Connections

Farm, Food and Resource Issues

Volume 4

December 2002

Drought

John Freebairn

Professor and Head of the Department of Economics,
The University of Melbourne, Parkville, Victoria.

Droughts are a natural and regular characteristic for Australian agriculture and other climate sensitive industries. Australia should, and most businesses do, invest their scarce labour and capital in agriculture only if on average they expect to earn as much here as they would in other parts of the economy. Most families recognise and plan to balance low incomes of drought periods with higher returns received in better seasons to maintain living standards. Drought assistance is another form of selective industry subsidy, just like tariffs and quotas. Worse, the history of Australian drought assistance reveals that some farmers are advantaged at the expense of other framers. Inevitably droughts result in some farm families, and perhaps more so other rural families and some in urban areas, being forced into poverty. Social security system support targeted on family incomes is a more direct and effective way of meeting society equity concerns than is drought assistance.

Australian agriculture is a game of uncertainty with fluctuating fortunes in seasonal conditions and commodity prices. While our ability to predict the timing and duration of drought is still limited, we know for sure that they will occur, and that in time rain will restore periods of favourable conditions. Drought causes losses of production, challenges maintenance of the capital stock, and it may threaten the environment. The adverse effects of drought are often worse for non-farm rural businesses and even for urban businesses and their employees providing agriculture with machinery, transport, materials and services, than drought is for farmers.

As a nation, and as individual businesses, we should allocate our limited and scarce labour and capital to wheat growing, sheep grazing, horticulture and other rural activities only if we expect to earn over time as much here as we would by investing in tourism, manufacturing, education, and so on. Good economic management for the economy and good business decision making recognises the ups and downs of the business environment.

Calls for drought assistance are really a call for selective subsidies to a particular industry, or particular components of an industry. Government subsidies for fodder, for transport, for concessional interest rates on credit, and direct grants to farmers in drought declared areas are no different to tariffs on motor vehicles, subsidies for first home buyers, restrictions on taxi plates, and quotas on domestic content on television. Drought assistance increases the return to agriculture above market returns. Such subsidisation causes over the longer run too much labour, capital and other scarce resources to be drawn into agriculture away from other parts of the economy. Australia's world class economic growth over recent decades has been achieved in part by removing selective industry assistance. Drought assistance would be a retrograde move for a productive economy.

Further, the selective nature of drought assistance as practiced in Australia has adverse effects on other efficient farmers. For example, a part of the subsidy for fodder for drought affected extensive sheep and cattle gazing is borne by higher prices for feed used by dairy, pig and poultry farmers. Concessional interest rates for farmers in debt quickly become capitalised in higher land values than otherwise, and these higher land values tend to hold-up and defer the transfer of land from those who do not prepare for drought to those who do. Again, why self prepare for drought if you know the government will provide some assistance.

Unfortunately, droughts often are the last straw on the camel's back that drives some families into poverty, or at least to living standards below community agreed levels. Australians clearly wish to support such families. The social security system is specifically designed for this purpose. It targets families in need. By contrast, drought assistance is aimed more at agricultural businesses, and not necessarily businesses of low income families.

Anticipating The Next Level Of Sophistication In Water Markets

Tim Cummins and Charles Thompson

Tim Cummins and Associates, Rosebank, NSW 2480.

Introduction

This paper is about "markets" in the sense of what demand there may be for different sorts of goods and services. It is less concerned with the market-place, or the actual process by which buyers and sellers connect with each other. Similarly, it is about sophistication in terms of what needs will drive markets in the future; more than it is about bringing buyers and sellers together with the aid of new technology.

Irrigators' risk management needs will drive the next level of sophistication in water markets. And they will do so quickly. The cap on diversions in the Murray-Darling Basin is accelerating what otherwise may have been a *relatively* slow process under the Council of Australian Governments (COAG) nation-wide approach to water reform.

Those reforms guaranteed a market driven future for the water industry. Since they were introduced, governments have also concluded that environmental sustainability for many of our river systems depends on no further growth in diversions. For example, the Murray Darling Basin Ministerial Council has agreed to cap Basin water use at the volume required to sustain 1994 levels of irrigation development. Caps on diversion have radically altered risk management processes in the water industry.

Risk Management Responsibility Is Being Transferred to Irrigators

In the past, water management agencies calculated seasonal allocations according to their understanding of storage levels (and probable inflows) combined with their expectations of actual irrigation water use relative to announced levels of availability. Prior to the introduction of water transfers, water management agencies could be confident that not all of the water announced for the season would actually be used. If they did underestimate actual usage, the shortfall was offset (at least partially) by reducing water for the environment.

The introduction of water trade initially transferred even greater risk to the environment. The increasing activation of "sleeping" and "dozing" allocations meant that historic records were no longer reliable guides for anticipating future water use. Consequently, actual water usage was more likely to be underestimated, and water for the environment was more likely to be reduced.

Caps on diversion stop this growth in environmental risk. They also transfer more risk to those irrigators who had been making full use of their seasonal allocation. Trade makes it likely that with time all entitlements will be activated. Total announced allocations are therefore more likely to match actual total water use each season.

At the same time, water management agencies are starting to take a more conservative approach in calculating the total volume available for allocation. Previously, seasonal allocations at the start of the irrigation season took into account both the volume in storage and the probable inflows expected later in the season. From now on, initial seasonal allocations will only account for water actually in storage plus an allowance for the minimal inflows expected in a dry year. Irrigators will have to make their own risk assessments about the probability of allocations increasing during the course of the season.

Three major policy changes: water trading; increased water scarcity (made clear by the cap); and more conservative assessments of seasonal allocations, are in conjunction. This is dramatically shifting risk management responsibility away from water management agencies and shifting it towards individual irrigators.

The *Chicken-and-Egg* of Different Industries and Different Risks

Water allocation policies have always influenced irrigation farming systems, just as irrigation farming systems have always influenced water allocation policies. For example, it is interesting to compare and contrast how the security of water supply systems have evolved in NSW and Victoria. The NSW supply system operates at relatively low security to maximise water use in any one year. Victoria's supply system operates at a higher level of security in an effort to ensure base levels of availability for at least two years in a row.

Have the farming systems in the two states developed in response to the security with which water authorities have managed systems? Or have the water authorities modified the security in response to irrigator needs and wants? Are irrigators in NSW willing to take more risk than Victorian irrigators? The answer appears to be that security policy has been tailored to the needs of the dominant irrigated enterprise mix. Rice, the major irrigated crop in southern NSW can accept more risk than dairying, the dominant irrigation enterprise in Victoria.

The most cohesive irrigation industries in the Murray-Darling Basin are rice, dairying, cotton and perennial horticulture. Each of those has a different irrigation risk profile.

Rice

Rice is the dominant irrigation enterprise in the southern parts of NSW. Rice based enterprises are mostly irrigated using ponded, contour irrigation systems. No other ponded irrigation enterprise is currently viable. Switching out of contour irrigation is difficult and expensive. Individual rice businesses are generally growing and viable, but the dollar return per megalitre is relatively low for the most limiting resource (water).

Low returns per megalitre places reliance on maintaining scale (megalitre/family). Before the current NSW water reforms this was relatively easy to achieve, but those reforms will reduce average seasonal allocations. This will make it more difficult for irrigators to maintain their scales of production. When market water prices are low, rice-based enterprises are likely to be net buyers of water.

