LONG TERM ANALYSIS OF THE ROLE OF DAMS

This paper presents an analysis of the economic importance of dams. The paper reviews the long-term economic performance of four regions that received substantial water investments, and one region that did not (the base case). It finds that the regions that received investments in dams all had different growth paths, but in all cases performed significantly more strongly than the base case.

March 2021

ACKNOWLEGEMENT

Limitations of this Study

This study has been produced as identified in the Executive Summary and the Introduction. The services provided for this report as commissioned comprise an advisory engagement, consequently no opinions, conclusions or recommendations are intended to convey assurance have been expressed.

Aurecon Australasia Pty Ltd (Aurecon) and FTI Consulting (FTI) cannot and do not make any representation or guarantee as to the accuracy, reasonableness or reliability of information provided by persons or business that have provided input to the study. There are significant data challenges in studies that track such a long period, and while best efforts have been made, no guarantees regarding accuracy can be made. Aurecon and FTI consulting have indicated where the information has been sourced from interviews with persons or businesses but have not sort to independently verify that information. The arguments and conclusions derived in this study have been formed on this basis.

Reliance

This study has been prepared solely for use by the Far North Queensland Region of Councils (FNQROC) and is not to be used by any other party. No reliance is owed to any other party.

EXECUTIVE SUMMARY

Dams are a long life infrastructure asset with a nominal life of 100-150 years, though no government owned and maintained dam in Australia has reached that age. The nature of the infrastructure is such that it can support transformative changes in the surrounding communities and their economies.

As the cost of a new major dam is typically over $100M, proposals for dams in Queensland are assessed under the Building Queensland (BQ) and Infrastructure Australia (IA) Business Case Frameworks including Cost Benefit Analyses (CBA) conducted throughout the course of the process.

The CBAs are generally assessed for an immediate period of 30 years including construction, with costs and benefits occurring beyond this timeframe being distilled to 'residual costs' for inclusion in the assessment. There are strict guidelines as to what can/ not be included in the CBA assessments including forecasts of future economic benefits.
Procedures in other states are similar to those in Queensland.

This study has at its focus, two core tenets about the current process for evaluating proposals for dams.

1. Current assessment processes do not adequately capture the benefits that can be derived through these long-lived pieces of infrastructure.

2. Where the investment has been made, the dams facilitate longer-term benefits for regions and communities compared to regions and communities where such investment has not been made.

To demonstrate these tenets, the Study has considered five sites:

1. Rockhampton, Queensland
2. Tinaroo Dam, Atherton Tablelands (Queensland)
3. Wellington Dam, Collie (Western Australia)
4. Copeton Dam, Inverell (New South Wales)
5. San Luis Dam, Mercer County, California (USA)

Rockhampton has been selected as a Base Case as while various dam sites have been mooted for this region for over 30 years, no dam was approved. It is acknowledged that since this Study was commissioned, Rookwood Weir has received approval for construction from the Queensland State Government. The other sites have had operating dams over 30 years old.

The Case Studies have considered for each site the following factors since the respective dam was commissioned and compared it to the Base Case:

- % changes in population
- The change in the type of employment and the sectors that have experienced growth
- The relative changes in Agricultural Productivity
- The change in the type of agricultural product and volume of production

For each of the dam sites the Study has also reviewed:

- Growth in associated markets
- Synergies that are attributable to the security of water provided by the dam
- How the dam has contributed to resilience for the community in the face of market / environmental changes

Based on the evidence identified for the various sites, the Case Studies indicate that:

Population in the case study sites has grown at approximately 2-3 times the rate of the Base Case over a similar timeframe

Agricultural and other markets have benefited as a result of synergies between the dam infrastructure and other non-related infrastructure, that could not have occurred without the dam infrastructure being in place.

