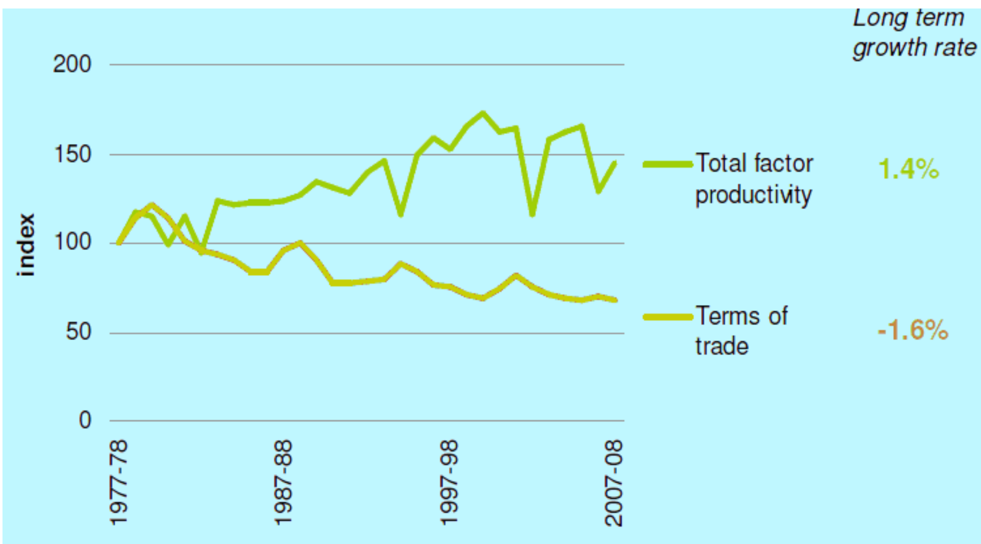
This is not unique to the agricultural sector, as Treasury has noted that for the economy as a whole, productivity growth varies over the business cycle. They recommend that care be taken in choosing periods over which to average productivity growth to ensure that similar parts of the business cycle are appropriately compared. The many productivity studies on agriculture have differing time periods for their calculation of annual productivity growth and are thus not generally directly comparable. However, they all tend to give similar trends and relativities between the different agricultural industries over roughly similar timeframes.

Even before the development of detailed economic studies into measuring productivity, there was considerable evidence of greatly enhanced partial productivity measures such as sheep carrying capacity being utilised in Australian agriculture throughout much of our history. Specific examples of productivity enhancing measures include the use of the stump jump plough and the use of superphosphate and subterranean clover. These were widely adopted in large parts of Australian agriculture and the various Departments of Agriculture measured the major partial productivity improvements arising from the adoption of these technologies.

From the various studies on productivity in agriculture certain general trends can be highlighted.

Productivity over the long term has generally managed to keep pace with the general decline in the terms of trade or prices received versus prices paid by Australian farmers, as shown in Figure 5.1. The terms of trade reflect the relative changes in prices of outputs compared to inputs. As shown in the graph over the last three decades the relative prices of agricultural products have been declining at an average rate of 1.6 percent per year. Improvements in the productivity of agriculture, as measured by the total factor productivity improvements, have been rising at a slightly lower rate of 1.4 percent per year.

Figure 5.1: Productivity changes in Australian agriculture compared to the changing terms of trade



Source: ABARE, Nossal & Sheng, 2009

There has been a great deal of variability in time periods and between different types of enterprises on rates of productivity improvement. As shown in Table 5.1, the ABARE analyses demonstrate that over the last decade there have been major decreases in productivity in the broad acre industries of Australia with most of the decline driven by reduced productivity levels in the cropping industries. In the previous two decades, the cropping industries had rates of productivity improvement exceeding all other broad acre industries and for the period 1979-80 to 1988-89, annual rates of productivity improvement were nearly 5 percent per year.

Table 5.1: Productivity growth rates- Australian agriculture

	Broadacre	Cropping	Mixed crop/livestock	Beef	Sheep
1979- 88	2.2	4.8	2.9	-0.9	0.4
1988-97	2.0	1.9	1.4	1.6	-1.2
1997-2006	-1.4	-2.1	-1.9	2.8	0.5

Source: Nossal and Sheng 2009

One notable characteristic of all these studies by ABARE, and other economic analysts researching overall productivity trends in the agricultural sector, is that with the exception of one study, the contribution of fertilizers to productivity improvements is not mentioned. The one study, from the Productivity Commission, actually mentioning fertilizers encompasses it with a variety of other agricultural improvements.

The Productivity Commission (2005) suggests that significant changes in cropping technologies over the last few decades are one of the main reasons for the superior productivity performance. They nominate the following technologies as key examples:

"• Crop varieties with improved disease resistance;
• Improvements to fertilizers and pesticides; and
• Adoption of minimum tillage practices."

The fertilizer industry may have been neglected in the economic studies as a contributor to agricultural productivity improvements but it is recognised by farmers.

In a recently published document on a series of ABARE-GRDC workshops on grains productivity growth involving farmers, the crucial role of the use of fertilizers in productivity improvements can be illustrated by these simple quotes from the report.

"Much of the increase in materials and services during the 1980s and 1990s reflected greater use of fertilisers, particularly nitrogen, and soil ameliorants such as lime and gypsum."

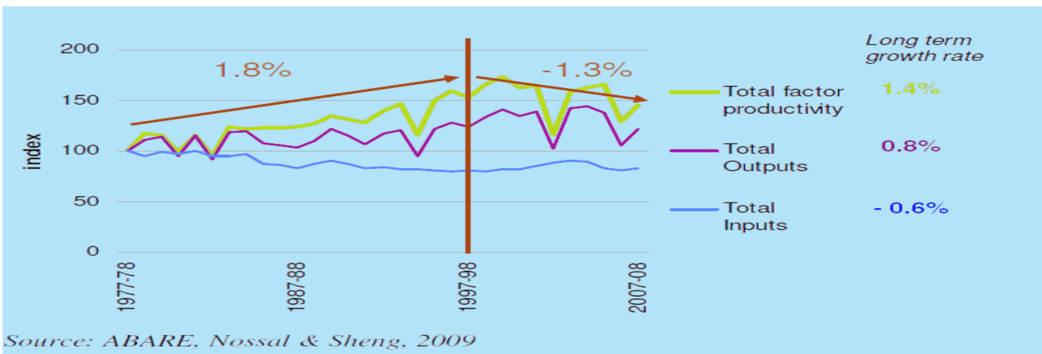
And

"the productivity of ex-grazing land had initially been high because there was a bank of soil nutrients left over from livestock enterprises. Once this bank was depleted, fertiliser requirements increased, reducing the measured productivity of this land."

All the workshops nominated greater use and efficiency of use of fertilizers as one of the primary productivity drivers.

As noted in Table 5.1 there are now claims that indicators of productivity growth in the agricultural sector have been slowing this century. For example, ABARE have estimated productivity growth as 3.6 percent on average between 1989-90 and 1998-99 compared to a negative trend whereby productivity growth rates have been falling at an average rate of 1.3 percent per annum between 1997-98 and 2007-08. Figure 5.2 provides details of the changes in output and input mixes for achieving measures of total factor productivity over the long term and the recent trend lines on productivity improvement separated between pre-1997 -- 1998 and post 1997-98.

Figure 5.2: Productivity trends for the agricultural sector



The Productivity Commission in its issues paper for the current review of the Rural Research and Development Corporations has also flagged as an issue the general decline in productivity improvements.

There are also indications from other countries, primarily other OECD nations that agricultural productivity improvements are slowing down as well. The analyses cover a relatively short time period and may not necessarily provide a reliable indication of long-term trends but many analysts consider that there are strong possibilities that these signs are reliable in showing a reduction in productivity growth. A recent study on this decline in productivity has attributed the issue to the decline in agricultural research generally.

"The recent Australian experience in terms of slowing agricultural sector productivity growth is a world-wide phenomenon. In a recently published book entitled "Persistence Pays: US Agriculture Productivity Growth & the Benefits from Public R&D Spending" (Alston, Anderson, James & Pardey, 2009) the authors suggest that public policy makers across the globe may have started to take agricultural productivity growth for granted. They

claim that worldwide growth in public agricultural investments has slowed and that given agricultural research takes time to generate benefits, public policy makers have become impatient in demanding more immediate outcomes." (Brown)

However, if this trend should continue the dilemmas for world agriculture, let alone Australian agriculture, become much more serious in providing the necessary agricultural production to feed the growing world population.

Chapter 6: The Australian fertilizer industry in a world context

6.1 The price of fertilizers

When fertilizer prices spiked upwards dramatically in 2008, there were a series of complaints and investigations into the competitive structure of the Australian fertilizer industry.

The ACCC undertook an investigation into the industry and concluded:

"The significant rises in fertiliser prices in Australia are mainly attributable to rapidly increasing global fertiliser prices. These increases have been caused by a substantial increase in world demand for fertilisers associated with an expansion in agricultural production (particularly grains for food, feed for livestock and bio-fuels) and by rises in costs of production associated with the increasing cost of energy. This is occurring in a market where the global supply capacity is limited in the short-to-medium term."

and

"A number of interested parties who made submissions to the ACCC as part of this inquiry raised concerns about the way in which fertiliser markets in Australia operated during the period from late 2007 to early 2008. Much of the conduct that raised concerns was caused by a situation of deficiency in short-term supply associated with an unexpected bringing forward of demand by end users in the context of rapidly increasing world prices."

However this did not put an end to the debate and the controversy, as a Senate Inquiry was convened and it concluded:

"Increases in biofuel production has resulted in less arable land being available for other agricultural production, which in turn puts pressure on supply and prices for food products. In addition, as the world population increases more land must be allocated to housing, therefore reducing the amount of land available for crops. The increased demand for agricultural products is being met by increasing productivity, primarily through the use of fertiliser.