Risk profiles for rice are dominated by the potential to vary the planted area according to water availability. Rice enterprises are characterised by: relatively low crop loss per megalitre of water shortage, and a low cost/income ratio means that the benefit of conserving current water for future seasons is low.

Dairy production

Dairying is the most important irrigation enterprise in Victoria. On average, Victorian dairy farmers have until now geared their enterprises towards a mix of feed sources that makes use of their entire water right plus more than 80 per cent extra water in the form of “sales”.

Under current reforms, average “sales” availability will drop by 20 per cent and it will be available in fewer years. It seems likely that “sales” will become better defined. It will become a separate property right with lower security than basic water right. The bottom line is that dairy farmers will have to adjust to very significant change. They are likely to be significant buyers in the water market. But for the first time they will be able to choose a mix of (well defined) high and medium security water “products” to suit their individual risk management strategies.

The high cost/high income ratio for dairying means that the benefits of conserving water are higher than for annual cropping enterprises. There is also limited capacity to use surplus water by increasing the planted area (the enterprise capacity is usually constrained by a limiting resource such as herd size rather than water). Moreover, each megalitre reduction in seasonal allocation incurs relatively high loss.

Cotton

Cotton is the most important irrigation enterprise in southern Queensland and northern NSW. Capital investment for cotton production is very high, and cotton markets want predictable throughput, therefore irrigators strive for consistent production. However, the climatically suitable growing areas happen to be within highly variable-flow river systems. Water storages on these systems are small relative to average flows, and very small relative to peak flows. Therefore, irrigators endeavour to keep water in (on-farm & off-farm) storages as long as possible. They use off-allocation flows first, in effort to obtain consistent production from “total available” water.

Although water reforms mean greater uncertainty about average annual allocations in the medium and long term, the major seasonal risk management strategy is likely to remain the same. More cotton will be grown when seasonal allocations are high, and less will be grown when seasonal allocations are low. Over the long run, some irrigators will try to maintain or improve existing allocations by buying extra water. This reinforces the need for interstate trade arrangements to be developed between Queensland and NSW.

Perennial Horticultural Crops

Perennial crops account for significant volumes of water use in Victoria, NSW and South Australia. Water allocation policies in each state have traditionally favoured these crops. Nonetheless, Victorian horticulturists now seem certain to be exposed to the risk of drought. In a repeat of the last hundred years of climatic records, they would endure four years below water right. In one year they would be reduced to 60 per cent of water right.

The prospect for NSW horticulturists appears better but it is subject to some uncertainty. On the Murray they are told to expect 100 per cent of their volumetric allocation ninety nine years out of a hundred. On the Murrumbidgee, they are told to expect 100 per cent of their volumetric allocation “in all but the worst drought." What constitutes the worst drought is not specified. Nor is the expected percentage allocation in that year specified.

South Australian horticulturists enjoy a very high level of security. The upper states are obliged to pass minimum flows into South Australia even in severe droughts.

Land not water is the limiting resource for horticulturists in normal years. They are potential sellers in the temporary market in normal years. Victorian horticulturists are likely buyers in the water market in drought years. Depending on the true nature of their property rights to water NSW horticulturists might also be potential buyers in drought years. However, without interstate trade, they may have no one to buy from; because when and if their high security allocations were reduced there would be no low security water available.

Risk Management Is Clouded by Uncertainty

Irrigators must deal with many risks. This paper focuses on the risk of their seasonal allocation being different to the volumetric allocation. In effect it concentrates on the risk of drought. And, to make life simple, it concentrates on the relative risks of drought for irrigators throughout the Murray-Darling Basin.

There is a difference between risk and uncertainty. To paraphrase John Maynard Keynes: The game of roulette is not subject to uncertainty, but the rate of inflation twenty years hence is. He went on to say that for some matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know!

Water managers throughout the Murray-Darling Basin have invested heavily in understanding the patterns of the past. As responsibility for risk management is transferred away from water managers, irrigators are developing progressively greater interest in "exceedance levels," "one-in-a-hundred-year droughts," and the like. This is invaluable information, nevertheless it is clouded by what Bernstein (1996) described as *"nature's tendency to repeat itself, but only imperfectly."*

Models of potential water availability are powerful guides to developing risk management options, but they can create a sense of unjustified confidence. Models are only as good as the weakest source of data used to construct them.

The business of risk management is clouded further still, in some jurisdictions, by a perceived lack of transparency about the way the security of water entitlements is being calculated. Therefore, for many irrigators, their immediate concern is the social and institutional risk that their rights may be eroded. They are uncertain about the true nature of their rights. The urgency of these concerns makes it difficult for some irrigators to explore fully the on-farm risk management options open to them. But if *"the essence of risk management lies in maximising the areas where we have some control over the outcome, while minimising the areas where we have absolutely no control over the outcome …"* (Bernstein, 1996), it is vital that they do explore their own management options. It is also vital for them to be involved in helping to resolve the policy issues.

Irrigators Have Four Main Risk Management Options;

Individual farmers have four broad strategies for managing irrigation risk. They can:

1 - Assess the risk in more detail

- Analyse probability of seasonal allocations being increased later in the season (eg using historic records of inflows to storages and tributary inflows)
- Forecast weather for the coming season (eg using Southern Oscillation Index data and climate predictions)

2 - Improve on-farm water use efficiency

- Improve irrigation management (e.g. improve irrigation scheduling)
- Improve irrigation technology (e.g. install automatic bay gates)
- Substitute with other inputs (e.g. buy in more feed for grazing enterprises)
- Change other cultural practices

3 - Use alternative water sources

- Groundwater
- On-farm storages

4 - Trade water

- temporarily – impacting on business cash flow
- permanently – impacting on business capital value and interest payments

This paper focuses on the trading option. Water trading gives individual irrigators considerable scope for irrigation risk management. In the past, water management agencies effectively managed risk and assigned uniform risk levels to all irrigators in each irrigation industry. From now on, individual irrigators will be able to manage their own exposure to the risk of drought by buying or selling water entitlements. In so doing, they will be substituting the risk of receiving a particular volume of water for the risk of having to pay more for that same volume.

The market price for water as a percentage of the total cost of production is an important driver in water trading decisions. In horticulture this will be fairly low and is unlikely to change existing plantings, but it may influence future development. In dairying it will influence replacement strategies such as purchasing feed versus irrigating pastures. In rice and mixed farms the market price for water may transform water users into water sellers.

Markets Can Help Manage Risk

The water market is still immature. Its risk management potential has yet to be fully explored. For example, it is possible that markets for water "futures" and "options" will develop over time. This is predictable because trade in such derivatives is usually associated with risk management, and the risk of individuals not receiving their full entitlement is steadily being more clearly defined and more widely understood. Derivatives do not remove the risks that go with owning assets subject to volatile markets, but they can determine who takes on the speculation and who avoids it

Futures are contracts for future delivery at specified prices. Options provide the opportunity for one side to buy from (or sell to) the other side at a prearranged price.

Bernstein (1996), gives a text book example of how futures work:

> "The farmer is helpless before the risk of weather and insects, but he can at least escape the uncertainty of what his selling price will be. He can do that by selling his crop when he plants it, promising future delivery to the buyer at a prearranged price. He may miss out on some profit if prices rise, but the futures contract will protect him from catastrophe if prices fall. He has passed along the risk of lower prices to someone else.
>
> "That someone else is often a food processor who faces the opposite risk – he will gain if the prices of his inputs fall while the crop is still in the ground, but he will be in trouble if prices rise and boost the cost of his raw materials. By taking on the farmer's contract, the processor lets the farmer assume that agricultural prices might rise. This transaction, involving supposedly risky contracts for both parties, actually lowers total risk in the economy."

