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Methods of estimating the Gross Value of Irrigated Agricultural Production

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AUSTRALIAN BUREAU OF STATISTICS

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PREFACE

The Gross Value of Irrigated Agricultural Production (GVIAP) refers to the gross value of agricultural commodities that are produced with the assistance of irrigation.

Maximising economic benefit from irrigation is a key theme emerging from recent water policies in Australia. There is strong interest in estimating the value generated from irrigating crops, however it is difficult to do so accurately without a reliable source of data. The Australian Bureau of Statistics (ABS) is well placed to estimate GVIAP using information collected in its agricultural censuses and surveys, which collect data that include area and production of crops, livestock numbers and products, area of crops/pastures irrigated and volume of water applied.

This information paper describes and evaluates the methods the ABS has used to produce estimates of GVIAP. It provides a description of a proposed improved methodology for calculating GVIAP for Australia, allowing increased accuracy and the flexibility to produce sub-state estimates. It is anticipated that the proposed new methodology will be used by the ABS to establish a system that enables the calculation of GVIAP estimates periodically.

Brian Pink
Australian Statistician

ABBREVIATIONS

$m	million dollars
ABS	Australian Bureau of Statistics
ANZSIC	Australian and New Zealand Standard Industrial Classification
cat. no.	Catalogue number
GVAP	gross value of agricultural production
GVIAP	gross value of irrigated agricultural production
ha	hectare
kg	kilogram
PC	Productivity Commission
t	tonne
VACP	Value of Agricultural Commodities Produced

INTRODUCTION

Gross Value of Irrigated Agricultural Production (GVIAP) refers to the gross value of agricultural commodities that are produced with the assistance of irrigation. The gross value of agricultural commodities produced is the value placed on recorded production at the wholesale prices realised in the marketplace.

The ABS publishes data on the Gross Value of Agricultural Production (GVAP) on an annual basis in *Value of Agricultural Commodities Produced, Australia* (cat. no. 7503.0). These data are primarily used for deriving gross income and gross operating surplus for the farm sector, but they are also used for monitoring trends in the production of various commodities at the regional and national level, and examining relationships between agricultural production, water quality and economic/environmental sustainability.

Focussing on irrigation-assisted production adds an extra dimension to the use of GVAP data, as well as helping to identify changes in the efficiency of water used in agriculture in Australia when presented with water use statistics. This is a critical issue for the Australian farm sector, because irrigated production was shown to account for 25% of the gross value of agricultural production in 2004–05, while irrigated agricultural land comprised less than 1% of all agricultural land in Australia.

Definition of GVIAP

Estimating the value that irrigation adds to agricultural production is difficult. This is because water used by crops and pastures comes from a variety of sources. In particular, rainwater is usually a component of the water used by irrigated crops, and the timing and location of rainfalls affect the amount of irrigation water required. Other factors such as evaporation and soil moisture also affect irrigation water requirements. These factors contribute to regional and temporal variations in the use of water for irrigation.

In addition, water is not the only input to agricultural production from irrigated land - land, fertiliser, labour, machinery and other inputs are also used. To separate the contribution that these factors make to total production is impossible with current data.

Bearing this in mind, the definition of GVIAP does *not* refer to the value that irrigation adds to production, or the "net effect" that irrigation has on production (i.e. the value of a particular commodity that has been irrigated "minus" the value of that commodity had it not been irrigated) - rather, it simply describes the gross value of agricultural commodities produced with the assistance of irrigation.

Therefore, the estimates of GVIAP that the ABS has presented in the past, and plan to present in the near future, attribute all of the gross value of production from irrigated land to irrigated agricultural production. For this reason, extreme care must be taken when attempting to use GVIAP figures to compare different commodities - that is, the gross value of irrigated production should not be used as a proxy for determining the highest value water uses. Rather, it is a more effective tool for measuring changes over time or comparing regional differences in irrigated agricultural production.

Methods of estimating GVIAP

To date, the ABS has used two methods to calculate GVIAP estimates which have been published in *Water Account, Australia* (cat. no. 4610.0), *Characteristics of Australia's Irrigated Farms* (cat. no. 4623.0) and *Water and the Murray-Darling Basin - A Statistical Profile 2000–01 to 2005–06* (cat. no. 4610.0.55.007). With the release of estimates from the 2005–06 Agricultural Census and planning commencing for the 2008–09 Water Account, it was deemed an appropriate time to review the methods used to calculate GVIAP.

The results of this review of GVIAP methodology have found the methods used previously led to an underestimation of GVIAP estimates. This paper discusses the review process and proposes an improved methodology for producing GVIAP estimates. It is proposed that experimental estimates based on the improved methodology will be published in *Experimental Estimates of the Gross Value of Irrigated Agricultural Production 2000–01 to 2006–07* (cat. no. 4610.0.55.008) in early 2009 and also the next edition of the ABS *Water Account, Australia* (cat. no. 4610.0) (for the reference period 2008–09).

Structure of this information paper

This information paper is made up of a number of sections:

The first section, "Methods used to calculate GVIAP", provides an outline of the "ideal" method of calculating GVIAP estimates if an ideal data source was available. It then gives an outline of the two methods previously used by the ABS to calculate GVIAP, under the constraints of the current annual ABS Agricultural Census/Survey. Finally, it describes a proposed improved methodology for calculating GVIAP, providing increased accuracy and the flexibility to produce sub-state estimates.

The second section summarises a few major issues and recommendations regarding the ABS' future methods of calculating GVIAP and also presents an overall summary of the paper.

The paper also contains three appendixes:

Appendix 1 provides a detailed analysis for GVIAP methodology - it analyses commodity groups separately and provides:

- a description of the methods used to calculate GVIAP estimates previously;
- an analysis of ABS data from the Agricultural Census/Survey, explaining how this data can help to develop the new methodology;
- an outline of the proposed new methodology and a comparison of estimates using the old and new methods.

Appendix 2 provides an analysis of the gross value of agricultural commodities produced (GVAP) by the level of irrigation on agricultural establishments (farms). It highlights the fact that the majority of GVAP is produced from crops/pastures that are either 100% irrigated (by area) or not irrigated at all.

Appendix 3 provides a list of the individual commodities in each commodity group.

Feedback

The ABS welcomes feedback on the proposed new methodology for estimating GVIAP that is presented in this information paper. Comments should be directed to Steven May, Environmental Accounts and Water Section, ABS, Canberra, on (02) 6252 5593 or email steven.may@abs.gov.au.

METHODS USED TO CALCULATE GVIAP

THE IDEAL METHOD FOR CALCULATING GVIAP (USING ABS DATA)

The methods used by the ABS to calculate GVIAP depend on data availability, which in turn depends on the purpose of data collection.

Although the ABS Agricultural Census/Survey is currently the best source of data for estimating GVIAP, in reality this survey vehicle is not ideal as its primary purposes are to act as a source of statistics about a wide variety of agricultural commodities, and to provide agricultural production data to derive gross operating surplus and gross income for the farm sector.

Nevertheless, an Agricultural Census is conducted every five years (the last was 2005–06) and an Agricultural Survey is conducted annually in intervening years, and the data can be used to calculate annual GVIAP statistics.

The "ideal" method

Ideally, to produce accurate estimates of GVIAP using an ABS Census/Survey as a data collection vehicle, details on irrigated agricultural production would be collected about each commodity at the unit (farm) level. That is, the following would be collected, for each commodity:

- gross revenue from sales of commodities grown on irrigated land.

However, as financial data are not generally collected on the Agricultural Census/Survey, it would be sufficient to simply collect, for each commodity:

- production (tonnes or kilograms) from commodities grown on irrigated land,

then apply unit prices to the production data to derive the gross value of irrigated production (price and production data are currently used to derive estimates of the total value of agricultural production as presented in *Value of Agricultural Commodities Produced* (cat no. 7503.0)). This method is currently used to derive GVIAP estimates for cotton, however this is the only commodity for which irrigated production data are collected directly from the Agricultural Census/Survey questionnaire.

In practice, as provider load is a key consideration in survey design, there are constraints on the amount of detailed irrigated production data that can be collected for each commodity. Therefore it is not currently possible to collect the information required to calculate GVIAP estimates for all commodities using this ideal methodology.

PREVIOUS METHODS USED BY THE ABS TO CALCULATE GVIAP

The ABS has used two methods to calculate GVIAP. The first method (Method 1) was developed by the ABS to produce national and state/territory estimates published in the three editions of the *Water Account, Australia* (cat. no. 4610.0, 1993–94 to 1996–97, 2000–01 and 2004–05) and *Water and the Murray-Darling Basin - A Statistical Profile 2000–01 to 2005–06* (cat.no. 4610.0.55.007). GVIAP was calculated at the state/territory level and was based on production areas and farm numbers. The second method (Method 2) was developed in conjunction with the Productivity Commission (PC) and used to produce estimates of GVIAP for the joint ABS and PC publication *Characteristics of Australia's Irrigated Farms 2000–01 to 2003–04* (cat. no. 4623.0). This method differs from the first in that it places more emphasis on differences in yield between irrigated and non-irrigated commodities. Furthermore, GVIAP was estimated at the unit (farm) level and aggregated to produce state/territory and sub-state estimates. Details of each of these methods are covered later in this section.

Data sources

The methods used previously to estimate GVIAP sourced data from the annual ABS Agricultural Census/Survey, which collects information on the production of agricultural commodities, the total area sown/grown for each commodity, and the area of irrigated land for several crop and pasture groupings.

As described above, the ABS generally does not collect details on the split between irrigated and dryland agricultural production (except in the case of cotton), so GVIAP estimates must be derived on the basis of a combination of information, including the:

- total (irrigated plus non-irrigated) production of each commodity;
- area of land used for each commodity;
- area of land used for each commodity that was under irrigation;
- number of units (farms) producing each commodity;
- number of units (farms) irrigating each commodity; and
- average difference in yield expected between irrigated and non-irrigated production.

This last factor is not collected directly from the survey form but can be estimated using collected data, as described under Method 2 (below). In this information paper "yield" is defined as the production of the commodity (in tonnes, kilograms or as a dollar value) per area grown/sown (in hectares).

COMMODITY GROUPS

GVIAP is calculated for each irrigated "commodity group" produced by agricultural businesses. That is, GVIAP is generally not calculated for individual commodities, rather for groups of "like" commodities according to irrigated commodity grouping on the ABS Agricultural Census/Survey form. The irrigated commodity groups vary slightly on the survey form from year-to-year. On the 2004–05 Agricultural Survey the data items collected were:

- pasture for grazing
- pasture harvested for seed production
- pasture cut for hay or silage (including lucerne for hay)
- cereal crops cut for hay (including wheat, oat and forage sorghum)
- cereal crops harvested for grain or seed (e.g. wheat, oats, maize)
- cereal crops for grazing or fed off
- rice
- sugar cane
- cotton
- other broadacre crops (e.g. canola, field beans, lupins, sunflowers)
- fruit trees, nut trees, plantation or berry fruits (excluding grapevines)
- vegetables for human consumption
- vegetables for seed
- nurseries, cut flowers or cultivated turf
- grapevines
- other crops

Data sources continued

COMMODITY GROUPS *continued*

The GVIAP estimates calculated for the commodity groups "pasture for grazing" and "cereal crops for grazing or fed off" actually refer to the production from the livestock (dairy and meat cattle, sheep and other livestock) that graze on these pastures/crops.

Note that the ABS Agricultural Census/Survey collects area and production data for a wide range of individual commodities within the irrigated commodity groups displayed in the list above. Appendix 3 provides more detail of what commodities comprise these groupings.

PRICE DATA

In addition to data collected from farms in the Agricultural Censuses/Surveys, both methods make use of estimates of the Value of Agricultural Commodities Produced (VACP), published annually in the ABS publication *Value of Agricultural Commodities Produced* (cat. no. 7503.0). VACP (referred to as GVAP in this paper) estimates are calculated by multiplying the wholesale price by the quantity of agricultural commodities produced. The price used in this calculation is the average unit value of a given commodity realised in the marketplace. Price information for livestock slaughterings and wool is obtained from ABS collections. Price information for other commodities is obtained from non-ABS sources, including marketing authorities and industry sources. It is important to note that prices are state-based average unit values.

Sources of price data and the costs of marketing these commodities vary considerably between states and commodities. Where a statutory authority handles marketing of the whole or a portion of a product, data are usually obtained from this source. Information is also obtained from marketing reports, wholesalers, brokers and auctioneers. For all commodities, values are in respect of production during the year (or season) irrespective of when payments were made. For that portion of production not marketed (e.g. hay grown on farm for own use, milk used in farm household, etc.), estimates are made from the best available information and, in general, are valued on a local value basis.

DESCRIPTION OF PREVIOUS METHODS USED TO CALCULATE GVIAP

Two methods have been used by the ABS to date to calculate GVIAP, and detailed descriptions of these are presented below. An example of each method using cotton is presented for comparison.

Method 1

The most recent publications to present estimates of GVIAP calculated using Method 1 were the *Water Account, Australia 2004–05* (cat. no. 4610.0) and *Water and the Murray-Darling Basin - A Statistical Profile 2000–01 to 2005–06* (cat. no. 4610.0.55.007).

This method is based on three formulae, as follows:

FORMULA A - THE AREA FORMULA

This formula is based on the ratio of irrigated area to total area of agricultural production for each commodity group.

$$GVIAP = \frac{A_i}{A_i + A_d} \times PQ$$

Method 1 continued

FORMULA A - THE AREA FORMULA *continued*

Where

A_i = area of the commodity under irrigation (ha)

A_d = area of the commodity that is not irrigated (ha)

P = unit price of production for the commodity ($ per t or kg)

Q = total quantity of the commodity produced (t or kg)

Note: $PQ = GVAP$ or gross value of production of the commodity group.

Below is an example of a GVIAP calculation using Formula A, with total Australia cotton data from the ABS Agricultural Survey 2004–05:

If

A_i = 269,677 ha

A_d = 34,194 ha

PQ = $945.10 million

Then

$$GVIAP = \frac{269{,}677}{303{,}871} \times 945.10$$

= $839 million

The main limitation with this methodology is that it does not take into account the increased yield (e.g. tonnes/ha) of irrigated production. As a result this method has a bias towards underestimation.

FORMULA B - THE FARMS FORMULA

This formula is based on the ratio of the number of irrigating agricultural establishments (farms) to the total number of agricultural establishments for each commodity group.

$$GVIAP = \frac{F_i}{F_i + F_d} \times PQ$$

Where

F_i = number of agricultural establishments irrigating the commodity

F_d = number of agricultural establishments producing but not irrigating the commodity

P = unit price of production for the commodity ($ per t or kg)

Q = total quantity of the commodity produced (t or kg)

Method 1 continued

FORMULA B - THE FARMS FORMULA *continued*

Below is an example of a GVIAP calculation using Formula B, with total Australia cotton data from the ABS Agricultural Survey 2004–05:

If

F_i = 668

F_d = 106

PQ = $945.10 million

Then

$$GVIAP = \frac{668}{774} \times 945.10$$

= $816 million

When this formula was developed it was assumed that it tended to overestimate GVIAP, as not all production from agricultural establishments using irrigation is irrigated. Therefore, some dryland production would be included in the estimates. Analysis of Agricultural Census/Survey unit record data from 2000–01 to 2004–05 (referred to in this paper as "ABS Agricultural unit record data") has since shown that this formula actually underestimates GVIAP in many cases, as it does not take into account that the production yield may be greater on irrigated farms than on non-irrigated farms. This is discussed in more detail later in this section (page 7) and in Appendix 1.