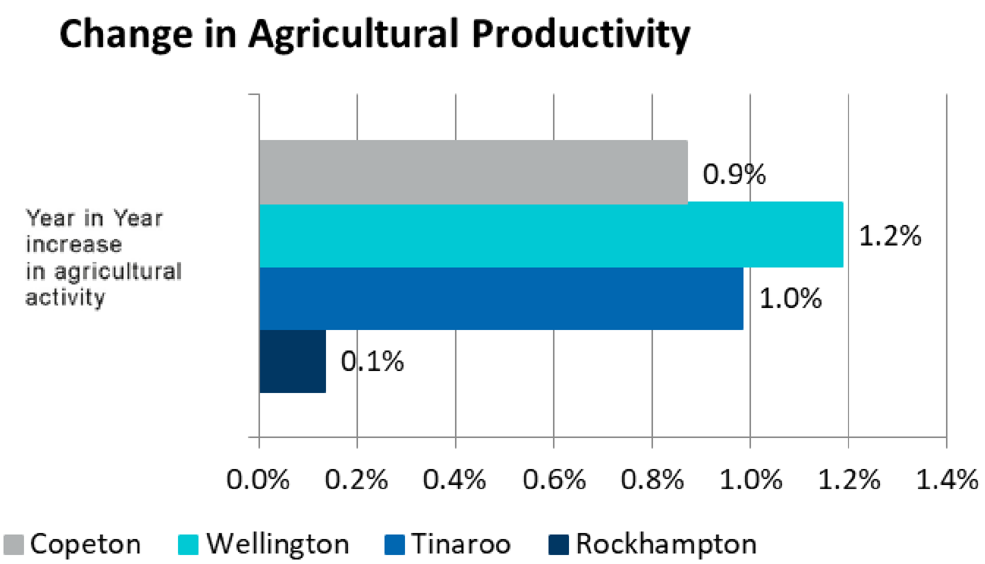
The security of water afforded by the dams has provided other public and private sector investment in subsequent infrastructure that would not have occurred without the initial investment in the dam.

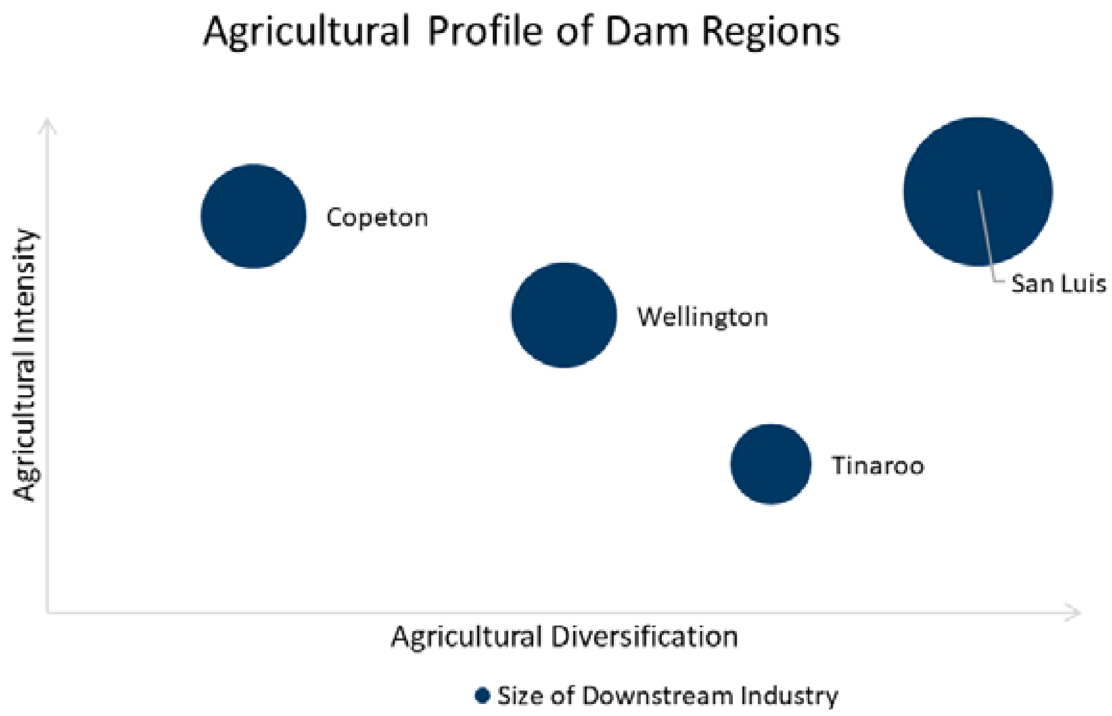
This investment has occurred not only in the initial 30 years, but significant investment has occurred in the period outside the 30 year post-commissioning milestone. The ability to consider the dam infrastructure as a 'sunk cost' has made the subsequent investments possible.

The relative growth of Agricultural production has been 60%-80% compared with 0%-10% growth in the Base Case over similar timeframes

Maturation of supply chains and technological developments have provided new markets for higher value produce than could have been envisaged at the time of the Business Cases for the subject Case studies. This has resulted in a higher value of return for the economies in these local communities and subsequent improved economic benefits for the State and Federal governments.

The security of water provided by the dams has been fundamental in providing a resilience to local communities to changes of markets, policy and economic conditions. This ability of local economies to pivot would not have been available without the dam.





