Robustness of Estimates of Australia's Sustainable Population

Lynn Henry and David Godden

Department of Agricultural Economics
University of Sydney, NSW 2006

Contributed Paper to be presented at the
38th Annual Conference of the
Australian Agricultural Economics Society,
Victoria University, Wellington, New Zealand,
8 - 10 February, 1994

Introduction

There has been a long running debate concerning the optimal size of Australia's population. Griffith Taylor argued in the 1920s and 1930s that "Australia's habitable lands had been almost completely settled during the nineteenth century so that there was very little scope for population expansion" (Clarke 1990a p.1). Others have estimated Australia's sustainable population to be in the range from 10 to 480 million (Migration Committee 1986 reported in Clarke 1990a p.1). These estimates are assumed to be based primarily on the potential for food production and the availability of water.

Clarke (1990b) believed that proponents for and against base most of their issues on either ethical grounds or on a computational or empirical nature depending on what values analysts wish to choose. Another important aspect determining the values chosen is the nature of the analysts' background eg economist, scientist or environmentalist. Swan (1991 p.113) listed the following as obvious perspectives in the debate: "reproductive biology; production of food and fibres; provision of clean air; provision of energy; disposal of wastes; lifestyles and recreation; political and economic questions about immigration policy; urban planning, housing and social organization; preservation of wilderness and genetic diversity; prevention of soil degradation and loss; and the avoidance of rapid global warming and ozone destruction".

There are two main sides of the argument about population "sustainability": those who follow the Malthus type arguments that the world's ecosystems cannot provide for unlimited population growth or "anti-Malthusians". The Business Council of Australia (1990) believed that increased knowledge and economic behaviour have not been accounted for with Malthus type arguments. Following on from this one would assume that rational economic behaviour would result in greater exploration of backstop technologies as resource stock prices increase as they became scarce.

Hare (1990) as quoted in Swan (1991) believes that population is only one of the three key factors in the sustainability debate - the others being the rate of consumption, and the kinds of technology used to satisfy those consumption levels and the corresponding disposal of the wastes generated.

In discussing population and sustainable development, French (1990) noted an earlier study by Gifford *et al* (1975) into the "sustainability" of Australia's population level. The latter concluded that, on reasonable assumptions about existing food production (including developments in agricultural technology), diets and agricultural exports, Australia could have fed a resident population of about 30 million from domestic food production around 1970. As French (1990, p.122) noted, "Such estimates are based on assumptions concerning patterns of land use, agricultural and food technology, and standards of living that may or may not apply in the future." The extent to which these previous estimates of population "sustainability" have been robust to change over time is examined in this paper.[1]

Previous study

Gifford *et al's* (1975) central theme was that Australia's potential food production constrains Australia's potential population. They estimated the production of food in Australia in the late 1960s and, by adding estimated potential food production from land not then in use, estimated Australia's maximum food production and the corresponding maximum population. Gifford *et al* (1975, p.221) concluded on the basis of potential food supply that, based on "biophysical and technical information", there was a "range of possible stabilised population targets" to which these criteria would lead. Their criteria and population targets are reproduced in Table 1.

1 The issue earns continuing press interest - eg. Armitage (1993). Even a poster presentation on the topic at the 1993 ANZAAS Congress in Perth received 14 column centimetres of coverage in the *Sydney Morning Herald* (SMH 1993), not to mention 25.5 column centimetres in the *West Australian* (van Niekerk 1993).

Table 1. Criteria and Associated Population Targets from Gifford *et al* (1975)

Scenario	Population (millions)
Total potential arable area in crops and sown pasture and irrigated culture; contemporary per capita food energy consumption; no food exports	82
Total potential arable area in crops and sown pasture and irrigated culture; contemporary per capita protein consumption; no food exports	60
Total potential arable area in crops and sown pasture and irrigated culture; contemporary per capita protein consumption; 50% of food protein produced is exported	30

Methods

Gifford *et al's* procedure was as follows:

(a) estimate domestic consumption plus exports of cereals for human consumption, sugar, dairy, meat, vegetables, fruits and nuts;

(b) estimate the food energy content and protein content of this food;

(c) assume that net cereal yields would remain unchanged but that sugar, vegetable, fruit and nut yields would double in the future;

(d) using contemporary proportions of crops, fallow and sown pastures in contemporary "intensive" land use, scale up contemporary production of energy and protein to use all of Nix's estimated 70m ha of land available for "intensive" production; and

(e) estimate how many people could be supported in terms of energy and protein requirements.