Evidence to the inquiry suggested that the high degree of industry concentration enables key market players to heavily influence prices in this market.

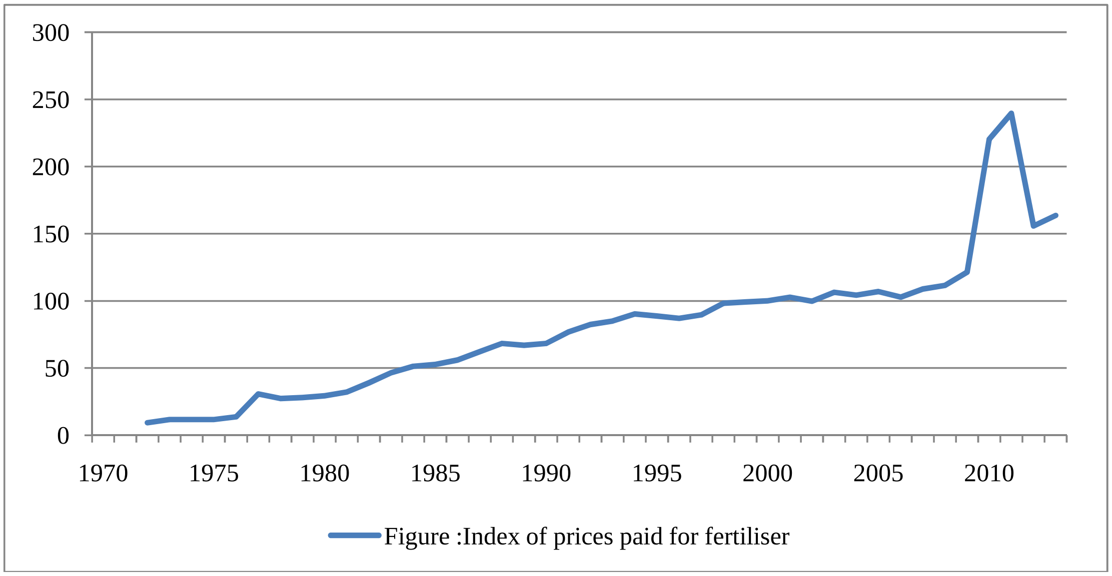
The committee considers that the ACCC report is flawed, especially in terms of providing a thoroughgoing analysis of the industry.

The committee notes that while global increases in fertiliser prices have influenced, to some degree, domestic price increases, it also believes that industry concentration in Australia and *consequent market manipulation also play a part in explaining high fertiliser prices paid by Australian farmers."*

After the various inquiries into the competitive nature of the Australian fertilizer industry, there was a downturn in the world economy which led to a drop in demand for most commodities. The effect on Australian fertilizer prices is shown in Figure 6.1. The price spike in fertilizers was followed by a price slump.

The price spike for fertilizers is not unique. After the first oil crisis in 1973, fertilizer prices increased by nearly the same extent as in the most recent set of price rises. Morocco, as the largest supplier of phosphate increased prices by 150 percent. Nitrogenous fertilizers also increased by an order of magnitude as oil prices quadrupled. The average rate of increase in Australia for fertilizers between 1973 and 1974 was well over 200 percent according to the then BAE.

Figure 6.1: Index of fertilizer prices (ABARE)



6.2 The Australian Fertilizer industry in a world context

A comprehensive database of the competitive position of the Australian the fertilizer industry in a world context is provided in Appendix 6.1. Production, consumption, imports and exports are provided for Australia and the major nations in every major category of fertilizer product are provided in the Appendix.

The top 10 nations in every category plus Australia, if it did not make the top 10, are provided in the detailed product tables in the Appendix . For the purposes of this analysis, the European Union is treated as one country as it allows free trade and free investment flows for the industry amongst all the member nations of the union.

Table 6.1 provides a summary of Australia's production and consumption of the major fertilizer products and their proportion compared to world production and consumption.

Some very simple observations to make from the analysis:

- Australia is generally a very small component of the world market for any of these products. It only occasionally makes the top 10 of any of the nations in any category, whether production or consumption. Except for ammonium nitrate, which is primarily used in the Australian mining industry and not as a fertilizer, there is no fertilizer product where Australian production exceeds 2.5 percent of world production.
- Even in the case of a product such as diammonium phosphate where we make the top 10 in imports, exports, production and consumption, the Australian industry is still a small player compared to the major countries in each category. In production of DAP Australia produces only 7 percent that of China, the major producer. In exports we account for 8 percent of the level of exports from the USA, the major exporter. In imports Australia is less than 9 percent of the imports of India and in consumption 5.5 percent of their consumption.
- In exports the only categories where we rank in the top 10 are for ammonium nitrate and diammonium phosphate. Again, despite being in the top 10, Australia is very much a small participant in the world market.
- Reflecting the seasonal demand surge for fertilizer in Australia, we also make the top 10 in imports of diammonium phosphate and for monammonium phosphate we come in at number three. Other products where we make the top 10 in imports are for phosphate rock and urea.
- For ammonia, where we rank number 18 in the world in production and consumption, Australian production is only 2.6 percent of the production in China. Our consumption level is only 28 percent of that in Indonesia, the number six producer and consumer in the world.

Table 6.1: Australia's ranking in world production and consumption of fertilizers: 2008

	Production kt	World rank	Proportion of world production (%)	Consumption kt	World rank	Proportion of world consumption (%)
Ammonia	1283	18	0.85	1,170	18	0.771
Ammonium nitrate	1,418	7	3.39	1,330	7	3.18
Ammonium sulphate	431	12	2.265	460	14	2.417
CAN	0			6.3	33	0.0458
DAP	588	9	2.236	498	6	1.8971
MAP	257	9	1.5337	657	6	3.9191
Potash	0			389	17	0.724
Phosphate rock	2,492	10	1.4289	3,309	8	1.8977
Sulphur	60	31	0.1236	774	13	1.8058
TSP	0			106	15	1.8058
Urea	275	31	0.1884	1,238	17	0.848

Source: IFA

- Our ammonium sulphate production is only 9.4 percent of European Union production and our imports are the equivalent of only 2.5 percent of Russian exports, the major exporter.
- Australia's monammoniumphosphate production is only 3.6 percent of China's and 6.4 percent of the US, the two largest producers. Yet for this fertilizer we rank number six in the world in consumption and number nine in production.
- In phosphate rock our consumption is only 10 percent of that of the US the largest consumer. Australia is the 10th largest producer but only produces 10 percent of that of Morocco, the largest exporter.
- For sulphur, a fertilizer mainly imported, our consumption is the equivalent of only 9 percent of China's imports and just over 10 percent of European Union exports, the largest exporter.
- In triple superphosphate, another entirely imported product, our consumption is only 6.3 percent of that of Brazil, the largest consumer.
- Our urea consumption is only 20 percent of that of India, the number five consumer in the world.
- There is no potash fertilizer production in Australia and therefore all usage is dependent upon imports. In this category Australia still only ranks number 12 in the world as an importer and number 17 as a consumer. Our imports are only 2.4 percent of Canadian exports, the largest exporter.

On a world scale, the Australian industry can be said to have no market power on world markets because it is such a small buyer and seller of fertilizer products in every category. In economic terms Australia would be considered a small country without the ability to influence prices on world markets.

6.3 Peak phosphorus?

An issue that has been raised in the public domain is that we are running out of rock phosphate. When this happens, agriculture will go into a serious decline in production because of the lack of phosphatic fertilizers.

It has even reached the stage where CSIRO can state in one of their publications:

“Scientists predict that peak P, the point where supply falls behind demand, may occur in as little as 25 years and high global demand will increase its price dramatically. Other estimates show that the time available may be longer. But in all cases predictions indicate

that phosphorus is a finite and valuable resource and that it is becoming an urgent matter to find ways to use P more efficiently so as to secure the profitability and competitiveness of Australian farming Industries." (CSIRO Plant Industry)

A simple analysis using current estimated reserves and production and inferred reserves using data provided by the US Geological Survey is presented in Table 6.2.

Table 6.2: World phosphate production and reserves

	Production	**Reserves**	**Reserve base**	**Production years-reserves**	**Production years-reserve base**
Morocco and Western Sahara	25,200	5,700,000	21,000,000	226	833
China	32,000	6,600,000	13,000,000	206	406
United States	30,700	12,000,000	3,400,000	391	111
Senegal	2,600	1,500,000	2,500,000	577	962
Jordan	6,400	900,000	1,700,000	141	266
Australia	2,050	77,000	1,200,000	38	585
Russia	11,000	2,000,000	1,000,000	182	91
Israel	3,000	180,000	800,000	60	267
Syria	3,600	100,000	800,000	28	222
Egypt	2,740	100,000	760,000	36	277
Tunisia	8,400	100,000	600,000	12	71
Brazil	5,500	260,000	370,000	47	67
Canada	1,000	25,000	200,000	25	200
Senegal	1,500	50,000	160,000	33	107
Togo	1,200	30,000	60,000	25	50
Other countries	6,700	890,000	2,200,000	133	328
World	145,000	18,000,000	50,000,000	124	345

As well as the existing reserves, identified and inferred, an inventory of more than 1,600 world phosphate mines, deposits, and occurrences was compiled by the U.S. Geological Survey. The great majority of these are not operational as mines, primarily because they are not economic at this stage because of many factors such as location or being of lower grade deposits. If prices rise significantly enough they can become additional sources of supply.

There will be no 'Peak Phosphorus' for some time yet.