In the water industry, there is at least one example of opposite risks. In highly regulated streams, for some of the environmental values serviced by "environmental water entitlements," water is effectively most scarce in seasons of low to moderate flooding. (River regulation can reduce flood height and duration and therefore it can limit environmental benefits.) In drought, when water is most scarce for irrigators it is not necessarily scarce for those particular environmental values that are being exposed to their natural drying cycle. Potentially at least, this offers the basis for developing derivatives in water markets. But it is not yet clear to what extent "environmental entitlements" could, or should, be traded. Nor is it clear how the price of delivering environmental water should be met.

In practice, relative differences in risk will probably be just as important as opposite risks in the development of derivatives. For example, the differences in risk profiles between annual crops and permanent horticulture in Victoria are certainly large enough to allow the exchange of risks. Even within particular industries, risk preferences, risk management options, and appropriate skills in decision making will vary. And often there is greater variation in profitability within industries than there is between industries.

Options make intuitive sense for the water market. Those with most at stake in the event of water shortages, those with high cost/income ratios, could buy *call* options. These options could give them the right, but not the obligation, to call on the other side to provide them with water at a prearranged price. Those with lower cost/income ratios could buy *put* options that gave them the right to put, or sell, water at a prearranged price.

The buyers of *call* options would effectively be insuring their crop production and insuring against the price of water rising. The buyers of *put* options might be prearranging a return from water that is greater than they can achieve by irrigating a crop. Or, they may be insuring against the price of water falling.

Call options would presumably be more attractive to those irrigators with contracts to supply produce to food processors or wineries. Such contracts are becoming a common feature of Australia's irrigated agriculture.

Australia's Water Markets Are Maturing

Market mechanisms were introduced more than a decade ago when water entitlements first became separately tradable. The process since then has been evolutionary. Pre-existing arrangements have been adapted and modified as they revealed themselves inadequate for the new demands placed upon them. In that sense, the subsequent change process has itself been market driven. In part this evolutionary approach has been deliberate; it has helped build community acceptance. But it has also been unavoidable. Any other approach would have required a fuller understanding of the market than was possible at the time.

Water markets have gradually evolved to the point where formal market structures are being developed to make trade more efficient. For example, water exchanges are starting to bring buyers and sellers together in an information rich environment. Even if most trade occurs outside these exchanges, they still provide "price-posting" for all buyers and sellers in the "temporary" water market.

More than ten years after trade commenced, most jurisdictions are now initiating thoroughgoing reviews of the way their water markets operate. There are many specific examples of the need for review of institutional arrangements. For example, water trade lacks the marketable instruments common to other tradable property rights. Land markets are based around "titles," stock markets are based around "scrip," but water markets are largely based around entries in "registers" held by Water Authorities. It is difficult to ensure that traded rights actually exist. A marketable instrument would allow the overall system to be audited. It would protect against fraud, and it would provide investors with confidence in the property right. Water property rights need to be explicit (regarding volume and reliability); exclusive; enforceable and tradable.

Market-Based Approaches to Risk Management Will Drive Market Sophistication

Derivatives have a value only in an environment of volatility. Water markets are certainly volatile, but we have only a primitive understanding of what drives that volatility. The potential buyers and sellers of options would want a more sophisticated understanding of the drivers behind demand and supply.

They would want some information in advance. They would want to know the full range of industries and valleys with which they might trade. They would want information on the ownership and size of entitlements for each valley, district and river reach. They would want to know at what stages of the season different players were likely to enter the market. They would want to know which dates were critical 'locked in' dates for different enterprises. They would want to know the value of water to each of those enterprises. And they would want to detailed information on the methodology for determining seasonal allocations.

They would have to have specific "real-time" information. They would want detailed information on usage for each valley, district and river reach. They would want information on trading prices, trading volumes and trading sentiment. They would want climatic outlooks. And they would want the latest readings for the factors affecting seasonal allocation upgrades.

Perhaps most controversially, trade in water derivatives would invite the involvement of people and organisations with sufficient reserves to weather some losses in the short-run in the expectation of making money in the long-run. Some stakeholders in the water industry would see this as akin to insurance companies smoothing volatility for all market players. Others would see it as naked speculation.

Introducing trade in water derivatives would invoke the same sort of controversy that surrounded the initial introduction of water trade.

Acknowledgements

The National Program for Irrigation Research and Development (1999) funded the report, *“Irrigation Risk Management in Current and Future Water Policy Environments,”* by Rendell McGuckian, Tim Cummins & Associates and Read Sturgess & Associates. It provides the basis for much of the information in this paper.

Peter L Bernstein (1996) wrote the book *“Against the Gods: the Remarkable Story of Risk”* (John Wiley and Sons) that informed most of the concepts in this paper.

Marsden Jacob Associates’ (1999) review of *Water Trading Development and Monitoring* in NSW gave depth to the information needs that will drive market sophistication.

The Victorian Department of Natural Resources and Environment funded various studies that have contributed to Tim Cummins’s understanding of water markets.

Prospects for Feeding the World and for Rural Landscapes [1]

T. Fischer

Australian Centre for International Research, GPO Box 1571, Canberra City, ACT 2601

Abstract

This paper discusses prospects for meeting world cereal demands up to the year 2020. Also considered are the issues of marginal lands, the persistence of large numbers of undernourished people, and some possible changes in rural landscapes. It is strongly informed by the various analyses of IFPRI on aspects of these issues. It is concluded that if research and development (R & D) investment is maintained in agriculture, crop yields can grow fast enough for the world to continue improving per capita food consumption without much increase in arable land used. Under-nourishment will however only decline rapidly if there is, in addition, more targeted investment in infrastructure and institutions to alleviate rural poverty. Increasing food production in the world's favourable arable lands can be sustainable and can relieve the pressure on the remaining forests, woodlands, uplands and dry marginal areas by making arable cropping there unattractive financially. Again targeted investments will be needed to facilitate the shift out of arable annual cropping to perennial cropping, land stewardship, and non-farm employment.

Introduction

Many have written recently on the subject of feeding the world, in particular Alexandratos, Evans, IFPRI, Cassman and Fresco, and I draw heavily on these sources. In the end however this is my view of what are the most important issues in this vast field. As I look at the food supply versus demand issue, I will concentrate on cereals, which comprise around 50 per cent of all food calories of mankind, not including their growing indirect contribution through feeding of grains such as maize and sorghum to food animals. Starting with the big picture, I then pass to the issues of land degradation, marginal lands and the uneven distribution of food. Finally I would like to speculate about the future structure of world agriculture, particularly rural landscapes. Much of my focus will be on developing countries, but developed countries cannot be ignored.