While generally maintaining Gifford *et al's* procedures, a number of amendments were made to accommodate subsequent changes in the characteristics of Australian agricultural production. The following agricultural product types were included:

winter cereals - wheat, oats, barley, rice
summer cereals - maize, sorghum
oilseeds - soybean, sunflower, cotton, safflower, other (seed, meal and oil component)
legumes - peas, lupins and other
industrial crops - wool, cotton, sugar
livestock and livestock products - beef and veal, sheepmeat, milk and milk products, pigmeat, poultry, eggs, honey, seafood
fruit, vegetables and nuts

Gifford *et al's* conversion rates of foodstuffs to energy or protein were used, adding conversion factors for "new" products. For industrial products such as wool and cotton, the export value of the product was determined and the "wheat import equivalent" of this export revenue was estimated as the amount of wheat this export revenue would purchase at the estimated import parity price (ie Australian average export wheat value plus twenty per cent). These wheat imports where then converted to energy and protein levels. This method of estimating the amount of food that could be obtained from the resources used to grow wool and cotton was used instead of directly estimating the amount of food that could be produced from the area currently used to produce these fibres, as resources were not available to implement the latter estimation method. Estimated domestic food production, and food availability including the food equivalent of wool and cotton, is presented in Table 2.

One of the major differences between Gifford *et al's* analysis and the current estimates is that Gifford *et al* included assumptions about future increases in yields of agricultural products. These assumptions were based on changes that were likely to occur due to improved yields, improved management techniques for irrigated crops and higher production rates per hectare of grazing (Gifford *et al* 1975, pp.214-215). No increases in yields were assumed in the current study. It was felt that yield prediction was too difficult as it required obtaining a weighted average of changes in new technology, changes in relative prices of inputs and outputs, land degradation and future government policy into the analysis.

Table 2: Estimated Food Availability, Australia

		Energy (10^{15} J pa)	Protein (10^{10} g pa)
Gifford *et al*		214	166
Contemporary (1990-91)	excl. wool/cotton	404	306
	total	764	601

Sources: ABS (1993), ABARE (1993), Gifford *et al* (1975), Godden (1976), Godden and Batterham (1977)

Land use in the Gifford *et al* and contemporary studies, which determines the factors used in scaling-up from actual food production to maximum potential food production, is described in Table 3.

Table 3: Land Utilised

	Crop	Sown pasture	Fallow	Total
Gifford *et al*	15.8	20.9	3.8	40.5
Contemporary	17.4	28.3	na.	45.7

Sources: ABS (1993), ABARE (1993), Gifford *et al* (1975)

As Gifford *et al* did not explicitly report their assumptions of energy and protein in diets, factors for converting energy and protein availability to supportable population were inferred from their data. These inferences are summarised in Table 4.

Table 4: Inferred Food Consumption Factors, Gifford *et al*

	Energy	Protein
scaled food output	466	294
projected population	82	60
inferred consumption rate factor (ie projected population/scaled food output)	0.1760	0.2041

Sources: ABS (1993), ABARE (1993), Gifford *et al* (1975)

In scaling-up estimated food production to the maximum available arable area, the present analysis was based on a simpler method than Gifford *et al's*. Three scenarios were examined. Firstly, domestic food production (ignoring wool and cotton) was scaled up by the ratio of Nix's maximum "intensive" agricultural land estimate (70m ha) to "intensive" land used in 1990-91 (45.7m ha). The corresponding population estimate is denoted as "contemporary excluding wool/ cotton" in Table 5. The second scenario was the same as the first, with the addition of an equivalent food value of wool and cotton, but not scaling up wool and cotton production by the factor used to scale other agricultural output ("no cotton/wool expansion" in Table 5). In the final scenario, population estimates were derived from total agricultural production, including wool and cotton production, scaled up by 70/45.7 (labelled as "total" in Table 5).