FORMULA C - THE PRODUCTION FORMULA

This formula (described earlier in the "ideal" method section) was only applied to cotton, as this was the only commodity for which data on irrigated and non-irrigated production (kg) was available from ABS collections. It is based on the ratio of irrigated production to total production for cotton.

$$GVIAP = \frac{Q_i}{Q_i + Q_d} \times PQ_t$$

$$= PQ_i$$

Where

Q_i = irrigated production of cotton (kg)
Q_d = non-irrigated production of cotton (kg)
P = unit price of production for cotton ($ per kg)
Q_t = total quantity of cotton produced (kg) = $Q_i + Q_d$

Method 1 continued

FORMULA C - THE PRODUCTION FORMULA *continued*

Below is an example of a GVIAP calculation using Formula C, with total Australia cotton data from the ABS Agricultural Survey 2004–05:

If

Q_i = 1.872 million kg

Q_d = 0.076 million kg

PQ_t = $945.10 million

Then

$$GVIAP = \frac{1.872}{1.948} \times 945.10$$

= $908 million

$= PQ_i$

APPLICATION OF FORMULAE TO COMMODITY GROUPS

Depending on the nature of the commodity and the availability of data, either one of the three formulae (or an average of two of them) was used to calculate GVIAP. For many commodities, the average of the area and farms formulae was used to determine the GVIAP. This was based on the assumption that the area formula tended to underestimate and the farms formula overestimate GVIAP - therefore, taking the average of the two resulted in a more accurate estimate.

EVALUATION OF METHOD 1

There are two main problems with calculating GVIAP estimates using Method 1:

1. Underestimation of GVIAP using the average of the area and farms formulae;
2. It is difficult to produce regional (sub-state) estimates.

Method 1 continued

These problems are discussed in detail below.

1. Underestimation of GVIAP using the average of the area and farms formulae

As described above, using Method 1, the GVIAP for many commodities was calculated by taking the average of the area and farms formulae. The logic behind this was that the area formula would underestimate and the farms formula would overestimate GVIAP, and therefore taking the average of both formulae would result in a relatively more accurate estimate. However, closer investigation of the underlying data has shown that this is not correct, as the farms formula also underestimates in many cases.

The perception that the farms formula overestimates GVIAP was based on the fact that not all production from irrigated farms is from irrigated land; therefore, some dryland production would be included in the estimates. However, another limitation with this formula is that it does not take into account that there may be a greater production yield on irrigated farms when compared to non-irrigated farms, which would cause an underestimation bias to the farms formula. If the underestimation bias of the farms formula outweighs the overestimation bias (from the inclusion of some dryland production), the result will be an overall underestimation bias.

For example, the farms formula will overestimate a commodity's GVIAP in cases where:

a. total irrigated area of the commodity is significantly less than the overall area of the commodity (resulting in a large overestimation bias) *and*
b. the agricultural production (per farm) on non-irrigated farms is similar to that on irrigated farms (resulting in low or no underestimation bias).

However, the farms formula will underestimate a commodity's GVIAP in cases where:

a. a high proportion of the commodity is irrigated; that is, the total irrigated area of the commodity is not significantly less than the overall area of the commodity (resulting in only a small overestimation bias) *and*
b. the agricultural production (per farm) on non-irrigated farms is significantly lower than that on irrigated farms (resulting in a relatively high underestimation bias).

Analysis of ABS Agricultural unit record data shows that with many commodities there is an overall underestimation bias in GVIAP calculated using the farms formula. Analysis shows that production per farm is generally much higher for irrigated than non-irrigated farms, and the underestimation bias that results often outweighs the overestimation bias described above. Examples of this are fruit, grapes and pastures for hay/seed (see Appendix 1 for a detailed analysis of all commodity groups).

Previously it was assumed that the overestimation bias of the farms formula would cancel out the underestimation bias of the area formula. However, if both formulas have the potential to have an underestimation bias this obviously results in an overall underestimation of GVIAP under Method 1.

Method 1 continued

2. It is difficult to produce regional (sub-state) estimates

It requires more effort to produce regional (sub-state) estimates under Method 1, as this methodology (in particular, the farms formula) does not calculate GVIAP at unit (farm) level (as the number of farms is part of the formula). So to calculate different sets of regional estimates the GVIAP has to be recalculated each time for each output area.

There are other commodity-specific problems with Method 1 (for example, for cereals for grain/seed, only the area formula is used, resulting in underestimation of GVIAP), and these are discussed in more detail in Appendix 1.

Method 2

Method 2 uses a single formula (Formula D, see below) to calculate GVIAP for all commodities, with the exception of cotton and livestock (including dairy). Method 2 was developed to account for the difference in production that results from irrigation, and uses an estimated ratio of irrigated to non-irrigated yield for each commodity. This ratio is referred to as the "yield difference factor".

Estimates of GVIAP calculated using Method 2 were published in *Characteristics of Australia's Irrigated Farms, 2000–01 to 2003–04* (cat. no. 4623.0).

FORMULA D - THE YIELD FORMULA

The yield formula can be presented as follows:

$$GVIAP = A_i Y_i P$$

where

$$Y_i = \frac{Q}{A_d/Y_{diff}+A_i}$$

hence

$$GVIAP = A_i \times \frac{Q}{A_d/Y_{diff}+A_i} \times P$$

Where

A_i = area of the commodity under irrigation (kg)

Y_i = estimated irrigated production for the commodity (t or kg)

P = unit price of production for the commodity ($ per t or kg)

Q = total quantity of the commodity produced (t or kg)

A_d = area of the commodity that is not irrigated (ha)

Y_{diff} = yield difference factor, i.e. estimated ratio of irrigated to non-irrigated yield for the commodity produced

Note: where Y_{diff} = 1, Formula D equals Formula A, i.e. the area formula.

Method 2 continued

FORMULA D - THE YIELD FORMULA *continued*

The difference in yield for irrigated and non-irrigated production will vary depending on the season and therefore in very dry years this method may understate the actual value of irrigated production.

The yield difference factors used in *Characteristics of Australia's Irrigated Farms, 2000–01 to 2003–04* (cat.no. 4623.0) were derived from a variety of sources. Some of the yield difference factors used in that publication were sourced from the NSW Department of Primary Industries (i.e. cereals and other broadacre crops). For example, it was assumed that a given area of irrigated wheat resulted in 1.5 times more production than the same area of non-irrigated wheat, i.e. yield difference factor (Y_{diff}) = 1.5. Yield estimates for other crops were based on conservative assumptions made by the ABS and Productivity Commission (see Appendix 1 for more details).

Below is an example of a GVIAP calculation using Formula D, with total Australia cotton data from the ABS Agricultural Survey 2004–05:

If

A_d = 34,194 ha

A_i = 269,677 ha

PQ = $945.10 million

Y_{diff} = 1.5

Then

$$GVIAP = 269,677 \times \frac{945.1}{(34,194/1.5)+269,677}$$

= $871 million

The example above is purely for demonstrative purposes, using "total Australia" data. In reality GVIAP is calculated at the unit (farm) level and then aggregated up, so the true value is different to the one shown in the example above. The cotton section in Appendix 1 provides a brief comparison of true GVIAP estimates using the area, farms, production and yield formulae.

Note that under Method 2, there were exceptions to using the yield formula. GVIAP estimates for

- cotton were calculated using the production formula, as used in Method 1;
- livestock (sheep, meat cattle and other livestock) were calculated using the area formula; and
- dairy were calculated using the assumption that if there is any irrigation of pastures on a farm that is involved in any dairy production, then all dairy production from that particular farm is classified as irrigated (see Appendix 1 for more detail).

Method 2 continued

EVALUATION OF METHOD 2

The yield difference factors used in Method 2 were very conservative (the ABS and PC erred on the side of caution as this was the first time this methodology had been used), leading to an underestimation bias. Further, they did not vary greatly from between commodity groups, and were not regionally based (i.e. a single factor was used for all of Australia).

In a review of the methodology, presented in *Characteristics of Australia's Irrigated Farms 2000–01 to 2003–04* (cat. no. 4623.0), it was discussed that further analysis and investigation needed to be conducted to obtain a greater understanding of the differences in production from irrigated and non-irrigated land, by commodity group. This would help to improve the accuracy of the yield difference factors used in Method 2.

An added complexity is the consideration of variability in yield differences from year-to-year or region-to-region; e.g. in low rainfall regions, or during drought periods, the difference in yields between irrigated and non-irrigated activity is likely to be greater. It was decided that a starting point for the investigation would be an analysis of ABS Agricultural unit record data, investigating differences in yield from irrigated and non-irrigated farms, by commodity group.

There are other commodity-specific problems with Method 2 (for example, for some crops it was assumed that the yield from irrigated crops was equal to the yield from non-irrigated crops).

Appendix 1 shows the formula used to calculate GVIAP for each commodity using Method 2. It also provides a brief description of the issues associated in applying the method. Note that some commodities were grouped differently in Method 2 compared to Method 1 (e.g. GVIAP for "Cereals for grain or seed" and "Cereals for hay" were calculated separately using Method 1, but were combined as "Cereals" using Method 2).

PROPOSED NEW METHODOLOGY FOR CALCULATING GVIAP

With the release of estimates from the 2005–06 Agricultural Census, it was decided to review the methods used to calculate GVIAP. The results of this review are discussed in general terms in the evaluation of Methods 1 and 2 above, and in more detail (i.e. by commodity group) in Appendix 1. As a result of the review, it was concluded that the methods used previously led to a slight underestimation of GVIAP estimates.

Assessing the deficiencies of each method leads to Method 2 being the preferred model for the future - Method 1 has an underestimation bias for most crops, which cannot be improved with the current data collection methods. Further, Method 1 is unable to calculate GVIAP at the unit (agricultural establishment) level (the farms formula requires multiple farms to calculate an accurate estimate).

Method 2 also has an underestimation bias through its conservative yield difference factors, but has more flexibility for improving its accuracy. Furthermore, Method 2 calculates GVIAP at the unit level, thus enabling the calculation of sub-state estimates. With further analysis and investigation, yield difference factors can be improved to increase accuracy of estimates using the yield formula.

The proposed new methodology (the New Method) is based on Method 2, i.e. the yield formula, for most commodity groups. Method 2 has been improved through adjustment

PROPOSED NEW METHODOLOGY FOR CALCULATING GVIAP *continued*

of the yield difference factors, following analysis of ABS Agricultural unit record data, as well as research from external sources.

Summary of the New Method

The New Method attempts to calculate GVIAP at the unit (farm) level, using three simple rules:

1. If the area of the commodity group irrigated = the total area of the commodity group grown/sown, then GVIAP = GVAP for that commodity group;
2. If the area of the commodity group irrigated is greater than zero but less than the total area of the commodity group grown/sown, then use the yield formula from Method 2, with a revised yield difference factor, to calculate GVIAP for the irrigated area of the commodity group;
3. If the area of the commodity group irrigated = 0, then GVIAP = 0 for that commodity group.

It is important to note that the majority of cases follow rules 1 and 3; that is, the commodity group on a particular farm is either 100% irrigated or not irrigated at all. For example, in 2004–05, 90% of total GVAP came from commodity groups that were totally irrigated or not irrigated at all. Therefore, only 10% of GVAP had to be "split" into either "irrigated" or "non-irrigated" using estimation via the yield formula (see Appendix 2).

The above three rules apply to *most* commodities; however there are some exceptions, as highlighted in Table 1 below and described in more detail in Appendix 1. This appendix provides a description of the New Method for each commodity group, discusses the problems and issues with the previous methodologies, and gives a brief summary of the analysis of ABS Agricultural unit record data which led to the development of the new yield difference factors for each commodity group.

The focus of the analysis of ABS Agricultural unit record data in Appendix 1 was the extent of irrigation of the commodity and yield differences between irrigated and non-irrigated commodities. Yield difference factors for a particular commodity group in a particular year were calculated by taking the yield (production per hectare sown/grown) of all farms that fully irrigated the commodity group and dividing this "irrigated" yield by the yield of all farms that did not irrigate the commodity group. The yield difference factors were determined by analysing data from 2000–01 to 2004–05 and are reported for each commodity group in Appendix 1.

Summary of the New Method continued

Table 1 provides a summary of the detailed analysis of commodity groups presented in Appendix 1:

1 SUMMARY TABLE OF NEW GVIAP METHODOLOGY AND COMPARISON WITH METHODS 1 & 2

Commodity group	*Method 1*	*Method 2*	*Proposed New Method*
Cereals for grain/seed	area formula only; underestimates GVIAP	yield formula with yield difference of 1.5; underestimates GVIAP	yield formula with yield difference of 2
Cereals for hay	average of area and farms formulae; underestimates GVIAP	yield formula with yield difference of 1.5; accurately estimates GVIAP	yield formula with yield difference of 1.5
Cotton	production formula; very accurate	production formula, however did not consider cotton seed and used local unit value for cotton lint, resulting in slight underestimation of GVIAP	production formula
Fruit (includes fruit trees, nut trees, plantation and berry fruits; excludes grapevines)	average of area and farms formulae; underestimates GVIAP	yield formula with yield difference of 1 (i.e. area formula); underestimates GVIAP	yield formula with yield difference of 2
Grapes	average of area and farms formulae; underestimates GVIAP	yield formula with yield difference of 1 (i.e. area formula); underestimates GVIAP	yield formula with yield difference of 1.2
Nurseries, cut flowers and cultivated turf	average of area and farms formulae; overestimates GVIAP	yield formula with yield difference of 1.5; overestimates GVIAP	yield formula with yield difference of 1 (i.e. the area formula)
Other broadacre crops	not considered	yield formula with yield difference of 1.5; underestimates GVIAP	yield formula with yield difference of 2
Pastures for grazing - dairy	the farms formula, but only considered dairy farms according to ANZSIC, and did not consider cereal crops for grazing; underestimates GVIAP	if there is any irrigation of pastures on a farm that is involved in any dairy, then all dairy production from that particular farm is classified as irrigated; possible overestimation of GVIAP	Method 2, using irrigated "pastures" and "cereal crops" for grazing
Pastures for grazing - meat cattle, sheep & other livestock	the area formula, but only considered non-dairy farms (according to ANZSIC), denominator was too large because it included all land "suitable" for grazing; did not include wool production or other livestock, and did not consider cereal crops for grazing; underestimates GVIAP	the area formula, but denominator was too large because it included all land "suitable" for grazing; did not include wool production or other livestock, and did not consider cereal crops for grazing; underestimates GVIAP	New method - take the average of the following: (1) the area formula; (2) if the farm has any irrigation of pastures or cereals for grazing then assume that all "other livestock" production on the farm is irrigated. Include production of wool and other livestock. Output as 2 categories: (a) meat cattle; and (b) sheep and other livestock
Pastures for hay/seed	average of area and farms formulae; underestimates GVIAP	yield formula with yield difference of 1 (i.e. the area formula); underestimates GVIAP	yield formula with yield difference of 2
Rice	assume all rice production is irrigated; assumption is backed up by industry experts	yield formula with yield difference of 3.5; underestimates GVIAP	assume all rice production is irrigated
Sugar	average of area and farms formulae; underestimates GVIAP	yield formula with yield difference of 1 (i.e. the area formula); underestimates GVIAP	yield formula with yield difference of 1.3
Vegetables (for human consumption and seed)	average of area and farms formulae; underestimates GVIAP	yield formula with yield difference of 1 for vegetables for human consumption (i.e. the area formula) and 1.5 for vegetables for seed; underestimates GVIAP	yield formula with yield difference of 1 (i.e. the area formula)

Summary of the New Method continued

Table 2 below displays a comparison of GVIAP estimates using Methods 1, 2 and the New Method. Appendix 1 provides a detailed discussion of these estimates.