Global Food Security - The big picture

If we take, as did Cassman in his recent paper, real grain prices on the world market as a bell wether to reflect the balance between supply and demand, the world's grain consumers are doing well. Prices have been declining for over 100 years, and the last few decades or so have been no different, despite a few shocks in the 1970s and 1990s, and despite the dire predictions of Lester Brown and others. Grain availability per capita has increased in the last 30 years, and especially so in most developing countries. This has been the result of some crop area increase, often associated with cropping intensification due to irrigation, but mostly it is the consequence of yield increase. The latter in turn is the combination of improved varieties, more artificial fertiliser, and a greater proportion of crops being irrigated. It is impossible to be precise regarding the relative importance of these factors due to the positive interaction between all three. By way of illustration, the summary figures for progress since 1970 in developing Asia are impressive (see Table 1).

Table : Key statistics for population, food and income in developing Asia in 1970 and 1995; source Asian Development Bank (3)

	Population million	**Food Consumption Kcal/cap/d**	**Cereal production m t**	**Cereal area m ha**	**Cereal yield t/ha**	**Income $/cap/year**
1970	1750	2045	313	235	1.32	177
1995	2793	2437	650	247	2.63	512
% change	+60	+24	+107	+4	+100	+189

1 This paper was presented at the 10th Australian Agronomy Conference, Hobart, 2001.

FAO have made detailed projections of food production to 2010, but I will focus on projections to 2020 by IFPRI economists using their IMPACT model, which seeks prices that balance supply and demand according to appropriate elasticities. IFPRI suggests there will be continuing increased availability of cereals per capita, and further declines in real prices of grain, albeit at slower rates than in the past. Table 2 shows the aggregate quantities for cereal demand and supply.

Noteworthy is the lower population (7.5 billion) than would have been projected only a few years ago; this is the median United Nations projection of 1998, which also puts peak world population at no more than 10 billion late in the century. Cereal demand increases 54 per cent in developing countries, comprising a 40 per cent increase in the food component, and a 100 per cent increase in the feed component to reach 445 million tonnes. Notwithstanding the large increase in their own production, there will be an almost doubling in developing country cereal imports.

Nevertheless, they will still be growing 88 per cent of their cereal consumption. The former Soviet Union and Eastern Europe (both considered developed by IFPRI) will emerge as net exporters. The numbers also disguise an increase in exports from some Latin American nations to other developing countries. Finally developing country meat consumption will double, and net imports will increase 8-fold, but will still only amount to 3 per cent of consumption.

Table 2: Developing (dev'g) and developed (dev'd) country population, and demand for and supply of cereals in 1995 and as projected for 2020 by the IMPACT model (IFPRI 1999).

	1995			**2020**		
	Dev'g	**Dev'd**	**World**	**Dev'g**	**Dev'd**	**World**
Population (million)	4495	1172	5666	6285	1217	7502
Demand (m t)	1071	706	1776	1652	814	2466
Supply: Area (m ha)	440	252	692	470	258	728
Yield (t/ha)	2.2	3.2	2.6	3.1	3.9	3.3
Production (m t)	965	812	1776	1460	1006	
Net Imports (m t)	+106	-106		+192	-192	

Details of the sources of cereal growth to the year 2020 are contained in Table 3. Note that these are exponential growth rates. Cereal crop area growth rate drops away to almost nothing in the developed world, and only manages 0.4 per cent per annum in the developing world. Yield growth becomes an even bigger fraction of future production growth, but at rates that are noticeably less than the last decade or so.

Maize demand in developing countries will grow at a greater rate (2.4 per cent per annum) than wheat and rice (1.6 and 1.2 per cent per annum, respectively) because of the rapidly rising demand for animal products all over the developing world. Earlier IFPRI publications highlighted the high sensitivity of model outcomes on yield growth (and prices) to reduction in the investment in public agricultural research. Later, IFPRI emphasized the importance of investment in rural infrastructure and institutions, as well as research, if the yield projections are to be met.

Table 3 : Current production, and past and projected future rates (in bold) of cereal area and yield growth (%, p.a.) in developing (dev'g) and developed (dev'd) countries, calculated from IFPRI projections (19,20) and FAO statistics (11)

	Cereals		Wheat		Rice		Maize	
	Dev'g	Dev'd	Dev'g	Dev'd	Dev'g	Dev'd	Dev'g	Dev'd
Production. 1998 (m t)			290	299	550	13	281	223
Area growth, % p.a.								
1966-1982	1.0	0.2	1.5	-0.1	0.6	3.7	1.7	0.7
1982-1998	0.4	-0.4	0.4	-1.2	0.2	-1.2	1.0	0.3
1995-2020	0.4	0.1	0.4	0	0.2	0.1	0.6	0.1
Yield growth, % p.a.								
1996-1982	2.7	2.4	3.7	2.3	2.3	0.2	2.9	3.1
1982-1998	1.7	1.0	2.2	1.3	1.3	2.0	2.1	1.3
1995-2020	1.3	0.8	1.5	0.8	1.2	0.8	1.3	0.8

Evans has an excellent discussion of all plausible means of meeting these growing future food demands, including reductions in post harvest losses and in grain fed to animals. Most debate, however, centres around the projected yield increases of Table 3, something Cassman has considered in detail recently. He has closely watched maize yields in USA and rice yields at IRRI, sounding a note of caution. He points out that linear growth rates imply falling exponential rates, and that world maize yields are at 4.34 tonnes per hectare in 2000 according to the linear trend, the slope of which (60 kilograms per hectare per year) is only 1.4 per cent per annum, and close to that projected in Table 3 until the year 2020. He argues that breeding progress for yield in rice at IRRI has been slower than claimed.

In discussion of future yield growth, I think it is useful to look both at likely movements in (i) potential yield and (ii) closing the so-called yield gap, the difference between on farm economically attainable yield and actual yield. Attainable yield can be considered as potential yield discounted, typically by about 20 per cent, for economic and other on-farm considerations. It is also useful to separate irrigated and well watered situations, where potential yield determined by radiation and temperature prevail, from rain-fed and especially dry-land regions where yields are inevitably cut due to lack of water, defined as water-limited potential yield.

Increases in genetic yield potential through new cultivars tend to be reflected in similar relative increases at the farm level. Some farm yields are already approaching attainable ones in favoured regions (e.g., maize in Iowa, wheat in irrigated Yaqui Valley of Mexico and Indian Punjab, rice in central Luzon), meaning actual farm yield growth is limited by potential yield growth. Future projections for yield potential growth are therefore important. Little or no evidence was presented in a 1998 symposium on the subject that the growth rate in genetic yield potential of most crops is decreasing. In most crops, rates are around 0.5 to 1.0 per cent per annum, but from time to time there has been faster progress associated with breakthroughs, like semi-dwarf wheat and rice, and hybrid rice and maize. Overall the power seems still to reside with the breeding, not to mention the role of agronomy in realizing genetic potential in favoured and water-limited environments. But breeding for yield is taking more resources, including the growing need for even greater input from allied disciplines such as physiology and molecular biology.

In many places there remains substantial scope for closing the yield gap, with actual yields less than one half of attainable ones (e.g., most of sub Saharan Africa). In the developing world this requires applied and adaptive agricultural research, and agricultural extension, posing many challenges to crop agronomists (e.g., site specific nutrient management, conservation tillage, crop rotation, etc.). But there must also be attention to rural infrastructure, institutions, and agricultural policy. Lately there has been a lot of attention to innovative technology transfer paradigms, many of which contain reference to farmer participation and to action research. None of these activities are sufficient in themselves, but taken together yield gap closing should result.

