Economic Impact of the Morgan Sawmill on the Yorke & Mid North Region

A report to

Morgan Sawmill

Prepared by

econsearch

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EconSearch Pty Ltd
214 Kensington Road
Marryatville SA 5068
Tel: (08) 8431 5533
Fax: (08) 8431 7710

www.econsearch.com.au

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ABBREVIATIONS

fte	full-time equivalent
GRP	gross regional product
GSP	gross state product
RISE	Regional Industry Structure and Employment
SA	South Australia

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EXECUTIVE SUMMARY

This report was commissioned by Morgan Sawmill to assess the regional economic impact of the company's sawmill at Jamestown. Morgan Sawmill is a family business, owned and operated through three generations of the Morgan family. The sawmill is situated on the outskirts of Jamestown, located in the Mid North Region of South Australia, 207km from Adelaide. Morgan Sawmill has used best endeavours to source accurate and credible information for the production of this report, and such information was made available to EconSearch.

This is an economic impact assessment. The estimates of economic impact presented are based on the use of an extension of the conventional input-output method. Over the past decade EconSearch has developed an extended input-output model known as the RISE model (Regional Industry Structure & Employment). The RISE model provides a comprehensive economic framework that is extremely useful in the resource planning process, particularly for regional economic impact applications.

The direct impacts were calculated using data provided by Morgan Sawmill and the indirect (flow-on) impacts were calculated using the RISE model adapted for this project.

At the regional level the Morgan Sawmill is estimated to have the following **annual** impact:

- **$9.4m in Gross Regional Product**
- **106 jobs** (fte) (3.3% of Jamestown regional economy, 10% of Jamestown township)

It is worth noting that in the Jamestown region (Northern Areas District Council), the employed work force is currently around 2,400. The direct and flow-on jobs generated by the Morgan Sawmill (106 fte) represent 3.3 per cent of the regional labour force. In the township of Jamestown, the resident workforce is, of course, much smaller and is estimated to be approximately 740. Although not all of the estimated 106 fte jobs generated (directly and indirectly) by the Morgan Sawmill are residents of Jamestown, the majority are and, based on information provided by the Sawmill regarding where employees live and the location of business expenditure, the proportion is likely to be in the range of 70 to 80 per cent. Even at the lower end of the range, the mill would (directly and indirectly) account for approximately 10 per cent of total employed residents.

The adaptive capacity analysis provided in Section 3 of the report describes Jamestown as a regional community with a below average adaptive capacity. Its vulnerabilities include a declining population and a workforce with relatively low levels of formal qualification. However, one of its strengths was shown to be its low rate of unemployment. The analysis here has shown that, without some offsetting or remedial measures, the loss of the Morgan Sawmill would have a significant and negative impact on regional employment, particularly in the township of Jamestown, and would thereby further erode the resilience, increase the vulnerability and diminish the adaptive capacity of the local community.

1. INTRODUCTION

1.1 Background

Morgan Sawmill is a family business, owned and operated through three generations of the Morgan family. The sawmill is situated on the outskirts of Jamestown, located in the Mid North Region of South Australia, 207km from Adelaide. The township of Jamestown has a population of approximately 1,405 and the broader Jamestown region (Northern Areas District Council) has a population of approximately 4,550.

The mill's product range includes posts, structural timber, pallets, bins/boxes, woodchips, sawdust and decking. Morgan Sawmill has evolved over time, growing significantly in size and developing new product lines for the dynamic timber products market.

The mill's timber supply is from locally grown plantation forests of *Pinus Radiata* maintained by Forestry SA. The majority of timber supplies are from the Wirrabara and Bundaleer Forests. Bundaleer forest was the state's first plantation forest, planted in 1876.

1.2 Objectives

The purpose of this report is to provide a statement of the economic contribution of the Morgan Sawmill to the regional economy.

An outline of the method, data sources and indicators of economic impact used in the analysis are provided in Section 2. An analysis of the adaptive capacity of the Jamestown region is presented in Section 3. Section 4 provides the estimates of the economic impacts of the Morgan Sawmill.

2. METHOD OF ANALYSIS

2.1 General Approach

This is an economic impact assessment. The estimates of economic impact presented are based on the use of an extension of the conventional input-output method. Over the past decade EconSearch has developed an extended input-output model known as the RISE model (Regional Industry Structure & Employment). The RISE model provides a comprehensive economic framework that is extremely useful in the resource planning process, particularly for regional economic impact applications.

The indicators used in impact analysis typically include output, employment, household income and gross state/regional product and these indicators are used in this report.

2.2 Estimation of Economic Effects – Key Concepts

2.2.1 Economic activity

Economic activity indicators: the primary focus in this report is on the concept of economic activity associated with the Morgan Sawmill. The key economic activity indicators considered in this analysis are employment and gross regional product (GRP).

Economic impact: changes in economic activity are referred to as economic impacts, i.e. changes in the economic activity indicators, resulting from some stimulus or external shock imposed on the system. In this report the stimulus is in the form of the continued operation of the Morgan Sawmill.

2.2.2 Employment and gross state product defined

Employment units: A further important distinction is the units in which employment numbers are reported. They are usually reported in either full time equivalent (FTE) units, or job units defined as follows:

- *FTE:* is a way to measure a worker's involvement in a project. An FTE of 1.0 means that the person is equivalent to a full-time worker, while an FTE of 0.5 signals that the worker is only half-time. Typically, different scales are used to calibrate this number, depending on the type of industry and scope of the analysis but the basic calculation is the total hours worked divided by average annual hours worked in full-time jobs.
- *Jobs:* is used to refer to the number of workers employed in a project at any point in time. It typically refers to either:
    - the *maximum* number of workers required any point over the duration of the project; or

- the *average* number of workers required over the duration of the project. This can be calculated on a daily, weekly or monthly basis.

In this report employment has been reported in terms of FTE units.

Gross regional product (GRP): is a measure of the contribution of an activity to the regional economy. GRP is measured as value of gross output (business revenue) less the cost of goods and services (including imports) used in producing the output. In other words, it can be measured as the sum of household income, 'gross operating surplus and gross mixed income net of payments to owner managers' and 'taxes less subsidies on products and production'. It represents payments to the primary inputs of production (labour, capital and land). Using GRP as a measure of economic impact avoids the problem of double counting that may arise from using value of output for this purpose

2.2.3 Categories of employment and GRP in the forest industry supply chain

A useful way to think about employment and GRP effects is using the concept of a 'supply chain'. The supply chain, in the context of a sawmill operation includes, the planning and management of all activities involved in sourcing and procurement, conversion of materials, and all the logistics management activities. It also includes coordination and collaboration with suppliers, intermediaries and third-party service providers.

Broadly speaking there are four categories of employment and GRP along the infrastructure supply chain.

1. *Direct employment and GRP* – this is employment in those firms, businesses and organisations that are directly engaged in timber processing. Typically this will include:
    a. sawmills
    b. secondary timber processing
    c. furniture and other high end use.
2. *First round employment and GRP* - refers to employment in firms that supply inputs and services to the 'direct employment' businesses, i.e. those categorised under #1 above.
    a. forestry
    b. logging
    c. hauling
    d. business support services
    e. fuel, energy and other direct inputs
3. *Industrial-support employment and GRP* - is the term applied to 'second and subsequent round' effects as successive waves of output increases occur in the economy to provide industrial support, as a response to the expenditure by the sawmill. The category excludes any employment associated with increased household consumption.

4. *Consumption-induced employment and GSP* - is the term applied to those economic activities induced by increased household income associated with the original sawmill expenditure. The expenditure of household income associated with all above three categories of employment, direct, first round and industrial-support, will generate economic activity that will in itself generate jobs.

Indirect, or *flow-on*, employment is the sum of categories 2, 3 and 4. In this analysis direct and first round (for construction impacts only) and flow-on employment and GRP (i.e. all categories) have been reported.