Chapter 7: Feeding the world in 2050

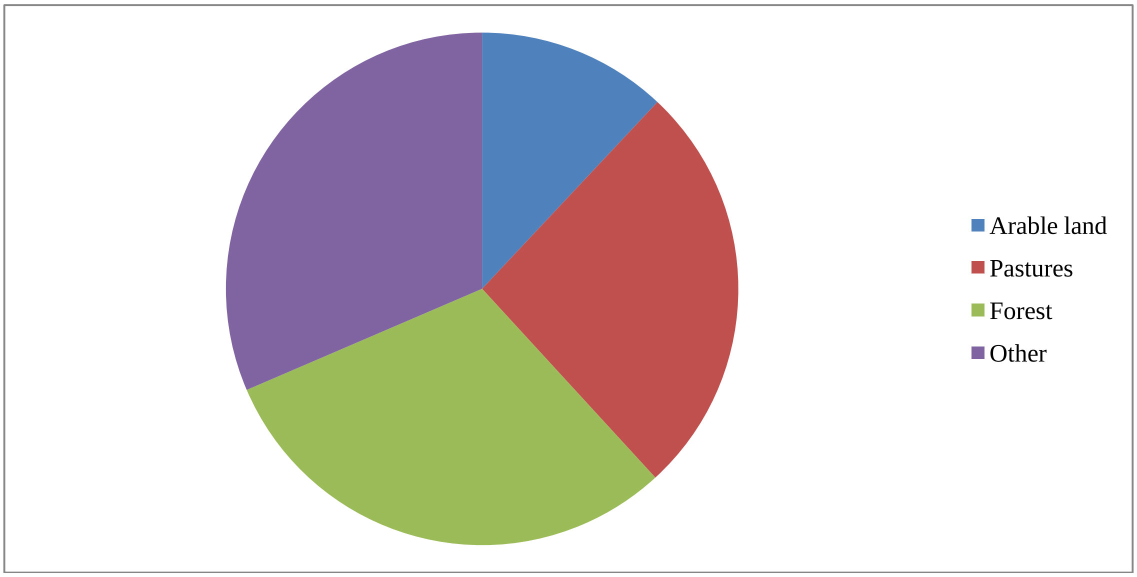
There is a huge challenge for agriculture and the fertilizer industry in delivering increases in production to feed the world's population in 2050. There are a range of forecasts of the size of the world population in 2050 but they all tend to centre around 9 billion people alive in the world at the one time. Current estimates of the world population are that it is around the 6.8 billion mark.

The FAO have noted that it will be not only be a larger population but it will also be a wealthier population in 2050, able to afford to purchase more food and also better quality food such as meat and other animal products which are dependent upon production of increased feed grains.

There are also many estimates for current world population which vary according to source and should be treated with caution as to the degree of precision. There are also many countries that do not conduct censuses and therefore estimates are made on limited information.

Figure 7.1 shows the current breakup of land use for the world in 2005 with the largest category "other" including urban areas, mountainous areas, protected lands, deserts and all other areas not classified to the three specific categories.

Figure 7.1: World land usage



7.1 FAO estimates of increased food production

One recent study on the task required for feeding the world population in 2050 was undertaken by the Food and Agriculture Organisation. It was cautious but believed the world could meet the food requirements of the population of an estimated 8.8 billion people in 2050. The FAO have estimated that the average world's daily food energy availability per person would reach 3050 kilocalories up from 2770 kcal in 2003/05. The number of undernourished people in the world would decline from 820 million people in 2003 -- 2005 to 370 million people in 2050.

However some of the assumptions can be challenged as to their realistic potential and also the fact that they have not taken into account other global requirements.

The FAO projections for production, area harvested and yields required in tonnes per hectare for the major crops for 2050 are provided in Table 7.1. As a comparison point the existing levels of production, area harvested and yields are provided for a base period of the average of 2005-2007.

As can be noted, to feed the expected 8.8 billion people under their modelling requires general expansions in area harvested for most of the major crops and significant yield increases per hectare. The increase in yields required can be converted to an annual rate of productivity increase for the different crops. Productivity improvements help maintain price pressures on the agricultural products. There is not a commensurate expansion of inputs to be purchased to cover the increase in outputs. This does not mean that there is an absolute reduction in the inputs required but a relative reduction to achieve higher rates of output per unit of input. Expanding production will still require additional inputs such as fertilizer but the relative amount required may decline due to management improvements such as reduced competition for the nutrients in the soils from fewer competing weed species.

In 2009, the FAO convened an expert forum to further consider the issue of feeding the world's population in 2050. For their experts' consideration, the following points were made:

"Increasing input use efficiencies in agricultural production will be essential as natural resources are getting scarcer, and prices of non-renewable resources like fossil fuels, nitrogen, and phosphorus are expected to increase over the next decades." and

"...globally the rate of growth in yields of the major cereal crops has been steadily declining. The rate of growth in global cereal yields, for example, dropped from 3.2 percent per year in 1960 to 1.5 percent in 2000. The challenge for technology is to reverse this decline, given that a continuous linear increase in yields at a global level following the pattern established over the past five decades would not be sufficient to meet food needs."

"Crop yields would continue to grow but at a slower rate than in the past. This process of decelerating growth has already been under way for some time. On average, annual crop yield growth rate over the projection period would be about half (0.8 percent) of its historical growth rate (1.7 percent ;). Cereal yield growth would slow down to 0.7 percent per annum , and average cereal yield would by 2050 reach some 4.3 tonne/ha, up from 3.2 tonne/ha at present."

Table 7.1: FAO 2050 forecasts and base year data

	Production Mt		**Area harvested m Ha**		**Yield t/Ha**	
	2005 -- 07	**2050**	**2005 -- 07**	**2050**	**2005-07**	**2050**
Wheat	611	907	224	242	2.72	3.75
Rice (paddy)	641	784	158	150	4.05	5.23
Maize	733	1153	155	190	4.73	6.06
Soybeans	218	514	95	141	2.29	3.66
Pulses	60	88	71	66	0.84	1.33
Barley	138	189	57	58	2.43	3.24
Sorghum	61	111	44	47	1.39	2.36
Millet	32	43	35	34	0.86	1.43
Seed cotton	71	90	36	32	1.95	2.8
Rape seed	50	106	31	36	1.61	2.91
Groundnuts	36	74	24	39	1.49	1.91
Sunflower	30	55	23	32	1.29	1.72
Sugarcane	1413	3386	21	30	67.02	112.34

The most obvious assumption available for challenge is that there would be an expansion of farmland on a global scale. They acknowledged that east and south Asia generally are likely to have reductions in farmland similar to that which has happened in Western industrial societies. The expansion of farmland is to occur primarily in South America and sub-Saharan Africa. The countries with the greatest potential expansion of farmland are those that are in the Amazon basin in South America with the biggest expansion meant to occur in Brazil. The next major potential country source of increased arable land is the Democratic Republic of Congo which again is primarily rainforest. They are also forecasting major increases in arable land expansion in Indonesia primarily in the less densely populated tropical rainforest regions of Kalimantan and Sumatra.

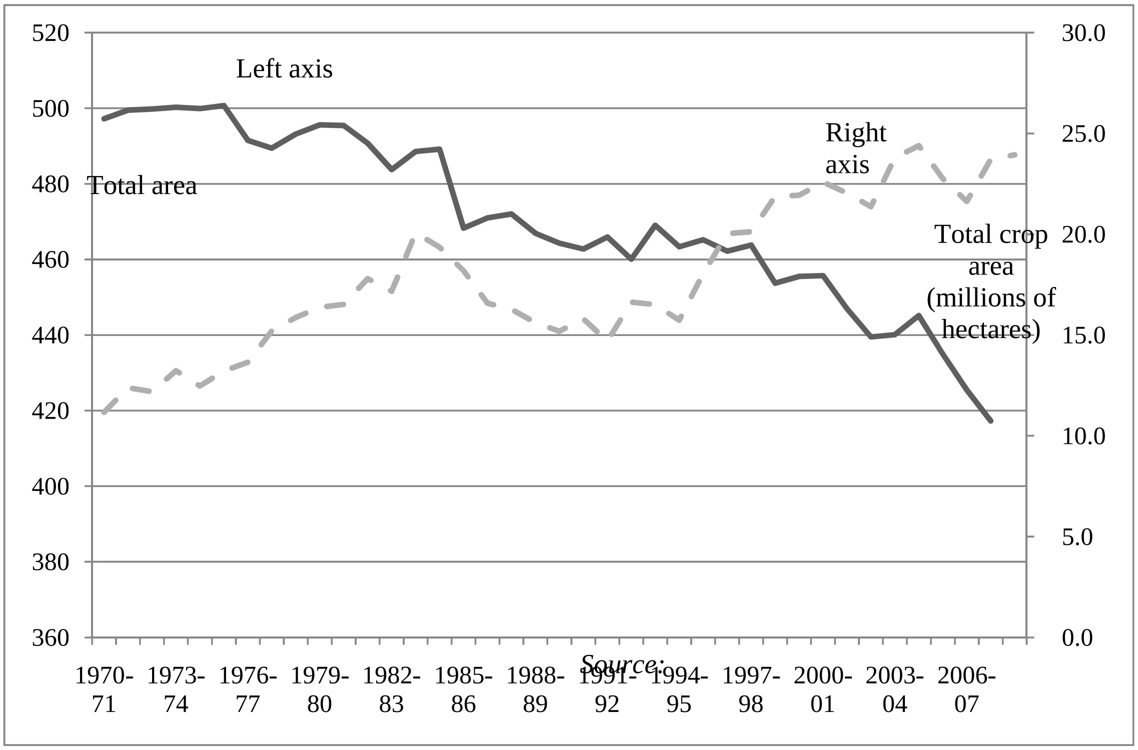
These lands have other values on a global scale such as acting as major carbon sinks in a carbon constrained world. As part of the international negotiations on climate change, discussions have taken place on whether wealthier countries should pay to maintain these rainforest regions as carbon sinks rather than allowing them to be developed for agricultural and other purposes. It is therefore not definite that by 2050 major proportions of these lands will be available for expanded agricultural production.

The FAO study noted for these lands that:

"much of the remaining land also suffers from constraints such as ecological fragility, low fertility, toxicity, high incidence of disease or lack of infrastructure. These reduce its productivity, require high input use and management skills to permit its sustainable use, or require prohibitively high investments to be made accessible or disease-free."