Table 5: Comparison of Supportable Populations

		Energy	Protein
• Gifford *et al*		82	60
• Contemporary:	contemporary excl. wool/cotton	109	96
	% increase over Gifford	33	60
	no wool/cotton expansion	172	156
	% increase over Gifford	110	160
	total	206	188
	% increase over Gifford	151	213

Both analyses ignored food imports in the determination of population levels.

Discussion

The results presented in Table 5 should not be taken as inferring that it is appropriate or desirable for Australia's population to increase to the levels postulated as possible. Rather, the implications of the results are that Gifford *et al's* (1975) population estimates are specifically related to their time - there have clearly been sufficient changes between their production estimates and contemporary ones to make dramatic changes to estimates of the number of people that could be supported by Australian agricultural production.

A first source of the difference between the current results and Gifford *et al's* is that an attempt - albeit crude - was made in the former to account for the food equivalent of "non-food" agricultural production (especially wool and cotton). The method of doing so - estimating the "domestically available" food equivalent of "non-food" agricultural production as food imports may seem inappropriate to those wanting an estimate of the truly sustainable population carrying capacity. Such estimates would require an assessment of the actual food production capability of land currently used to produce such products. Such an undertaking was beyond the resources of the current study.

A second source of difference between the current and previous results is that no assumptions were made in the current study as to the future direction of technical improvements in agriculture. This contrasts with Gifford *et al's* analysis where it was assumed that sugar yields and the yields of vegetables, fruit and nuts would be double the then-current values.

Two different directions might be taken concerning further analysis of these results. The first, noted by French (1990), is that the environmental context of agricultural production should be accounted for. Thus, for example, if the increase in agricultural production noted in the current results were achieved by a reduction in "environmental capital", then the increase in "estimated sustainable population" would be more apparent than real, because this increase would be based on an "unsustainable" use of natural resources (cf. Chisholm 1992). The contemporary existence of degraded land is not, however, sufficient to invalidate the current population estimates. The agricultural production estimates on which Gifford *et al's* population estimates were based were also drawn from agricultural production in a degraded agricultural environment. In comparing the two sets of estimates, therefore, what is required is evidence that the current agricultural production statistics are based on a natural resource base that is more degraded than the base to which Gifford *et al's* estimates related. There appears to be no reliable quantitative data as to the aggregate degree of degradation of agricultural land in the intervening two decades.

A second direction that might be embarked upon following this revised analysis is to enquire into the economic context of changing the Australian population. To do so requires an appreciation of the implicit economic model underlying Gifford *et al's* analysis. This economic model implies an infinitely inelastic supply curve for Australian agricultural output at the current production level (line Z in Figure 1 corresponding to output Q0). Using Nix's estimated 70m ha of total available arable land, there is a potential agricultural supply curve Z* (corresponding to output Q0* in Figure 1). There is no obvious reason, however, as to why output should currently be Q0, nor why output might increase to the Nix-maximum Q0*. Explanation of the current output level Q0, and how Q0* might eventuate, requires a behavioural model of the aggregate agricultural market. The following behavioural model is in the neoclassical economics tradition: given Australian agricultural supply S (assuming "average" weather conditions) and world prices Pw, then Australia produces Q0 (corresponding to Z); at price Pw and given domestic demand D, Qd is consumed domestically and (Q0-Qd) is exported.

However, suppose a large increase in Australian population reduced the export availability of Australian agricultural production. What might be the expected consequences?

Firstly, as the domestic demand for food rose (demand shifts from D to D' in Figure 1) then more Australian agricultural production would be consumed domestically. Domestic consumption would rise from Qd to Qd', and exports would fall from (Q0-Qd) to (Q0-Qd'). If the population rose sufficiently far, then all domestic production would be consumed domestically (some domestic demand curve Qd* would intersect the supply curve S exactly corresponding to world price Pw at the output Q0). In this model, the increase in domestic demand does not induce any increased domestic agricultural output.