2.3 Economic Impact Model

Input-output models are widely used to assess the economic impact, including employment and GRP impacts, of various economic policy instruments[1], such as industry development and infrastructure projects and programs. I-O models are available at the national, state and regional levels. The RISE[2] I-O model of the South Australian and regional economies, constructed by EconSearch, are widely used by the SA Government and, as noted above, the model for the Yorke and Mid North region (Figure 2-1) has been used in this assessment.

The RISE model provides industry sector employment multipliers (in terms of employment, GRP and household income), which are applied directly to output and spending estimates to formulate impact estimates. This approach makes implicit assumptions about the operation of the economy. It has the benefit of being relatively simple and transparent.

2.4 Data and Assumptions

Data for the analysis was provided to EconSearch by Morgan Sawmill and we have relied on that information as the basis for estimating the economic impact of the sawmill operations.

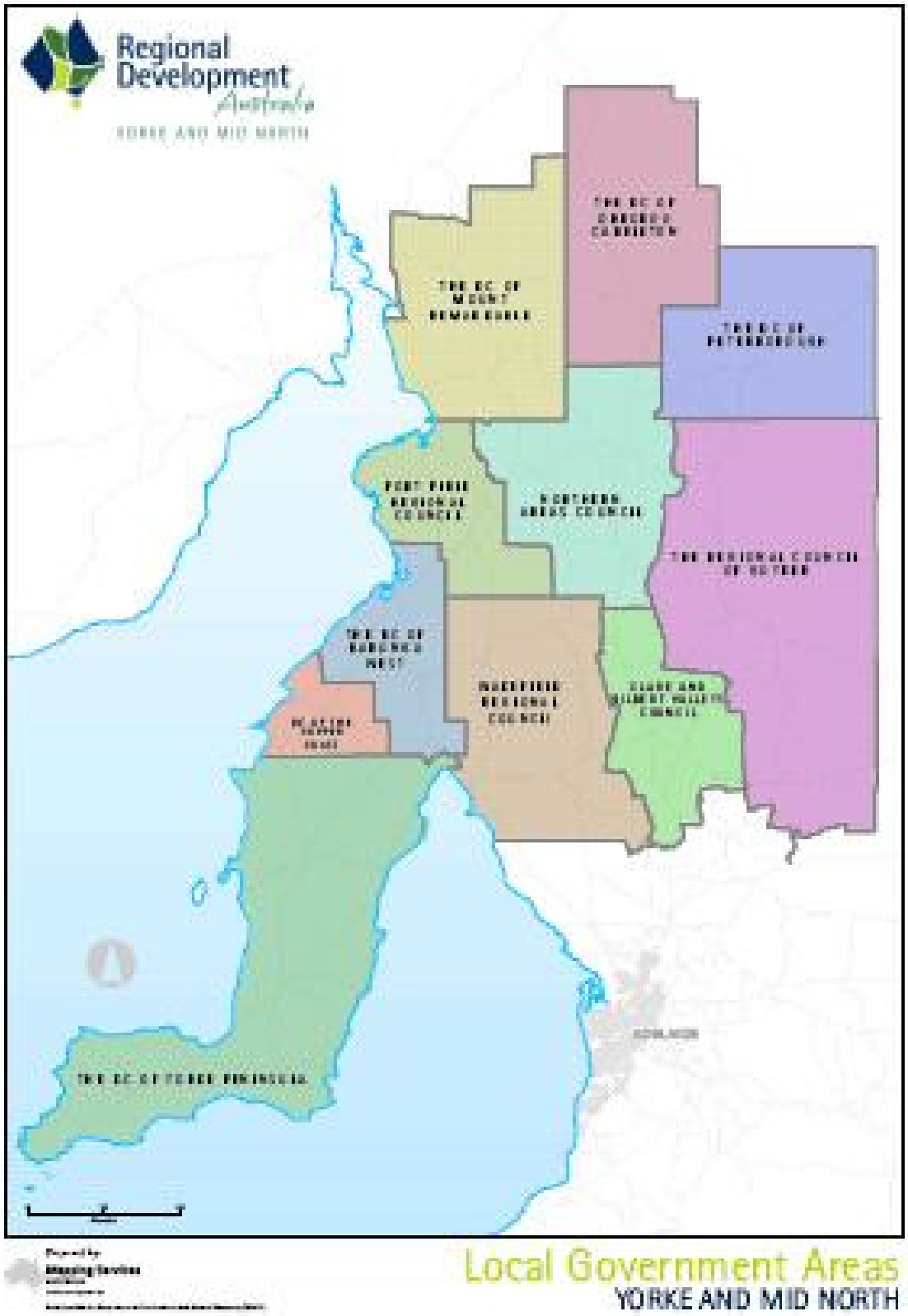
There are currently 44 full time equivalent jobs at the sawmill. Another 5 contractors are employed on-site giving total direct employment of 49. There are an additional 23 jobs in linked activities: 3 forestry, 5 logging and 15 Forestry SA contractors.

Annual wages and payments to on-site contractors are approximately $2.2 million. Other significant annual expenditures include haulage ($1.4m), repairs and maintenance ($0.4m) and fuel ($0.3m). These data were incorporated into the RISE model for the Yorke and Mid North region to estimate the annual contribution of the Morgan Sawmill to the regional economy.

[1] Called an 'exogenous shock' in model terminology.

[2] http://www.lga.sa.gov.au/webdata/resources/files/Ensuring_LG_Services_Provision_-_Practical_Guide_RISE_Model_-_August_2011.pdf

Figure 2-1 Yorke and Mid North Region



3. ADAPTIVE CAPACITY OF THE JAMESTOWN REGION

3.1 Introduction

The method of analysis used to measure a region's adaptive capacity was developed as part of a project in regional Victoria described in Schirmer and Mylek (2013). In order to better understand the vulnerability of Victorian towns to change—in particular change in the Forestry and Wood Products Industries—a community adaptive capacity (AC) index was developed. The method is further explained in Appendix 2.

A common way of describing a region's resources is to classify them as forms of capital, namely built, human, natural, social or financial capital. The five capitals commonly discussed at the community scale are as follows:

- human capital - labour and influences on the productivity of labour including education, skills and health
- social capital - claims on others by virtue of social relationship
- natural capital - land, water and biological resources
- physical capital - produced by economic activity including infrastructure, equipment and technology
- financial capital - savings and credit.

The index developed for the Victorian study consisted of four of these forms of capital, while excluding natural capital. This was principally because there were no readily available and robust measures of natural capital, and partly because the natural resource of principal interest in Schirmer and Mylek (2013), namely timber, was addressed through other parts of their analysis. Similarly, in this analysis, the natural resource of interest is timber and because its long term future accessibility and availability is uncertain it has been excluded from the analysis.

3.2 Adaptive Capacity Index and Contextual Data

The community adaptive capacity index for the Jamestown region[3] is provided in Table 3–1. To give context to the index, the socio-economic indictors that contribute to the index are presented in Table 3-2. A discussion of each of the sub-indices follows.

[3] The Jamestown region is Jamestown Statistical Area 2 (SA2) as defined by the ABS. It includes all of the Northern Areas District Council and a very small portion of the Mount Remarkable and Orroroo/Carrieton District Councils. In percentage terms the Jamestown SA2 region is 98.8% Northern Areas DC, 0.7% Orroroo/Carrieton DC and 0.5% Mount Remarkable DC.