2 GVIAP, AUSTRALIA, 2004–05

Commodity group	*GVIAP - Method 1* $ million	*GVIAP - Method 2* $ million	*GVIAP - New Method* $ million	*GVAP* $ million
Cereals for grain/seed (excluding rice)	97.5	192.1	207.3	6 293.8
Cereals for hay	16.4	18.3	17.3	258.4
Cotton	908.2	880.1	908.2	945.1
Fruit	1 777.3	1 665.8	1 948.8	2 546.8
Grapes	1 326.9	1 297.2	1 361.8	1 508.2
Nurseries, cut flowers and cultivated turf	685.6	654.6	651.1	768.2
Other broadacre crops	52.5	69.3	72.2	1 203.9
Dairy	1 643.2	1 803.6	1 802.5	3 193.8
Meat cattle	35.8	291.2	810.9	7 828.3
Sheep and other livestock	16.0	65.8	239.4	4 186.1
Pasture for hay/seed	172.5	142.5	248.6	974.7
Rice	100.6	98.0	100.6	100.6
Sugar	447.0	379.7	459.9	1 000.4
Vegetables	1 790.5	1 750.4	1 746.9	2 207.2
Non-irrigated commodities	n/a	n/a	n/a	2 538.5
Total	**9 070.0**	**9 308.6**	**10 575.5**	**35 554.0**

UNDERESTIMATION OF GVIAP ESTIMATES FOR LIVESTOCK (EXCLUDING DAIRY) USING METHODS 1 AND 2

For most commodity groups, the New Method produces the highest GVIAP estimate, as reflected in the overall total, supporting the theory of the underestimation bias contained in Methods 1 and 2. Table 2 shows that in the cases of Meat cattle and Sheep and other livestock the difference between the GVIAP estimates calculated via the New Method and the old methods is very large. The reason for this is that Method 1 and 2 estimates for these commodity groups were based on a ratio of "area irrigated" to "total area" (i.e. "area of irrigated pastures" to "area of land suitable for grazing") which resulted in a very small ratio (less than 1%). This ratio was then applied to the total GVAP for the commodity group and the result was the estimate for GVIAP.

To produce a more accurate GVIAP estimate it would have been preferential to use "area of land *used* for grazing" in this ratio, rather than land *suitable* for grazing - this would have resulted in a much higher ratio. Unfortunately the area *used* for grazing was not collected on the Agricultural Census/Survey form up until 2006–07, however this has been addressed for future collections.

The New Method addresses the problem by using an alternative method that overestimates GVIAP for these livestock groups (see Appendix 1) and then taking the average of this new overestimating method and the old underestimating method. This is not ideal but it improves the accuracy of the Method 1 and 2 estimates, and is the best method possible given the available data sources.

Summary of the New Method continued

EXAMPLES WHERE THE NEW METHOD PRODUCES A LOWER ESTIMATE THAN METHODS 1 AND 2

Going against the trend of the New Method producing higher estimates than Methods 1 and 2, there are a few examples, which can be identified in Table 2, where the New Method produces an estimate *lower* than either/both of Methods 1 and 2 (these are discussed in more detail in Appendix 1):

- Cereals for hay and Vegetables - the New Method is exactly the same as Method 2, however improved data editing measures (not discussed in this paper) lead to a slightly lower estimate.
- Nurseries, cut flowers and cultivated turf - only a very small proportion of these commodities are not irrigated and the production/ha for irrigated and non-irrigated commodities is very similar, leading to overestimation of GVIAP estimates under Methods 1 and 2.

MAIN RECOMMENDATIONS

In summary, the following recommendations are suggested for the production of GVIAP estimates.

Adopt a new methodology for producing GVIAP estimates

The New Method, as proposed in this paper, should be adopted to calculate GVIAP estimates. The New Method is based on a method previously used (Method 2) which has been improved, mainly in relation to the accuracy of the yield difference factors (Y_{diff}) in the following formula (the yield formula):

$$GVIAP = A_i Y_i P$$

where

$$Y_i = \frac{Q}{A_d/Y_{diff} + A_i}$$

hence

$$GVIAP = A_i \times \frac{Q}{A_d/Y_{diff} + A_i} \times P$$

Where:

A_i = area of the commodity under irrigation (ha)
Y_i = estimated irrigated production for the commodity (t or kg)
P = unit price of production for the commodity ($ per t or kg)
Q = total quantity of the commodity produced (t or kg)
A_d = area of the commodity that is not irrigated (ha)
Y_{diff} = yield difference factor, i.e. estimated ratio of irrigated to non-irrigated yield for the commodity produced

The New Method can calculate GVIAP at the unit (farm) level, using three simple rules:

1. If the area of the commodity group irrigated = the total area of the commodity group grown/sown, then GVIAP = GVAP for that commodity group;
2. If the area of the commodity group irrigated is greater than zero but less than the total area of the commodity group grown/sown, then use the yield formula from Method 2 (shown above), with a revised yield difference factor, to calculate GVIAP for the irrigated part of the commodity group;
3. If the area of the commodity group irrigated = 0 then GVIAP = 0 for that commodity group.

The above three rules apply to most commodity groups, however there are some exceptions, as described in the summary table in Appendix 1.

Produce a new time series of GVIAP estimates

The proposed New Method for calculating GVIAP will be used to produce experimental estimates and provide a time-series of GVIAP from 2000–01 to 2006–07 at national and state-territory levels, with consideration for various other geographic levels (Statistical Divisions, Natural Resource Management regions and the Murray-Darling Basin). These data will be released in *Experimental Estimates of the Gross Value of Irrigated Agricultural Production 2000–01 to 2006–07* (cat. no. 4610.0.55.008).

Produce GVIAP estimates periodically

The ABS is expecting to compile GVIAP estimates on an annual basis, from 2007–08. They will continue to be released in every issue of the *Water Account, Australia* (cat. no. 4610.0), which is currently produced every 4 years.

Monitor yield differences periodically

The New Method described in this paper proposes a set of new yield difference factors for input into the yield formula. However a complexity that has not been thoroughly considered is the variability in yield differences across time and regions; e.g. in low rainfall regions, or during drought periods, the difference in yields between irrigated and non-irrigated activity is likely to be greater. It is recommended that ABS Agricultural unit record data be analysed regularly so that major fluctuations in yield differences can be monitored, and implemented into the formula where appropriate. A thorough review of the yield difference factors should be performed after each Agricultural Census.

OTHER ISSUES

There are a number of issues related to the Agricultural Census/Survey form that could, if adequately addressed, aid in the production of GVIAP estimates. As mentioned earlier, the current data collections do not enable the calculation of GVIAP to an ideal method. Any changes to the agricultural collections would need to be considered within broader data requirements.

Collection of irrigated production data on the Agricultural Census/Survey form

Currently, irrigated production data is only directly collected for cotton on the survey form. The accuracy of GVIAP estimates could be greatly increased if irrigated production data was collected directly for all commodity groups; however, this has provider load implications. For example, it would be very difficult to collect an irrigated/dryland production split for vegetables, as a farm may be producing many different varieties of vegetables and it would be a large burden for a survey respondent to split every variety into their irrigated and dryland components.

There are, however, two commodity groups (in addition to cotton) for which the collection of an irrigated/dryland split would (a) not create a great amount of extra provider load (because these commodity groups do not consist of multiple varieties, as explained in the vegetables example above) and (b) greatly increase the reliability of GVIAP estimates. These commodity groups are grapes and sugar. The reason that it would be beneficial to collect a irrigated/dryland production split for these groups is that, apart from the fact that they are single-commodity groups, a large proportion of their total GVAP is from farms growing "partially-irrigated" crops (i.e. crops that are irrigated at less than 100% of their total area), which means a large proportion of their GVIAP currently has to be estimated using the yield formula (see Appendix 2).

Collection of regional commodity price data

GVIAP data is calculated using GVAP data which, in turn, is calculated as the product of price and quantity data for each agricultural commodity. Price data refer to the average unit value of a given commodity realised in the marketplace, and are currently calculated on a state level basis. The accuracy of GVIAP estimates would be increased if prices were collected at a sub-state level. Obviously, this would also greatly increase provider load and the cost of data collection and processing.

CONCLUSION

Using data collected on its Agricultural Census/Surveys, the ABS is in a good position to produce reliable estimates on the Gross Value of Irrigated Agricultural Production (GVIAP) in Australia. To date the ABS has used a couple of different methods to produce GVIAP estimates, but the accuracy and robustness of these estimates can be improved using a proposed New Method, as described in this paper.

"Irrigation alone does not provide an economic return, but can allow production and/or product quality levels to be lifted on any given piece of land, or the land use to be determined from a wider range of options. However, gaining an economic return on the irrigation investment usually requires increases in the use of other inputs. This leads to considerable increases in economic activity and usually, but not always, in profit per unit of employed capital or the margins of the agricultural enterprise" (Doak et al, 2004).

It is important to remember that this paper describes methods of calculating the GVIAP simply in terms of the gross value of production of agricultural commodities that were produced with the assistance of irrigation.

The methods discussed do not attempt to estimate the value that irrigation adds to production, or the "net effect" that irrigation has on production (i.e. the value of a particular commodity that has been irrigated "minus" the value of that commodity had it not been irrigated). The net irrigation effect would obviously be much smaller in value than the numbers that result from the methods discussed in this paper.

The resulting GVIAP estimates must be treated with great care (particularly dairy and livestock production numbers, where irrigated production relates to production from an animal that has grazed on an irrigated pasture/crop) and should not be used as a proxy for determining the highest value water uses.

APPENDIX 1 DETAILED ANALYSIS OF COMMODITY GROUPS

DETAILED ANALYSIS OF COMMODITY GROUPS

Outlined in this appendix is a comparison of the different methods of calculating GVIAP, including the New Method, by commodity group.

As noted in the body of this paper, the various methods for calculating GVIAP vary between commodity groups. The following section discusses each commodity group, describing methods used previously, analyses data for each commodity group and explains how this assisted in the development of the New Method, outlines the proposed New Method for each commodity group, and then compares results from previously used methodologies with the New Method.

Data summaries for each commodity group are presented. An explanation of the column headings is as follows:

irrigation category: whether the agricultural establisment (farm) is irrigating 100% of the area of the commodity group ("Fully irrigating"), less than 100% ("Partly irrigating"), or not irrigating at all ("Not Irrigating").

proportion of total farms: the percentage of farms growing the commodity group that fit into each of the irrigation categories.

proportion of total GVAP: the percentage of the total GVAP derived from the commodity group (Australia-wide) that fit into each of the irrigation categories.

GVAP/ha: the yield, or the GVAP generated from the commodity group, per hectare, for each irrigation category. Note that GVAP is directly proportional to production (in tonnes or kilograms) as it is calculated by multiplying production values by average unit prices (see "price data" section on page 3).

area irrigated on irrigating farms: the proportion of area that is irrigated of the total area of the commodity group grown/sown, on irrigating farms.

yield difference factor: GVAP/ha (i.e. yield) on fully irrigating commodity groups divided by GVAP/ha on non-irrigating commodity groups.

Note that in all of the tables in this appendix, "n/a" indicates "not applicable".

In the evaluation of Method 1, there was a focus on the farms formula and whether or not it provided an overestimation or underestimation of GVIAP. When Method 1 was developed, it was perceived that the farms formula would overestimate GVIAP, based on the fact that not all production from irrigating farms is from irrigated land; therefore, some dryland production would be included in the estimates. However, another limitation with this formula is that it does not take into account that there may be a greater production yield on irrigated farms when compared to non-irrigated farms (i.e. the GVAP per farm may be higher on irrigated than non-irrigated farms), which would cause an underestimation bias to the farms formula. If the underestimation bias of the farms formula outweighs the overestimation bias, the result will be an overall underestimation bias.

As part of the commodity group analysis of Method 1 (below), an attempt is made to quantify the levels of overestimation and underestimation bias, in those cases where the farms formula is used.

One way of analysing the overestimation bias is to consider the proportion of the total area of the commodity group that is irrigated on irrigating farms (e.g. if the total area of a particular commodity group sown/grown = total area irrigated of the commodity group, the proportion is 100% and there is no overestimation bias; however if the proportion is less than 100% there is some overestimation bias).

A way of analysing the underestimation bias is to consider the total GVAP on irrigating farms. For example, if the total GVAP on irrigating farms = the GVIAP calculated using the farms method, then there is no underestimation bias; however, if the total GVAP on

DETAILED ANALYSIS OF COMMODITY GROUPS *continued*

irrigating farms is greater than the GVIAP calculated using the farms method there is some underestimation bias.

The "overestimation factor" is calculated simply by subtracting the irrigated proportion of the total area of the commodity group on irrigating farms from 100%. That is,

$$OF = 100 - prop_{irrig}$$

Where

OF = overestimation factor

$prop_{irrig}$ = irrigated proportion of the total area of the commodity group on irrigating farms

For example, if 70% of the area of a particular commodity group is irrigated, the overestimation factor

= 100 - 70 = +30%

The "underestimation factor" is calculated by taking the total GVAP generated from the commodity group on irrigating farms, then calculating the percentage difference between this value and the GVIAP calculated using the farms formula:

$$UF = (GVIAP_{farms} - GVAP_{irrig})/GVAP_{irrig} \times 100$$

Where

UF = underestimation factor

$GVIAP_{farms}$ = GVIAP calculated using the farms formula

$GVAP_{irrig}$ = GVAP from irrigating farms

For example, if for a particular commodity group the GVIAP calculated using the farms formula = $15 million and total GVAP generated from irrigated farms = $20 milllion, then the underestimation factor

= (15 - 20) / 20 * 100 = -25%.

Finally, a comparison of the two factors is conducted and a conclusion is drawn as to which has greater effect.

CEREALS FOR GRAIN/SEED (excluding rice)

A1 CEREALS FOR GRAIN/SEED (EXCLUDING RICE)

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2002–03					
Fully irrigating	2.0	2.1	974.8	n/a	n/a
Partly irrigating	5.2	7.6	446.7	n/a	n/a
Not irrigating	92.8	90.3	243.9	n/a	n/a
Total	100.0	100.0	256.8	34.4	4.0
2003–04					
Fully irrigating	2.0	1.0	872.4	n/a	n/a
Partly irrigating	4.5	5.4	519.7	n/a	n/a
Not irrigating	93.5	93.6	405.3	n/a	n/a
Total	100.0	100.0	412.4	30.9	2.2
2004–05					
Fully irrigating	2.4	1.3	698.1	n/a	n/a
Partly irrigating	3.8	4.9	408.7	n/a	n/a
Not irrigating	93.8	93.8	301.1	n/a	n/a
Total	100.0	100.0	307.3	34.3	2.3

Proportion of farms irrigating: a high percentage (over 90%) of farms growing cereals for grain/seed did not irrigate these crops at all. Only a very low percentage (less than 2.5%) irrigated 100% of their crops.

Yield difference: in each year, the yield was more than twice as high for 100% irrigated farms than it was for farms that were not irrigated. The yield difference was extremely high in 2002–03, compared with 2003–04 and 2004–05, probably due to lower rainfall in much of Australia at that time.

% area of crop irrigated on irrigating farms: on the farms that did irrigate, only about a third of their land was irrigated.

GVAP on irrigating Vs non-irrigating farms: GVAP per farm was similar on irrigated and non-irrigated farms, therefore the proportion of total GVAP that was produced on irrigating farms was similar to the proportion of farms that irrigated.

Year-to-year variability: the data are fairly stable from year-to-year, other than the high yield difference in 2002–03.

Other comments: note that for 2000–01 and 2001–02 it was not possible to separate irrigated cereals for grain/seed from irrigated cereals for hay, as they were combined into one category on the Agricultural Census/Survey form.

METHOD 1:

Formulae used

Area formula only

Description of method

The area formula was used on its own (rather than the average of the farms and area formulae) as it was assumed that the irrigated area of cereals for grain/seed makes up only a small fraction of the production area on most farms (this was subsequently proven correct - see above comments). As such, attributing all production from irrigated farms to irrigation (the farms formula) was likely to greatly overestimate irrigated production.

CEREALS FOR GRAIN/SEED (excluding rice) continued

Evaluation of method

Using only the area formula results in an underestimate of GVIAP because the differences in yield between irrigated and non-irrigated crops are not considered, but are significant (see above table A1).