From this evidence based approach, it is contended that the nature of dam infrastructure does not comfortably lend itself to the current approach used for assessing government investment. While the Business Framework Guidelines acknowledge that there can be substantial lags between the initial outlay in terms of construction cost and resulting economic benefit, dams take considerably longer to demonstrate those benefits compared to other infrastructure such as roads, hospitals and energy projects. The ability to forecast these longer terms benefits beyond 30 years does not appear to appropriately capture the opportunities that arise either directly or indirectly as a result of the investment in dams. However, subsequent investment is easier to validate.

The current Guidelines advocate that longer term studies should be conducted to review the initial investment decision. However, no evidence of this type of study being undertaken on the Case Study sites (or other sites) was identified. Such studies could of helped inform recent dam assessment processes. These Case Studies appear to be the first attempt to identify longer-term benefits. It is acknowledged that the work undertaken to date is not a comprehensive economic evaluation, but it is indicative that longer-term benefits that could not have been considered (under current day guidelines) have arisen and are significant, particularly when compared to a region that did not receive that initial investment.

In regions where the initial investment has not been made, potential economic growth in the community is stunted both directly and indirectly. This decision making does not provide regional and generational equity.

Accordingly, FNQROC calls on the State and Federal Governments to reconsider their positions on the assessment procedures for investment in dams.

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1.0 INTRODUCTION

1.1 Background

Aurecon and FTI Consulting were engaged by FNQROC to review a number of dams that have been in operation for extended periods of time (greater than 30 years), with a view to identifying the longer-term benefits that such critical pieces of infrastructure can bring to regions and their communities. This report presents two core tenets:

1. Current assessment processes do not adequately capture the benefits that can be derived through these long-lived pieces of infrastructure
2. Where the investment has been made, the dams facilitate longer-term benefits for regions and communities compared to regions and communities where such investment has not been made.

Case Studies of the nominated dams will be used to support these tenets.

1.2 The nominated case studies

The dams and associated regions assessed as Case Studies in this report include:

1. Rockhampton Region (Base Case where a dam was considered but not constructed. It is noted that the Rookwood Weir on the Fitzroy River has recently been approved for construction).
2. Tinaroo Falls Dam – Atherton Tablelands and the Mareeba-Dimbulah Water Supply Scheme (MDWSS)
3. Copeton Dam – Northern NSW (near Inverell)
4. Wellington Dam Western Australia (near Collie)
5. San Luis Dam, Merced County, California (near Los Banosv)

1.3 Methodology

The approach to this study has been to undertake a series of evidence-based case studies on dams operating for 30 years and over and compare them to a base case where a dam has been considered but not developed. To provide for realistic and meaningful comparisons, the sites selected for this study have the following characteristics:

- The dam had to be a public sector developed piece of infrastructure (implying a substantive minimum capacity availability of the water and appropriate maintenance over its life)
- Water was available for commercial use under the prevailing National Water Initiatives pricing principles (NWIPP) or its predecessors / equivalents
- The primary function of the dam has been to provide water security for agricultural production
- Potable water supply may be an adjunct use but not the primary use of the water
- Power generation and recreational use can be adjunct but secondary uses

This approach was adopted to compare, as much as possible, the type of development triggered by the dams' construction.

It is noted that these case studies are not the type of analysis required by Building Queensland (BQ) and Infrastructure Australia (IA) project assurance frameworks due to various constraints including access to relevant information. If the current processes for assessing Business Cases had been applied to these dams when being assessed, some of the resulting benefits would not have been considered as they have occurred outside of the typical time horizon, and/or they are not the types of benefits considered in a typical business case.

However, this collection demonstrates that:

- Traditional Cost Benefit Analysis (CBA) for large scale investments in water infrastructure typically takes a relatively narrow view of the potential benefits because of the inherent information uncertainties in assessing benefits that will evolve over the 'expected economic' life of the dam.
- When water security/soil productivity is markedly impacted by investments in water infrastructure, there are potentially transformative impacts on the types of local agriculture available in that region. These changes are dynamic, and not able to be predicted by policymakers/ decision-makers at the time of the investment. For example, the global demand boom for avocados was not foreseen by policymakers in the 1950s, but the well irrigated soil of the Tablelands region combined with the region's water security enabled local farmers to pivot to this crop when the domestic tobacco industry declined.
- Transformational changes to local agriculture can have significant upstream and downstream impacts, potentially impacting the breadth and depth of the manufacturing industry and providing critical mass for transport and services industries. In the case of the transport industry, consultation has strongly indicated that high value crops lead to high margin transport that is an important source of local employment and revenue.