Table 3–1 Community adaptive capacity index for the Jamestown region

Indicator	Weighting	State Average SA2	Jamestown SA2
Physical Capital			
Remoteness (ARIA)	10%	0.00	-0.65
Population size	5%	0.00	-0.94
Population change	5%	0.00	-0.79
Internet access	5%	0.00	-0.74
Physical Capital Index	**25%**	**0.00**	**-1.02**
Economic Capital			
Economic diversity	5%	0.00	-1.15
Median household income	7%	0.00	-0.58
Income/housing cost	11%	0.00	0.40
Unemployment	11%	0.00	0.79
Median household size	2%	0.00	0.51
Economic Capital Index	**36%**	**0.00**	**0.23**
Human Capital			
Graduates	5%	0.00	-0.74
Population 65 over	4%	0.00	-0.78
Completed high school	5%	0.00	-0.77
One parent households	5%	0.00	0.91
Lone person households	3%	0.00	-0.39
Females in non-routine jobs	3%	0.00	0.61
Human Capital Index	**25%**	**0.00**	**-0.32**
Social Capital			
Voluntary work	4%	0.00	2.21
Community Strength	10%	0.00	0.71
Social Capital Index	**14%**	**0.00**	**1.25**
Adaptive Capacity Index	**100%**	**0.00**	**-0.10**

Sources: ABS (2001, 2011) *Census of Housing and Population*; Australian Population and Migration Research Centre *Accessibility/Remoteness Index of Australia*; PHIDU (2011); EconSearch analysis.

Table 3–2 Socio-economic indicators, Jamestown region

Indicator	Measure	State Average SA2	Jamestown SA2
Physical Capital			
Remoteness	ARIA Index (transformed)	0.00	-0.65
Population size	No. of persons	9,835	4,559
Population change	% change between 2001 to 2011	9%	-3%
Internet access	% households	76%	69%
Economic Capital			
Economic diversity	Hachman Index	0.66	0.37
Median household income	$ per household per week	1,125	900
Income/housing cost	$ income per $1 housing cost	3.91	5.17
Unemployment	Unemployment rate	5.7%	3.6%
Median household size	No. of persons per household	2.41	2.31
Human Capital			
Graduates	% graduates in the population	52%	44%
Population 65 over	% population aged 65 or more	16%	20%
Completed high school	% persons completing high school	43%	31%
One parent households	% one parent families	16%	10%
Lone person households	% lone person households	28%	30%
Females in non-routine jobs	% females in non-routine jobs	23%	26%
Social Capital			
Voluntary work	% population volunteering	20%	39%
Community Strength	% community strength	67%	71%

Sources: ABS (2001, 2011) *Census of Housing and Population*; Australian Population and Migration Research Centre *Accessibility/Remoteness Index of Australia*; PHIDU (2011); EconSearch analysis.

3.3 Discussion

3.3.1 Physical Capital

Remoteness:

This is based on ARIA, which is an index of remoteness derived from measures of road distances between populated localities (SA2s) and Service Centres. Localities that have communities comparatively closer to Service Centres and populated areas are considered to have a greater adaptive capacity. Because Jamestown is more remote than the state average SA2 it has a negative remoteness score.

Population size:

Population size is the population recorded for each sub-region standardised to a ratio based on the median population of localities (SA2s) in the set (i.e. SA2s in South Australia). Regions with populations that are greater than the state median SA2 population are considered to have a greater adaptive capacity. The state median population for a SA2 is 9,835 persons whereas the Jamestown regional population approximately half that.

Population change:

Is the rate of population change recorded for each SA2 (2001 to 2011) standardised to a ratio based on the median rate of population change calculated for SA2s in the set (i.e. SA2s in South Australia). A region with population change that is greater than the state median SA2 population change is considered to have a greater adaptive capacity. The state average population change has been an increase of nine per cent from 2001 to 2011 whereas for the Jamestown region it was three per cent.

Internet access:

Internet access is the proportion of households with an internet connection for each SA2 (2011) standardised to a ratio based on the proportion for South Australia. SA2s with a proportion of internet connections that are lower than the state average are considered to have a less adaptive capacity. The average proportion of internet access for the state is 76 per cent and slightly lower in the Jamestown region at 69 per cent.

3.3.2 Economic Capital

Economic diversity:

Economic diversity is an index calculated from industry of employment data available from the ABS *Census of Population and Housing* and is based on the Hachman Index. SA2s which have a large portion of employment in a few key industries, which differ considerably from the portion of employment for those industries state-wide, will have a relatively low Hachman Index value. Conversely, those SA2s which more closely reflect the state-wide employment distribution will have a relatively high Hachman Index value. The benchmark index for the state is 0.66. The Jamestown region has a notably low Hachman Index of 0.31.

Median household income:

Median household income is calculated as the median household income for each SA2 standardised to a ratio based on the median for South Australia. SA2s with median household income that is greater than the state median are considered to have greater adaptive capacity. The state median household income is $1,125 per week. The Jamestown region has a median household income of $900 per week which is well below the state median.

Income to housing cost ratio:

Income to housing cost ratio is based on a ratio of the median household income to average household housing cost for each locality (SA2) standardised to the ratio for all households in South Australia. Housing cost includes both rent and mortgage payments. This is a measure of housing affordability. SA2s with income to housing cost ratios that are greater than the state ratio are considered to have greater adaptive capacity. The state income to housing cost ratio is 3.91, whereas the Jamestown region has a substantially higher household income to housing cost ratio than the state average being 5.17.

Unemployment rate:

Unemployment rate is calculated as the total number of unemployed persons as a proportion of the total labour force for each locality (SA2) standardised to a ratio based on unemployment for South Australia. SA2s with unemployment rates that are lower than the state average are considered to have greater adaptive capacity. The state's unemployment rate is 5.7 per cent and significantly lower in the Jamestown region at around 3.6 per cent.

Median household size:

Median household size is calculated as average number of persons per household for each locality (SA2) standardised to a ratio based on average household size for South Australia. SA2s with median household sizes that are lower than the state average are considered to have greater adaptive capacity. The state's median household size is 2.41 persons, very similar to that in the Jamestown region (2.31).

3.3.3 Human Capital

Percentage Graduates:

Percentage graduates is calculated as the total persons with a post-school qualification as a proportion of the total persons aged 15 and over for each locality (SA2) standardised to a ratio based on the percentage for South Australia. SA2s with graduate rates that are higher than the state average are considered to have greater adaptive capacity. The state's proportion of graduates is 52 per cent which is substantially higher than the proportion of graduates in the Jamestown region (44 per cent).

Percentage of the population aged 65 and over:

Percentage of the population aged 65 and over is calculated as the total number of persons aged 65 and over as a proportion of the total number of persons for each locality (SA2) standardised to a ratio based on the percentage for South Australia. SA2s with lower proportions of the population aged 65 and over than the state average are considered to have greater adaptive capacity. The state's percentage of the population aged 65 and over is 16 per cent compared to the Jamestown region which has 20 per cent of the population aged over 65.

Percentage people completing high school:

Percentage people completing high school is calculated as the number of persons aged 15 and over to have completed high school as a proportion of the total persons aged 15 and over for each locality (SA2) standardised to a ratio based on the percentage for South Australia. SA2s with higher proportions of the population completing high school than the state average are considered to have greater adaptive capacity. The state's percentage of the population completing high school is 43 per cent compared to just 31 per cent for the Jamestown region.

Single parent households:

Single parent households is calculated as the total number of single parent families as a proportion of the total number of families for each locality (SA2) standardised to a ratio based on the percentage for South Australia. Regions with lower proportions of single parent families than the state average are considered to have greater adaptive capacity. The state's percentage of single parent families is 16 per cent which is well above the rate of 10 per cent in the Jamestown region.

Lone person households:

Lone person households is calculated as the total number of one person households as a proportion of the total number of occupied dwellings for each locality (SA2) standardised to a ratio based on the percentage for South Australia. SA2s with lower proportions of lone person households than the state average are considered to have greater adaptive capacity. The state's percentage of lone person households is 28 per cent, slightly lower than the rate in the Jamestown region (30 per cent).

Females in non-routine jobs:

Females in non-routine jobs is calculated as the total number of females in non-routine occupations (managers, professionals, technicians and trades workers, and community and personal service workers) as a proportion of the total number of female employed persons for each locality (SA2) standardised to a ratio based on the proportion for South Australia. SA2s with higher proportions of women in non-routine jobs than the state average are considered to have greater adaptive capacity. The state's percentage of women in non-routine jobs is 23 per cent which is lower than the rate in the Jamestown region of 26 per cent.