The continuing urbanisation and industrialisation is taking usually productive agricultural lands out of use as cities and their required infrastructure expand into them. Even a nation as large and relatively un-populated as Australia has seen a decline in the area of farmland over the last four decades. Figure 7.2 shows the amounts and trends over that time for Australia.

Figure 7.2: Area in farmland and cropping area -- Australia



To assess the agricultural production requirements for 2050 a set of scenarios showing the required growth rates and productivity improvements for various crops, holding the amount of land available for them constant, and with a 5 percent decrease in the land available for cropping and only a 5 percent increase in cropping land compared to the FAO scenario.

The technical coefficient of production or fixed land/output composition ratios are held constant over the time period to 2050. In actual circumstances there would be changes in the mix of products reflecting relative prices and demands and supply factors, but these have not been modelled.

The base case of productivity improvements is that required to meet the 2050 production target of tonnes per hectare yield from that achieved in 2005- 07 from the FAO database for each crop. It is based upon using the assumptions on area harvested for each crop in 2050 and expected yield.

Table 7.2: Annual rate of productivity improvement to meet FAO 2050 food production targets (%)

	Productivity growth 1961-63 to 2005-07	base case	land constant	land+ 5%	land -5%
Wheat	2.00	0.72	0.89	0.78	1.00
Rice (paddy)	1.70	0.57	0.45	0.34	0.57
Maize	1.99	0.55	1.01	0.90	1.13
Soybeans	1.60	1.05	1.93	1.82	2.05
Pulses	0.81	1.03	0.87	0.76	0.98
Barley	1.21	0.64	0.69	0.58	0.81
Sorghum	0.92	1.18	1.33	1.22	1.45
Millet	0.90	1.14	0.80	0.69	0.91
Seed cotton	1.72	0.81	0.55	0.44	0.67
Rape seed	2.43	1.32	1.69	1.58	1.80
Groundnuts	1.26	0.55	1.63	1.52	1.75
Sunflower	0.58	0.64	1.38	1.27	1.50
Sugarcane	0.75	1.15	1.97	1.86	2.09

Source: FAO 2009

The productivity improvements on an annual basis are not extremely high compared to what has been achieved in recent historical times, such as from the Green Revolution achievements in Asia, or even from the grains industry productivity improvements in Australia over the last few decades. As shown in Table 7.2 the required rates of productivity improvement out to 2050 are only higher than that which has been achieved in the period 1961-63 to 2005- 07 for pulses, sorghum, millet, sugarcane and some oilseed crops such as rape seed and sunflower. As shown previously in Figure 5.1, Australian broadacre agriculture has achieved an annual rate of productivity increase of 1.4 percent per year on average over the last three decades.

The target yields in productivity improvements under the various assumptions rise but not to levels that have never been achieved in the past. However, these levels of productivity improvements need to be sustained on an annual basis for the next four decades which will be a considerable challenge.

The FAO estimate a near 50 percent increase in cereal production from 2000 million metric tonnes to 3000 million metric tons, and an increase in meat production from 249 million tonnes to 460 million tonnes for their base case assessments. A large proportion of cereal production is expected to be used as feed for the livestock industries. As the FAO noted:

"Meat consumption per caput (sic) for example would rise from 37 kg at present to 52 kg in 2050 implying that much of the additional crop (cereal) production will be used for feeding purposes in livestock production." FAO 2009

7.2 The potential impact of biofuels

There was no allowance made for potential expansion of crops for bio-fuels which could have a significant impact on future food availability in the FAO study.

If agricultural products such as sugar, grains and oilseeds are diverted to bio-fuel production then there will be increasing demand for them. The current estimates of conversion ratios are:

- 1 tonne of sugar will produce 560 litres of ethanol
- 1 tonne of grain (wheat or coarse grains) will produce 360 litres of ethanol
- 1 tonne of oilseeds will produce 400 litres of bio-diesel.

Current world consumption for diesel has approximated 750 billion litres per year, and for petrol over 1100 billion litres per year.

A number of countries have mandated the use of these bio-fuels on various grounds such as enhanced energy security or for perceived environmental benefits in reduced greenhouse emissions. Brazil, the European Union and the United States are examples who have been moving to mandated consumption levels of these fuels. There are regular changes or attempting to increase the proportion of bio-fuels relative to fossil fuel derived petroleum products.

If agriculture should be required to meet 1 percent of the current world consumption of petrol and bio-diesel on an annual basis over the period to 2050 then that target can be met on an annual basis by:

- 30 million tonnes of grain or approximately two percent of production in 2005- 07 for conversion into bio ethanol as a substitute for petrol; or
- 20 million tonnes of sugar or approximately 1.5 percent of production in the 2005- 07 base period to meet the same target; and
- 19 million tonnes of oilseeds or 10 percent of production in the base period (excluding soya bean) to meet the 1 percent bio-diesel target.

Any diversion into bio-fuels will increase the productivity improvements required in agricultural crop production to meet the food plus biofuel requirements of the expanded population.

Research is being undertaken into developing alternative sources of plant material to provide the feedstock for bio-fuels. The intent of this research is to provide an alternative to using food grade plants for the production of these bio-fuels and therefore reduce the demand and hence price of foodstuffs. An example of this is the idea to use a plant called switchgrass in the US with hoped-for technological developments in enzymes to allow the breakdown of the cellulose in the plant for conversion into ethanol.

Even if this should work and be grown on marginal land that is unsuitable for producing foodstuffs there is still no magic pudding for resource use for the world. The fertilizer industry could be one of the hidden beneficiaries if these developments should prove viable. Whenever the switchgrass is harvested it would be removing nutrients from the soil which would have to be compensated with additional chemical fertilizers.

Harvesting switchgrass or other plant materials for the production of cellulosic ethanol will require major additional nutrients to ensure sustainable production.

7.3 The challenge?

The Royal Society published an assessment of the needs for productivity improvements in agriculture to feed the world's growing population. It concluded from the review that:

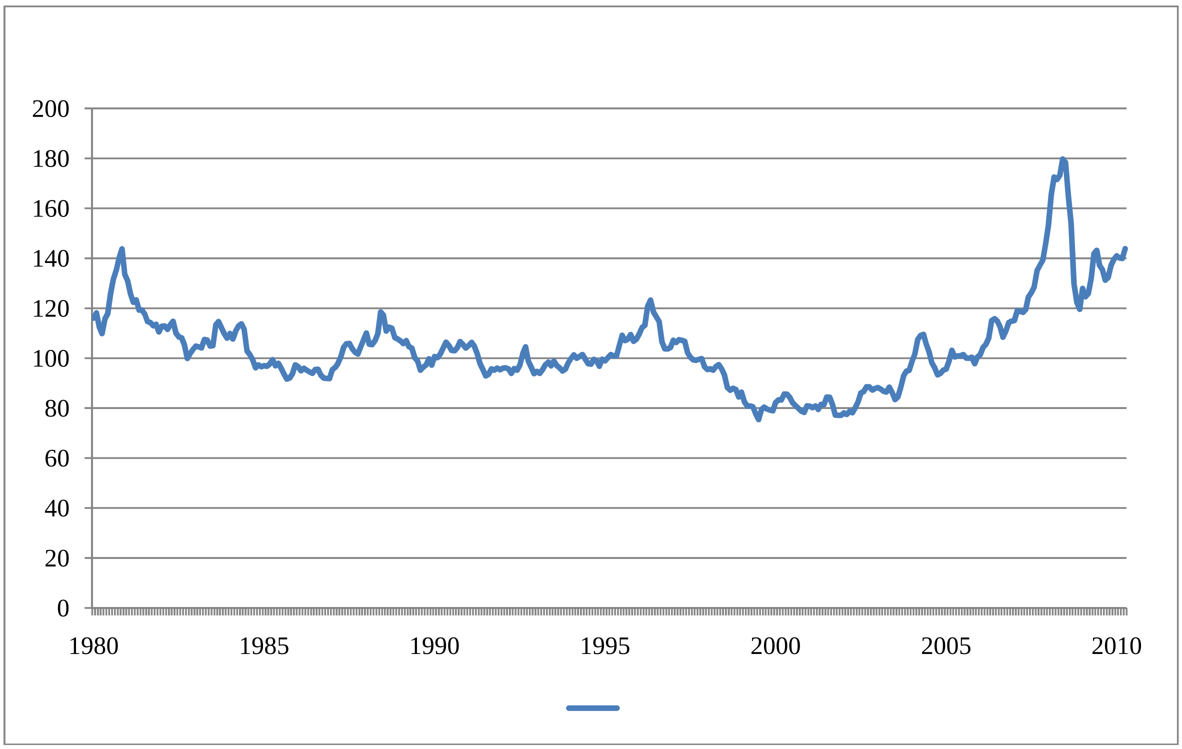
"Different assessments place different emphases on science, technology, markets, trade and social and political interventions. Most agree that the challenge of food security can only be met through a combination of measures across all relevant science and policy arenas. Those that focus on science and technology offer various options for improvement, but all agree that there is no simple 'magic bullet'. Their shared conclusion is that the complacency about food availability over the last two decades has resulted in a steady erosion of investment in relevant scientific research and that this needs to change. (Royal Society 2009)

If the productivity improvements cannot be delivered in the time frame required then the only solution to delivering the food required to feed the growing population is an intensification of production using existing technologies. Fertilizer is the crucial fall back technology to deliver the increased production necessary.

Chapter 8: The International Food Price Spike of 2008

The downward trend of real food prices for the past 25 years came to an end when world prices started to rise in 2006 and escalated into a surge of price inflation in 2007 and 2008. A new peak in world agricultural prices was seen in 2008. Figure 8.1 shows the rise in the food price index in SDRs from the International Monetary Fund. The upturn in these agricultural prices also coincided with record petroleum and fertilizer prices. The ramifications of this will be long term and are still being worked through. However there is no doubt that there will be major impacts on both the Australian agricultural sector and the Australian and international fertilizer industries.