In conclusion, and not wanting to down play the critical role of maintaining real investment in agricultural R & D, as emphasized by the IFPRI sensitivity analyses, and in rural infrastructure and institutions, I believe that a 1.3 per cent per annum growth rate in cereal yields out to 2020 is well within the capability of developing countries. A rate of 0.8 per cent per annum seems fine for developed countries, bearing in mind that some of the slow down in Table 3 in 1982-1998 has been due to the upheavals in the ex-USSR.

Land degradation, irrigation and the big picture

The world's vegetated land is 8,700 million hectares, comprising forest and woodland (4,000 million hectares), permanent pasture (3,200 hectares), and in 1997, arable crop land (,380 million hectares) and permanent crop land (trees and shrubs, 131 hectares). Scheer and Yadav cite a 1992 study pointing to 38 per cent of the world's arable crop land being degraded, having lost some or much productive capacity, principally due to water erosion, but nutrient loss and salinization are also important. The degradation of cropland is greatest in Africa (65 per cent) and Latin America (51 per cent). They also cite estimates that the productivity depressing effect of the increasing degradation of cropped land globally amounted to a yield loss of about 0.4 per cent per annum over the last 45 years. But this is mostly temporary degradation, and not loss of crop land area, such that the past yield gains referred to above in Table 3 are net of this loss, while likewise our forward projections may assume it will continue. Besides if it were slowed, or even reversed through more sustainable farming practices, then this would add to expected yield growth. Research points to many ways that the soil base of arable cropping could be improved.

More relevant to our discussion here is severe degradation, leading to permanent loss of cropland, essentially irreversible things like severe erosion, permanent salinization, exhaustion of non renewable water resources and loss of water to non-agricultural activities (to this we should also add cropland loss due to urbanization, but in Asia, where this is greatest, I estimate that it does not exceed 0.1 per cent per annum). How much loss of cropland is occurring is not clear. If severe degradation was running at 5 million hectares per annum, a high estimate, it would amount to 0.3 per cent per annum loss of crop land. Recent estimates for China and India, where talk of land losses due to degradation and urbanization is most common, do not show net loss of arable areas (FAO 1999).

It should also be pointed out that although potential new arable land of reasonable quality is scarce in the developed world and Asia, several hundred million hectares do exist in sub Saharan Africa and South America. There, net crop area increases in excess of the 0.4 per cent per annum referenced in Table 3 seem quite possible. Remoteness appears to be a major economic constraint on the development of this new land which is mostly tropical savanna; developed society may wish to impose other constraints, but it is unlikely the developing countries with favourable potential arable land would feel bound by this.

The percentage of cropland irrigated and the intensity of cropping (crop area per annum relative to cropland or arable land) are two other very important aspects of land management. In 1997, 268 million hectares, or approximately 19 per cent of all arable land, were irrigated, of which 218 million hectares were in developing countries, an area which included 48 per cent and 43 per cent of their wheat and rice areas, respectively, and a significantly greater proportion of the production. Indeed, about 57 per cent of developing country cereal production is irrigated (cf., only 23 per cent for developed countries). Irrigation expansion in developed countries appears to have almost ceased. For developing countries, Alexandratos estimated that irrigation area, after increasing at 2 per cent per annum between 1970 and 1990, would only increase at 0.8 per cent per annum from then until 2010, while cropping intensity on irrigated lands may also increase slightly, from 110 per cent in 1990 to 124 per cent. These intensity numbers exclude China, for which the national average in 1997 was claimed to be 154 per cent across all arable land, meaning that much of the land carries two crops per year. Development of new irrigation is becoming more expensive and water is becoming scarcer. There is clamour about a water crisis, but demand management and better agronomy to increase irrigation efficiency, which is presently very low in most developing countries, and water recycling in industry, could prevent increasing non-agricultural demands for water from reducing crop irrigation for some time to come. Overall then, expansion in irrigated cropping should continue to contribute to the yield growth, but not nearly to the extent seen in the last 30 years (see also Epilogue).

Marginal lands and the big picture

Favoured crop lands (irrigated and moderate to high rainfall areas) have undoubtedly shown remarkable yield progress in the last three decades. It is commonly stated that the remaining croplands, variously defined as less favoured or marginal or dryland, have largely missed out on progress. Marginal lands usually suffer from insufficient rainfall (some lands are considered marginal for other reasons, like irreversible soil problems of shallowness, excessive slope or high acidity, but lack of water is by far the main cause). I will use the definition of CIMMYT that a rainfed environment is marginal when the water-limited potential yield of a crop falls to less than 40 per cent of its potential yield. For example by this definition much of the Australian wheat belt, with an average ET of about 300mm compared to a potential one of around 500-600mm, is marginal. There is growing pressure for more focus on marginal croplands of developing countries. Partly this is because such areas are commonly perceived to have the greatest rural poverty and land degradation, while others see poorer progress to date, and hence greater scope for future progress through research. It is this last-mentioned issue that interests us here.

It is difficult to get a measure of the area and production of marginal croplands. Much of the wheat of North America, Australia and Eastern Russia is produced under marginal moisture conditions, but apart from this, most marginal cropland is in developing countries. CIMMYT estimates for the mid 80s indicate that 36 per cent of the area and 18 per cent of the production of developing country wheat is marginal. For rice, if marginal production is assumed to be all rice cropping which is not bunded and fully flooded through irrigation or high rainfall, and if we take the latter to be half of the rainfed lowland area and all the rainfed upland, we can estimate from IRRIs recent numbers that 32 per cent of area, but only 15 per cent of production, is marginal. For maize in the mid 90s, CIMMYT estimated 22 per cent of the non-temperate area of 65 million hectares, and 15 per cent of its production, is marginal (there are however also 31 million hectares of temperate maize in developing countries, and 43 million hectares in the rest of the world, most of which is definitely not marginal). Sorghum, millet, and barley are the marginal area cereals, and some 60 per cent of their area and 40 per cent of their production appears to come from marginal areas. However these crops only contributed 11 per cent of total developing world's cereal production in 1998.

Overall it would appear that no more than 20 per cent of world cereal production takes place in marginal lands, an amount relatively insignificant for the big picture. In addition, although there may be the impression that yield progress has been slower in such lands, especially in developing countries, there has been good progress in developed countries, as technologies spill over from more favoured areas and others are developed especially for dry areas. High yield potential wheat varieties are one example of spill over, while conservation tillage and chemical fallowing are examples of techniques targeting dry areas. The consequences are well illustrated by wheat yield change in Australia, a largely marginal production region . Wheat yield increase has averaged 1.0 per cent per annum since 1950, and over 2 per cent per annum in the last decade. Herbicides, more timely operations, improved varieties, reduced tillage techniques, and more recently, better crop rotations and greater use of nitrogen fertilizers are all implicated in this progress. Similar progress in wheat yields under dry conditions can be pointed to in developing countries like Turkey and Tunisia. In conclusion, although at first glance it might appear that marginal croplands are a major constraint on future yield progress needed to feed the world, progress can be made if research and extension is focussed on the problem. Besides even if it isn't made at the rate anticipated in Table 3, the relatively small contribution to global production from the marginal lands means that the pressure on good lands is not greatly increased.

