A Note on Estimating Australia's Sustainable Population

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This note examines Australia's "sustainable population" under simple assumptions about food production and export demand, and demonstrates the severe limitations of such estimates for policy making.

1. 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, 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, p.1). These estimates appear to be based primarily on the potential for food production and the availability of water.

In discussing population and sustainable development, French noted an earlier study by Gifford *et al.* 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 35 million from domestic food production around 1970 Gifford *et al.* p.220). As French (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.[1]" The issues raised by arguments about Australia's "sustainable" population are of continuing political importance as indicated by the call in February 1994 for submissions to the Inquiry into Australia's Population Carrying Capacity by the House of Representatives' Standing Committee for Long Term Strategies.

Despite subsequent authors' apparent eagerness to continue to quote their quantitative results, Gifford *et al's* estimates are time specific. The extent to which their 1975 estimates of population "carrying capacity" have been robust to change over time is examined in section 2. Further these estimates not only imply "technical" assumptions about existing food production, diets and agricultural exports, but also assumptions about the economic context which gives rise to these technical conditions. These economic assumptions are evaluated in section 3.

It is concluded that Gifford *et al's* estimating procedure is highly sensitive to assumptions about contemporary agricultural production. Using the methods outlined in their paper, estimates of an Australian population that could be supported by current domestic agricultural production range from 33 per cent to 213 per cent higher than those in the original study.

2. Re-evaluation of Previous Study

Gifford *et al's* central theme was that Australia's potential food production constrains Australia's potential population. Other issues included water, energy and fertilizer availability. They estimated the production of food in Australia in the late 1960s and, by adding potential food production from land not then in use, estimated Australia's maximum food production and the corresponding maximum population. They concluded from the estimated 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 (Table 1).

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[1] Birch (p.136) reported that "Australia at present produces enough food to support about 35 million people". This estimate also appears to be based on Gifford *et al's* (p.220) estimates of 35 million people from existing food production in the late 1960s with no Australian exports of food. As shown below, Gifford *et al.* (p.221) recognised that sufficient land was available to increase agricultural production to support an Australian population of 60 million on the same assumptions.

Table 1: Criteria and Associated Population Targets from Gifford *et al*

Scenario	Population target (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

Gifford *et al's* analytical 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 (cf. Gifford *et al.* p.214);

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

(f) parameterise results for various percentages of total food production being exported.

While generally maintaining Gifford *et al's* procedures, several amendments were made in the current study 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 (i.e. Australian average export wheat value plus twenty per cent). These wheat imports were 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 contemporary domestic food production, and food availability including the food equivalent of wool and cotton, is presented in Table 2.

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)

A major difference 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.*, 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 incorporating 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. Both previous and contemporary analyses ignored food imports in the determination of population levels.

Table 3: Land Utilised (m. ha)

	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)

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.

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 (Table 4).

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) (Gifford *et al*, p.214). For example, the estimated energy production (excluding wool and cotton) of 404×10^{15} J pa in 1990-91 (Table 2)was assumed to be derived from the current area of 45.7 m. ha (Table 3). If similiar yields were available from the other 24.3 m. ha potentially available, then the estimated potential food production is $(404 \times 70/45.7) \times 10^{15}$J pa = 618.8. The corresponding population estimate is 618.8 x 0.1760 (Table 4) and is denoted as "contemporary excluding wool/ cotton" in

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

	Energy	Protein
scaled food output (10^{15} J pa or 10^{10}g pa respectively)	466	294
projected population (m)	82	60
inferred consumption rate factor (i.e. projected population/scaled food output)	0.1760	0.2041

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

Table 5: Comparison of Supportable Populations (m)

		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

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).

The results presented in Table 5 do not imply 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* population estimates are specifically related to their time. There have clearly been sufficient changes between previous and contemporary Australian agricultural production to result in dramatic changes to estimates of the number of people that could be supported by this 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 but this analysis 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.