Figure 8.1: IMF Food index- monthly



There were riots, demonstrations and protests about the rise in prices in many countries around the world. Governments responded to these price increases and protest actions with a suite of policies, some rational and unfortunately some irrational that could have serious negative impacts in the long run.

Apart from the political developments and problems in many countries there were also some serious humanitarian issues raised. For example, an FAO mission visiting Bangladesh in April/May 2008 estimated that about 37 percent of households were consuming fewer than three meals per day because of high food prices.

Though prices have come back down, this episode provides an advance view of what could happen, but on a longer term and more serious scale, if agricultural production and productivity do not continue to rise well into the long-term.

For this particular episode, a number of factors contributed to raising food prices according to the FAO (2009). On the demand side:

- food consumption expanded rapidly in developing countries as a result of strong global economic growth from 2004.
- A dietary transition from cereals toward more animal protein has also increased demand for feed crops, such as maize, in emerging economies
- Demand for non-food agricultural products, such as timber, fibre and bio-fuel, had also increased sharply.

On the supply side, there was a reduction attributed to:

- stagnation in area under cultivation and yield, as well as low investment
- Bad weather reduced production levels in many important exporting countries, notably Australia
- World cereals stocks as a proportion of production also declined to one of their lowest levels in recent years, exacerbating the crisis.

The then record high oil prices, which resulted in higher food production and transport (including freight) costs, the weak US dollar, speculative activities and trade policies are also said to have contributed to high food prices.

Table 8.1 provides details of the subset of countries imposing export restrictions on their agricultural products which were major exporters of fertilizer products. Their ranking as a fertilizer product exporter is also provided for the individual products. Though these countries imposed export restrictions on foodstuffs, they did not necessarily impose restrictions on fertilizer exports. The potential for future interferences in the export market will be dependent upon many factors other than food security such as dependence upon particular export commodities for trade purposes and more than adequate domestic self-sufficiency in fertilizer products.

As was observed at the time of the food price spike, some major fertilizer exporters such as China were prepared to interfere in some of their markets for domestic political reasons. This sends a signal to customers that market supply conditions may well be subject to interference and manipulation by governments in the future. Other major suppliers of fertilizer products on world markets also took policy action to reduce prices in their domestic market.

These were not always negative policy initiatives — some moved to redress or remove restrictive trade policy positions. For instance, Morocco cut tariffs on wheat imports from 130 percent to 2.5 percent, a positive move for Morocco's economic welfare and its domestic consumers. The scale of this action indicates the serious degree of concern that was held over food security. Having undertaken this major reform in response to the Food Price Spike shock, a question remains as to the types of policies it might be willing to adopt to ameliorate domestic food supply and price concerns in the future.

A significant number of agricultural product exporting countries imposed export restrictions on various agricultural products because of the Food Price Spike. These restrictions took many forms including export embargos, export taxes and domestic subsidies to divert product from export to domestic markets. In many cases the policy intention was to protect domestic consumers from the much higher prices then prevailing in the international market.

Some members of the Cairns Group were amongst the countries imposing export restrictions. The Cairns Group is a group of agricultural trading nations who have combined together in international trade negotiations to try and achieve reductions in import barriers and other trade restrictions in world agricultural markets.

Because of the restrictions imposed on food exports, there is a great deal of uncertainty as to where the long-term policies of many of these food importing countries will go, but the issue is likely to be important for many of them.

Table 8.1: Countries Applying Food Export Restrictions and Exports of Fertilizer Commodities

Country	**Fertilizer commodity exports**	World rank as exporter of product
Brazil	TSP	9
China	TSP	1
	Urea	1
	Ammonium nitrate	9
	Ammonium sulphate	5
	CAN	8
	MAP	3
	DAP	5
Egypt	Phosphate Rock	6
	TSP	8
	Urea	7
Iran	Ammonia	3
	Sulphur	9
Jordan	Phosphate rock	3
	Potash	6
	DAP	6
Kazakhstan	Ammonium nitrate	10
	MAP	8
	Sulphur	5
Syria	Phosphate rock	3

Source: IFA, FAO

This is not the first time that sovereign risk has been introduced into world agricultural markets by governments seeking to manipulate domestic food prices and availability. However, history has shown that the consequences of such action can be long term and extremely damaging to the countries and industries involved. US action to protect its feed grain using livestock industries is a good example. Following a disease outbreak and major drop in the availability of feed grain, the United States imposed a soybean export embargo in 1973. Japan, a major importing country, diverted its demand elsewhere and fuelled the rapid expansion of the Argentinean and Brazilian Soybean industries. Today, US dominance in the production and export of this commodity has been significantly diminished.

As well as the riots from consumers over high food prices in the 2008 Food Price Spike, simultaneous high fertilizer prices also led to riots among farmers in developing countries. Fertilizer protests had been reported in Egypt, India, Kenya, Nepal, Nigeria, Pakistan, Taiwan and Viet Nam.

The IFA noted that for fertilizer-consuming countries for Fertilizer Year (FY) 2007/08, the majority of those implementing fertilizer subsidies are among the major fertilizer exporting countries, with China topping the list.

A number of countries implemented policies that had an impact on the price and demand for fertilizers by farmers:

- In Bangladesh the existing fertilizer subsidy was increased significantly;
- In Indonesia the government aimed to achieve food self-sufficiency through increasing subsidies for seeds, fertilizers and loan schemes for farmers;
- India expanded in some cases its subsidy on fertilizer that was paid to manufacturers and importers;
- China imposed a 150 percent export tax on fertilizer;
- A few African countries, including Madagascar, Malawi, Tanzania and Zambia attempted to introduce or expand input (mainly fertilizer) subsidy programmes; and
- Kenya, Uganda and Tanzania are discussing the possibility of setting up a regional fertilizer plant to offset high costs and ensure long-term sustainable supplies.

The implications of the 2008 Food Price Spike and the policy reactions of governments auger potential difficulties for agricultural producers around the world including in major food exporters such as Australia. The interference in fertilizer markets and the potential for future trade restrictions in reaction to high prices should be of concern for economic policymakers, and the fertilizer industry.

Policy issue: The Department of Foreign Affairs and Trade (DFAT) do not monitor or collect information on barriers to trade in fertilizer products. They have a detailed database on restrictions in agricultural product trade but not on the inputs to agriculture. DFAT should extend their monitoring and scope of trade negotiations to include the major inputs into agricultural production.

Chapter 9: Carbon Pollution Reduction Scheme

9.1 CPRS background

The fertilizer industry could face major changes from the introduction of the CPRS without a comprehensive international agreement to maintain its competitiveness. It will create a very different competitive market for all industries in Australia with ramifications on firm and industry competitiveness across the board. The impacts on the fertilizer industry and its customers need to be understood to ensure that there is effective adaptation to the changed competitive environment.

The CPRS has been officially deferred until 2013 and there are alternative views as to the timetable and the policy instruments that should be used in reducing Australia's greenhouse gas emissions. The status of the debates on what will be the path for Australia to reduce its emissions is still unresolved. There is no doubt however those industries that directly emit greenhouse gases or indirectly through their usage of fossil fuel energy sources such as natural gas will face an additional cost impost in a carbon constrained world.

The institutional policy drivers for an emissions trading scheme for Australia are in place and despite the current political and policy differences on whether to adopt such a scheme and the timing of its implementation, there is a very real possibility that an emissions trading system or other carbon pricing mechanism could well be implemented in the near future. Some industries such as the electricity generation sector are pursuing implementation of such a scheme to reduce the risks of investment in long-lived assets.

Apart from the political and policy impetus in favour of adoption there are also market signals flagging that there will be some type of carbon constraint adopted for 2013. For example, the futures prices of electricity contracts are approximately double in that year compared to 2012. This is a current market signal in a contract market with all the latest information available to market participants including the current state of political processes. Market based signals are generally more accurate precursors of future policy options than current statements by political participants. It is therefore a proactive stance to ensure the impacts of carbon pricing are well understood by all industries and the community generally.

These potential additional costs can be measured for the fertilizer industry on the assumption that something like the parameters used in the Carbon Pollution Reduction Scheme will be adopted in any future emissions reduction scheme.

It is worthwhile noting the amount of work that has gone into developing the emissions trading model for climate change in Australia.

The timeline of preparation for introducing emissions trading into the Australian economy for reducing greenhouse gas emissions has been:

- Australian Greenhouse Office (AGO) discussion papers (1999)
- State Task Force (2006)
- PM's Task Group (2007)
- Dept of Climate Change (2008)
- Garnaut draft (June 2008)
- Green Paper (July 2008)
- Garnaut final report (Oct 2008)
- White Paper (Dec 2008)
- exposure legislation (Mar 2009)
- First revisions (May 2009)
- Senate re-consideration (Nov 2009).

Despite having governments of differing political persuasions throughout this time period, they all came to the conclusion that an emissions trading scheme was preferable to imposing a carbon tax or a regulatory means of reducing emissions trading. There is a momentum built in to the climate change/carbon reduction debate to favour some form of emissions trading ahead of all other methods of constraining greenhouse gas emissions.

The general principles of the scheme are that the proposed 'cap and trade' CPRS operates as follows:

1. Significant emitters of greenhouse gases need to acquire a ‘carbon pollution permit’ for every tonne of greenhouse gas that they emit
2. The quantity of emissions produced by firms will be monitored and audited
3. At the end of each year, each liable firm would need to surrender a ‘carbon pollution permit’ for every tonne of emissions that they produced in that year. The number of ‘carbon pollution permits’ issued by the Government in each year will be limited to the total carbon cap for the Australian economy
4. Firms compete to purchase the number of ‘carbon pollution permits’ that they require. Firms that value carbon permits most highly will be prepared to pay most for them, either at auction, or on a secondary trading market. For other firms it will be cheaper to reduce emissions than to buy ‘permits’. Certain categories of firms might receive some ‘permits’ for free, as a transitional assistance measure. These firms could use these or sell them.