Uneven distribution of food and need for targeted interventions

Many observers point with deep concern to the persistence of serious malnutrition in the world despite an apparently positive big picture of growing average per capita food production and a falling percentage of undernourished. According to IFPRI there are currently 800m people, largely in developing countries, who do not have access to sufficient food to lead healthy, productive lives. Some 160m of these are children, more than one in every four in developing countries. The majority of these people are in rural areas, many are subsistence farmers and the rural landless. Their numbers are not projected to decline rapidly, unless special attention is paid to both food access as well as food availability for the undernourished, the former meaning that they have the livelihood to acquire adequate amounts and quality of food. Studies in India have shown that investment in rural roads through its effect on non-farm rural employment has the biggest impact on rural poverty, followed by investment in agricultural research and development, and then investment in education, and finally in rural development. More recent work in China also supports investment in agricultural R and D, and in roads for greatest alleviation of poverty. These studies point out that many of these investment policies can be better targeted at the undernourished poor (e.g. land reform, market development for inputs and outputs, micro-credit, women’s education, non-farm rural employment, research against micronutrient deficiencies, etc.). However targeting marginal areas referred to above may not necessarily be the most effective: at least one review of the situation failed to find a clear association between these and greater poverty. Still, wise targeting of substantial investments in the rural sector will be necessary if the absolute numbers of undernourished can be brought down to 300m by 2020, the goal of the recent World Food Summit.

It is an open question as to what extent mainstream agricultural research and development should be focussed on the twin problems of abject rural poverty and malnutrition. Some pose it as a moral imperative for the public research sector such as the CGIAR and Government researchers. Others justify it on the grounds that the private research sector will never be interested in poor farmers, many of whom are at subsistence levels, selling and purchasing little, whereas they may be interested in the relatively wealthy commercial small farmer sector of developed country agriculture. Some, working under the banner of low input systems or agroecology, seem to believe that targeted research and indigenous knowledge can be used to sustain fruitful livelihoods with the natural resource levels of subsistence farming. All these approaches have emotional appeal, but transactional costs are high, and until it is clear that the private sector can fully service the commercial farmer sector, it may be unwise to reduce the current level of public investment so directed, in order to better target the very poor sector, because it is clearly this commercial sector which largely feeds, and will continue to feed, the developing world. At the same time there are some research fields of likely benefit to all farmers (e.g., disease resistance breeding). There are also potential new technologies currently in the hands of the private sector which could be of great benefit to even the smallest farmers (e.g., varieties with stable insect resistance through genetic engineering).

Other issues and the big picture

The last section hinted at one of the several other issues impinging on the big picture of research and development investment keeping world agriculture sustainable and ahead of growing food demand and sustainable . I refer to ownership by the private sector of biotechnologies which may be important in meeting this challenge, and to uncertainties about their availability to developing countries and especially to poor farmers. Also threatening progress is uninformed negative comment on the potential benefits of genetically-engineered cultivars to developing country agriculture. Again on the theme of intellectual property, we have growing uncertainties about the ownership of both unimproved and improved plant genetic resources: this could stifle the very beneficial and ready global exchange of germplasm which has characterized the last four decades of rapid breeding advances. Other issues include the clear decline in public sector agricultural research investment, which the IFPRI model predicts will have a notable depressing effect on productivity growth. Then, further out there are concerns about global climate change, and global energy supplies. Space however doesn't permit discussion of all these important issues. Suffice to say that, like Evans, I am a cautious optimist, believing that mankind will find a way to beat these challenges, that agricultural research will be a necessary, but not by itself a sufficient, part of this struggle, and that arable agriculture will remain a dominant part of many, but not all, rural landscapes.

Future Rural Landscapes

It is towards the shape of future agricultural or rural landscapes that I would like to direct my final comments, for my cautious optimism about feeding the world suggests we should also start to think beyond that challenge. Rural landscapes can have components of social and cultural, as well as economic values. In addition to the agricultural land, under both annual and perennial crops, for food, feed, fibre, and/or feed-stock, there is natural vegetation and wild life, and there is likely to be water bodies. There are also dwellings, villages and even towns with industry, and infrastructure such as transport, communications and power supply systems. The goods which this landscape can produce, in addition to the strictly agricultural ones, are clean water, a sink for CO_2 and perhaps urban waste, and space and an environment for non-agricultural production, for living, and for recreation. Finally people can have aesthetic and spiritual perceptions about their landscape; its beauty, harmony, diversity, and its history: such values are however difficult to measure, being rather subjective.

Views from Western Europe

A recent visit to regions of favourable soils in northern Europe in the height of a bounteous summer brought this home to me. Ten tonne/ha winter wheat crops and 4 tonnes per hectare canola crops appeared amongst dense hedge rows, rich dairy pastures, wild-flower filled set-aside land, small patches of forest, ponds and streams, and prosperous-looking villages, some with obvious industrial activities. Personally this was a most agreeable scene and, given the environmental regulations now in place, one which I suspect is quite sustainable biophysically. A recent analysis of the favoured cropping areas of South-Eastern Scotland presents a similar picture. How has this come about? There is no doubt that one factor was the large amounts of support injected into European agriculture by the old Common Agricultural Policy (CAP). But this support is changing, and the Agenda 2000 of the EU is giving much less direct support to production (although the presence of sugar beet fields reminds one that the distortions have not gone yet), and much more to environmental services, and is backing this by fostering environmental regulation. This is delivering on the EC notion of “multifunctionality”. Partly this has come about because of the low price of grain on the world market, for this makes production support too expensive. There is also the uniquely European reaction against modern high-input agriculture, spawned in a sense by the abuses of the CAP. But I believe that modern grain production can continue in the favoured areas, for with increase in the size of operating units (not necessarily farms), the very high potential yields, and new technologies, they can be globally competitive and environmentally sustainable in all senses. Less favoured areas are being withdrawn from arable cropping and/or intensive grazing, and will return to perennial crops, parks, natural vegetation and wildlife. This is a vision of European agriculture that I can recall was advocated strongly by C.T. de Wit. The elevated sensitivity of the Europeans towards food quality (contamination with agricultural chemicals, GMOs, nutritional value) however remains an issue. Since this sensitivity is not very scientifically based, it would seem to contradict their enlightened approach to rural landscapes.

Grain fields of the New World

Are there implications for the rest of the world in the rural landscape developments in Western Europe? Let us start with the grain growing regions of relatively low population density in the New World (to which one day we will probably add the steppes of central Asia, Russia and the Ukraine). I refer to the vast plains of North America, the new crop lands of central-southern Brazil and of Argentina, and the wheat lands of Australia. These largely rainfed regions have for over 100 years been driving down the real cost of producing grain (not rice), and pressuring the European producers. It has come about through relatively cheap land, efficiency gains from the consolidation of operating size, technologies derived from agricultural research, and outstanding rural infrastructure and agricultural institutions. We are all aware of the protracted process of consolidation, or substitution of capital for labour, in the Australian agricultural landscape. Currently (1996-99) the average Australian grain farm is 1,653 hectares with 521 hectares of grain crop harvested annually. These farms remain essentially family farms, but since 1920 at least, size seems to be growing at around 1.5 per cent per annum, with farm population density falling at the same rate. This reduction in farm population density is surely a major cause of our rural decline. It has also happened in North America, and although there has been massive Government support in USA lately, ostensibly to prevent agricultural income decline, in none of these places has there been the level of recognition of the importance of "maintaining" the rural landscape as is found in Europe. Perhaps it is a consequence of the distances involved in these relatively people-sparse landscapes. Perhaps it is part of the New World culture.