3.3.4 Social Capital

Voluntary work:

Voluntary work is calculated as the total number of volunteers as a proportion of the total number of persons aged 15 and over for each locality (SA2) standardised to a ratio based on the percentage for South Australia. SA2s with higher proportions of volunteers than the state average are considered to have greater adaptive capacity. The state's percentage of people engaging in voluntary work is 20 per cent, little over half the rate in Jamestown (39 per cent).

Community Strength:

The community strength measure is based on the *Social Health Atlas of Australia data on community strength* and is calculated as the simple average of the following measures of community strength (proportion of households who can answer 'yes' to the following questions):

- Can you get help from family, friends or neighbours when you need it?
- Are you a member of an organised sport or church or community group in your local area?
- If you have school aged children, are you actively involved with activities in their school?

Those localities (SA2s) that have a community strength indicator that is a higher per cent than the state average are considered to have greater adaptive capacity. The state average for this measure is 67 per cent and it is slightly higher in the Jamestown region at 71 per cent.

3.4 Summary

Physical capital: overall the Jamestown region has lower than average endowment of physical capital. It is a sub-region that is comparatively remote, has below average internet access, a smaller than average population and has seen population decline.

Economic capital: overall this sub-region has a below average endowment of economic capital. It has a substantially low economic diversity with employment concentrated in the agriculture sector. Agriculture has experienced declining terms of trade which is reflected to some degree in the substantially below average median household income. However this is balanced by having close to the state average income to housing cost, relatively small median household sizes and relatively low levels of unemployment.

Human capital: overall this sub-region is below average in its endowment of human capital. It has a comparatively high proportion of elderly people and lone person households, and a substantially lower number of graduates and number of people who have completed high school. However, this is balanced, to certain extent, by a below average proportion of single parent families and the above average number of women in managerial or technical occupations.

Social capital: this sub-region has a substantially above average endowment of social capital. The level of volunteering in the region is well above average, an indication of a socially cohesive community, which is reflected in the community strength score.

Overall the Jamestown region has a community adaptive capacity index score of -0.10, indicating regional communities with a below average adaptive capacity. Its vulnerabilities lie in a concentration of employment in one industry sector, an ageing population, a declining population and a workforce with relatively low levels of formal qualification. However its strengths lie in its community cohesion and low rate of unemployment.

4. MORGAN SAWMILL ECONOMIC IMPACT

4.1 Results

Cost estimates of the sawmill operation were provided by Morgan Sawmill for the purpose of the economic impact analysis of the project. The data were used to estimate the economic impacts in terms of GRP and employment for the local region using the latest available RISE model for the Yorke and Mid North region. The estimated impacts are reported below.

The direct impacts were calculated using data provided by Morgan Sawmill and the indirect (flow-on) impacts were calculated using the RISE model adapted for this project. The model is used to measure the economic effects in other sectors of the economy generated by the direct activities, that is, the multiplier effects. In addition to the assumptions embodied in the RISE model itself (see Appendix 2), it was necessary to make a number of other general assumptions in estimating the economic impacts:

- The impacts were measured using models that represent the structure of the Yorke and Mid North economy for the year in which the most recent data are available (2011/12).
- Over time there are likely to be improvements in primary factor productivity in these economies. To allow for the improvements an across-the-board (all sectors) labour productivity improvement rates of 1 per cent per annum for subsequent years of the construction have been incorporated into the modelling.

Gross regional product (GRP) …

GRP is a measure of the net contribution of an activity or industry to the regional economy. It represents payments to the primary inputs of production (labour, capital and land) and is a regional/state level equivalent of gross domestic product.

The results of the economic impact assessment of the Morgan Sawmill are detailed in Table 4-1. In Yorke and Mid North region GRP generated annually is as follows:

- $3.5m directly
- $5.9m in flow-on activity
- $9.4m in total

The GRP for the Jamestown region (Northern Areas DC) has not been estimated as part of this study but, on an employment shares basis, is likely to be around $275m (in 2012/13 dollars). On this basis, the $9.4m GRP generated by the Morgan Sawmill would represent 3.4 per cent of GRP in the broader Jamestown region (Northern Areas DC). Needless to say, the relative contribution of the mill to the economy of the Jamestown township would be significantly greater and likely to account for at least 10 per cent of economic activity in the town.

Table 4-1 Annual economic impact of the Morgan Sawmill

	Gross Regional Product ($m)	Employment (fte)
Direct	*3.5*	*49*
Flow-on:		
First round	3.1	32
Industrial support	0.9	9
Consumptin induced	1.9	16
Total Flow-on	*5.9*	*57*
Total	**9.4**	**106**

Source: EconSearch analysis

Employment (fte)...

Employment is an important indicator of both regional economic activity and the welfare of regional households. The results of the economic impact assessment of the Morgan Sawmill are detailed in Table 4-1. In the Yorke and Mid North region employment generated annually was estimated as follows:

- 49 fte jobs directly
- 57 fte jobs in flow-on activity
- 106 fte jobs in total.

4.2 Conclusions

It is worth noting that in the Jamestown region (Northern Areas District Council), the employed work force is currently around 2,400. The direct and flow-on jobs generated by the Morgan Sawmill represent 3.3 per cent of the regional labour force. In the township of Jamestown, the resident workforce is, of course, much smaller and is estimated to be approximately 740. Although not all of the estimated 106 fte jobs generated (directly and indirectly) by the Morgan Sawmill are residents of Jamestown, the majority are and, based on information provided by the Sawmill regarding where employees live and the location of business expenditure, the proportion is likely to be in the range of 70 to 80 per cent. Even at the lower end of the range, the mill would (directly and indirectly) account for 10 per cent of total employed residents.

The adaptive capacity analysis provided in Section 3 described Jamestown as a regional community with a below average adaptive capacity. Its vulnerabilities include a declining population and a workforce with relatively low levels of formal qualification. However, one of its strengths was shown to be its low rate of unemployment. The analysis here has shown that, without some offsetting or remedial measures, the loss of the Morgan Sawmill would have a significant and negative impact on regional employment, particularly in the township of Jamestown, and would thereby further erode the resilience, increase the vulnerability and diminish the adaptive capacity of the local community.

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APPENDIX 1 AN OVERVIEW OF ECONOMIC IMPACT ANALYSIS USING THE INPUT-OUTPUT METHOD

Economic impact analysis based on an input-output (I-O) model provides a comprehensive economic framework that is extremely useful in the resource planning process. Broadly, there are two ways in which the I-O method can be used.

First, the I-O model provides a numerical picture of the size and shape of an economy and its essential features. The I-O model can be used to describe some of the important features of an economy, the interrelationships between sectors and the relative importance of the individual sectors.

Second, I-O analysis provides a standard approach for the estimation of the economic impact of a particular activity. The I-O model is used to calculate industry multipliers that can then be applied to various development or change scenarios.

The input-output database

Input-output analysis, as an accounting system of inter-industry transactions, is based on the notion that no industry exists in isolation. This assumes, within any economy, each firm depends on the existence of other firms to purchase inputs from, or sell products to, for further processing. The firms also depend on final consumers of the product and labour inputs to production. An I-O database is a convenient way to illustrate the purchases and sales of goods and services taking place in an economy at a given point in time.

As noted above, I-O models provide a numerical picture of the size and shape of the economy. Products produced in the economy are aggregated into a number of groups of industries and the transactions between them recorded in the transactions table. The rows and columns of the I-O table can be interpreted in the following way:

- The rows of the I-O table illustrate sales for intermediate usage (i.e. to other firms in the region) and for final demand (e.g. household consumption, exports or capital formation).

- The columns of the I-O table illustrate purchases of intermediate inputs (i.e. from other firms in the region), imported goods and services and purchases of primary inputs (i.e. labour, land and capital).