METHOD 2:

Formulae used

Yield formula, where $Y_{diff} = 1.5$

Description of method

A conservative assumption for the yield difference for cereals for grain/seed was that the irrigated yield is 1.5 times greater than the non-irrigated yield. This estimate is consistent with calculated long-term yield differences in broadacre crops in NSW (NSW Department of Primary Industries - Agriculture 2005).

Evaluation of method

The yield difference of 1.5 was deemed a conservative assumption, which was confirmed (for grain and seed) by ABS Agricultural unit record data analysis (see yield difference in above table A1). In low rainfall regions, or during drought periods, these estimates are likely to underestimate the difference in yields between irrigated and non-irrigated activity.

PROPOSED NEW METHOD FOR CEREALS FOR GRAIN/SEED

Use the yield formula with a yield difference factor of 2. This is higher than that used in Method 2 (1.5) but 1.5 was deemed as conservative and ABS Agricultural unit record data analysis supports this. The yield difference factor should be monitored from year-to-year, because in very dry years a yield difference of 2 may be too low (e.g. in 2002–03, a year of particularly low rainfall, the yield difference appeared to be around 4).

- If the proportion of the total area of cereals for grain/seed that is irrigated = 100%, then $GVIAP_{cereals\ for\ grain/seed} = GVAP_{cereals\ grain/seed}$;
- If the proportion of the total area of cereals for grain/seed that is irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 2;
- If the proportion of the total area of cereals for grain/seed that is irrigated is 0%, then $GVIAP_{cereals\ for\ grain/seed} = 0$.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A2 CEREALS FOR GRAIN/SEED (EXCLUDING RICE), AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	97.5	192.1	207.3

CONCLUSION

The predicted underestimation of GVIAP estimates using Methods 1 and 2 is shown, relative to the New Method. As predicted, Method 1 had a greater level of underestimation as it did not consider the difference between irrigated and non-irrigated yield, and Method 2 used a yield difference factor (1.5) that was more conservative than the New Method (2). Yield difference factors should be monitored regularly, to check for large deviations from 2, as in 2002–03.

A3 CEREALS FOR HAY

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2002–03					
Fully irrigating	5.3	5.6	1 094.4	n/a	n/a
Partly irrigating	3.3	5.6	912.7	n/a	n/a
Not irrigating	91.3	88.9	629.9	n/a	n/a
Total	100.0	100.0	656.8	74.4	1.7
2003–04					
Fully irrigating	3.1	2.5	1 078.7	n/a	n/a
Partly irrigating	1.5	4.7	1 437.3	n/a	n/a
Not irrigating	95.3	92.8	896.7	n/a	n/a
Total	100.0	100.0	916.7	66.3	1.2
2004–05					
Fully irrigating	5.3	5.4	644.7	n/a	n/a
Partly irrigating	1.2	2.5	489.8	n/a	n/a
Not irrigating	93.5	92.1	437.0	n/a	n/a
Total	100.0	100.0	446.0	78.4	1.5

Proportion of farms irrigating: only a small percentage of farms (5-9%) irrigated cereals for hay.

Yield difference: the production/ha was 1.2-1.7 times higher for 100% irrigated farms than it was for farms that were not irrigated. The yield difference was highest in 2002–03, possibly due to the effects of severely low rainfall.

% area of crop irrigated on irrigating farms: on the farms that did irrigate, 66-78% of their land was irrigated.

GVAP on irrigating Vs non-irrigating farms: GVAP per farm was higher on irrigated than non-irrigated farms. In 2004–05, 7.9% of GVAP came from the 6.5% of farms that were irrigating.

Year-to-year variability: the amount of irrigation was down in 2003–04, compared to 2002–03 and 2004–05.

Other comments: note that for 2000–01 and 2001–02 it was not possible to separate out irrigated cereals for grain/seed from irrigated cereals for hay, as they were combined into one category on the Agricultural Census/Survey form.

METHOD 1:

Formulae used

Average of the area & farms formulae

Description of method

Theoretically, the underestimation bias of the area formula cancels out the overestimation bias of the farms formula, thus the average of the two formulae should result in a relatively accurate estimate.

Evaluation of method

Farms formula

For 2004–05:

Farms formula GVIAP estimate ($ million) = 16.7

Proportion area irrigated on irrigating farms (%) = 78.4

GVAP on irrigating farms ($ million) = 20.4

CEREALS FOR HAY continued

Overestimation factor = 100-78.4 = +22%

Underestimation factor = (16.7-20.4) / 16.7 * 100 = -22%

Therefore the farms formula should provide a fairly accurate estimate, as the overestimation bias due to the proportion of area irrigated on irrigated farms (78%) is cancelled out by the underestimation bias due to the GVAP/farm being much greater on irrigating farms than non-irrigated farms. The same can be said for 2002–03 and 2003–04 data, where, although the proportion irrigated was lower, the GVAP/farm was higher.

Area formula: the area formula will underestimate GVIAP as the yield per hectare is greater on irrigated than non-irrigated land.

Average of area and farms formulae: overall, Method 1 will underestimate GVIAP.

METHOD 2:

Formulae used

Yield formula, where $Y_{diff} = 1.5$

Description of method

A conservative assumption for the yield difference for cereals for hay was that the irrigated yield is 1.5 times greater than the non-irrigated yield. This estimate is consistent with calculated long-term yield differences in broadacre crops in NSW (NSW Department of Primary Industries - Agriculture 2005).

Evaluation of method

The yield difference factor of 1.5 was proven to be fairly accurate by ABS Agricultural unit record data analysis.

PROPOSED NEW METHOD FOR CEREALS FOR HAY

Data analysis supports use of the yield difference factor of 1.5 suggested by the ABS/Productivity Commission collaboration (2006) for cereals for hay.

- If the proportion of the total area of cereals for hay that is irrigated = 100%, then $GVIAP_{cereals\ for\ hay} = GVAP_{cereals\ for\ hay}$;
- If the proportion of the total area of cereals for hay that is irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 1.5;
- If the proportion of the total area of cereals for hay that is irrigated is 0%, then $GVIAP_{cereals\ for\ hay} = 0$.

Note that the yield difference factor is only used to calculate GVIAP for farms that partially irrigate, so in the case of cereals for hay it is only a very small percentage of farms. Therefore, even if the yield difference factor is inaccurate, total GVIAP for cereals for hay estimates will not be greatly affected.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A4 CEREALS FOR HAY, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	16.4	18.3	17.3

CONCLUSION

It was predicted that Method 1 would slightly underestimate and Method 2 would be fairly accurate, and this appears to be the case, when comparing these methods with the New Method. The New Method is basically the same as Method 2 - the slightly different result occurs because of improved data editing methods (not discussed in this paper) used in the New Method.

COTTON

SUMMARY OF ABS AGRICULTURAL UNIT RECORD DATA ANALYSIS

Methods 1 & 2 used the same methodology for cotton - the production formula. Below is a comparison, for 2004–05, of GVIAP estimates using the four different formulae:

The area formula: $839 million

The farms formula: $816 million

The production formula: $908 million

The yield formula (Y_{diff} = 1.5): $901 million

The yield formula (Y_{diff} = 3): $909 million

The above confirms that the area formula and the farms formula both underestimate GVIAP, in the case of cotton. The area formula produces a lower GVIAP than the production formula because the yield on irrigated land (6,945 kg/ha in 2004–05) is higher than the yield on non-irrigated land (2,223 kg/ha). The farms formula also produces a lower estimate than the production formula because irrigated cotton farms are generally almost fully irrigated and produce almost twice the amount of cotton of non-irrigated farms.

Estimates produced using the yield formula are also displayed above, one using a Y_{diff} of 1.5 and the other using a Y_{diff} of 3. These estimates prove that if an accurate yield difference factor is used in the yield formula (in this case the value of 3 was derived by taking the ratio of the yield on irrigated land to non-irrigated land, i.e. 6,945/2,223), the resulting estimate will be very close to the true value (note the difference between the yield formula estimates and the production formula estimate above).

Note that the above estimate for the yield formula (where Y_{diff}=1.5) is slightly different to that displayed in the example provided in the "Methods used to calculate GVIAP" section of this paper (page 9). The example on page 9 used "total Australia" values in the formula (for demonstrative purposes), whereas in the example above the formula was used to produce estimates at unit record level, which were then aggregated up to national level (this is how the method is used in practice). The same applies to the estimate for the production formula above, which is slightly different to the value shown in the example on page 6, however this difference is not noticeable due to rounding.

METHOD 1:

Formulae used

Production formula

Description of method

The Agricultural Census/Surveys collect the split between irrigated and non-irrigated cotton production (kg), therefore irrigated production can be directly identified. Cotton is the only commodity for which irrigated production is collected on the form.

Evaluation of method

This method will result in an accurate estimate of GVIAP.

METHOD 2:

Formulae used

Production formula

Description of method

The Agricultural Census/Survey collects the split between irrigated and non-irrigated cotton production (kg), therefore irrigated production can be identified. Cotton is the only commodity for which the irrigated production is collected on the form. Note that data on both cotton lint and seed production is collected in the Agricultural Census/Survey, however Method 2 only used cotton lint production in its formula.

COTTON continued

Further, Local Unit Value was used, rather than Gross Unit Value. These minor oversights led to an underestimation of GVIAP.

Evaluation of method

Due to the minor oversights described above, this method resulted in an underestimation of GVIAP.

PROPOSED NEW METHOD FOR COTTON

Use the same methodology as used previously by Method 1.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A5 COTTON, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	908.2	880.1	908.2

CONCLUSION

The production formula produces an accurate result because it makes use of irrigated production data. Table A5 shows that Method 2 slightly underestimated GVIAP because it did not consider both cotton lint and seed production, and it used the Local Unit Value rather than the Gross Unit Value.

FRUIT (includes fruit trees, nut trees, plantation and berry fruits; excludes grapevines)

A6 FRUIT

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2000–01					
Fully irrigating	43.9	52.3	13 161.0	n/a	n/a
Partly irrigating	15.0	25.6	12 030.0	n/a	n/a
Not irrigating	41.0	22.2	9 447.0	n/a	n/a
Total	100.0	100.0	11 844.4	85.2	1.4
2001–02					
Fully irrigating	44.3	57.9	15 123.0	n/a	n/a
Partly irrigating	15.4	27.2	14 073.0	n/a	n/a
Not irrigating	40.3	14.9	7 594.0	n/a	n/a
Total	100.0	100.0	12 947.9	85.6	2.0
2002–03					
Fully irrigating	37.6	49.0	15 902.0	n/a	n/a
Partly irrigating	23.1	37.4	10 958.0	n/a	n/a
Not irrigating	39.4	13.6	7 248.0	n/a	n/a
Total	100.0	100.0	11 947.6	78.8	2.2
2003–04					
Fully irrigating	46.2	62.6	16 087.0	n/a	n/a
Partly irrigating	16.7	25.3	11 936.0	n/a	n/a
Not irrigating	37.2	12.1	6 402.0	n/a	n/a
Total	100.0	100.0	12 658.4	84.5	2.5
2004–05					
Fully irrigating	43.5	52.1	17 700.0	n/a	n/a
Partly irrigating	20.0	33.4	13 686.0	n/a	n/a
Not irrigating	36.6	14.5	13 038.0	n/a	n/a
Total	100.0	100.0	15 395.9	81.3	1.4

Proportion of farms irrigating: there was an almost equal proportion of farms (around 40%) irrigating all of their fruit as there was not irrigating at all.

Yield difference: the average yield difference over the 5-year period was 1.9. Analysis of specific fruits was not possible for most fruits because "hectares grown" was not collected for all the orchard varieties. The yield difference factor varied considerably from year-to-year (from 1.4 to 2.5) and seemed to be related to rainfall - i.e. in years of low rainfall the yield difference was higher. However, the high variability in yield difference from year-to-year is probably also due to: (a) the large variety of commodities that made up this commodity group and (b) the different types of fruits being spread across all parts of Australia with high variability in seasonal conditions between areas.

% area of crop irrigated on irrigating farms: the proportion was fairly high and fluctuated between 79% and 86% over the five years.

GVAP on irrigating Vs non-irrigating farms: GVAP/farm for irrigating farms is much greater than for non-irrigating farms, so the proportion of total GVAP on irrigating farms was 1.3-1.4 times greater than the proportion of irrigating farms.

Year-to-year variability: yield difference varied considerably from year-to-year, but the proportion of farms irrigating and the level of irrigation did not vary much, apart from 2002–03, when the levels dropped, probably due to that year being one of extremely low levels of rainfall.

METHOD 1:

Formulae used

Average of the area & farms formulae

FRUIT (includes fruit trees, nut trees, plantation and berry fruits; excludes grapevines) continued

Description of method

Theoretically, the underestimation bias of the area formula cancels out the overestimation bias of the farms formula, thus the average of the two formulae should result in a relatively accurate estimate.

Evaluation of method

Farms formula:

For 2004–05:

Farms formula GVIAP estimate ($ million) = 1,615.6

Proportion area irrigated on irrigating farms (%) = 81.3

GVAP on irrigating farms ($ million) = 2,178.1

Overestimation factor = 100 - 81.3 = +19%

Underestimation factor = (1615.6 - 2178.1) / 1615.6 * 100 = -35%

Therefore the farms formula underestimates GVIAP, as the overestimation bias due to the high proportion of area irrigated on irrigated farms (81%) is outweighed by the underestimation bias due to the GVAP/farm for irrigated farms being much higher than that of non-irrigated farms.

Area formula: the area formula will underestimate GVIAP as the yield per hectare is considerably greater on irrigated than non-irrigated land.

Average of area and farms formulae: overall, Method 1 underestimates GVIAP.

METHOD 2:

Formulae used

Yield formula, where $Y_{diff} = 1$ (i.e. the area formula)

Description of method

A conservative approach was taken to use the area formula without taking into account yield differences between irrigated and non-irrigated crops.

Evaluation of method

This method results in an underestimation of GVIAP, as it uses the assumption that irrigated and non-irrigated yields are equal, which is clearly not the case for fruit.

PROPOSED NEW METHOD FOR FRUIT

A yield difference factor of 2 is reasonable, considering the results of the yearly variability in yield described above. It must be remembered that there are many varieties of fruit and each one would have a different yield difference factor, so it is not easy to derive a single factor that represents all fruit. Generally, only around 20% of crops are "partially" irrigated, so it is not crucial to the overall GVIAP of fruit if the yield difference factor is not 100% accurate.

- If the proportion of the total area of fruit irrigated = 100%, then $GVIAP_{fruit} = GVAP_{fruit}$;
- If the proportion of the total area of fruit irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 2;
- If the proportion of the total area of fruit irrigated is 0%, then $GVIAP_{fruit} = 0$.

FRUIT (includes fruit trees, nut trees, plantation and berry fruits; excludes grapevines) continued

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A7 FRUIT, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	1 777.3	1 665.8	1 948.8

CONCLUSION

It was predicted that Method 1 and 2 would underestimate GVIAP, and the comparison in Table A7 shows this. The New Method provides a higher estimate, as it takes into account the difference in yield.

A8 GRAPES

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2000–01					
Fully irrigating	43.9	48.7	10 427.0	n/a	n/a
Partly irrigating	37.7	43.9	10 067.0	n/a	n/a
Not irrigating	18.3	7.4	9 443.0	n/a	n/a
Total	100.0	100.0	10 188.2	92.2	1.1
2001–02					
Fully irrigating	47.0	53.5	11 012.0	n/a	n/a
Partly irrigating	31.6	39.2	9 812.0	n/a	n/a
Not irrigating	21.4	7.3	9 435.0	n/a	n/a
Total	100.0	100.0	10 386.9	92.2	1.2
2002–03					
Fully irrigating	44.2	37.6	8 037.0	n/a	n/a
Partly irrigating	40.1	58.9	8 400.0	n/a	n/a
Not irrigating	15.7	3.4	8 169.0	n/a	n/a
Total	100.0	100.0	8 251.8	83.6	1.0
2003–04					
Fully irrigating	63.8	69.7	10 417.0	n/a	n/a
Partly irrigating	16.5	24.6	10 504.0	n/a	n/a
Not irrigating	19.7	5.8	9 613.0	n/a	n/a
Total	100.0	100.0	10 425.5	92.5	1.1
2004–05					
Fully irrigating	71.2	77.1	9 395.0	n/a	n/a
Partly irrigating	13.8	19.0	8 545.0	n/a	n/a
Not irrigating	15.1	4.0	9 849.0	n/a	n/a
Total	100.0	100.0	9 237.7	92.9	1.0

Proportion of farms irrigating: proportion of farms fully irrigating grapes increased across the 5-year reference period - in 2004–05 around 70% of vineyards were entirely irrigated and only 15% were not irrigated at all.