The New World grain regions are facing the severest competition pressures, whereby the most efficient (tending to be the largest) do well enough, but the least efficient disappear, and whereby marginal lands have been and will continue to be simply abandoned if real prices continue to fall. Wheat farming has disappeared from the marginal hill lands of eastern USA. In Australia it has gone from some of the semiarid lands of southern Australia, although new tillage techniques have permitted recent expansions of the dry margin in the east, and have actually put the driest cropping parts of the Great Plains of North America on a sounder basis. Parts of Australia's croplands may well be marginalized by rising salinity and abandoned over the next century. It is not at all clear to me when the process of consolidation will stop, or whether the still predominant family farm will be overtaken by the corporate grain farm. For example, in North America in particular consolidation has proceeded to the stage where a few huge agribusinesses control many of the resources, if not the land, involved in certain commodities, especially animal products. But if we consider the unwillingness of the nations involved to intervene in a targeted fashion, it seems we are destined to develop a landscape of vast fields, managed by remote sensors and robotic tractors, and producing the world's least expensive grain. But these regions will be producing the grain which, in tomorrow's global free market, will meet the import demands of the developing world, at very attractive prices to the consumer, and I would add, utilize modern cropping techniques which pose little threat to the agricultural resource base. There may be islands of population, with irrigated horticulture and intensive animal industries, and scattered national parks, but for the most part it will not be a rich or diverse scene to the common observer. Indeed it may be a monotonous and bleak rural landscape for many, with abandoned farmsteads and struggling small towns.

Food bowls of the developing world

Finally we turn to the prospects for rural landscapes in the developing world. I will concentrate on the important densely populated food-producing regions of the developing world, often irrigated, usually having cropping intensities well over 100 per cent, and in Asia, inevitably growing rice. These include the great river valleys, tropical highlands, and wet islands: IndoGangetic plains, the lower Yangste, Yellow River and Nile valleys, the central African and American highlands, Java, Taiwan, Sri Lanka, etc. The agricultural potential is higher than in Europe, due to available water and favourable temperature, but so is the population density: Egypt has around 1000/km^2 in the Nile valley, Java about the same, Bangladesh overall has 870/km^2, Taiwan 610/km^2, and Shandong and Henan Provinces in China, 580/km^2 and 560/km^2, respectively. In comparison, The Netherlands is the most densely populated European nation with 460/km^2, while Germany has 235/km^2. Densities in developing countries are likely to increase 20-30 per cent by 2020, whereas European numbers are fairly stable. Can Bangladesh, which has 58 per cent of its population in agriculture, ever look like The Netherlands, with only 3.6 per cent of the population engaged in a productive and sustainable agriculture, in a rural landscape of prosperous towns with space for land to be set aside for nature and recreation?

One and a half centuries of economic growth, driven by technological innovation, are behind the transition in Europe (The Netherlands had 60 per cent of its population in agriculture around 1850). IFPRI suggests that economic growth will be high in South and East Asia from now until 2020, averaging around 5 per cent per annum. Even so by 2020 per capita real incomes will have only reached 1/25th of developed world ones today. Nevertheless this growth, which amounts to a doubling of per capita income, must impact on the shape of agriculture. There will be higher real wages, and a rapidly growing demand for more diverse and higher value foods, especially fruit, vegetables, animal products, vegetable oil and even sugar. With globalization keeping staple grain prices steady (rice may be an exception), this will mean that farmers move towards the higher value crops, especially those which are more labour intensive. Where grain cropping persists, mechanization will grow steadily and the size of operating units will increase. These processes are already happening in South Asia and China. Mechanization is evident in the growing numbers of threshers, pumps, then tractors and finally harvesters, while the consolidation of operating units is coming about more through land renting as through land purchase. Curiously renting is also something evident in Europe: in both situations land prices far exceed that justified by its agricultural productivity. There will also be continued rapid urbanization, such that by 2020 IFPRI predicts that 52 per cent of the developing worlds population will be urban, up from 38 per cent in 1995; rural populations will have almost stabilized. But given the huge pressure on arable land, some coming directly from the urbanization and economic growth itself, it is hard to see that there will be any land left over for natural vegetation or wild life. The only recreational lands will be city parks, sports grounds (including golf courses), and the odd peri-urban green belts. The only hope for forests, woodlands and rangelands will lie in the less densely populated lands: the remaining humid forests, the uplands and the dry marginal areas.

Just as in Europe, growth in wealth and agricultural productivity could permit the concentration of arable cropping on the best lands, freeing up other land for other purposes. This can happen and must be encouraged in the favoured densely-populated lands of the developing world. But whether developing countries have the means to keep population pressure down in the remaining less-densely populated lands, and to convert farmers in less favoured lands to perennial cropping and land stewardship is doubtful. Whatever happens, continued growth in agricultural productivity, especially in the good lands, is essential to save the relatively untouched environments, or permit eventual rehabilitation of damaged lands, as in civilization ravaged southern Europe. It has often been pointed out that if India had not experienced the crop yield growth of the last 35 years, to feed itself it would have had to plough up another 100 million hectares or one third of its total land area, including all its forest and woodland!

Conclusion

With increased investment in agricultural research and rural development the world can relatively comfortably feed itself. This will be facilitated by targeted investment in rural infrastructure and institutions, in order to especially rapidly reduce the persistently high numbers of rural poor and undernourished. Increasing productivity of annual crops on the favourable arable lands of the world could make such cropping unattractive in the less favourable landscapes, and could eventually lead to a differentiation of landscapes according to their multiple functions, as appears to be happening already in western Europe.

Epilogue

This paper was prepared in late 1999. The importance of IFPRI analyses, evident in the paper, has just been reinforced by the 2002 publication of IFPRI/IWMI, entitled World Water and Food to 2025 (authors Rosegrant, Cai and Cline). The water constraints on world food production have been incorporated into the afore-mentioned IMPACT model to give the IMPACT-WATER model. Use of the model suggests that despite growing water scarcity in many parts of the world (eg China, India, West Asia-North Africa, western USA), water-relevant research, institutions and policy, can insure that growing water demand is met and that real grain prices remain steady or declining, even while environmental flows improve. However for this to come about there must be increased political commitment and investment. Reductions in these essential ingredients below today’s barely satisfactory levels will lead to growing water scarcity and rising real grain prices, with dire consequences for the poor.

References

ABARE. 2000. A supplement to the Australian Farm Surveys Report 2000, Canberra.

Alexandratos, N. 1995. In: World Agriculture: Towards 2010. An FAO Study. (FAO and John Wiley & Sons: New York)

Asian Development Bank. 2000. Beyond the Green Revolution.

Brennan, J.P. and Quade, K. 2000. Agricultural Science NS Vol13, No3, 37-41.

Cassman, K.G. 2000. In Proc. Third International Crop Science Congress. 17-22 August 2000. Hamburg, Germany (CABI, UK. In press)

Report on special symposium "Post-Green-Revolution Trends in Crop Yield Potential: Increasing, Stagnant, or Greater Resistance to Stress. Crop Science 39: 1543-1635.

Crosson, P. and Anderson, J.R. 1992. Global Food - Resources and Prospects for the Major Cereals. World Development Report 1992, Background Paper No 19. (World Bank, Washington)

Duvick, D.N. and Cassman, K.G. 1999. Crop Science 39: 1622-1630.