But what would happen if Australia's population continued to rise? This would depend upon how the prices for agricultural products are formed. If the prices for agricultural products are formed on world markets (as assumed above) then, as Australia's population rose, there would be no incentive for Australian farmers to expand their production beyond current levels - agricultural production is still determined by world price Pw. Once domestic consumption rose above domestic production, Australia would become a net food importer, purchasing food at a price Pw from net exporters such as North America and the European Community (there may be some "import parity" difference between the export price Pw and the actual price of imports Pm, but this refinement is ignored here for simplicity). (With a greatly expanded population, and if the Europeans and Americans were crazy enough to keep on subsidising their agricultural output, it would make economic sense for Australia to buy food from them more cheaply than it could be produced domestically.) Alternatively, for those products not entering international trade, continued increases in Australian domestic demand arising from population increases would increase prices and thus profitability, inducing farmers to increase agricultural output (some demand curve D** would intersect supply curve S above output Q0) using more agricultural land. Thus, Australian agriculture might eventually use all the arable land postulated by Nix as available for agricultural production.

The economics paradigm used here is a long run one. In the short run, Z might comprise a constraint on agricultural output - ie if there were temporary increases in price above Pw, the resulting profits may not induce farmers to undertake investments in land beyond the area corresponding to Z. Only if the increase in price was perceived to be permanent would there be a sufficiently large increase in profitability to justify the investment in expanding agricultural capacity. Further, it has also been assumed that technology is constant, and that only changes in domestic or world demand induce output changes. As a crude approximation, improvements in technology may be represented as a rightward shift in the supply curve. With such a shift, the intersection of some such new supply curve S' and world price Pw would be to the right of the original optimal output level Q0. Thus, even if output prices remained constant, production levels may change as technology improves, effectively reducing input costs - ie there is an improvement in the farmers' "real" terms of trade.

But what would happen as agricultural exports declined? The preceding analysis assumed that there are no feedback effects between the agricultural sector and the rest of the economy. Gifford *et al* (1975, p.221) assumed that "the present relative proportion of food export would have to be maintained into the indefinite future." Ironically, agricultural exports as a proportion of total exports have fallen dramatically over the period 1970-90 (from about 85 per cent in 1950-51, to about 65 per cent in the mid-1960s, to about 20 per cent in the early 1980s: Australian Bureau of Agricultural and Resource Economics 1992, p.8) while the proportion of agricultural production that was exported fluctuated between 50-60 per cent in the 1950s and 1960s, and (with occasional aberrations) between 60-75 per cent in the 1970s-early 1990s. However, there is no particular reason that the exported proportion of agricultural output should have any particular numerical value: since Australia has a comparative advantage in agricultural production then - unless subsidisation of farmers in the European Community, North America and Japan becomes unbearably onerous - we would expect a high proportion of Australian agricultural production to be exported. However, we also know there are macroeconomic effects of changes in export mix - eg the rapid increase in mineral exports in the 1970s (Australian Bureau of Statistics 1993) - can change the profitability of agricultural exports via relative appreciation of the exchange rate (ie an exchange rate higher than it would otherwise have been).

Thus, if because of a growing domestic population Australian agricultural exports fell and if there were no simultaneous counter-acting forces, total Australian exports would fall, leading to a depreciation of the exchange rate. (Crudely, if total exports fell, total imports would have to fall; the equilibrating mechanism is the exchange rate depreciation.) But, as the exchange rate fell, the Australian dollar value of agricultural (and other) exports would rise, increasing the export demand for Australian agricultural output - world prices would look to Australian farmers like Pw* rather than the original Pw (Figure 2). This increased demand would induce Australian farmers to increase output, potentially as far as Nix's potential arable farm area (there is some world price Pw** which intersects the supply curve S at the same point as the Nix-maximum output intersects Z* at output level Q0*). (This analysis also ignores, for simplicity, the exchange rate effects on the agricultural supply curve arising from the increased cost of imported agricultural inputs.)

A complete analysis of the economic effects of a rising population on the agricultural sector and domestic food supply therefore needs a behavioural model of agricultural demand and supply response, and a model of the interaction between agricultural sector exports and the macroeconomy.

Conclusions

Gifford *et al's* (1975) estimates of Australia's sustainable population are contingent upon the assumptions of the model they used and are firmly located in the historical circumstances of their empirical data. Their "sustainable" population estimates are not appropriate to Australia in the 1990s. The revised population estimates presented in this paper are similarly located within the assumptions and empirical circumstances in which they were estimated. Neither set of estimates may be used to infer any conclusion other than that - at a particular point in time - Australia's given agricultural production could be used to support a certain number of people at a specified dietary intake. Whether or not that estimated population is desirable is an entirely separate issue. The dramatic differences between the population estimates of the earlier and current studies is good evidence that the specified procedures are simply incapable of being used in a forecasting sense to infer anything meaningful for population policy.