Yield difference: there was not a large difference in production/ha between irrigating and non-irrigating farms - the yield was marginally higher on irrigating farms throughout the reference period.

% area of crop irrigated on irrigating farms: very high (92-93% in most years), although was only 84% in 2002–03, a year of particularly low rainfall.

GVAP on irrigating Vs non-irrigating farms: analysis showed that in 2004–05 the GVAP per irrigating farm was $212,000, compared with $56,000 per farm for non-irrigated farms. This translated into a large difference between the proportion of farms irrigating grapes (85%) and the proportion of GVAP from irrigated grapes (96%). This difference was observed throughout the reference period.

Year-to-year variability: there was not a great deal of variability from year-to-year, although the proportion of land irrigated on irrigating farms was lower in 2002–03 than the other years. The proportion of farms not irrigating remained fairly constant over the reference period.

Other notes: Grapes were one of the few crops for which a significant amount of research on differences in irrigated and non-irrigated yields has been undertaken. Data from four different sources show that the yield from irrigated grapes is between 1.2-1.3 times greater than that of non-irrigated grapes. See the following:

GRAPES *continued*

Final Report - Clare Valley Water Supply Scheme - The 186th report of the Public Works Committee (Public Works Committee, Parliament of South Australia, 2005): yield difference factor = 1.3

Drip Irrigation for Grapes (Morris, 1980): yield difference factor = 1.3

Yield and Quality of 'Concord' Grapes as Affected by Irrigation, Pruning Severity, and Nitrogen (Spayd and Morris, 1979): yield difference factor = 1.2

Economics of Drip Irrigation for Juice Grape Vineyards in New York State (Cuykendall, White, Shaffer, Lakso, Dunst, 1999): yield difference factor = 1.3

METHOD 1:

Formulae used

Average of the area & farms formulae

Description of method

Theoretically, the underestimation bias of the area formula cancels out the overestimation bias of the farms formula, thus the average of the two formulae should result in a relatively accurate estimate.

Evaluation of method

Farms formula:

For 2004–05:

Farms formula GVIAP estimate ($ million) = 1,280.8

Proportion area irrigated on irrigating farms (%) = 92.9

GVAP on irrigating farms ($ million) = 1,448.1

Overestimation factor = 100 - 92.9 = +7%

Underestimation factor = (1280.8 - 1448.1) / 1280.8 * 100 = -13%

Therefore, the farms formula underestimates GVIAP, as the relatively small overestimation bias due to the high proportion of area irrigated on irrigated farms is outweighed by the underestimation bias due to the GVAP/farm for irrigated farms being much higher than that of non-irrigated farms.

Area formula: the area formula will slightly underestimate GVIAP as the production per hectare is slightly greater on irrigated than non-irrigated land

Average of area and farms formulae: overall, Method 1 will underestimate GVIAP.

METHOD 2:

Formulae used

Yield formula, where $Y_{diff} = 1$ (i.e. the area formula)

Description of method

A conservative approach was taken to use the area formula without taking into account yield differences between irrigated and non-irrigated crops.

Evaluation of method

This method results in a small underestimation of GVIAP, as it uses the assumption that irrigated and non-irrigated yields are equal, which is not the case for grapes, although the difference in yield in minimal.

PROPOSED NEW METHOD FOR GRAPES

Use the yield formula with yield difference factor of 1.2 (this is at the lower end of the scale of the yield difference factors calculated by other studies (see above) and at the higher end of ABS Agricultural unit record data analysis (see Table A8 above)):

GRAPES continued

- If the proportion of the total area of grapes that is irrigated = 100%, then $GVIAP_{grapes}$ = $GVAP_{grapes}$;
- If the proportion of the total area of grapes that is irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 1.2;
- If the proportion of the total area of grapes that is irrigated is 0%, then $GVIAP_{grapes}$ = 0.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A9 GRAPES, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	1 326.9	1 297.2	1 361.8

CONCLUSION

Comparison of estimates using each methodology highlights the underestimation bias, albeit it relatively small, of Methods 1 and 2, relative to the New Method.

Nurseries, cut flowers and cultivated turf

A10 NURSERIES, CUT FLOWERS AND CULTIVATED TURF

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2002–03					
Fully irrigating	36.7	31.8	48 371.0	n/a	n/a
Partly irrigating	22.1	45.2	49 803.0	n/a	n/a
Not irrigating	41.2	23.0	49 385.0	n/a	n/a
Total	100.0	100.0	49 243.2	77.5	1.0
2003–04					
Fully irrigating	51.5	60.7	51 126.0	n/a	n/a
Partly irrigating	13.3	21.9	54 530.0	n/a	n/a
Not irrigating	35.2	17.4	49 353.0	n/a	n/a
Total	100.0	100.0	51 508.5	88.8	1.0
2004–05					
Fully irrigating	79.6	74.2	47 806.0	n/a	n/a
Partly irrigating	13.2	21.6	51 676.0	n/a	n/a
Not irrigating	7.2	4.1	45 091.0	n/a	n/a
Total	100.0	100.0	48 469.7	88.6	1.1

Proportion of farms irrigating: proportion of farms fully irrigating nurseries, cut flowers and cultivated turf fluctuated greatly from year-to-year. It was only 37% in 2002–03 and had risen to 80% in 2004–05.

Yield difference: in each year, the yield was very similar for farms that were 100% irrigated and farms that were not irrigated.

% area of crop irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms fluctuated between 78 and 89% over the three years.

GVAP on irrigating Vs non-irrigating farms: although GVAP/farm for irrigating farms was much greater than for non-irrigating farms, the proportion of total GVAP on irrigating farms (96%) was only slightly greater than the proportion of irrigating farms (93%) in 2004–05; this difference was much greater in 2002–03 and 2003–04.

Year-to-year variability: analysis of agricultural survey data from 2002–03 to 2004–05 showed large variability in the proportion of farms that irrigated these commodities.

Other notes: note that for 2000–01 and 2001–02 it was not possible to separate out nurseries, cut flowers and cultivated turf from "other crops", as they were combined into one category on the form.

METHOD 1

Formulae used

Average of the area & farms formulae

Description of method

Theoretically, the underestimation bias of the area formula cancels out the overestimation bias of the farms formula, thus the average of the two formulae should result in a relatively accurate estimate.

Evaluation of method

Farms formula:

For 2004–05:

Farms formula GVIAP estimate ($ million) = 712.9

Proportion area irrigated on irrigating farms (%) = 88.6

Nurseries, cut flowers and cultivated turf continued

GVAP on irrigating farms ($ million) = 736.4

Overestimation factor = 100 - 88.6 = +11%

Underestimation factor = (712.9 - 736.4) / 712.9 * 100 = -3%

Therefore, the farms formula slightly overestimates GVIAP, as the relatively small overestimation bias due to the high proportion of area irrigated on irrigated farms (78-89%) outweighs the very small underestimation bias due to the proportion of GVAP on irrigating farms being only slightly higher than the proportion of all farms that are irrigating.

Area formula: the area formula will be fairly accurate because GVAP/ha on irrigated farms is similar to GVAP/ha on non-irrigated farms.

Average of area and farms formulae: overall, Method 1 overestimates GVIAP.

METHOD 2

Formulae used

Yield formula, where $Y_{diff} = 1.5$

Description of method

"Nurseries, cut flowers and cultivated turf", along with "other broadacre crops", were included in the group "other crops" so that an analysis over a longer period (2000–01 to 2003–04) could be conducted - without grouping the commodities this would not have been possible due to differences in the ABS Agricultural survey forms over time. A yield difference factor of 1.5 was decided on for "other crops" as it was deemed this would broadly cover all included commodity categories.

Evaluation of method

In general, grouping these categories together was not ideal as they are quite different types of commodities. For nurseries, cut flowers and cultivated turf, analysis of ABS Agricultural unit record data showed very little difference in yield between irrigated and non-irrigated crops, so a yield difference factor of 1.5 results in an overestimation.

PROPOSED NEW METHOD FOR NURSERIES, CUT FLOWERS AND CULTIVATED TURF

Data analysis suggests there is very little difference in yield between irrigated and non-irrigated crops, therefore yield difference factor = 1, i.e. use the area formula.

- If the proportion of the total area of nurseries, cut flowers and cultivated turf that is irrigated = 100%, then $GVIAP_{\text{nurseries, cut flowers and cultivated turf}} = GVAP_{\text{nurseries, cut flowers and cultivated turf}}$;
- If the proportion of the total area of nurseries, cut flowers and cultivated turf that is irrigated is less than 100% but greater than 0, then use the area formula;
- If the proportion of the total area of nurseries, cut flowers and cultivated turf that is irrigated is 0%, then $GVIAP_{\text{nurseries, cut flowers and cultivated turf}} = 0$.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A11 NURSERIES, CUT FLOWERS AND CULTIVATED TURF, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	685.6	654.6	651.1

CONCLUSION

A comparison of the three methods supports the theory that Methods 1 and 2 overestimate GVIAP, albeit only slightly, so the New Method appears to be sound.

Other broadacre crops

A12 OTHER BROADACRE CROPS

irrigation category	proportion of total farms	proportion of total GVAP	GVAP/ha	area irrigated on irrigating farms	Yield difference factor
	%	%	$	%	
2002–03					
Fully irrigating	4.0	6.2	3 038.0	n/a	n/a
Partly irrigating	2.8	6.0	831.6	n/a	n/a
Not irrigating	93.2	87.8	289.4	n/a	n/a
Total	100.0	100.0	320.0	44.9	10.5
2003–04					
Fully irrigating	4.8	4.6	2 118.7	n/a	n/a
Partly irrigating	2.5	3.5	729.8	n/a	n/a
Not irrigating	92.7	91.9	467.5	n/a	n/a
Total	100.0	100.0	491.3	54.5	4.5
2004–05					
Fully irrigating	2.9	3.3	1 330.7	n/a	n/a
Partly irrigating	2.3	4.5	633.2	n/a	n/a
Not irrigating	94.9	92.2	340.0	n/a	n/a
Total	100.0	100.0	356.2	51.4	3.9

Proportion of farms irrigating: a very small proportion (less than 8%) of farms growing these commodities irrigated them.

Yield difference: in each year, the yield was a lot higher for 100% irrigated farms than it was for farms that were not irrigated, and this difference was quite variable.

The yield difference factor for 2002–03 was extremely high compared with 2003–04 and 2004–05, possibly because of the extremely low rainfall, however figures for all three years appear to be very high compared to other crops. Data collection errors and differences in the mix of crops between years could be contributing to this variation. Therefore, a more conservative yield difference factor should be used to calculate GVIAP. It could be assumed that "other broadacre" crops would have a similar yield difference to similar types of crops, such as sugar (1.3), cereals for grain/seed (2) and pastures for hay/seed (2). As less than 3% of farms partially irrigated "other broadacre" crops, a yield difference factor of 2 would be a conservative estimate but would not affect total GVIAP estimates greatly

% area of crop irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms fluctuated between 45-55% over the three years.

GVAP on irrigating Vs non-irrigating farms: the proportion of total GVAP on irrigating farms (8%) was only slightly greater than the proportion of irrigating farms in 2003–04 (7%) and 2004–05 (5%).

Year-to-year variability: there was not a large variability in the data over the three years except in the case of the yield difference, which was very high in 2002–03.

Other notes: note that for 2000–01 and 2001–02 it was not possible to separate out "other broadacre crops" from "other crops", as they were combined into one category on the form.

METHOD 1

GVIAP for "other broadacre crops" was not considered in the Water Account, however it was calculated for this information paper for the purpose of comparing GVIAP methods, using the "average of the farms and area formulae" method (see Table A13).

Other broadacre crops continued

METHOD 2

Formulae used

Yield formula, where $Y_{diff} = 1.5$

Description of method

This commodity group was included in the group "other crops" so that analysis over a longer period (2000–01 to 2003–04) could be conducted - without grouping the commodities this would not have been possible due to differences in the ABS Agricultural Census/Survey forms over time. A yield difference factor of 1.5 was decided on as it was deemed this would broadly cover all included commodity categories.

Evaluation of method

In general, grouping these categories together was not ideal as they are quite different types of commodities. For other broadacre crops, a yield difference factor of 1.5 was consistent with calculated long-term yield differences in broadacre crops in NSW (NSW Department of Primary Industries - Agriculture 2005), but it appears to result in underestimation, based on ABS Agricultural unit record data analysis.

PROPOSED NEW METHOD FOR OTHER BROADACRE CROPS

Use a yield difference factor of 2:

- If the proportion of the total area of other broadacre crops that is irrigated = 100%, then $GVIAP_{other\ broadacre\ crops} = GVAP_{other\ broadacre\ crops}$;
- If the proportion of the total area of other broadacre crops that is irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 2;
- If the proportion of the total area of other broadacre crops that is irrigated is 0%, then $GVIAP_{other\ broadacre\ crops} = 0$.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A13 OTHER BROADACRE CROPS, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	52.5	69.3	72.2

Note: although other broadacre crops were not previously measured using Method 1, it was calculated for the purposes of this comparison using the "average of the farms and area formulae" method.

CONCLUSION

The New Method produces a slightly higher estimate than Method 2, obviously due to the higher yield difference factor used. The difference is minimal, however, because the proportion of farms "partially irrigating" other broadacre crops (and therefore the proportion of GVIAP estimated using the yield formula) is very low.

Dairy production from irrigated pastures

A14 DAIRY PRODUCTION FROM IRRIGATED PASTURES

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2002–03					
Fully irrigating	1.9	2.4	2 973.7	n/a	n/a
Partly irrigating	41.6	47.1	1 314.1	n/a	n/a
Not irrigating	56.5	50.4	321.1	n/a	n/a
Total	100.0	100.0	516.2	26.9	9.3
2003–04					
Fully irrigating	9.3	4.7	1 018.5	n/a	n/a
Partly irrigating	39.6	51.3	1 292.3	n/a	n/a
Not irrigating	51.1	44.0	809.3	n/a	n/a
Total	100.0	100.0	1 013.1	30.1	1.3
2004–05					
Fully irrigating	9.1	8.4	2 787.3	n/a	n/a
Partly irrigating	41.9	49.6	1 327.1	n/a	n/a
Not irrigating	49.0	42.1	974.8	n/a	n/a
Total	100.0	100.0	1 197.4	31.3	2.9

Most of the irrigated commodities discussed in this paper are irrigated simply by the application of water directly on to the commodity itself, or the soil in which it is grown. The exceptions are commodities related to livestock, which obviously includes dairy.

The GVIAP of "dairy" simply refers to all dairy production from dairy cattle that grazed on irrigated pastures or crops during the reference period. Estimates of GVIAP for dairy must be used with caution, because in this case the irrigation is not simply applied directly to the commodity, rather it is applied to a pasture/crop which is then eaten by the cattle that produces the commodity (milk). Therefore, for dairy production, the true net contribution of irrigation (i.e. the value added by irrigation, or the difference between irrigated and non-irrigated production) will be much lower than the total irrigation-assisted production (the GVIAP estimate).

The difference between (a) the net contribution of irrigation to production and (b) the GVIAP estimate, is probably greater for livestock grazing on irrigated crops/pastures than for commodity groups where irrigation is applied directly to the crops/pastures.