Evans, L.T. 1998. Feeding the Ten Billion: Plants and Population Growth (Cambridge University Press, Cambridge)

Evans, L.T. and Fischer, R.A. 1999. Crop Science 39: 1544-1551.

FAO. 1998. FAO Yearbook: Production. Vol 52, 1998.

Fan, S., Hazell, P. and Thorat, S. 1999. IFPRI Research Report 110.

Fischer, R.A. 1999. In: Wheat: Ecolgy and Physiology of Yield Determination (Ed. E.H. Sartorre and G.A. Slafer) (Food Products Press, London). pp.277-294.

Fresco, L. 2000. Plenary address. 3rd International Crop Science Congress, Hamburg.

Hay, R.K.M., Russell, G. and Edwards, T.W. 2000. Crop Production in the East of Scotland. (Scottish Agricultural Science Agency, Edinburgh).

Hazell, P. and Garrett, J.L. 1996. IFPRI 2020 Brief 39.

Heisey, P. W. and Edmeades, G.O. 1999. Part 1 of CIMMYT 1997/98 World Maize Facts and Trends (CIMMYT, Mexico D.F.)

Morris, M.L., Belaid, A. and Byerlee, D. 1991. Part 1 of CIMMYT 1990-91 World Wheat Facts and Trends (CIMMYT, Mexico D.F.)

Pinstrup-Anderson, P., Pandya-Lorch, R. and Rosegrant, M. W. 1999. World Food Prospects: Critical Issues for the early Twenty-First Century. (IFPRI: Washington)

Pinstrup-Anderson, P., Pandya-Lorch, R. and Rosegrant, M.W. 2000. Food Security: Problems, Prospects and Policy. (IFPRI, Washington)

Rosegrant, M. W., Agcaoili-Sombrilla, M. and Perez, N.D. 1995. Global Food Projections to 2020: Implications for Investment. Food, Agriculture and the Environment Discussion Paper 5 (IFPRI, Washington)

Rosegrant, M.W. 1997. Water Resources for the Twenty-First Century: Challenges and Implications for Action. Food, Agriculture and the Environment Discussion Paper 20. (IFPRI, Washington)

Scherr, S.J. and Yadav, S. 1996. Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to 2020. Food, Agriculture, and the Environment Discussion Paper 14. (IFPRI, Washington).

Quantitative Measures and Performance Indicators In The Agri-Business Sector[2]

Venton Cook

Principal Strategy Consultant, Primary Industries and Resources, SA.

Developing ways to measure farm business performance has led to a range of indicators such as interest cover, income to debt, income to operation expense and many others. These indicators, often expressed as ratios, allow farm managers, their advisers and financiers to assess financial health of a farm business. However, no single ratio is usually sufficient to provide a complete picture of the business, rather a suite of measures is preferred (Cook, Edwards and Ronan 1994).

The means of analysing farm businesses has developed greatly in recent decades. Pre 1970 in Australia the concept of gross margin was, if not new, unexplained and was certainly not adopted as a useful management tool by farmers. Similarly, cash flow budgets, prepared on a monthly or quarterly basis, were almost unheard of.

Progress with farm business tools such as these has been stimulated by a number of factors including, increasing reliance on bank finance and the need for external parties to understand the farm business, the growth of farm businesses and importantly the advent and adoption of personal computers on farms. The latter, with increasing friendly software, has made the use of financial management tools very much easier.

There are parallels between the analysis of the farm as a business and appraisal of agricultural and food producing sectors of the Australian economy. These similarities include production of commodities for sale without significant or even minimal value adding - production of intermediate products, eg feed and grains, which are used on farm for fattening livestock and in some cases the existence of extensive value adding enterprises.

Value chains have been analysed for a range of agricultural enterprises (O'Sullivan 1998-99).

The agri-food sector includes all of the attributes of individual enterprises and they are a part of what is known as the agri-food value chain, with goods passing from the producers, to export and domestic markets, sometimes with value adding along the way (Agriculture and Agri-Food Canada, 2000).

One measure of the size of the agri-food sector is turnover, at the final level of sale (Cook, Langberg and Esvelt 2001).

Measurement of the turnover of national agri-food industry is a straightforward summation of food exports (commodities and processed products) and domestic food sales.

This amount, to coin a phrase, is called 'gross national food revenue', However, as this turnover figure includes the contribution of imported food products, a further indicator (of national food turnover), taking imports into account, may be termed 'net national food revenue'.

A deeper look at the sector indicates that the value chain for the food industry shows that the value chain comprises more than export and domestic sales, as described above. Intermediate outputs can be identified and easily monitored from the Australian Bureau of Statistics (ABS). Farm gate production and agri-food processing turnover for example are clear indicators of production and manufacturing trends. Combined with export and domestic sales performance a clear picture is built up of the size and structure of the agri-food industry. Looked at in the ways described above, the industry can be monitored over time and by drilling into the figures, industry sectors and individual food products can be analysed (Cook, Esvelt and Langberg 2002).

[2] The author has pioneered the development of an agri-food scorecard for the South Australian food industry. Details of his work are available, www.foodonline.gov.au and look for the Food Biz Link.

Using this framework, data from ABS is enhanced to assist understanding of the value chain including its strengths and weaknesses. For instance, the trend of processing output, combined with employment and new capital investment shows extent of growth.

Compared with traditional means of measuring industry output, such as input-output tables and national accounts, a food industry scorecard as described above is a timely and easily understood data-base for users.

Such an industry scorecard, as described, can be constructed quite readily on a state-by-state basis. One qualification should be emphasised however. As agricultural and food products move freely between States some account should be taken of these flows. They are effectively interstate exports and imports. In the absence of official statistics on these flows Primary Industries and Resources South Australia has developed a methodology for measuring interstate imports and exports (Cook, Esvelt and Langberg 2001).

Indicators and measures of farm business and agric-food industry performance are all designed to cast light on sometimes complex farm and industry systems. Performance indicators and ratios are management tools designed to dissect industry structure.

In many ways, development and adoption of measures of agri-food value chains is similar to the progress of farm business that occurred in the period 1970-1990. Concepts such as ‘gross food revenue’ and ‘net food revenue’, as applied to national or State agri-food sectors, provide an indicator of sector size. Intermediate outputs, such as farm gate production and processing turnover, are the fuel for the final products sold on export or domestic markets. As such they correspond to the inputs of the farm business that contribute to farm gross revenues.

Scorecard concepts presented here are not new; rather they are an extension of measures and indicators being routinely applied by farm and business managers.

References

Agriculture and Agri-Food Canada, 2000*, A Portrait of the Canadian Agri-Food System*, Economic and Policy Analysis Directorate.

Brown, Mark Graham, 1996, *Keeping Score – Using the Right Metrics to Drive World-Class Performance*, Quality Resource Books.

Cook, Venton, Esvelt, Rob and Langberg, Jack, January 2001, *Measuring the Value of the Food Industry – A Revenue Approach as applied to South Australia,* Paper presented to 45th Annual Conference of Australian Agricultural and Resource Economics Society, Adelaide, South Australia.

Cook, Venton, Esvelt, Rob and Langberg, Jack, January 2002, 2000-2001 *Scorecard* Papers*,* PIRSA publication Adelaide, South Australia.

O’Sullivan, Mark, 1998/1999, *Queensland Value Chain Analysis Series (Vol 1-4)*, Queensland Department of Primary Industry.