We are following on from the original European model which has had in place an emissions trading scheme for carbon dioxide and other greenhouse gases since 2007. The history of emissions trading for providing a low-cost means of getting market forces for dealing with industrial emissions goes back much further to the original emissions trading scheme in the US for acid rain emissions. That scheme was highly successful in delivering significant emissions cuts in gases such as sulphur dioxide at much lower cost than was originally thought. That model ended up being the template for market mechanisms for reducing emissions by industries and countries in the greenhouse debate. It was a US Government initiative that was adopted under then President Clinton in the climate change negotiations which led to the Kyoto protocol. History has shown that the US did not sign on to its own proposal with their domestic politics ensuring non-ratification by the US Government. There was a "sense of the Senate" 95 to nil vote against ratification of the Kyoto Protocol. The U.S. Senate is responsible for ratifying all international treaties to allow them to be enforced in the US. The US Government did not try and have the Kyoto Protocol implemented.

The Kyoto Protocol was adopted in 1996 and Australia was one of what are called Annex One countries that would be bound to reduce their emissions or achieve lower rates of emissions than were forecast under the Business As Usual case. Australia negotiated an increase in its allowable emissions of 8 percent from 1990 levels under the agreement.

As shown there has been a very large amount of work undertaken by governments of different political persuasions and their bureaucracies at federal and state level developing the model for the CPRS. This indicates a momentum built into governments for the introduction of emissions trading ahead of other alternative measures such as regulatory action or direct carbon and other emissions taxation.

Though the CPRS scheme has been deferred and there are alternatives being floated such as the carbon tax proposed by Prof Garnaut, there is a strong institutional bias for an emissions trading scheme.

The CPRS remains in limbo at this stage but the government has promised to try and have it implemented by 2013. If implemented in its proposed form the Australian fertilizer manufacturing industry will be subject to new costs that competing imports will generally not face. These costs will mainly be associated with price increases for fossil fuel based energy use. Non-combustion uses of fuel, such as using natural gas as a chemical feedstock, will not attract an impost under the CPRS.

The major specific components of the scheme are:

- a 5 percent reduction in our emissions from 2000 levels by 2020. As no international agreement was reached in Copenhagen, the option of increasing targets of 15 or 25 percent reductions has been shelved for the time being
- for the first year of the scheme which was meant to start in 2011 -- 12 but has been postponed to 2013 by the federal government, emissions prices were to be fixed at $10 per tonne. Fixed-price emissions permits of $42 per tonne were to be made available for the next four years putting a cap on the potential price rises
- Approximately 1100 entities whose emissions exceed 25,000 tonnes per year were to be subject to direct permit liabilities the scheme
- Special arrangements were to be put in place for the emission intensive trade exposed industries. If emissions exceed 2000 tonnes of CO2 equivalent per million dollars of revenue or 6000 tonnes of CO2 equivalent per million dollars of value added then those companies would be able to receive free permits equal to 90 percent of their

requirements and an additional 5 percent from the so-called Global Recession Buffer which was brought in after the international financial sector problems in the Global Financial Crisis came to light (bringing the exemption to 94.5 per cent)

- If emissions exceeded 1000 tonnes of carbon dioxide equivalent per million dollars of revenue or their emissions were between 3000 and 5999 tonnes of carbon dioxide equivalent per million dollars of value added then those activities would receive free permits equal to 60 percent of their assessed requirements plus an additional 10 percent from the Global Recession Buffer (bringing the emission exemption to 66 per cent)
- The allocation of free permits was to decline at the rate of 1.3 percent per year
- one-way link to international markets. We could import emissions permits from overseas schemes such as the Clean Development Mechanism or Joint Implementation which were available to Kyoto Protocol signatories.

The Global Recession Buffer was not to be removed after five years unless there was an international agreement on climate change which Australia was a party to and five years notice was to be given of any modifications to the allocation of free permits to the emission intensive trade exposed industries.

The one-way link allowing imports but not exports of permits was a means of ensuring that Australian emissions permit prices would not rise to the levels prevailing in Europe under their Emissions Trading Scheme but would allow Australia to import cheaper offsets from other countries and therefore reducing the need to reduce Australian emissions if there were cheaper alternatives overseas.

To provide an indication of the magnitude of the effects of the proposed scheme if a permit for 1 tonne of carbon dioxide or its equivalent costs $20, the Scheme will have a direct cost of $8.4 billion to liable parties (not counting free permit allocations). There will also be indirect costs to all Australians as the carbon cost is passed through in the supply chain. A $20 permit price is anticipated to raise inflation by 1 percent, increase electricity prices by 16 percent, gas by 9 percent and fuel prices by 5.6c per litre (although for the first 3 years the government has pledged to reduce fuel tax by a similar amount).

9.2 CPRS and the Fertilizer manufacturing Industry

The effects of the currently proposed CPRS on fertilizer manufacturing in Australia will be an additional cost for producing in Australia compared to competing imports from countries if there is no broad scale international agreement. Fertilizer manufacturing in Australia is not an emissions intensive industry but will still incur significant additional costs.

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Table 9.1: Greenhouse emissions, Australia 2008

	Fertilizer Manufacturing	Manufacturing Sector
Direct emissions -- scope 1	49,199	72,700,000
Energy use emissions -- scope 2	932,803	63,600,000
Total emissions	982,002	136,300,000

Source: FIFA, Department of Climate Change and Energy Efficiency 2010

The impact on the fertilizer industry from the implementation of the current parameters for the Carbon Pollution Reduction Scheme is detailed in Table 9.2.

Table 9.2: Fertilizer industry and eligibility for EITE support

	Tonnes emitted per million dollars
Revenue	226
Value added	958

The fertilizer manufacturing industry only accounts for 0.7 percent of the total emissions of the manufacturing sector. It does not meet the general value added and revenue criteria to receive concessional permits under the Emissions Intensive Trade Exposed industries schemes.

If the scheme had been in place in 2008 then the industry would have been subject to additional costs under the CPRS of $19.6 million at a hypothetical price of $20 per permit. In 2009, the industry achieved significant reductions in its emissions, where they dropped to 755,000 tonnes compared to the previous year. The additional cost impost on the sector at a $20 permit price would have dropped to $15.1 million.

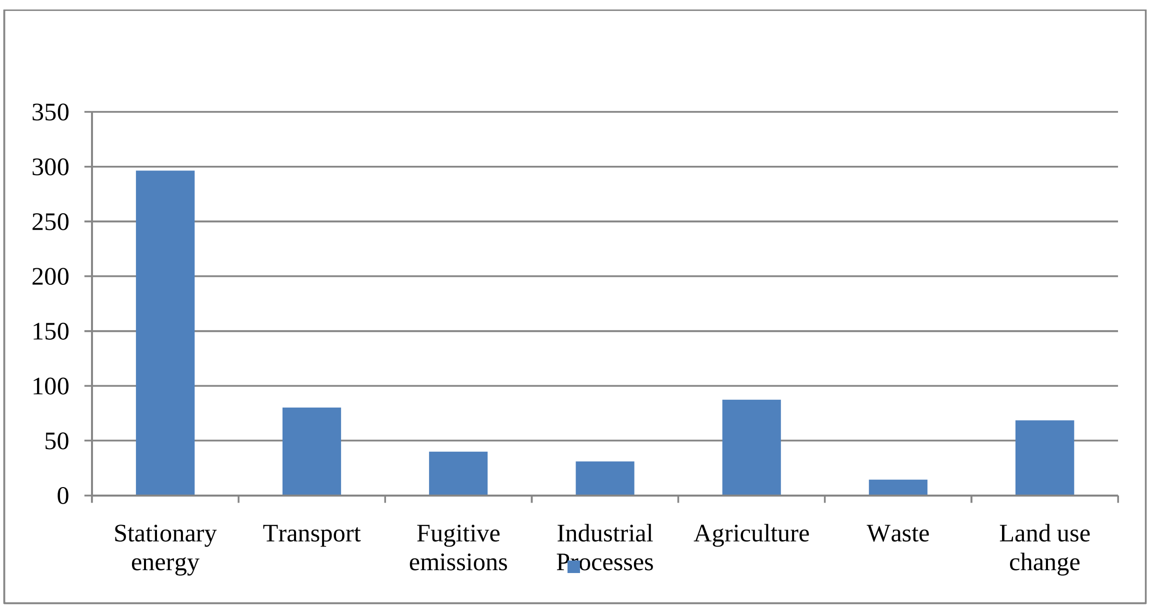
As an indication of the scale of this additional cost for the fertilizer manufacturing industry, it is equivalent to nearly an additional 2 percent on the value added of the industry or 6 percent on the wages and salaries bill of the industry.

9.3 The CPRS and the Agricultural Sector

The major impact for the fertilizer industry may not be its own direct impact of higher costs and inability to compete with imports, if they are not under the same carbon price constraint, but on demand for their products from the agricultural sector.

Putting Australia's emissions in perspective in 2006, Australia's net greenhouse gas emissions using the Kyoto accounting provisions were 576.0 million tonnes of CO_2-equivalent (Mt CO_2-e), with the bulk of Australia's emissions coming from stationary energy (primarily electricity generation), transport and agriculture, as can be seen from Figure 9.1, below.

Figure 9.1: Emissions Profile - Australia: 2008(mt)



Source: Department of Climate Change and Energy Efficiency, 2010

Agriculture was to be initially exempt from coverage in the scheme but would be considered for inclusion five years after the commencement of the scheme. The agriculture sector produces most of Australia's methane and nitrous oxide emissions. Agriculture produced an estimated 88.1 Mt CO2-e emissions or 14.8 percent of net national emissions in 2007.