Proportion of farms irrigating: overall, around 50% of farms producing dairy had irrigated their pastures each year. In 2002–03 only 2% of farms with dairy production irrigated all of their pastures, this rose to 9% in 2003–04 and 2004–05.

% area of pastures/crops irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms was around 30% over the three years. However, in 2003–04 and 2004–05 only 14% and 15% respectively of all grazing land on farms with dairy production was irrigated, and only around 9% of all dairy farms irrigated 100% of their grazing pastures. However, it should be noted that grazing land includes "land suitable for grazing", which obviously means it was not necessarily "used" for grazing.

Other notes: note that 2000–01 and 2001–02 is not presented for comparison, because data on "irrigated pastures for grazing" was not collected on the Agricultural Census/Survey in those years (only data on "total irrigated pastures" was collected).

METHOD 1

Formulae used

Farms formula only

Dairy production from irrigated pastures continued

Description of method

The farms formula was used because data from the Victorian Dairy Industry Survey of 1999 and Armstrong, et al. (1998) indicated that where a dairy farm was irrigated, nearly all milk production could be attributed to irrigation. Method 1 only considered dairy production from farms that were classified "dairy" according to ANZSIC; i.e. number of dairy farms irrigating as a proportion of all dairy farms, multiplied by the gross value of milk produced.

Evaluation of method

This method excludes dairy production from farms that produced dairy, but were not classified to dairy according to ANZSIC, resulting in an underestimation of GVIAP.

However, it is possible that by assuming that if a farm has irrigated pastures then all dairy production on that farm is irrigated could overestimate the GVIAP for dairy.

Note: the method should have included "cereal crops for grazing" in addition to "pastures for grazing", to utilise all available grazing data.

METHOD 2

Formulae used

n/a - if any irrigation on the farm, assume all dairy is irrigated

Description of method

If there is any irrigation of pastures on a farm that is involved in any dairy production (note the farm does not necessarily have to be classified as dairy according to ANZSIC), then all dairy production from that particular farm is classified as irrigated.

Evaluation of method

"Irrigation of pastures" included pastures for "grazing", "seed production" and "hay and silage". This could result in a slight overestimation bias. The method should have only included "pastures for grazing."

Note: should have included "cereal crops for grazing" in addition to "pastures for grazing", to utilise all available grazing data.

PROPOSED NEW METHOD FOR DAIRY

It is recommended that Method 2 be used - i.e. if there is any irrigation of pastures for grazing or cereal crops for grazing on a farm that is involved in any dairy production (note the farm does not necessarily have to be classified as dairy according to ANZSIC), then all dairy production from that particular farm is classified as irrigated. Note the inclusion of cereal crops for grazing.

It is possible that by assuming that if a farm has irrigated pastures then all dairy production on that farm is irrigated could overestimate the GVIAP for dairy.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A15 DAIRY PRODUCTION FROM IRRIGATED PASTURES, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	1 643.2	1 803.6	1 802.5

CONCLUSION

Method 1 produces a lower estimate than Method 2 and the New Method, as predicted. Method 2 and the New Method produce very similar estimates, as expected. The slight difference in the Method 2 and New Method estimates occurs because the New Method

Dairy production from irrigated pastures continued

considers "cereal crops for grazing" (which have a relatively low irrigated area proportion) as well as "pastures for grazing".

Meat cattle, sheep and other livestock production from irrigated pastures

The GVIAP of "Meat cattle, sheep and other livestock" simply refers to all production from livestock (other than dairy cattle) that grazed on irrigated pastures or crops during the reference period. However, the methodology for calculating GVIAP for "Meat cattle, sheep and other livestock" differs slightly to that for dairy to allow for the fact that "Meat cattle, sheep and other livestock" are less likely to spend as much time grazing on irrigated pastures as dairy cattle. An area-based ratio is used (i.e. area of irrigated pastures to area of all pastures) rather than assuming that all livestock production is irrigated on farms that have irrigated pastures.

Estimates of GVIAP for livestock must be treated with caution, because as for dairy production, the issues around irrigation not being directly applied to the commodity also apply to this commodity group.

Meat cattle

A16 MEAT CATTLE PRODUCTION FROM IRRIGATED PASTURES

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2002–03					
Fully irrigating	0.6	0.3	695.4	n/a	n/a
Partly irrigating	13.7	10.8	110.7	n/a	n/a
Not irrigating	85.8	88.8	21.3	n/a	n/a
Total	100.0	100.0	23.4	32.7	8.1
2003–04					
Fully irrigating	1.0	0.5	455.0	n/a	n/a
Partly irrigating	13.5	11.7	96.1	n/a	n/a
Not irrigating	85.5	87.8	20.8	n/a	n/a
Total	100.0	100.0	23.0	21.9	7.4
2004–05					
Fully irrigating	1.7	1.0	663.8	n/a	n/a
Partly irrigating	13.4	10.7	99.2	n/a	n/a
Not irrigating	84.9	88.3	23.1	n/a	n/a
Total	100.0	100.0	25.4	28.7	8.2

Proportion of farms irrigating: overall, only around 14-15% of farms with meat cattle production have some pasture irrigation.

% area of pastures/crops irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms was only around 7-8% over the three years. However, only about 0.2% of all grazing land on farms with meat cattle production was irrigated, and around 85% of all meat cattle farms did not irrigate grazing pastures at all. It should be noted that grazing land includes land "suitable for grazing", which obviously means it was not necessarily "used" for grazing.

Other notes: note that 2000–01 and 2001–02 is not presented for comparison, because data on "irrigated pastures for grazing" was not collected on the Agricultural Census/Survey in those years (only data on "total irrigated pastures" was collected).

METHOD 1

Formulae used

Area formula only

Description of method

Applied the area formula as follows:

GVIAP = (area of pastures for grazing irrigated (on non-dairy farms) / total area of land suitable for grazing (on non-dairy farms)) * total production from cattle slaughterings. Note that "non-dairy" farms were categorised as such according to ANZSIC.

Meat cattle continued

Evaluation of method

The area formula underestimates GVIAP for meat cattle, mainly due to the fact that the denominator (total area of land *suitable* for grazing) in the above equation is extremely large. Up until 2005–06, the Agricultural Census/Survey form collected all land *suitable* for grazing, rather than simply collecting land *used* for grazing. Also, meat cattle production on "dairy farms" (according to ANZSIC) is not considered, resulting in further underestimation.

The method used should have also considered the irrigation of "cereal crops for grazing or fed off" in addition to the area of grazing pastures.

METHOD 2

Formulae used

Yield formula, where $Y_{diff} = 1$ (i.e. the area formula)

Description of method

Applied the area formula as follows:

GVIAP = (total area of pastures irrigated (on farms with any meat cattle production) / total area of land suitable for grazing (on farms with any meat cattle production)) * total production from cattle slaughterings.

Evaluation of method

As discussed above under Method 1, the area formula probably underestimates GVIAP for meat cattle, because of its use of all *suitable* grazing land.

The "total area of pasture irrigated" used by this method included pastures for "grazing", "seed production" and "hay and silage" - the method should have only included "pastures for grazing" (note: additionally, should have included "cereal crops for grazing or fed off").

PROPOSED NEW METHOD FOR MEAT CATTLE

Take the average of two methods:

(a) the area formula;

(b) if the farm has any irrigation of pastures or cereals for grazing then assume that all meat cattle production on the farm is irrigated.

The area formula underestimates GVIAP so it is recommended that this should be countered by taking the average of it and an "overestimating" method, (b) above.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A17 MEAT CATTLE PRODUCTION FROM IRRIGATED PASTURES, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	35.8	291.2	810.9

CONCLUSION

The results in the table above highlight the gross underestimation of Methods 1 and 2, particularly the former. Method 2 produces a higher estimate than Method 1 because Method 2 used "all irrigated pastures" (including pastures for grazing, hay, silage and seed) in the area formula, rather than just "pastures for grazing".

The New Method is more robust, although the accuracy of the estimate, considering the methodology used due to the data available, is questionable. A more robust estimate

Meat cattle continued

would be possible if the area actually *used* for grazing was available. It is recommended that this is collected on the Agricultural Census/Survey in future collections.

Sheep

A18 SHEEP PRODUCTION FROM IRRIGATED PASTURES

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2002–03					
Fully irrigating	0.1	0.1	514.8	n/a	n/a
Partly irrigating	6.0	7.1	82.7	n/a	n/a
Not irrigating	93.9	92.9	37.7	n/a	n/a
Total	100.0	100.0	39.2	4.1	13.7
2003–04					
Fully irrigating	0.3	0.1	338.7	n/a	n/a
Partly irrigating	6.5	7.1	62.4	n/a	n/a
Not irrigating	93.1	92.7	32.7	n/a	n/a
Total	100.0	100.0	33.9	5.1	10.3
2004–05					
Fully irrigating	0.7	0.3	259.0	n/a	n/a
Partly irrigating	6.7	7.8	74.4	n/a	n/a
Not irrigating	92.5	91.9	29.2	n/a	n/a
Total	100.0	100.0	30.7	7.1	8.9

Proportion of farms irrigating: overall, only around 6-7% of farms with sheep production have some irrigation of pastures.

% area of pastures/crops irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms was between 4-7% over the three years. However, only about 0.2% of all grazing land on farms with sheep production was irrigated, and around 93-94% of all sheep farms did not irrigate grazing pastures at all. It should be noted that grazing land includes land "suitable" for grazing, which obviously means it was not necessarily "used" for grazing.

Other notes: note that 2000–01 and 2001–02 is not presented for comparison, because data on "irrigated pastures for grazing" was not collected on the Agricultural Census/Survey in those years (only data on "total irrigated pastures" was collected).

METHOD 1

Formulae used:

Area formula

Description of method:

Applied the area formula as follows:

GVIAP = (area of pastures for grazing irrigated (on non-dairy farms) / total area of land suitable for grazing (on non-dairy farms)) * total production from sheep slaughterings.

Evaluation of method: the area formula underestimates GVIAP for sheep, for the same reasons discussed in the Meat cattle section.

Sheep production on "dairy farms" (according to ANZSIC) is not considered, resulting in further underestimation.

The method used should have also considered the irrigation of "cereals for grazing or fed off" in addition to the area of grazing pastures.

The production of wool from sheep was ignored, resulting in further underestimation.

METHOD 2

Formulae used

Yield formula, where $Y_{diff} = 1$ (i.e. the area formula)

Sheep continued

Description of method

Applied the area formula as follows:

GVIAP = (total area of pastures irrigated (on farms with any sheep production) / total area of land suitable for grazing (on farms with any sheep production)) * total production from sheep slaughterings.

Evaluation of method

"Irrigation of pastures" included pastures for "grazing", "seed production" and "hay and silage". This could result in a slight overestimation bias. The method should have only included "pastures for grazing."

Note: should have included "cereal crops for grazing" in addition to "pastures for grazing."

The production of wool from sheep was ignored, resulting in further underestimation.

PROPOSED NEW METHOD FOR SHEEP

- Include wool production
- Take the average of two methods:
  - the area formula;
  - if the farm has any irrigation of pastures or cereals for grazing then assume that all sheep production on the farm is irrigated.

The area formula underestimates GVIAP so it is recommended that this should be countered by taking the average of it and an "overestimating" method, (b) above.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A19 SHEEP PRODUCTION FROM IRRIGATED PASTURES, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	16.0	65.8	237.4

CONCLUSION

The results in Table A19 highlight the gross underestimation of Methods 1 and 2, particularly the former. The New Method is more robust, although the accuracy of the estimate, considering the methodology used due to the data available, is questionable.

While the New Method is not ideal it is superior to Methods 1 and 2. A more robust estimate would be possible if the area actually used for grazing was available. It is recommended that this is collected on the Agricultural Census/Survey in future collections.

Other livestock

A20 OTHER LIVESTOCK PRODUCTION FROM IRRIGATED PASTURES

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2003–04					
Fully irrigating	1.5	4.8	3 913.8	n/a	n/a
Partly irrigating	9.1	1.9	24.1	n/a	n/a
Not irrigating	89.4	93.3	5.5	n/a	n/a
Total	100.0	100.0	5.9	18.6	711.4
2004–05					
Fully irrigating	—	—	n/a	n/a	n/a
Partly irrigating	7.4	6.1	104.9	n/a	n/a
Not irrigating	92.6	93.9	7.7	n/a	n/a
Total	100.0	100.0	8.1	13.9	n/a

— nil or rounded to zero (including null cells)

Proportion of farms irrigating: a fairly low percentage of farms with production from "other livestock" irrigated their pastures.

% area of pastures/crops irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms was between 14-19% over the two years. However, less than 0.1% of all grazing land on farms with other livestock production was irrigated. It should be noted that grazing land includes land "suitable" for grazing, which obviously means it was not necessarily "used" for grazing.

Other notes: note that 2000–01 and 2001–02 was not presented for comparison, because data on "irrigated pastures for grazing" was not collected on the Agricultural Census/Survey in those years (only data on "total irrigated pastures" was collected). 2002–03 is not presented either because data was not collected for the same categories of "other livestock". In 2004–05, no farms with production from "other livestock" reported the irrigation of pastures.

METHOD 1

GVIAP for "other livestock" was not considered in the Water Account.

METHOD 2

GVIAP for "other livestock" was not considered in Characteristics of Australia's Irrigated Farms.

PROPOSED NEW METHOD FOR OTHER LIVESTOCK

Take the average of two methods:

- the area formula;
- if the farm has any irrigation of pastures or cereals for grazing then assume that all other livestock production on the farm is irrigated.

The area formula underestimates GVIAP so it is recommended that this should be countered by taking the average of it and an "overestimating" method, (b) above.

Summary of the New Method for meat cattle, sheep and other livestock

Calculate GVIAP for "meat cattle" and "sheep and other livestock" separately; i.e. combine "sheep" and "other livestock" as "other livestock" contributes very little to GVIAP.

Note that "sheep and other livestock" includes

- Wool - Shorn *
- Wool - Other *
- Sheep and lambs slaughtered
- Buffaloes slaughtered *

Summary of the New Method for meat cattle, sheep and other livestock continued

- Sales of goats (domesticated) * - only included in 2003–04 and 2004–05 Agricultural Surveys
- Sales of all other livestock * - not included from 2003–04 onwards

* not included in GVIAP for Methods 1 and 2

Pastures for hay/seed

A21 PASTURES FOR HAY/SEED

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2002–03					
Fully irrigating	9.6	13.0	2 201.2	n/a	n/a
Partly irrigating	7.7	19.2	1 616.3	n/a	n/a
Not irrigating	82.6	67.8	970.5	n/a	n/a
Total	100.0	100.0	1 140.7	66.0	2.3
2003–04					
Fully irrigating	10.0	16.3	2 074.2	n/a	n/a
Partly irrigating	6.5	16.4	1 250.3	n/a	n/a
Not irrigating	83.6	67.3	835.3	n/a	n/a
Total	100.0	100.0	984.9	66.6	2.5
2004–05					
Fully irrigating	9.8	15.1	1 540.0	n/a	n/a
Partly irrigating	6.0	15.6	1 090.0	n/a	n/a
Not irrigating	84.2	69.3	713.3	n/a	n/a
Total	100.0	100.0	824.7	69.7	2.2

Proportion of farms irrigating: only around 15-17% of farms growing pastures for hay/seed irrigated these pastures

Yield difference: in each year, the yield was more than twice as high for fully irrigated farms as it was for farms that were not irrigated

% area of crop irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms fluctuated between 66-70% over the three years.

GVAP on irrigating Vs non-irrigating farms: over the reference period, the proportion of total GVAP on irrigating farms (30-33%) was much greater than the proportion of irrigating farms (16-17%).

Year-to-year variability: the data was very consistent over the three-year reference period.

Other notes: note that for 2000–01 and 2001–02 it was not possible to separate out irrigated pastures for hay/seed from pastures for grazing, as they were combined into one category, "pastures", on the Agriculture Survey form.