1.4 Limitations

This series of case studies will use data which has some inherent limitations. For example:

- The 'old' economic data for the before intervention case is not as fulsome as the more modern data. As such comparisons are made to the extent possible. For example, the older data does not break fruit crops into subcomponents.
- There are inconsistencies in geographic boundaries over time and across data sets, making exact like-for-like comparisons not possible. In these circumstances, efforts have been made to filter data to provide a realistic comparison as much as possible.
- There are a number of factors that can differ over periods of 30 or more years in a region, above and beyond water investment. As such, not all differences in outcomes are based on these dam infrastructure investments. However, there are clear trends that will come out of the analysis.

As such, the approach of this case study is to be transparent about these limitations throughout the discussion. It is also to make clear that this analysis is attempting to find and provide evidence for the existence of benefits that are not currently considered. It is not to set parameters for these benefits as would be found in Australian Transport Assessment and Planning (ATAP) guidelines for a road study.

This study will show that there are benefits and potentially regionally transformational ones at that, which are not captured in standard Cost Benefit Analysis (CBA) process. However, not all of the case studies will feature all of the same benefits. To that end, this study will attempt to link features of the regions and features of the investments themselves to the outcomes obtained.

2.0 CONSIDERATION FOR DAM ASSESSMENTS

2.1 Summary

Major dams are different from most other forms of infrastructure due to the long-term life of the asset (recommended design life is 150 years). They take longer to deliver (very large upfront costs) and longer for the associated direct and indirect benefits to come to fruition (lagging benefits). However, the government assessment process for dams is the same as other pieces of major infrastructure that can be developed over far shorter timeframes, start to produce predicted benefits immediately after commissioning and reach target performance thresholds within 5 – 10 years. The financial assessment process is primarily based around forecasting and pricing benefits and costs that will occur over a 30-year period from construction and discounting those cashflows to current day figures. Projects that can provide targeted financial benefits in shorter timeframes achieve stronger results in a CBA despite the benefits waning after the design life and requirements for major refurbishment. Traits of dams such as transformative land use changes do not occur in the short to median term. Where a benefit cannot be priced or costed directly, indirect methods are applied that are far more complex in water management than a question such as 'what toll would you pay to travel a length of road?'

Despite acknowledgement by the various departments of the inherent difficulty of long term forecasting and those processes' own recommendations for undertaking a long-term Benefits Realisation Plan associated with long-life infrastructure; the same process is used and the opportunity to learn from historical evidence is not taken up.

2.2 Dams are different

This section provides a commentary on the standard processes for assessing dams and considers where the framework could be augmented or modified to better consider regional focus; and how regions transform over the life of dam infrastructure. The development framework process for dams, from a needs assessment and Strategic Business Plan through to final commissioning can take over 8 – 10 years, if it is continuous. However, there are numerous examples of dam sites that have been under consideration or investigation for decades without the infrastructure being constructed. This timeline is longer than the standard time frame for other major pieces of infrastructure (e.g. roads and hospitals). Once the dam is commissioned, it can then take years for the associated infrastructure to be brought online and markets to be developed such that end users can realise the benefits considered possible from constructing the dam. This is a marked difference to infrastructure such as hospitals and major roads where benefits start to accumulate immediately the infrastructure is opened and tend to develop to predicted operational levels inside the first 5-10 years.

It is noted that none of the public-sector dams designed, constructed and operated in Queensland since the early 1900s have been decommissioned or demolished with the potential exception of Paradise Dam which has been reported as having a flaw in the construction of the dam wall. It is understood that there is ongoing consideration as to how to remediate that problem, but decommissioning the dam is not being considered. The Australian National Committee of Large Dams (ANCOLD) recommends a design life of 150 years for major dam assets, a design life that is yet to be reached by any major dam in Australia. Maintenance and review programs are recommended on regular basis to identify potential upgrades or refurbishment requirements.

2.3 Review of the business case framework for dam assessments

In Queensland, as the scale of dams being considered typically cost in excess of $100M, they are subject to Building Queensland's (BQ) Business Case Development Framework (BCDF) process for assessing and evaluating the investment decision. This suite of documents addresses requirements of the Federal Government's Infrastructure Australia's (IA) Reform and Investment Framework as projects of this scale typically require both State and Federal funding.