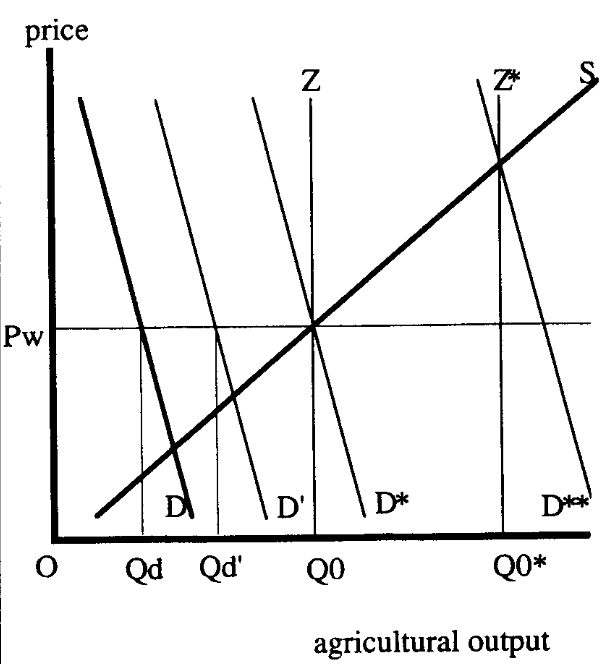
Two different directions might be taken concerning further analysis of these results. The first, noted by French, is that the environmental context of agricultural production should be accounted for. Thus, for example, if the increase in agricultural production noted in the current results were achieved 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). The contemporary existence of degraded land is not, however, sufficient to invalidate the population estimates in the current study. 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. Further, it would be useful to know whether or not the current level of agricultural production is degrading the agricultural environment so that current production levels could be maintained.

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 model and its limitations are discussed in section 3.

3. An Implicit Economic Model

The economic model implicit in Gifford *et al's* population model requires 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 an implied 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 the basis of what follows: 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.

Figure 1



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, all domestic production would be consumed domestically (some domestic demand curve D* would intersect the supply curve S exactly corresponding to world price Pw at the output Q0). In this model, the increase in domestic demand resulting from an increased population does not induce any increased domestic agricultural output due to the external price setting assumptions.

But what would happen if Australia's population continued to rise? The consequence 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 Union (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 Europeans and Americans were daft 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.

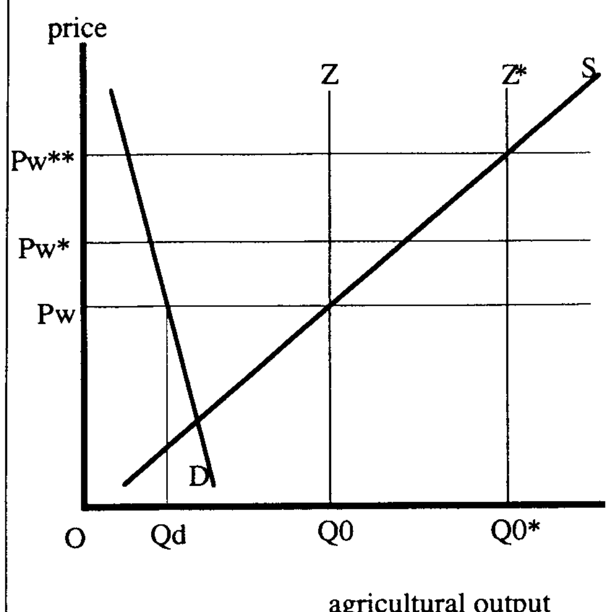
Alternatively, for those products not entering international trade, continued increases in Australian domestic demand arising from population increases would increase prices and thus profitability, inducing farmers to increase agricultural output (some demand curve D** would intersect supply curve S above output Q0) by 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 - i.e. 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 - i.e. 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.* (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; ABARE 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 a high proportion of Australian agricultural production would be expected to be exported unless subsidisation of farmers in the European Union, North America and Japan becomes unbearably onerous. However, there are also macroeconomic effects of changes in export mix - e.g. the rapid increase in mineral exports in the 1970s (ABS) changed the profitability of agricultural exports via relative appreciation of the exchange rate (i.e. 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 *ceteris paribus*; 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.)

Figure 2



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.

4. Conclusions

Gifford *et al's* 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 to infer anything meaningful for population policy.

References

ABARE (1992), *Commodity Statistical Bulletin* , AGPS, Canberra.

ABARE (1993), *Commodity Statistical Bulletin*, AGPS, Canberra.

ABS (1993), *Apparent Consumption of Foodstuffs and Nutrients, Australia, 1990-91*, 4306.0, AGPS, Canberra.

BIRCH, C. (1993), *Confronting the Future. Australia and the world: the next hundred years*, Revised Edition, Penguin, Ringwood.

CLARKE, H.R., (1990), "Immigration, population and the environment: Australian studies", pp. 1-27 in 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", *Australian Journal of Agricultural Economics* 36(1), 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* 45(1 and 2), 28-44.