In the latest inventory nitrous oxides from the use of nitrogen fertilizers on Australian soils are estimated to account for 17 percent of agricultural emissions and an additional 1.8 percent is attributed to manure management, part of which could be attributed to the higher production of livestock from enhanced fertilizer use.

There is a dispute as to the accuracy of the measurement of these emissions as the Australian government has used IPCC parameters based upon European studies of their agricultural emissions for determining the emissions from Australian soils. These European parameters are being questioned as not being reliable or accurate for Australian soils and climatic conditions. If the European case is overturned emissions from agriculture and Australia will be assessed at lower levels. This however will not change emissions targets to be met by other industries such as the fertilizer manufacturing industry.

Another area of contention is determining the global warming potential or cumulative radiative forcing of nitrous oxide relative to carbon dioxide over a 100-year time horizon. This potential has varied in recent times from one molecule of nitrous oxide being equal to 296, then 298 and now 310 or 312 times that of a molecule of carbon dioxide. The Australian government in its latest report has used 310 times as the forcing factor. The science and therefore the impact of nitrogenous fertilizers is still being determined.

The total nitrous oxide emissions from agriculture are approximately equivalent to the emissions from one large coal-fired base load power station.

Table 9.3: Nitrous oxide emissions and the agricultural sector (mt)

	N_2O emissions	Percentage of agricultural emissions
Manure management	1.6	1.8
Agricultural soils	15	17.0
Savanna burning	3.5	4.0
Agricultural residues burning	0.1	0.1
Total N_2O emissions	20.2	22.9
Total agricultural sector emissions	88.1	100.0

Source: Department of Climate Change and Energy Efficiency, 2010

There have been many exercises trying to determine the impact of climate change on Australian and world agricultural production. As an example ABARE modelling (Gunasekera 2007) indicated:

- that future climate change and associated declines in agricultural productivity and global economic activity may affect global production of key commodities: e.g. global wheat, beef, dairy and sugar production could decline by 2–6 per cent by 2030 and by 5–11 per cent by 2050, relative to what would otherwise have been the case (the 'reference case')

- Australian production of these commodities could decline by an estimated 9–10 per cent by 2030 and 13–19 per cent by 2050, relative to the reference case

- These changes would also have significant implications for international agricultural trade. For example, Australian agricultural exports of key commodities are projected to decline by 11–63 per cent by 2030 and by 15–79 per cent by 2050, relative to the reference case.

There is a great deal of uncertainty about the nitrous oxide emissions from the use of fertilizers in Australian agriculture. A review article on this subject by CSIRO stated:

> *"Estimates of N_2O emissions from various agricultural systems vary widely. For example, in flooded rice in the Riverina Plains, N_2O emissions ranged from*

0.02% to 1.4% of fertiliser N applied, whereas in irrigated sugarcane crops, 15.4% of fertiliser was lost over a 4-day period. Nitrous oxide emissions from fertilised dairy pasture soils in Victoria range from 6 to 11 kg N_2O-N/ha, whereas *in arable cereal cropping, N_2O emissions range from <0.01% to 9.9% of N fertiliser applications. Nitrous oxide emissions from soil nitrite and nitrates resulting from residual fertiliser and legumes are rarely studied but probably exceed those from fertilisers, due to frequent wetting and drying cycles over a longer period and larger area. In ley cropping systems, significant N_2O losses could occur, from the accumulation of mainly nitrate-N, following mineralisation of organic N from legume-based pastures. Extensive grazed pastures and rangelands contribute annually about 0.2 kg N/ha as N_2O (93 kg/ha per year CO_2-equivalent). Tropical savannas probably contribute an order of magnitude more, including that from frequent fires. Unfertilised forestry systems may emit less but the fertilised plantations emit more N_2O than the extensive grazed pastures. However, currently there are limited data to quantify N_2O losses in systems under ley cropping, tropical savannas, and forestry in Australia. Overall, there is a need to examine the emission factors used in estimating national N_2O emissions; for example, 1.25% of fertiliser or animal-excreted N appearing as N_2O."* (Dalal 2003)

The basic conclusion from this article is that we do not know with any degree of certainty what the emissions of nitrous oxide are from agricultural soils due to fertilizer usage.

Before agriculture can be included in an emissions trading scheme, the science on the emissions arising from the use of nitrogenous fertilizers in all the different agronomic and crop conditions in Australia will have to be much further developed. The imposition of a blanket set of rules could have adverse impacts on agricultural efficiency without achieving the lowest cost of emission reductions.

Policy issue: Indirect Greenhouse Gas Emissions Due to Fertilizers

Because of the great deal of uncertainty and the relative importance of nitrous dioxide emissions from agriculture in Australia's emissions profile, there is a need to have a much more robust and soundly based set of parameters for determining greenhouse emissions from fertilizer use.

Though there have not been any direct regulatory measures on the usage of chemical fertilizers for greenhouse purposes, there are precursor measures that could be utilised to enforce such measures being adopted in other countries. For example in Germany, Table 9.4 provides an example of the records that have to be kept by farmers under their legislation. The administrative arrangements and the information databases are already being put in place in that country and these could be quite easily utilised for other purposes such as regulated methods for reducing nitrous oxide emissions in agriculture.

Success in one country in developing such a framework and having it successfully adopted usually encourages other countries to adopt similar policies

Table 9.4: Farm nitrogen records to be kept under the German Fertilizer Act

Nitrogen input	**Nitrogen removal**
Nmin (pre-plant soil test)	Crop N removal with harvest (yield x crop N-content)
Organic and mineral fertilizers	Removal through stock (estimated via stocking rates)
Recycled organic materials	Feeding-off or removal (sales) of crop residues and green crops
Animal manure	Sales of manure
N-fixing legume crops	N-losses (denitrification & volatilisation) when spreading manure (20% of total)
Crop residues and green crops	

Source: Blaesing 2003

Policy issue: approaches to control of fertiliser use

With international precedents for imposing blanket regulatory approaches on the reporting and possible later regulation of usage and application, it is essential to try and improve the usage of decentralised market based approaches for fertiliser use, especially nitrogenous fertilisers.

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Appendix 6.1: Australian and International Production, Consumption, Exports and Imports of the Major Fertilizer Products -- 2008

The database used in this Appendix is from the International Fertilizer Industry Association and provides information on the top 10 countries in every category of production, consumption, exports and imports for all the major fertilizer products.

Where Australia does not rank in the top 10 it has been included as an additional item including the specific statistics from the International Fertilizer Association and its ranking in that category.

The member countries of the European Union (EU) have been included in the aggregate figure for that trade bloc and disaggregated information is not provided on those specific countries.

TABLE A6.1 - AMMONIA

WORLD AMMONIA (NH3) STATISTICS BY COUNTRY IN '000 TONNES PRODUCT

Rank	PRODUCTION		Rank	EXPORTS		Rank	IMPORTS		Rank	CONSUMPTION	
	World	151,904		World	18,768		World	18,768		World	151,904
1	China	48,953		Trinidad and Tobago	4,566		USA	7,442		China	49,239
2	EU	15,386		Russia	3,728		EU	3,882		EU	17,644
3	Russia	12,683		EU	1,624		India	1,305		USA	16,911
4	India	11,800		Ukraine	1,394		Korea Rep.	1,029		India	13,105
5	USA	9,702		Indonesia	1,245		Taiwan, China	716		Russia	8,959
6	Indonesia	5,415		Canada	1,218		Turkey	650		Indonesia	4,202
7	Ukraine	4,998		Saudi Arabia	881		Norway	374		Canada	3,727
8	Trinidad and Tobago	4,975		Iran	752		Morocco	332		Ukraine	3,604
9	Canada	4,730		Algeria	539		China	286		Egypt	3,257
10	Egypt	3,393		Qatar	452		Thailand	285		Pakistan	3,208
18	**Australia**	**1,283**	**13**	**Australia**	**321**	**16**	**Australia**	**208**	**18**	**Australia**	**1,170**

TABLE A6.2 - AMMONIUM NITRATE

WORLD AMMONIUM NITRATE (AN) STATISTICS BY COUNTRY IN '000 TONNES

Rank	PRODUCTION		EXPORTS		Rank	IMPORTS		CONSUMPTION	
	World	41,828	World	8,485		World	8,484	World	41,827
1	Russia	8,046	Russia	3,167		EU	1,417	USA	7,914
2	USA	7,367	EU	869		Brazil	777	EU	4,984
3	EU	4,435	Ukraine	812		USA	738	Russia	4,879
4	China	4,212	Canada	634		Turkey	568	China	4,042
5	Ukraine	2,358	Uzbekistan	444		Indonesia	475	Ukraine	1,796
6	Uzbekistan	1,873	Georgia	334		Peru	292	Uzbekistan	1,429
7	**Australia**	**1,418**	**Australia**	**223**		Morocco	284	**Australia**	**1,330**
8	Canada	1,296	USA	192		Ukraine	250	Egypt	1,245
9	Egypt	1,225	China	170		Mexico	240	Brazil	1,217
10	South Africa	1,136	Kazakhstan	140				South Africa	1,040
					17	**Australia**	**136**		

TABLE A6.3 - AMMONIUM SULPHATE

WORLD AMMONIUM SULPHATE (AS) STATISTICS BY COUNTRY IN '000 TONNES

Rank	PRODUCTION		Rank	EXPORTS		Rank	IMPORTS		Rank	CONSUMPTION	
	World	19,027		World	9,140		World	9,144		World	19,031
1	EU	4,595		EU	3,409		EU	2,420		EU	3,606
2	USA	2,529		Russia	1,201		Brazil	1,451		USA	1,899
3	China	2,381		USA	1,022		Malaysia	912		China	1,706
4	Russia	1,457		Japan	730		Vietnam	667		Brazil	1,669
5	Japan	1,412		China	675		Turkey	513		Indonesia	1,180
6	Mexico	942		Korea Rep.	613		Indonesia	488		Mexico	1,121
7	Canada	904		Canada	443		Philippines	406		Malaysia	912
8	Korea Rep.	710		Ukraine	386		USA	392		Japan	693
9	Indonesia	692		Taiwan, China	267		Mexico	198		Vietnam	667
10	Taiwan, China	530		Belarus	156		Thailand	193		Turkey	616
12	**Australia**	**431**	**14**	**Australia**	**30**	**20**	**Australia**	**59**	**14**	**Australia**	**460**