- Each item is shown as a purchase by one sector and a sale by another, thus constructing two sides of a double accounting schedule.

In summary, the I-O model can be used to describe some of the important features of a state or regional economy, the interrelationships between sectors and the relative importance of the

individual sectors. The model is also used for the calculation of sector multipliers and the estimation of economic impacts arising from some change in the economy.

Using input-output analysis for estimation of economic impacts

The I-O model conceives the economy of the region as being divided up into a number of sectors and this allows the analyst to trace expenditure flows. To illustrate this, consider the example of a vineyard that, in the course of its operation, purchases goods and services from other sectors. These goods and services would include fertiliser, chemicals, transport services, and, of course, labour. The direct employment created by the vineyard is regarded in the model as an expenditure flow into the household sector, which is one of several non-industrial sectors recognised in the I-O model.

Upon receiving expenditure by the vineyard, the other sectors in the regional economy engage in their own expenditures. For example, as a consequence of winning a contract for work with vineyard, a spraying contractor buys materials from its suppliers and labour from its own employees. Suppliers and employees in turn engage in further expenditure, and so on. These indirect and induced (or flow-on) effects4, as they are called, are part of the impact of the vineyard on the regional economy. They must be added to the direct effects (which are expenditures made in immediate support of the vineyard itself) in order to arrive at a measure of the total impact of the vineyard.

It may be thought that these flow-on effects (or impacts) go on indefinitely and that their amount adds up without limit. The presence of leakages, however, prevents this from occurring. In the context of the impact on a regional economy, an important leakage is expenditure on imports, that is, products or services that originate from outside the region, state or country (e.g. machinery).

Thus, some of the expenditure by the vineyard (i.e. expenditure on imports to the region) is lost to the regional economy. Consequently, the flow-on effects get smaller and smaller in successive expenditure rounds due to this and other leakages. Hence the total expenditure created in the regional economy is limited in amount, and so (in principle) it can be measured.

Using I-O analysis for estimation of regional economic impacts requires a great deal of information. The analyst needs to know the magnitude of various expenditures and where they occur. Also needed is information on how the sectors receiving this expenditure share their expenditures among the various sectors from whom they buy, and so on, for the further expenditure rounds.

[4] A glossary of I-O terminology is provided in Appendix 3.

In applying the I-O model to economic impact analysis, the standard procedure is to determine the direct or first-round expenditures only. No attempt is made to pursue such inquiries on expenditure in subsequent rounds, not even, for example, to trace the effects in the regional economy on household expenditures by vineyard employees on food, clothing, entertainment, and so on, as it is impracticable to measure these effects for an individual case, here the vineyard.

The I-O model is instead based on a set of assumptions about constant and uniform proportions of expenditure. If households in general in the regional economy spend, for example, 13.3 per cent of their income on food and non-alcoholic beverages, it is assumed that those working in vineyards do likewise. Indeed, the effects of all expenditure rounds after the first are calculated by using such standard proportions (i.e. multiplier calculations). Once a transactions table has been compiled, simple mathematical procedures can be applied to derive multipliers for each sector in the economy.

Input-output multipliers

Input-output multipliers are an indication of the strength of the linkages between a particular sector and the rest of the state or regional economy. As well, they can be used to estimate the impact of a change in that particular sector on the rest of the economy.

Detailed explanations on calculating I-O multipliers, including the underlying assumptions, are provided in any regional economics or I-O analysis textbook (see, for example, Jensen and West (1986)). They are calculated through a routine set of mathematical operations based on coefficients derived from the I-O transactions model, as outlined below.

The transactions table may be represented by a series of equations thus:

$$X_1 = X_{11} + X_{12} + \ldots\ldots\ldots\ldots\ldots + X_{1n} + Y_1$$
$$X_2 = X_{21} + X_{22} + \ldots\ldots\ldots\ldots\ldots + X_{2n} + Y_2$$
$$X_n = X_{n1} + X_{n2} + \ldots\ldots\ldots\ldots\ldots + X_{nn} + Y_n$$

where X_i = total output of intermediate sector *i* (row totals);

X_{ij} = output of sector *i* purchased by sector *j* (elements of the intermediate quadrant); and

Y_j = total final demand for the output of sector *i*.

It is possible, by dividing the elements of the columns of the transactions table by the respective column totals to derive coefficients, which represent more clearly the purchasing pattern of each sector. These coefficients, termed 'direct' or 'I-O' coefficients, are normally denoted as aij, and represent the direct or first round requirements from the output of each sector following an increase in output of any sector.

In equation terms the model becomes:

$$X_1 = a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots\ldots\ldots + a_{1n}X_n + Y_1$$
$$X_2 = a_{21}X_1 + a_{22}X_2 + \ldots\ldots\ldots\ldots\ldots + a_{2n}X_n + Y_2$$
$$X_n = a_{n1}X_{11} + a_{n2}X_2 + \ldots\ldots\ldots\ldots\ldots + a_{nn}X_n + Y_n$$

where a_{ij} (the direct coefficient) = X_{ij}/X_j. This may be represented in matrix terms:

$X = AX + Y$

where A = $[a_{ij}]$, the matrix of direct coefficients.

The previous equation can be extended to:

$(I\text{-}A)X = Y$

where $(I\text{-}A)$ is termed the Leontief matrix,

or $X = (I\text{-}A)^{-1}Y$

where $(I\text{-}A)^{-1}$ is termed the 'general solution', the 'Leontief inverse' or simply the inverse of the open model.

The general solution is often represented by:

$Z = (I\text{-}A)^{-1} = [z_{ij}]$

The I-O table can be 'closed' with respect to certain elements of the table. Closure involves the transfer of items from the exogenous portions of the table (final demand and primary input quadrants) to the endogenous section of the table (intermediate quadrant). This implies that the analyst considers that the transferred item is related more to the level of local activity than to external influences. Closure of I-O tables with respect to households is common and has been adopted in this project.

The 'closed' direct coefficients matrix may be referred to as A^*. The inverse of the Leontief matrix formed from A^* is given by:

$Z^* = (I\text{-}A^*)^{-1} = [z^*_{ij}]$

Z^* is referred to as the 'closed inverse' matrix.

A multiplier is essentially a measurement of the impact of an economic stimulus. In the case of I-O multipliers the stimulus is normally assumed to be an increase of one dollar in sales to final demand by a sector. The impact in terms of output, contribution to gross regional product, household income and employment can be identified in the categories discussed below.

(i) The initial impact: refers to the assumed dollar increase in sales. It is the stimulus or the cause of the impacts. It is the unity base of the output multiplier and provides the identity

matrix of the Leontief matrix. Associated directly with this dollar increase in output is an own-sector increase in household income (wages and salaries, drawings by owner operators etc.) used in the production of that dollar. This is the household income coefficient h_j. Household income, together with other value added (OVA), provide the total gross regional product from the production of that dollar of output. The gross regional product coefficient is denoted v_j. Associated also will be an own-sector increase in employment, represented by the size of the employment coefficient. This employment coefficient e_j represents an employment/output ratio and is usually calculated as 'employment per million dollars of output'.

(ii) The first round impact: refers to the effect of the first round of purchases by the sector providing the additional dollar of output. In the case of the output multiplier this is shown by the direct coefficients matrix [a_{ij}]. The disaggregated effects are given by individual a_{ij} coefficients and the total first-round effect by Σa_{ij}. First-round household income effects are calculated by multiplying the first-round output effects by the appropriate household income coefficient (h_j). Similarly, the first-round gross regional product and employment effects are calculated by multiplying the first-round output effects by the appropriate gross regional product (v_j) and employment (e_j) coefficients.