Figure 1:

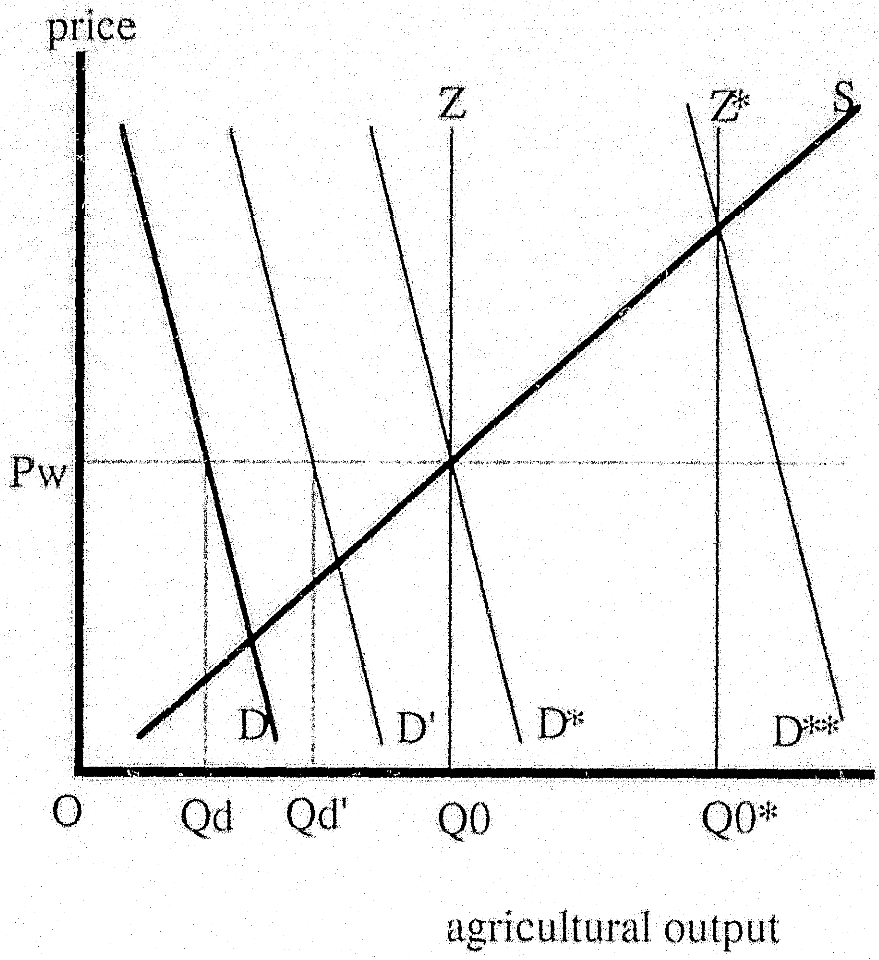
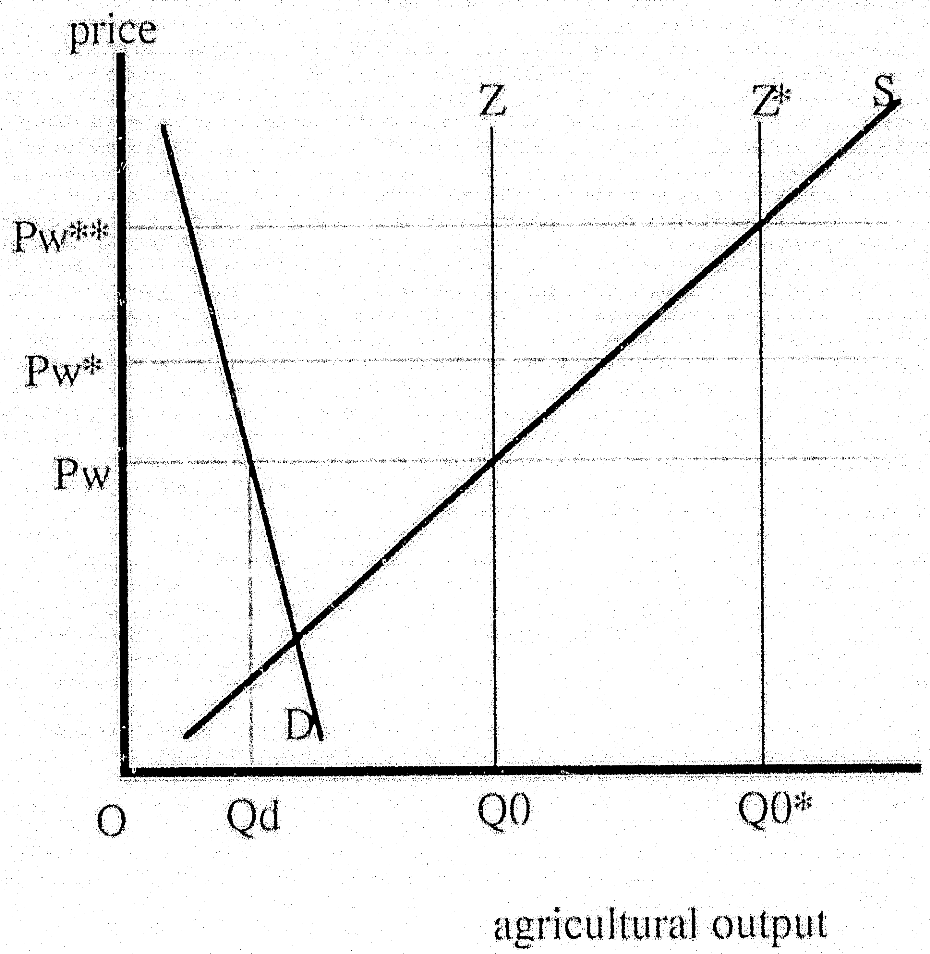