METHOD 1

Formulae used

Average of the area & farms formulae

Description of method

Theoretically, the underestimation bias of the area formula cancels out the overestimation bias of the farms formula, thus the average of the two formulae should result in a relatively accurate estimate.

Evaluation of method

Farms formula:

For 2004–05:

Farms formula GVIAP estimate ($ million) = 153.6

Proportion area irrigated on irrigating farms (%) = 69.7

GVAP on irrigating farms ($ million) = 299.5

Overestimation factor = 100 - 69.7 = +30%

Pastures for hay/seed continued

Underestimation factor = (153.6 - 299.5) / 153.6 * 100 = -95%

Therefore, the farms formula will greatly underestimate GVIAP, because the large overestimation bias due to the relatively low proportion of area irrigated on irrigated farms (66-70%) is outweighed by the extremely high underestimation bias, due to the proportion of total GVAP on irrigating farms being much higher than the proportion of all farms that are irrigating.

Area formula: the area formula will underestimate because GVAP/ha on irrigated farms is more than double that on non-irrigated farms

Average of area and farms formulae: overall, Method 1 will underestimate GVIAP.

METHOD 2

Formulae used

Yield formula, where $Y_{diff} = 1$ (i.e. the area formula)

Description of method

The area formula was used; this was a simplification equivalent to assuming there is no yield difference arising from irrigation of pastures.

Evaluation of method

The assumption that there is no yield difference arising from irrigation of pastures leads to an underestimation of GVIAP.

PROPOSED NEW METHOD FOR PASTURES FOR HAY/SEED

Use a yield difference factor of 2 for pastures for hay/seed. This goes against the assumption used in Methods 1 and 2 that there is no yield difference arising from irrigation of pastures but ABS Agricultural unit record data analysis supports this.

- If the proportion of the total area of pastures for hay/seed that is irrigated = 100%, then $GVIAP_{pastures\ for\ hay/seed} = GVAP_{pastures\ for\ hay/seed}$;
- If the proportion of the total area of pastures for hay/seed that is irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 2;
- If the proportion of the total area of pastures for hay/seed that is irrigated is 0%, then $GVIAP_{pastures\ for\ hay/seed} = 0$.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A22 PASTURES FOR HAY/SEED, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	172.5	142.5	248.6

CONCLUSION

The New Method appears to be more accurate than Methods 1 and 2 as it produces a much higher estimate, as predicted.

Rice

METHOD 1

Formulae used

n/a - use the theory that all rice grown in Australia is irrigated

Description of method

Assume all rice production is irrigated.

Evaluation of method

Will result in an accurate estimate.

METHOD 2

Formulae used

Yield formula, where $Y_{diff} = 3.5$

Description of method

ABS Agricultural unit record data for 2000–01 to 2003–04 suggested that the yield difference factor was around 3.5; however the sample for non-irrigated rice would have been extremely small (in theory, there should not be any non-irrigated rice in Australia) and is probably a data collection anomaly.

Evaluation of method

Rice authorities in Australia report that all rice production is irrigated production. Therefore Method 2 underestimates rice GVIAP. In low rainfall regions, or during drought periods, these estimates are likely to understate the difference in yields between irrigated and non-irrigated activity.

General comments on rice data collected on the ABS Census/surveys 2000–01 to 2004–05

The Rice industry authority confirmed that all rice in Australia is irrigated. ABS data generally supports this, although in 2002–03 the total area irrigated was 95.4% of total area grown and in 2003–04 it was 98.6%.

PROPOSED NEW METHOD FOR RICE

Follow the Method 1 theory, supported by rice authorities, that all rice production in Australia is irrigated production.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A23 RICE, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	100.6	98.0	100.6

CONCLUSION

Method 2, which allowed for a small proportion of non-irrigated rice in Australia, produced a slightly lower estimate of GVIAP than Method 1 and the New Method.

Sugar

A24 SUGAR

irrigation category	*proportion of total farms* %	*proportion of total GVAP* %	*GVAP/ha* $	*area irrigated on irrigating farms* %	*Yield difference factor*
2000–01					
Fully irrigating	7.3	10.2	1 772.2	n/a	n/a
Partly irrigating	35.5	49.0	1 329.4	n/a	n/a
Not irrigating	57.2	40.8	1 125.1	n/a	n/a
Total	100.0	100.0	1 267.8	67.4	1.6
2001–02					
Fully irrigating	9.4	11.5	2 463.9	n/a	n/a
Partly irrigating	38.8	47.5	1 865.8	n/a	n/a
Not irrigating	51.8	41.0	1 684.9	n/a	n/a
Total	100.0	100.0	1 836.1	72.1	1.5
2002–03					
Fully irrigating	7.6	9.2	2 303.9	n/a	n/a
Partly irrigating	35.4	40.4	1 808.0	n/a	n/a
Not irrigating	57.0	50.4	1 778.9	n/a	n/a
Total	100.0	100.0	1 829.0	72.4	1.3
2003–04					
Fully irrigating	11.0	15.6	2 274.3	n/a	n/a
Partly irrigating	35.7	43.8	1 450.9	n/a	n/a
Not irrigating	53.3	40.5	1 494.2	n/a	n/a
Total	100.0	100.0	1 557.3	70.3	1.5
2004–05					
Fully irrigating	14.5	15.1	2 319.8	n/a	n/a
Partly irrigating	32.3	42.7	1 916.2	n/a	n/a
Not irrigating	53.2	42.2	1 725.3	n/a	n/a
Total	100.0	100.0	1 877.8	72.9	1.3

Proportion of farms irrigating: on average, just under 50% of farms that grew sugar cane were irrigating it, but only between 8-15% were fully irrigating.

Yield difference: the yield difference factor did not vary much from year-to-year, with a range of 1.3-1.5.

% area of crop irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms fluctuated between 67-73% over the five years.

GVAP on irrigating Vs non-irrigating farms: over the reference period, the proportion of total GVAP on irrigating farms (57-59%, except in 2002–03 when it was 50%) was much greater than the proportion of irrigating farms (47-48%, except in 2002–03 when it was 43%).

Year-to-year variability: there was not a great amount of variability over the five-year reference period.

METHOD 1:

Formulae used

Average of the area & farms formulae

Description of method

Theoretically, the underestimation bias of the area formula cancels out the overestimation bias of the farms formula, thus the average of the two formulae should result in a relatively accurate estimate.

Evaluation of method

Farms formula:

Sugar continued

For 2004–05:

Farms formula GVIAP estimate ($ million) = 468.2

Proportion area irrigated on irrigating farms (%) = 72.9

GVAP on irrigating farms ($ million) = 577.9

Overestimation factor = 100 - 72.9 = +27%

Underestimation factor = (468.2 - 577.9) / 468.2 * 100 = -23%

Therefore, the farms formula will slightly overestimate GVIAP, because the large overestimation bias due to the relatively low proportion of area irrigated on irrigated farms (67-73%) outweighs the high underestimation bias due to the total proportion of GVAP on irrigating farms being much higher than the proportion of all farms that are irrigating.

Area formula

The area formula will underestimate, because the production per hectare is 1.3 to 1.5 times greater on irrigated than non-irrigated farms.

Average of area and farms formulae: overall, Method 1 will underestimate GVIAP, as the level of underestimation from the area formula appears to outweigh the small overestimation bias of the farms formula.

METHOD 2:

Formulae used

Yield formula, where $Y_{diff} = 1$ (i.e. the area formula)

Description of method

A conservative approach was taken to use the area formula without taking into account yield differences between irrigated and non-irrigated crops.

Evaluation of method

This method results in an underestimation of GVIAP, as it uses the assumption that irrigated and non-irrigated yields are equal, which is clearly not the case for sugar.

PROPOSED NEW METHOD FOR SUGAR

Use the yield formula with yield difference factor of 1.3 (this number is at the more conservative end of the scale (see Table A25):

- If the proportion of the total area of sugar that is irrigated = 100%, then $GVIAP_{sugar} = GVAP_{sugar}$;
- If the proportion of the total area of sugar that is irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 1.3;
- If the proportion of the total area of sugar that is irrigated is 0%, then $GVIAP_{sugar} = 0$.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A25 SUGAR, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	447.0	379.7	459.9

CONCLUSION

The comparison between the results for each method shows that Method 2's assumption of zero yield difference led to an underestimation. Method 1 produces an estimate that is slightly lower than the New Method, and it was predicted that Method 1 would underestimate, so the New Method appears to be fairly accurate.

Vegetables (for human consumption and seed)

A26 VEGETABLES (FOR HUMAN CONSUMPTION AND SEED)

irrigation category	*proportion of total farms*	*proportion of total GVAP*	*GVAP/ha*	*area irrigated on irrigating farms*	*Yield difference factor*
2002–03					
Fully irrigating	42.8	43.0	16 625.0	n/a	n/a
Partly irrigating	26.0	38.7	15 300.0	n/a	n/a
Not irrigating	31.2	18.2	27 542.0	n/a	n/a
Total	100.0	100.0	17 293.7	84.2	0.6
2003–04					
Fully irrigating	48.6	56.1	18 219.0	n/a	n/a
Partly irrigating	19.0	30.6	17 010.0	n/a	n/a
Not irrigating	32.3	13.3	25 486.0	n/a	n/a
Total	100.0	100.0	18 516.0	88.9	0.7
2004–05					
Fully irrigating	59.8	59.5	15 802.0	n/a	n/a
Partly irrigating	17.0	30.9	18 680.0	n/a	n/a
Not irrigating	23.2	9.6	20 723.0	n/a	n/a
Total	100.0	100.0	16 997.6	91.7	0.8

Proportion of farms irrigating: the proportion of farms irrigating vegetables on farms that grew vegetables fluctuated between 67-77%; the majority of irrigators irrigated 100% of the area of the vegetables grown.

Yield difference:

Production/ha for vegetables was actually higher on non-irrigated farms than irrigated farms, so separate analyses of yield difference were conducted for vegetables for human consumption and vegetables for seed, in attempt to discover where this anomaly occurred.

Vegetables for human consumption:

Varied from year-to-year, but in some cases yield was higher for non-irrigated vegetables than irrigated vegetables.

Individual vegetables were analysed. Generally, the GVAP/ha for 100% irrigated crops was fairly similar to non-irrigated crops for most vegetables, however there were some exceptions:

- mushrooms had an extremely high GVAP/ha, and it was higher for non-irrigated crops ($1.9 million/ha) than irrigated ones ($1.4 million/ha);
- "other melons" had a relatively high GVAP/ha, and it was also higher for non-irrigated crops ($73 thousand/ha) than irrigated ones $35 thousand/ha).

The above two vegetables were the main reason that the overall GVAP/ha for vegetables was higher for non-irrigated crops than irrigated ones.

Conclusion: the difference in production per ha between 100% irrigated vegetable crops and 0% irrigated vegetable crops varies by vegetable type but, in general, is minimal.

Vegetables for seed:

Varied from year-to-year, but in some cases yield was higher for non-irrigated vegetables than irrigated vegetables.

In 2004–05, "vegetables for seed" was made up of only 2 categories: "potatoes for seed" and "all other vegetables for seed".

GVAP/ha for potatoes for seed was $12,500/ha for 100% irrigators and $11,000 for non-irrigators. For "all other vegetables for seed" it was $13,000 for 100% irrigators and $78,000 for non-irrigators, however the sample was quite small (there was only 75ha of "all other").

Vegetables (for human consumption and seed) continued

Conclusion: vegetables for seed only makes up a small proportion of all vegetables, and there is insufficient evidence to suggest that irrigated vegetables for seed have a significantly greater production per hectare than non-irrigated vegetables for seed.

% area of crop irrigated on irrigating farms: the irrigated proportion of the total area grown on irrigating farms was very high (84-92%).

GVAP on irrigating Vs non-irrigating farms: over the reference period, the proportion of total GVAP on irrigating farms (82-90%) was much greater than the proportion of irrigating farms (68-77%).

Year-to-year variability: there was not a great amount of variability over the three-year reference period, although irrigation was at its highest in 2004–05, relative to the other years.

Other notes: note that for 2000–01 and 2001–02 it was not possible to combine vegetables for human consumption and vegetables for seed, as irrigation data for vegetables for seed was collected in the "other crops" category and could not be separated out.

METHOD 1:

Formulae used

Average of the area & farms formulae

Description of method

Theoretically, the underestimation bias of the area formula cancels out the overestimation bias of the farms formula, thus the average of the two formulae should result in a relatively accurate estimate.

Evaluation of method

Farms formula:

For 2004–05:

Farms formula GVIAP estimate ($ million) = 1683.0

Proportion area irrigated on irrigating farms (%) = 91.7

GVAP on irrigating farms ($ million) = 1980.8

Overestimation factor = 100 - 91.7 = +8%

Underestimation factor = (1683.0 - 1980.8) / 1683.0 * 100 = -18%

Therefore, the farms formula will underestimate GVIAP, because the relatively small overestimation bias due to high proportion of area irrigated on irrigated farms (92%) is outweighed by the high underestimation bias due to the total proportion of GVAP on irrigating farms being much higher than the proportion of all farms that are irrigating.

Area formula: the area formula will actually slightly overestimate, because there is a unique situation where the production per hectare is greater on non-irrigated farms than it is on irrigated farms.

Average of area and farms formulae: overall, Method 1 will overestimate GVIAP, as the high level of overestimation from the area formula outweighs the small underestimation bias of the farms formula.

METHOD 2:

Formulae used

Yield formula, where $Y_{diff} = 1$ (i.e. the area formula)

Description of method

A conservative approach was taken to use the area formula without taking into account yield differences between irrigated and non-irrigated crops.

Vegetables (for human consumption and seed) continued

Evaluation of method

This method results in an overestimation of GVIAP, as it uses the assumption that irrigated and non-irrigated yields are equal, which is not the case for vegetables, as the non-irrigated yields are higher, as discussed above.

PROPOSED NEW METHOD FOR VEGETABLES

Although the data shows that overall non-irrigated vegetables have a higher yield than irrigated vegetables, closer inspection of the data proved that this anomaly was driven by very high yields for a couple of specific vegetables, both of which were generally non-irrigated. It is therefore assumed that, in general, the difference in yield between non-irrigated and irrigated vegetables is minimal.

Combine vegetables for human consumption and vegetables for seed (from 2005–06 they are collected as one category in the irrigation question on the agricultural survey).

For both vegetables for human consumption and vegetables for seed:

- If the proportion of the total area of vegetables that is irrigated = 100%, then $GVIAP_{vegetables} = GVAP_{vegetables}$;
- If the proportion of the total area of vegetables that is irrigated is less than 100% but greater than 0, then use the yield formula, with a yield difference factor of 1;
- If the proportion of the total area of vegetables that is irrigated is 0%, then $GVIAP_{vegetables} = 0$.

COMPARISON OF METHODS 1 AND 2 WITH THE NEW METHOD - 2004–05

A27 VEGETABLES FOR HUMAN CONSUMPTION AND SEED, AUSTRALIA

	Method 1	*Method 2*	*New method*
Year	$m	$m	$m
2004–05	1 790.5	1 750.4	1 746.9

CONCLUSION

In theory the New Method should produce a result that is similar to Method 2, which uses the area formula - differences are due to different data editing methods. Method 1 produces a slightly larger estimate than the New Method, which supports the discussion above that Method 1 should provide an overestimate.

APPENDIX 2 ANALYSIS OF GVAP BY LEVEL OF IRRIGATION

ANALYSIS OF GVAP BY LEVEL OF IRRIGATION

Calculating the GVIAP of a farm's crops/pastures involves taking the total agricultural production (GVAP) of each of the crops/pastures and splitting it into irrigated and non-irrigated production. In many cases, this is quite straightforward, because the crops/pastures are either completely irrigated (i.e. 100% of a crop's area is irrigated) or not irrigated at all. The other scenario is where the crops/pastures are partially irrigated (i.e. there is some irrigation of the crop/pasture but it is less than 100% of the total area grown/sown for the crop/pasture). In these instances, using the new methodology described in this paper, GVIAP is calculated using the yield formula. That is, the GVAP of the crop is split into irrigated and non-irrigated by giving irrigated GVAP (GVIAP) a heavier "weighting", depending on the crop/pasture type.