(iii) Industrial-support impacts. This term is applied to 'second and subsequent round' effects as successive waves of output increases occur in the economy to provide industrial support, as a response to the original dollar increase in sales to final demand. The term excludes any increases caused by increased household consumption. Output effects are calculated from the open Z inverse, as a measure of industrial response to the first-round effects. The industrial-support output requirements are calculated as the elements of the columns of the Z inverse, less the initial dollar stimulus and the first-round effects. The industrial support household income, gross regional product and employment effects are defined as the output effects multiplied by the respective household income, gross regional product and employment coefficients. The first-round and industrial-support impacts are together termed the production-induced impacts.

(iv) Consumption-induced impacts: are defined as those induced by increased household income associated with the original dollar stimulus in output. The consumption-induced output effects are calculated in disaggregated form as the difference between the corresponding elements in the open and closed inverse (i.e. $z^*_{ij} - z_{ij}$, and in total as $\Sigma(z^*_{ij} - z_{ij})$. The consumption-induced household income, gross regional product and employment effects are simply the output effects multiplied by the respective household income, gross regional product and employment coefficients.

(v) Flow-on impacts: are calculated as total impact less the initial impact. This allows for the separation of 'cause and effect' factors in the multipliers. The cause of the impact is given by the initial impact (the original dollar increase in sales to final demand), and the effect is represented by the first-round, industrial-support and consumption-induced effects, which together constitute the flow-on effects.

Each of the five impacts are summarised in Appendix Table 2.1. It should be noted that household income, gross regional product and employment multipliers are parallel concepts, differing only by their respective coefficients h_j, v_j and e_j.

The output multipliers are calculated on a 'per unit of initial effect' basis (i.e. output responses to a one dollar change in output). Household income, gross regional product and employment multipliers, as described above, refer to changes in household income per initial change in output, changes to gross regional product per initial change in output and changes in employment per initial change in output. These multipliers are conventionally converted to ratios, expressing a 'per unit' measurement, and described as Type I and Type II ratios. For example, with respect to employment:

Type I employment ratio = [initial + first round + industrial support]/initial

and

Type II employment ratio = [initial + production induced[5] + consumption induced]/initial

[5] Where (first round + industrial support) = production induced.

Appendix Table 1.1 The structure of input-output multipliers for sector *i* [a]

Impacts	General formula
Output multipliers ($)	
Initial	1
First-round	$\Sigma_i a_{ij}$
Industrial-support	$\Sigma_i z_{ij}$-1-$\Sigma_i a_{ij}$
Consumption-induced	$\Sigma_i z^*_{ij}$-$\Sigma_i z_{ij}$
Total	$\Sigma_i z^*_{ij}$
Flow-on	$\Sigma_i z^*_{ij}$-1
Household Income multipliers ($)	
Initial	h_j
First-round	$\Sigma_i a_{ij} h_i$
Industrial-support	$\Sigma_i z_{ij} h_i$- h_j-$\Sigma_i a_{ij} h_i$
Consumption-induced	$\Sigma_i z^*_{ij} h_i$-$\Sigma_i z_{ij} h_i$
Total	$\Sigma_i z^*_{ij} h_i$
Flow-on	$\Sigma_i z^*_{ij} h_i$-h_j
Gross regional product multipliers ($)	
Initial	v_j
First-round	$\Sigma_i a_{ij} v_i$
Industrial-support	$\Sigma_i z_{ij} v_i$- v_j-$\Sigma_i a_{ij} v_i$
Consumption-induced	$\Sigma_i z^*_{ij} v_i$-$\Sigma_i z_{ij} v_i$
Total	$\Sigma_i z^*_{ij} v_i$
Flow-on	$\Sigma_i z^*_{ij} v_i$-v_j
Employment multipliers (full time equivalents)	
Initial	e_j
First-round	$\Sigma_i a_{ij} e_i$
Industrial-support	$\Sigma_i z_{ij} e_i$- e_j-$\Sigma_i a_{ij} e_i$
Consumption-induced	$\Sigma_i z^*_{ij} e_i$-$\Sigma_i z_{ij} e_i$
Total	$\Sigma_i z^*_{ij} e_i$
Flow-on	$\Sigma_i z^*_{ij} e_i$-e_j

[a] In a DECON model, Z^* (the 'closed inverse' matrix), includes a population and an unemployed row and column (see below for details).

Model assumptions

There are a number of important assumptions in the I-O model that are relevant in interpreting the analytical results.

- Industries in the model have a linear production function, which implies constant returns to scale and fixed input proportions.

- Another model assumption is that firms within a sector are homogeneous, which implies they produce a fixed set of products that are not produced by any other sector and that the input structure of the firms are the same. Thus it is preferable to have as many

sectors as possible specified in the models and the standard models for this study were compiled with 66 sectors (see Appendix 1 for further detail).

- The model is a static model that does not take account of the dynamic processes involved in the adjustment to an external change, such as a permanent change in natural resources management.

Extending the standard economic impact model as a DECON model

Based on work undertaken by EconSearch (2009 and 2010a) and consistent with Mangan and Phibbs (1989), the I-O model developed for this project was extended as demographic-economic (DECON) model. The two key characteristics of the DECON model, when compared with a standard economic model, are as follows.

1. The introduction of a population 'sector' (or row and column in the model) makes it possible to estimate the impact on local population levels of employment growth or decline.
2. The introduction of an unemployed 'sector' makes it possible to account for the consumption-induced impact of the unemployed in response to economic growth or decline.

The population 'sector'

The introduction of a population 'sector' to the standard I-O model allows for the calculation of population multipliers. These multipliers measure the flow-on population impact resulting from an initial population change attributable to employment growth or decline in a particular sector of the regional economy.

Calculation of population multipliers is made possible by inclusion of a population row and column in the 'closed' direct coefficients matrix of the I-O model.

Population row: the population coefficient (pj) for sector j of the DECON model is represented as:

$p_j = -rho_j * e_j * family\ size_j$

where rho_j = the proportion of employees in sector *j* who remain in the region after they lose their job (negative employment impact) or the proportion of new jobs in sector *j* filled by previously unemployed locals (positive employment impact);

e_j = the employment coefficient for sector *j*; and

$family\ size_j$ = average family size for sector *j.*

Population column: the population column of the DECON model is designed to account for growth or decline in those sectors of the economy that are primarily population-driven (i.e. influenced by the size of the population) rather than market-driven (i.e. dependent upon monetary transactions). Clearly, many of the services provided by the public sector fit this description and, for the purpose of this analysis, it was assumed that the following intermediate sectors were primarily population-driven:

- public administration and defence;
- education;
- health and community services; and
- cultural and recreational services.

Thus, the non-market coefficient for sector j of the DECON model is represented as expenditure on that non-market service (by governments) in $million per head of population.

The population multiplier for sector *j* is represented as: z^*_{pj} / p_{pj}

where z^*_{pj} = coefficient of the 'closed inverse' matrix in the population row for sector *j*; and

p_{pj} = coefficient of the direct coefficients matrix in the population row for sector *j*.

Sources of local data for the population sector of the DECON models used in this project included the following.

- rho: little or no published data are available to assist with estimation of this variable, particularly at a regional level. The DECON models have been constructed to enable the analyst to estimate this variable on the basis of the availability superior data or assumptions.
- Family size: in order to estimate average family size by industry, relevant data were extracted from the Australian Bureau of Statistics 2011 Census of Population and Housing using the TableBuilder database. These data were modified by the consultants in order to ensure consistency with the specification and conventions of the I-O models.

The unemployed 'sector'

As outlined above, the introduction of an unemployed 'sector' to the standard I-O model makes it possible to account for the consumption-induced impact of the unemployed in response to economic growth or decline.

Through the inclusion of an unemployed row and column in the 'closed' direct coefficients matrix of the standard I-O model it is possible to calculate Type III multipliers (for output, gross regional product, household income and employment).

The key point to note is that, in the situation where at least some of the unemployed remain in a region after losing their job (negative employment impact) or some of the new jobs in a region are filled by previously unemployed locals (positive employment impact), Type III multipliers will be smaller than the more frequently used Type II multipliers.