T A B L E A 6.4 - C A N

W O R L D C A N S T A T I S T I C S B Y C O U N T R Y I N '0 0 0 T O N N E S P R O D U C T

Rank	PRODUCTION		EXPORTS			IMPORTS			CONSUMPTION	
	World	13,734	World	7,204		World	7,204		World	13,734
1	EU	10,661	EU	6,438		EU	6,285		EU	10,508
2	Turkey	816	Ukraine	338		South Africa	157		Turkey	796
3	Ukraine	385	Russia	192		Argentina	72		South Africa	433
4	Russia	342	Croatia	101		Luxembourg	67		Pakistan	336
5	Pakistan	336	Serbia and Montenegro	68		Canada	58		China	239
6	South Africa	321	South Africa	45		Switzerland	58		Croatia	186
7	Croatia	284	Turkey	20		Kenya	54		Russia	150
8	China	241	China	2		USA	46		Syria	128
9	Syria	128				Chile	44		India	127
10	India	127				Mexico	40		Argentina	72
	Australia	**0**	**Australia**	**0**	**24**	**Australia**	**6**	**33**	**Australia**	**6**

T A B L E A 6.5 - D A P

W O R L D D A P S T A T I S T I C S B Y C O U N T R Y I N '000 T O N N E S P R O D U C T

Rank	PRODUCTION		EXPORTS		IMPORTS		CONSUMPTION	
	World	26,277	World	10,417	World	10,416	World	26,276
1	China	8,158	USA	4,104	India	5,578	India	8,902
2	USA	7,285	Russia	1,595	EU	863	China	7,437
3	India	3,324	EU	862	Brazil	415	USA	3,183
4	Russia	1,609	Tunisia	854	Japan	351	EU	1,283
5	EU	1,282	China	817	Pakistan	303	Pakistan	774
6	Tunisia	1,123	Jordan	637	Ethiopia	283	**Australia**	**498**
7	Morocco	843	Morocco	599	**Australia**	**268**	Japan	441
8	Jordan	665	**Australia**	**357**	Vietnam	258	Brazil	412
9	**Australia**	**588**	Mexico	275	Thailand	256	Ethiopia	283
10	Pakistan	471	Korea Rep.	151	Argentina	226	Tunisia	269

T A B L E A 6.6 - M A P

W O R L D M A P S T A T I S T I C S B Y C O U N T R Y I N '0 0 0 T O N N E S P R O D U C T

Rank	PRODUCTION		EXPORTS		IMPORTS		CONSUMPTION	
	World	16,752	World	4,061	World	4,061	World	16,752
1	**China**	**7,096**	**USA**	**1,327**	**Brazil**	**1,029**	**China**	**6,197**
2	USA	4,160	Russia	1,235	Canada	423	USA	2,946
3	Russia	1,952	China	899	**Australia**	**400**	Brazil	2,196
4	Brazil	1,167	Morocco	348	EU	394	Canada	930
5	Canada	517	EU	70	Argentina	267	Russia	717
6	Morocco	444	Ukraine	68	India	266	**Australia**	**657**
7	South Africa	318	Uzbekistan	34	Japan	134	EU	591
8	EU	267	Kazakhstan	33	Belarus	121	South Africa	362
9	**Australia**	**257**	Mexico	23	USA	113	Argentina	267
10	Ukraine	130	Israel	13	Thailand	103	India	266
		13	**Australia**	**0**				

TABLE A6.7 - POTASH

WORLD POTASH STATISTICS BY COUNTRY IN '000 TONNES PRODUCT

Rank	PRODUCTION		Rank	EXPORTS		Rank	IMPORTS		Rank	CONSUMPTION	
	World	53,721		World	41,136		World	41,139		World	53,724
1	Canada	17,265		Canada	16 223		USA	7,632		USA	8,672
2	Russia	9,893		Russia	8 598		India	6,201		China	8,583
3	Belarus	8,279		Belarus	6 560		Brazil	5,793		EU	7,243
4	EU	6,886		EU	4 874		China	5,283		Brazil	6,379
5	Israel	3,557		Israel	3 035		EU	5,231		India	6,201
6	China	3,300		Jordan	1 699		Indonesia	1,907		Indonesia	1,907
7	Jordan	2,005		USA	90		Malaysia	1,784		Malaysia	1,784
8	USA	1,130		Chile	57		Japan	772		Belarus	1,719
9	Chile	820					Korea Rep.	671		Russia	1,327
10	Brazil	586					Vietnam	645		Canada	1,048
	Australia	**0**		**Australia**	**0**	**12**	**Australia**	**389**	**17**	**Australia**	**389**

TABLE A6.8 - PHOSPHATE ROCK

WORLD PHOSPHATE ROCK (PR) STATISTICS BY COUNTRY IN '000 TONNES P_2O_5

Rank	PRODUCTION		Rank	EXPORTS		IMPORTS		CONSUMPTION	
	World	174,389		World	30,549	World	30,549	World	174,388
1	USA	30,850		Morocco	11,825	EU	8,101	USA	33,604
2	Morocco	24,198		Jordan	3,976	India	5,261	Morocco	12,373
3	Russia	9,810		Syria	2,473	USA	2,755	EU	8,881
4	Tunisia	7,623		Russia	2,372	Brazil	1,288	Brazil	7,632
5	Brazil	6,344		Algeria	1,664	Mexico	1,021	Russia	7,605
6	Jordan	6,148		Egypt	1,618	New Zealand	871	India	6,861
7	Syria	3,221		Tunisia	887	Ukraine	823	Tunisia	6,736
8	Egypt	3,179		Christmas Island	750	**Australia**	**818**	**Australia**	**3,309**
9	Israel	3,034		Israel	719	Malaysia	768	South Africa	2,422
10	**Australia**	**2,492**		Togo	687	Turkey	682	Israel	2,412
			17	**Australia**	**0.3**				

TABLE A6.9 - SULPHUR

WORLD SULPHUR STATISTICS BY COUNTRY IN '000 TONNES S

Rank	PRODUCTION		Rank	EXPORTS		Rank	IMPORTS		Rank	CONSUMPTION	
	World	48,531		World	27,836		World	27,835		World	48,531
1	USA	8 549		Canada	6 804		China	8 073		USA	10,431
2	Canada	6 978		Russia	3 448		USA	3 072		China	9,505
3	Russia	6 513		Saudi Arabia	3 229		Morocco	3 060		EU	4,820
4	EU	5 930		EU	2 641		Brazil	2 257		Russia	3,295
5	Saudi Arabia	3 100		Kazakhstan	2 138		Tunisia	1 796		Morocco	3,060
6	Japan	2 034		Abu Dhabi, UAE	1 504		EU	1 530		Brazil	2,410
7	Abu Dhabi, UAE	1 900		Japan	1 251		India	1 445		India	2,395
8	Kazakhstan	1 750		USA	1 190		South Africa	910		Tunisia	1,796
9	Iran	1 600		Iran	1 155		**Australia**	**720**		Mexico	1,065
10	China	1 474		Kuwait	785		Ukraine	517		South Africa	1,054
31	**Australia**	**60**	**34**	**Australia**	**6**				**13**	**Australia**	**774**

T A B L E A 6.10 - T S P

W O R L D T S P S T A T I S T I C S B Y C O U N T R Y I N '0 0 0 T O N N E S P R O D U C T

Rank	PRODUCTION		EXPORTS		IMPORTS			CONSUMPTION	
	World	5,851	World	3,398	World	3,398		World	5,851
1	China	1,457	China	982	Brazil	882		Brazil	1,668
2	Tunisia	1,018	Tunisia	669	Bangladesh	523		Bangladesh	568
3	Brazil	789	Israel	601	Iran	499		Iran	499
4	Morocco	681	Morocco	545	EU	302		China	474
5	Israel	600	Others	235	India	182		EU	388
6	EU	272	EU	185	USA	172		Tunisia	349
7	Lebanon	217	Mexico	123	Indonesia	161		Lebanon	217
8	Belarus	191	Egypt	56	**Australia**	**106**		Belarus	191
9	Syria	164	Brazil	3	Chile	93		India	182
10	Mexico	148	Iceland	0	Sri Lanka	75		USA	172
	Australia	**0**	**Australia**	**0**			**15**	**Australia**	**106**

TABLE A6.11 - UREA

WORLD UREA STATISTICS BY COUNTRY IN '000 TONNES PRODUCT

Rank	PRODUCTION		Rank	EXPORTS		Rank	IMPORTS		Rank	CONSUMPTION	
	World	145,968		World	33,071		World	33,072		World	145,968
1	China	56,331		China	56,331		India	6,147		China	51,615
2	India	20,248		Russia	5,603		USA	5,218		India	26,395
3	EU	7,744		Saudi Arabia	3,606		EU	4,758		USA	11,120
4	Indonesia	6,375		Ukraine	3,465		Brazil	1,900		EU	10,112
5	USA	6,135		Qatar	2,997		Thailand	1,717		Indonesia	6,211
6	Russia	5,603		EU	7,744		Turkey	1,538		Pakistan	5,468
7	Pakistan	4,970		Egypt	4,516		Mexico	1,127		Brazil	3,083
8	Egypt	4,516		Oman	1,955		**Australia**	**1,025**		Canada	2,787
9	Canada	3,816		Canada	3,816		Vietnam	707		Bangladesh	2,585
10	Saudi Arabia	3,606		Venezuela	1,627		Philippines	666		Egypt	2,289
31	**Australia**	**275**	**23**	**Australia**	**62**				**17**	**Australia**	**1,238**