Figure 2:



References

Australian Bureau of Agricultural and Resource Economics (1992), *Commodity Statistical Bulletin* , Australian Government Publishing Service, Canberra.

Australian Bureau of Agricultural and Resource Economics (1993), *Commodity Statistical Bulletin*, Australian Government Publishing Service, Canberra.

Australian Bureau of Statistics (1993), *Apparent Consumption of Foodstuffs and Nutrients, Australia ,1990-91*, 4306.0, Australian Government Publishing Service, Canberra.

Armitage, C. (1993), "The number crunch", Section 5: Spectrum, *Sydney Morning Herald* 18 September, 1A,8A.

Business Council of Australia, (1990), *Achieving Sustainable Development - A discussion paper*, BCA, Melbourne.

Clarke, H.R., (1990a), "Immigration, population and the environment: Australian studies", 1-27 in Clarke *et al* (1990)

Clarke, H.R., (1990b), "Optimal population, immigration and resources", 30-50 in Clarke *et al* (1990)

Clarke, H.R., Chisholm, A.H., Edwards, G.W. and Kennedy, J.O.S (1990), *Immigration, Population Growth and the Environment*, Bureau of Immigration Research, Melbourne.

Chisholm, A.H. (1992), Australian agriculture: a sustainability story, *The Australian Journal of Agricultural Economics*, Vol 36(1), April, 1-29

French, J.R. (1991), 'Population and Sustainable Development', *Search* 22(4), 122-123.

Gifford, R.M., Kalma, J.D., Aston, A.R. and Millington, R.J. (1975), 'Biophysical constraints in Australian food production: implications for population policy', *Search* 6(6), 212-223.

Godden, D. (1976), A Preliminary Analysis of the New South Wales Protein Feeds Industry, Miscellaneous Bulletin No 23, Division of Marketing and Economics, New South Wales Department of Agriculture, Sydney.

Godden, D.P. and Batterham, E.S. (1977), The economic impact of free lysine on the protein feeds industry in N.S.W., *Review of Marketing and Agricultural Economics*, Vol 45, No 1 and 2, March and June.

Swan, J (1991) 'Population, Environment and Quality of Life', *Search* Vol 22(4), June, 113-114.

Sydney Morning Herald (1993), "Aust could feed 100m people, say experts", 30 September, 8.

van Niekerk, M. (1993), "Nation can feed 190m", *West Australian* 30 September, 8.