Unemployed row: the unemployed coefficient (u_j) for sector *j* of the DECON model is represented as:

$u_j = -\text{rho}_j * (1-ess_j) * e_j$

where rho_j = the proportion of employees in sector *j* who remain in the region after they lose their job (negative employment impact) or the proportion of new jobs in sector *j* filled by previously unemployed locals (positive employment impact);

ess_j = the proportion of employed in sector *j* who are not eligible for welfare benefits when they lose their job*; and*

e_j = the employment coefficient for sector *j*.

Unemployed column: the unemployed column of the DECON model is an approximation of total consumption expenditure and the consumption pattern of the unemployed. It is represented as dollars per unemployed person rather than $million for the region as a whole, as is the case for the household expenditure column in a standard I-O model.

Sources of local (i.e. state and regional) data for the unemployed sector of the DECON models used in this study included the following.

- ess: in order to estimate the proportion of employed by industry who are not eligible for welfare benefits when they lose their job, relevant data were were extracted from the Australian Bureau of Statistics 2011 Census of Population and Housing using the TableBuilder database. These data were modified by the consultants in order to ensure consistency with the specification and conventions of the I-O models.

- Unemployed consumption: total consumption expenditure by the unemployed was based on an estimate of the Newstart Allowance whilst the pattern of consumption expenditure was derived from household income quintiles in the 2009/10 Household Expenditure Survey (ABS 2011).

Incorporating a tourism demand profile in the I-O model

Tourism expenditure is a measure of the value of sales of goods and services to visitors to the state or region. The following method and data sources were used to estimate tourism expenditure by industry sector for the region.

- The primary data were sourced from Tourism Research Australia (TRA).

- Base datasets included total tourism expenditure by TRA tourism region and average expenditure profiles, by region, across a range of goods and services (e.g. food and drink, fuel, shopping, etc.).

- Estimates were available for domestic day, domestic overnight and international visitor expenditure.

- The first adjustment to the base data was the development of a concordance between the TRA tourism regions and I-O model regions and the allocation of these base data to the relevant I-O model region. These allocations were based, in turn, on an ABS concordance between TRA tourism regions and SLAs.

- The second adjustment to the base data was the application of a more detailed expenditure breakdown from the ABS Australian National Accounts: Tourism Satellite Account for both domestic and international visitor expenditure (ABS 2010d).

- The third adjustment to the base data was the conversion of tourism expenditure estimates from purchasers' to basic prices (i.e. reallocation of net taxes (taxes minus subsidies) and marketing and transport margins) to make the data consistent with accounting conventions used in the national, state and regional I-O models. Purchasers' to basic price ratios for tourism expenditure categories were derived from ABS data.

- The final adjustment to the base data was the allocation of the tourism expenditure data in basic prices to the relevant input-output sectors (intermediate sectors, taxes less subsidies or imports) in which the expenditure occurred, thus compiling a profile of sales to final demand. This process was undertaken for each type of tourism expenditure (domestic day, domestic overnight and international visitor) and the results aggregated to form a single tourism demand profile. Profiles were developed at the state and regional levels.

Constructing a RISE v3.0 economic impact model

In the final model construction stage the data described above were incorporated into a *Microsoft Excel®* spreadsheet based economic impact model for the region and state (i.e. *RISE v3.0*)[6]. This model allows for description of the structure of the economy. It can also be used for the estimation of economic impacts over time in response to the introduction of a new industry or a change in the final demand for the output of one or many sectors. Model assumptions can be modified to account for:

- price changes between the model construction year (2009/10) and the base year for the analysis;

- labour productivity change over time (as above and for the subsequent years);

- the level of regional migration (e.g. for a positive employment impact, the proportion of new jobs filled by previously unemployed locals).

[6] For further details on the use and application of this type of model see EconSearch (2010b).

APPENDIX 2 MEASURING ADAPTIVE CAPACITY

Background

The method of analysis used in this study was developed as part of a project in regional Victoria described in Schirmer and Mylek (2013). In order to better understand the vulnerability of Victorian towns to change—in particular change in the Forestry and Wood Products Industries—a community adaptive capacity (AC) index was developed. The design of this Community Adaptive Capacity Index was by the State of Victoria through the Department of Environment and Primary Industries (DEPI), Dr Jacki Schirmer (University of Canberra) and EconSearch.[7] The index was designed in reference to the extensive research literature in this area, plus novel empirical research conducted for DEPI in 2012.[8]

There are many 'off the shelf' approaches to measuring community adaptive capacity, and related concepts such as the vulnerability or wellbeing of communities. For a succinct discussion and review of these approaches, see Price-Robertson and Knight (2012). As described in ABARE-BRS (2010), there is considerable agreement in the literature that adaptive capacity can be understood in terms of a community's endowments of various resources. A common way of describing these resources is to classify them as forms of capital, namely built, human, natural, social or financial capital (Burnside 2007; Ellis 2000; Nelson et al. 2005; Yohe and Tol 2002). The five capitals commonly discussed at the community scale are as follows (Ellis 2000):

- human capital - labour and influences on the productivity of labour including education, skills and health
- social capital - claims on others by virtue of social relationship
- natural capital - land, water and biological resources
- physical capital - produced by economic activity including infrastructure, equipment and technology
- financial capital - savings and credit.

[7] Copyright of the Community Adaptive Capacity Index is vested in the State of Victoria through DEPI and may not be used by any other party or for any other purpose without the written consent of the State of Victoria through DEPI.

[8] This research was led by Fiona McKenzie, from the Victorian Government's Department of Planning and Community Development.

The index developed for the Victorian study consisted of four of these forms of capital, while excluding natural capital. This was principally because there were no readily available and robust measures of natural capital, and partly because the natural resource of principal interest in Schirmer and Mylek (2013), namely timber, was addressed through other parts of their analysis. In this analysis, natural capital relevant to the region is described adequately in the Regional NRM Plan, and hence has not been included again when measuring community adaptive capacity. The way in which the remaining four capitals have been operationalised was adapted from ABARE-BRS (2010) and expanded and modified to reflect novel empirical research conducted for DEPI in 2012 (forthcoming).

The ABARE-BRS (2010) study sought to identify measures available from the ABS Census that might serve as indicators of adaptive capacity, then subjected these measures to Principal Component Analysis (PCA) in order to determine which of them best explained the variation among the measures and towns examined. This useful process eliminated redundancy between a number of variables, and thereby enabled some variables to be dropped from the index. Removing unnecessary or low-value measures is an important exercise when building an AC index, because during aggregation minor measures otherwise 'dilute' the influence of more important ones.

The index used in this study makes use of the final set of measures recommended by ABARE-BRS (2010), but modified as follows:

- We did not use the specific factors generated by the ABARE-BRS PCA. Rather, we used the original measures which the PCA indicated best explained the variation among the towns and measures examined.

- ABARE-BRS (2010) classified the measures which they examined as indicators of human capital or social capital (with economic diversity used as the sole proxy for financial capital). In our index we have reclassified some of their measures under different capitals, and have reinstated the physical and financial capitals. For example, where ABARE-BRS had characterised 'median weekly rent as a fraction of the Australian median' as a measure of human capital, we considered that it was more useful as a measure of financial capital, and reclassified it accordingly. Some measures, it should be noted, can act as proxies for more than one capital.

- Some of the measures originally included by ABARE-BRS were removed, on the basis that their relationship to adaptive capacity was insufficiently compelling (e.g. '% employed in the public sector'), or because the measure appeared to have multiple but contradictory relationships to adaptive capacity (e.g. '% living at a different address one year ago', since high mobility may increase the adaptive capacity of individuals, but decrease it for towns).

- A number of measures which were not originally included in the ABARE-BRS analysis were added, on the basis that the DEPI study (2013) and the wider research literature indicated they were important to adaptive capacity. These new measures helped to populate the reinstated capitals (physical and financial), and included ABS Census and other data as described below.