Table A28 below provides an indication of how much of each commodity group falls into these three categories (irrigated fully, irrigated partially, non-irrigated). The final column provides an indicator of how much of the commodity group's GVAP had to be estimated using the yield formula, that is, how much of the GVAP from the commodity group was produced on a partially irrigated crop/pasture. Note that for cotton and dairy, although some production was on a partially irrigated crop/pasture, the production that was estimated using the yield formula was zero, because the yield formula does not apply to these commodities.

A28 GVAP GENERATED BY LEVEL OF IRRIGATION, AUSTRALIA, 2004–05

Commodity group	*GVAP from fully irrigated crops/pastures* $m	*GVAP from crops/pastures not irrigated at all* $m	*GVAP from partially irrigated crops/pastures* $m	*Amount of GVAP "split" using the yield formula* $m	*Total GVAP* $m	*proportion of GVAP "split" using the yield formula* %
Cereals for grain/seed	79.7	5 904.4	309.6	309.6	6 293.8	4.9
Cereals for hay	13.9	238.0	6.5	6.5	258.4	2.5
Cotton	819.8	21.3	104.0	—	945.1	—
Fruit	1 328.0	368.7	850.1	850.1	2 546.8	33.4
Grapes	1 162.1	60.0	286.1	286.1	1 508.2	19.0
Nurseries, cut flowers and cultivated turf	570.3	31.9	166.1	166.1	768.2	21.6
Other broadacre crops	40.3	1 110.1	53.6	53.6	1 203.9	4.5
Dairy	259.5	1 391.2	1 543.1	—	3 193.8	—
Meat cattle	76.9	6 951.4	800.1	800.1	7 828.3	10.2
Sheep and other livestock	11.4	3 857.9	316.8	316.8	4 186.1	7.6
Pastures for hay	140.0	581.4	94.3	94.3	815.7	11.6
Pastures for seed	20.3	104.7	33.9	33.9	159.0	21.3
Rice	100.7	—	—	—	100.7	—
Sugar	151.0	422.5	426.9	426.9	1 000.4	42.7
Vegetables	1 303.3	602.6	301.3	301.3	2 207.2	13.6
Non-irrigated commodities	n/a	n/a	n/a	n/a	2 538.5	n/a
Total	**6 077.2**	**21 646.0**	**5 292.3**	**3 645.2**	**35 554.0**	**10.3**

— nil or rounded to zero (including null cells)

For some commodity groups, the majority of GVAP comes from fully irrigated crops/pastures. Examples are rice (100%), cotton (87%), grapes (77%) and nurseries, cut flowers and cultivated turf (74%). For others, most of the GVAP comes from non-irrigated crops/pastures (cereals for grain/seed (94%), meat cattle (93%), other broadacre crops (92%) and cereals for hay (92%).

So, for a large proportion of GVAP, the task of splitting into irrigated and non-irrigated is simple and the yield formula only has to be used to calculate irrigated GVAP for a small proportion of GVAP. In the cases of cotton, dairy and rice the yield formula is not used at all, due to the alternative methods used to calculate GVIAP for each of these commodity groups. Other commodity groups such as cereals for hay, other broadacre crops and

ANALYSIS OF GVAP BY LEVEL OF IRRIGATION *continued*

cereals for grain/seed only have a very small proportion of GVIAP calculated using the yield formula (3, 4 and 5% respectively).

There are a few commodity groups where the GVAP comes mainly from partially-irrigated crops/pastures, meaning the yield formula is used to calculate a larger percentage of GVIAP. Sugar (43% of GVAP) and fruit (33% of GVAP) are the commodity groups with the highest proportions of GVAP coming from partially irrigated crops.

Overall, the table A28 above shows that only 10.3% of all GVAP was "split" into irrigated and non-irrigated production using the yield formula. The rest is accounted for as follows:

- Dairy, cotton and rice
- Fully irrigated crops/pastures
- Non-irrigated crops/pastures
- Other non-irrigated commodities

In summary, this analysis illustrates the robustness of the new method of calculating GVIAP. Approximately 90% of GVAP is easily split into irrigated and non-irrigated GVAP, because it is produced from crops/pastures that are either completely irrigated or not irrigated at all. Only around 10% of GVAP has its allocation *estimated* in that it comes from partially-irrigated land and requires the yield formula to determine a split of irrigated versus non-irrigated production.

APPENDIX 3 DESCRIPTION OF COMMODITY CATEGORIES

DESCRIPTION OF COMMODITY CATEGORIES

CEREALS FOR GRAIN/SEED

This commodity group includes:

- Wheat for grain
- Oats for grain
- Barley for grain
- Sorghum for grain
- Maize for grain
- Millet for grain
- Triticale for grain
- All other cereals for grain or seed

CEREALS FOR HAY

Commodity description: Cereals (including wheat, oats, and forage sorghum) cut for hay.

COTTON

This commodity group includes:

- seed cotton
- cotton lint

FRUIT (includes fruit trees, nut trees, plantation and berry fruits; excludes grapevines)

This commodity group includes:

- Oranges - navel
- Oranges - valencia
- Oranges - other
- Grapefruit
- Lemons & limes
- Mandarins
- All other citrus
- Apples - trees 6 years and over
- Apples
- Pears (excl. Nashi) - trees 6 years and over
- Pears (excl. Nashi)
- Nashi pears - trees 6 years and over
- Nashi pears
- All other pome fruit
- Apricots
- Avocados
- Carambola
- Cherries
- Custard apples
- Dates
- Jackfruit
- Guava
- Mangoes
- Nectarines
- Olives
- Peaches (processing)
- Peaches (fresh)
- Plums
- Prunes
- Rambutan
- All other stone fruit
- All other orchard fruit
- Almonds (kernel weight)
- Cashews
- Macadamia
- Pecans
- Walnuts

FRUIT (includes fruit trees, nut trees, plantation and berry fruits; excludes grapevines) continued

- Nuts nec
- Black currants
- Blueberries
- Raspberries
- Strawberries
- Bananas
- Kiwi fruit
- Papaws / Papaya
- Pineapples
- All other fruit

NURSERIES, CUT FLOWERS AND CULTIVATED TURF

This commodity group includes the following:

- Cultivated turf
- Nurseries
- Cut flowers

OTHER BROADACRE CROPS

This commodity groups includes the following:

- Popcorn for grain
- Mung beans
- Other field beans
- Soybeans
- Hops
- Lupins for grain
- Oil poppies
- Peanuts
- Field peas for grain
- Chickpeas for grain
- Canola
- Safflower
- Sesame
- Sunflower
- Tobacco
- Vetches for seed
- Lentils
- Coriander
- Faba beans (incl. tick & horse)
- Peppermint
- Crops (excl. cereals) for hay
- Fennel (bitter)
- Lavender
- Pyrethrum
- All other crops

Other livestock

Other livestock includes the following:

- buffaloes
- goats (domesticated) - only included in 2003-04 and 2004-05 Agricultural surveys
- all other livestock - total number (not included from 2003-04 onwards)

PASTURES FOR HAY/SEED

This commodity group includes the following:

- Lucerne pasture for hay
- Other pasture for hay
- Pasture for seed

VEGETABLES

This commodity group includes:

- Vegetables for human consumption:

VEGETABLES continued

- Potatoes
- Asparagus
- French & runner beans (processing)
- French & runner beans (fresh)
- Beetroot
- Broccoli
- Brussels sprouts
- Cabbages
- Chinese cabbage
- Capsicums & chillies & peppers
- Carrots
- Cauliflower
- Celery
- Cucumbers
- Eggplant
- Herbs - lemon grass etc
- Leeks
- Lettuce
- Marrows & squashes
- Zucchini
- Melons - rock & cantaloupe
- Melons - watermelons
- Melons - other
- Melons - bitter (gourd)
- Mushrooms
- Onions - spring (incl. shallots)
- Onions - white & brown
- Parsley
- Parsnips
- Peas - green (processing) - shelled weight
- Peas - green (fresh) - pod weight
- Snow peas
- Pumpkins; triambles; trombones; etc
- Sweetcorn
- Tomatoes - processing
- Tomatoes - fresh
- Swedes
- All other vegetables

And vegetables for seed:

- French & runner beans for seed
- Carrots for seed
- Cabbages for seed
- Cauliflower for seed
- Onions for seed
- Peas - green for seed
- Potatoes for seed
- All other vegetables for seed

GLOSSARY

ABS Agricultural unit record data

Individual agricultural establishment (farm) level data collected on the ABS Agricultural Censuses/Surveys. Unit record data is unaggregated data - it is the "raw" farm level data presented in its simplest form.

Agricultural establishment

An establishment which is engaged primarily in agricultural activities.

Average gross unit value

Calculated by dividing the gross value of each commodity produced by the total production of each corresponding commodity. It includes any relevant subsidy and bounty payments based on production.

Commodity groups

The groups of "like" commodities according to the irrigated commodity grouping on the ABS Agricultural Census/Survey form. On the Agricultural Census/Survey form, irrigation data is collected for these "commodity groups", rather than for the wide range of individual commodities for which area and production data is collected.

Formula A - the area formula

This formula is based on the ratio of irrigated area to total area of agricultural production for each commodity group.

$$GVIAP = \frac{A_i}{A_i+A_d} \times PQ$$

Where

A_i = area of the commodity under irrigation (ha)
A_d = area of the commodity that is not irrigated (ha)
P = unit price of production for the commodity ($ per t or kg)
Q = total quantity of the commodity produced (t or kg)
Note: $PQ = GVAP$ or gross value of production of the commodity.

Formula B - the farms formula

This formula is based on the ratio of the number of irrigating agricultural establishments (farms) to the total number of agricultural establishments for each commodity group.

$$GVIAP = \frac{F_i}{F_i+F_d} \times PQ$$

Where

F_i = number of agricultural establishments irrigating the commodity
F_d = number of agricultural establishments producing but not irrigating the commodity
P = unit price of production for the commodity ($ per t or kg)
Q = total quantity of the commodity produced (t or kg)

Formula C - the production formula

This formula is based on the ratio of irrigated production to total production. This formula was only applied to cotton, as this was the only commodity for which data on irrigated and non-irrigated production (kg) was available from ABS collections.

$$GVIAP = \frac{Q_i}{Q_i+Q_d} \times PQ_t$$

Where

Q_i = irrigated production of cotton (kg)
Q_d = non-irrigated production of cotton (kg)
P = unit price of production for cotton ($ per kg)
Q_t = total quantity of cotton produced (kg)

Formula D - the yield formula

The yield formula was developed to account for the difference in production that results from irrigation, using an estimated ratio of irrigated to non-irrigated yield for each commodity group.

$$GVIAP = A_i Y_i P$$

where

$$Y_i = \frac{Q}{A_d/Y_{diff}+A_i}$$

hence

$$GVIAP = A_i \times \frac{Q}{A_d/Y_{diff}+A_i} \times P$$

Formula D - the yield formula *continued*

Where:

A_i = area of the commodity under irrigation (ha)
Y_i = estimated irrigated production for the commodity (t or kg)
P = unit price of production for the commodity ($ per t or kg)
Q = total quantity of the commodity produced (t or kg)
A_d = area of the commodity that is not irrigated (ha)
Y_{diff} = yield difference factor, i.e. estimated ratio of irrigated to non-irrigated yield for the commodity produced

Gross Unit Value (GUV)

See Average gross unit value.

Gross Value of Agricultural Production (GVAP)

Refers to the "gross value of agricultural commodities produced". This is the value placed on recorded production at the wholesale prices realised in the marketplace.

Gross Value of Irrigated Agricultural Production (GVIAP)

Refers to the gross value of agricultural commodities that are produced with the assistance of irrigation. The gross value of commodities produced is the value placed on recorded production at the wholesale prices realised in the marketplace. Note that this definition of GVIAP does not refer to the net contribution of irrigation to the gross value of production of agricultural commodities (GVAP) (i.e. the difference in value between an irrigated and a non-irrigated commodity), rather it describes the total GVAP of commodities produced with the assistance of irrigation.

Local Unit Value (LUV)

See Local value of commodities produced.

Local value of commodities produced

The value placed on commodities at the point of production (i.e. farm gate). It is calculated by deducting marketing costs from the gross value of commodities produced. Gross and local value of agricultural commodities produced involve some duplication as they include certain agricultural commodities which are consumed as raw materials to produce other agricultural commodities (e.g. hay consumed by livestock).

Marketing costs

Marketing costs represent the difference between gross and local values. Although there are difficulties in obtaining complete information on marketing costs (which include freight, cost of containers, commission and other marketing charges), the information provides a perspective on the marketing costs of major commodities. Significant differences in the marketing costs for individual commodities may occur as a result of different marketing arrangements.

Marketplace

In general, the marketplace is the metropolitan market in each state. In cases where commodities are consumed locally, or where they become raw material for a secondary industry, these points are presumed to be the market place.

Megalitre

One million litres.

Method 1

Method 1 was developed by the ABS to produce national and state/territory estimates published in the three editions of the *Water Account, Australia* (cat. no. 4610.0, 1993–94 to 1996–97, 2000–01 and 2004–05) and *Water and the Murray-Darling Basin - A Statistical Profile 2000–01 to 2005–06* (cat. no. 4610.0.55.007).

This method is based on three formulae:

- Formula A - the area formula
- Formula B - the farms formula
- Formula C - the production formula

Depending on the nature of the commodity group and the availability of data, either one of the three formulae (or an average of two of them) was used to calculate GVIAP. For many commodity groups, the average of the area and farms formulae was used to determine the GVIAP. This was based on the assumption that the area formula tended to underestimate and the farms formula overestimate GVIAP - therefore, taking the average of the two resulted in a more accurate estimate.

Method 2

Method 2 was developed in conjunction with the Productivity Commission (PC) and used to produce estimates for the joint ABS and PC publication *Characteristics of Australia's Irrigated Farms 2000-01 to 2003-04* (cat. no. 4623.0).

Method 2 differs from Method 1 in that it places more emphasis on differences in yield between irrigated and non-irrigated crops. It uses a single formula (Formula D - the yield formula) to calculate GVIAP for all commodity groups, with the exception of cotton, rice and livestock (including dairy). Method 2 was developed to account for the difference in production that results from irrigation, using an estimated ratio of irrigated to non-irrigated yield for each commodity.

The New Method

The proposed new methodology is based on Method 2, i.e. the yield formula (for most commodity groups). Method 2 has been improved through adjustment of the yield factors, following analysis of ABS Agricultural Census/Survey unit record data, as well as research from external sources.

Summary of the new method:

The proposed new methodology attempts to calculate GVIAP at the unit (farm) level, using three simple rules:

1. If the area of the commodity group irrigated = the total area of the commodity group grown/sown, then GVIAP = GVAP for that commodity group;

2. If the area of the commodity group irrigated is greater than zero but less than the total area of the commodity group grown/sown, then use the yield formula from Method 2, with a revised yield difference factor, to calculate GVIAP for the irrigated part of the commodity group;

3. If the area of the commodity group irrigated = 0, then GVIAP = 0 for that commodity group.

The above three rules apply to *most* commodity groups; however there are some exceptions, described in more detail in Appendix 1.

Value of Agricultural Commodities Produced (VACP)

The value placed on recorded production at wholesale prices realised in the marketplace. Generally referred to as gross value of production. Referred to in this paper as Gross Value of Agricultural Production (GVAP).

Yield

The production of a commodity (in tonnes, kilograms or as a dollar value) per area grown/sown (in hectares).

Yield difference factor

The estimated ratio of irrigated to non-irrigated yield for a given commodity.

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