- All of the measures were weighted on the basis of discussion among Schirmer, EconSearch and DEPI of the research literature and the 2012 DEPI study. The weightings

are by no means the only valid approach, and alternative weightings could be equally (or more) valid. However it was felt that, on balance, the weighting adopted gave appropriate precedence to those measures whose robustness and relevance appeared greatest, while retaining more minor but nonetheless worthwhile measures.

- Individual measures in this AC index were normalised using z-transformation prior to being weighted and aggregated; first into subindices (for each capital), and then into the final index. This was necessary because some of the new measures in the final index were not commensurable with others, and therefore could not be aggregated in their original form. For example, whereas the value of the measures already included in the ABARE index ranged in magnitude from 0 to 100 (enabling direct aggregation), some newly introduced measures had very different ranges (e.g. population size, remoteness). A further advantage of using Z-transformation was to cast the index and subindex scores into a form which facilitates easy interpretation relative to all regions in South Australia. For this last reason, the final aggregate AC score was again subjected to z-transformation, to re-establish it as a proper z-score and thereby enable easy interpretation.

Data for the sub-indices have been sourced from the Australian Bureau of Statistics' (ABS) *Census of Housing and Population,* the Public Health Information Development Unit *Social Health Atlas of Australia* and the *Accessibility/Remoteness Index of Australia (ARIA)* constructed by the Australian Population and Migration Research Centre at the University of Adelaide. The index was constructed using the ABS SA2 geography.

Adaptive Capacity Index and Sub-indices Defined

Each sub-index of the community adaptive capacity index is briefly described below.

Physical capital

The physical capital index has four components (ARIA, population size, population change and internet access), as described below.

Remoteness – measured by ARIA is an index of remoteness derived from measures of road distances between populated localities and Service Centres. These road distance measures are then used to generate a remoteness score for any location in Australia. It is a continuous varying index with values ranging from 0 (high accessibility) to 15 (high remoteness), based on road distance measurements from over 12,000 populated localities to the nearest Service Centres in five categories based on population size. The five distance measurements, one to each level of Service Centre, is recorded for each populated locality and standardized to a ratio.

Population size – the population recorded for each locality (2011) standardised to a ratio based on the median population of localities in the set (e.g. SA2s in South Australia).

Population change – the rate of population change recorded for each locality (2001 to 2011) standardised to a ratio based on the median rate of population change calculated for localities in the set (e.g. SA2s in South Australia).

Internet access - the proportion of households with an intent connection for each locality (2011) standardised to a ratio based on the proportion for South Australia.

Economic capital

The economic capital index has five components (economic diversity, median household income, income/housing cost, unemployment and mean household size), as described below.

Economic diversity – an index calculated from industry of employment data available from the ABS *Census of Population and Housing* and is based on the Hachman Index described in Moore (2001). For this study it was calculated spatially at the SA2 level and at the industry level using two-digit ANZSIC code employment data.

The Hachman Index is calculated, for a given locality, as the inverse of the weighted sum, across all industries, of the ratio of the share of a locality's employment in a given industry to the share of the state's employment in the same industry. The weights are the share of a locality's employment in a given industry.

Localities which have a large portion of employment in a few key industries, which differ considerably from the portion of employment for those industries state-wide, will have a relatively low Hachman Index value. Conversely, those localities which more closely reflect the state-wide employment distribution will have a relatively high Hachman Index value.

The Hachman Index is defined as:

$$HI = 1 \Big/ \sum_j (emp\ share_{UCLj} \times \frac{emp\ share_{UCLj}}{emp\ share_{statej}})$$

where:

$emp\ share_{UCLj}$: the share of the UCL's employment in industry j; and

$emp\ share_{statej}$: the share of the state's employment in industry j.

Median household income – calculated as the median household income for each locality standardised to a ratio based on the median for South Australia.

Income/housing cost - the household income to mortgage differential calculated as (median household weekly income * 52 / 12) – (median monthly housing loan repayment) for each locality standardised to a ratio based on the median for South Australia.

Unemployment - calculated as (total unemployed) / (total labour force) for each locality standardised to a ratio based on the unemployment rate for South Australia.

Mean household size – calculated as average number of persons per household for each locality standardised to a ratio based on average household size for South Australia.

Human capital

The human capital index has six components (percentage graduates, population 65+, percentage completed high school, one parent households, lone person households and females in non-routine occupations), as described below.

Percentage graduates – calculated as (total persons with a bachelor degree + total graduate diploma or certificate) / (total persons 15+) for each locality standardised to a ratio based on the percentage for South Australia.

Percentage 65 and over – calculated as (total persons aged 65 and over) / (total persons) for each locality standardised to a ratio based on the percentage for South Australia.

Percentage completed high school – calculated as (number of persons aged 15 and over to have completed high school) / (total persons aged 15 and over) for each locality standardised to a ratio based on the percentage for South Australia.

Percentage one parent – calculated as (total single parent families) / (total families) for each locality standardised to a ratio based on the percentage for South Australia.

Percentage lone person households – calculated as (total one person households) / (total occupied dwellings) for each locality standardised to a ratio based on the percentage for South Australia.

Proportion of females in non-routine occupations – calculated as (female managers + female professionals + female technicians + female community and personal) / (total female employed persons) for each locality standardised to a ratio based on the proportion for South Australia.

Social capital

The social capital index is comprised of two indicators, voluntary work and community strength, as described below.

Percentage voluntary work – calculated as (total volunteers) / (total persons aged 15 and over) for each locality standardised to a ratio based on the percentage for South Australia.

Social Health Atlas of Australia data on community strength - calculated as the simple average of the following measures of community strength:

- Can you get help from family, friends or neighbours when you need it?
- Are you a member of an organised sport or church or community group in your local area?
- If you have school aged children, are you actively involved with activities in their school?

Weighting and Polarity

Once the scores were derived by the processes briefly described above, they were then transformed in three ways. First they were standardised using the z-transformation. This means that each indicator is transformed so that the set of values for an indicator has a mean of zero and a standard deviation of one. The sub-indices (physical capital, economic capital, etc.) and the final aggregate AC score were again subjected to z-transformation, to re-establish them as proper z-scores and thereby enable easy interpretation.

Second, each indicator was weighted to reflect its relative importance. The weights across all indicators must sum to 100 per cent.

Thirdly, each indicator was assigned a polarity (+1 or -1) which simply indicates whether the indicator is expected to have a positive or negative influence on the adaptive capacity of a locality.

The weighting and polarity of each of the components that comprise the community adaptive capacity index are provided in Table 0–1. As noted in Section 2.1, all of the measures were weighted on the basis of discussion among Schirmer, EconSearch and DEPI of the research literature and the 2012 DEPI study.

Table 0–1 Weighting and polarity of community adaptive capacity index components

	Weighting (%)	Polarity (1=pos, -1=neg)
PHYSICAL CAPITAL (25%)		
Remoteness (ARIA)	10	-1
Population size	5	1
Population change	5	1
Internet access as a fraction of South Australia	5	1
ECONOMIC CAPITAL (36%)		
Economic diversity	5	1
Median household income as fraction of the South Australian median	7	1
Income/housing cost as a fraction of the South Australian median	11	1
Unemployment as fraction of the South Australian rate	11	-1
Mean household size as fraction of the South Australian mean	2	-1
HUMAN CAPITAL (25%)		
Graduates as a fraction of South Australia	5	1
65 over as a fraction of South Australia	4	-1
Completed high school as a fraction of South Australia	5	1
One parent as a fraction of South Australia	5	-1
Lone persons households as a fraction of South Australia	3	-1
Proportion of females in non-routine occupations as a fraction of South Australia	3	1
SOCIAL CAPITAL (14%)		
Voluntary work as a fraction of South Australia	4	1
Community strength	10	1
TOTAL (ALL CAPITALS)	**100**	