BQ's Cost Benefit Analysis Guide (2020) notes *"a lag between investment timing and the accruing of project-benefit streams characterises many infrastructure proposals…Returns on infrastructure investments – in the form of proposal benefits – are often realised over the long term. Benefits accruing may be small relative to both the proposed capital outlay and ongoing costs of infrastructure… Ultimately, these benefits are typically driven by underlying social, economic and demographic trends.*"

This investment process includes undertaking a Cost Benefit Analysis (CBA) as a means to allocating public monies appropriately – "*a core issue fundamental to the discipline of applied economics i.e. assigning scarce funding among competing investment choices*" (BQ Cost Benefit Analysis Guide April 2016).

"*CBA requires that all relevant costs and benefits are identified, whether they are readily quantifiable or no*t" (BQ ibid). Non-quantifiable costs and benefits are to be assessed via a contingent valuation technique. These techniques can be based on inferred pricing based on similar markets, indicative pricing or consumer willingness to pay to obtain or avoid an outcome. All of these are reliant upon what information is available for comparison at the time and consumers' willingness to identify a value to having/not having an outcome.

2.4 What do CBAs for dams currently consider

The current CBA framework treats a relatively narrow subset of benefits as per Table 2.1 below.

Table 2.1 CBA Considerations

Benefit	Comments
Flood mitigation	Theoretical models of lives saved based on population at risk
Agricultural benefits	Agricultural productivity affected by availability of water (simulations around the increased productivity per sqm)
Upstream and downstream industries	Not considered
Water security	Insurance value derived from water security largely not considered

The current CBA approach for agricultural dams is to consider the benefits of the investment in terms of the additional productivity of the irrigated land. This involves comparing the historical value of high-water crops to the value of low-water crops. The net benefit, less the costs of irrigation, the costs of replanting and the costs of the water infrastructure are the core benefits from an agricultural standpoint. The impacts of changing technological processes are either not considered or not properly assessed. At the time of the investment, yields are compared and contrasted with and without water. Over time, the gulf in relative productivity between irrigated and non-irrigated land has evolved and improved. This effect can have significant impact because of the long-life of dams.

In the case of dams, the assumptions/ requirements in the Detailed Business Case's "*initial market soundings*" might not accurately identify or capture future new markets and accordingly, might not be able to be priced accurately. The market sounding is unlikely to accurately identify what a current day customer might consider reasonable over a 30 – 50 year+ horizon; or capture a client who might not exist for 20 years or more. The Detailed Business Case's "initial market soundings" might not accurately anticipate the total market that could develop as a result of the dam's construction. Market soundings are based on what the potential customers indicate as a willingness to pay based on their own understanding of where their market is at the time of the study; not necessarily where the market will be in 30 or 50 years.

"*The current generation makes decisions that affect the welfare of future generations. Care about future generations is expressed through the current generation's willingness to pay. This needs to be measured empirically or through the political process. There is little justification for the analyst to override intergenerational preferences or predict future generations' preferences.*" (BQ op cit)

The value of well-being of future generations might need to have a regional perspective. However, discount rates applied tend to be based on a view of national or state rates. State and Federal subsidies for renewable energy appear to be an example of where governments are seeking to impose an intergenerational fairness that might/not reflect either the current generation's or future generation's willingness to pay. Water management and food production could be considered as similar resources.

"CBA structured approaches are applied throughout other elements of the Queensland Government…plays a critical role informing investment decision-making ... and is applied across Building Queensland's BCDF" (op cit). The decision making is highly reliant upon the quality of the inputs to this process; and where the inputs are inaccurate or omit potential future benefits, the decision that follows might not achieve the stated objectives of the process. This process itself identifies a number of constraints which shape what can be considered in the Business Case and CBA including:

Materiality – *"the impact also has to be relevant in the sense it arises as a result of the option being proposed rather than as a result of the status quo or some other action independent of the option" (BQ op cit). "Only those costs and benefits directly attributable to the relevant option should be taken into account."* (BQ op cit) This might obviate benefits that are derived as a synergy of the dam and other independent infrastructure or investment (e.g. market opportunities of the dam that arise due to colocation near an international airport).

Time Duration for assessment of costs and benefits - *"The appraisal period should be based on the expected life of the asset created by the initiative or project, with the construction period added. It is assumed that the expected life of the asset is generally equivalent to the operating phase of the asset, which is measured from the first year in which the benefits of the initiative accrue. This recommendation is consistent with the recommendations made in 2016 ATAP guidelines".*

However, this is not consistent with BQ and other state governments' practices. BQ has a recommended evaluation period of 30 years regardless of the economic life of the asset. "In Queensland, the evaluation period should *be the life of the project, but the measurement of project impacts which are longer than 30 years is generally not recommended due to uncertainty in the forecast*" (BQ op cit).

BQ acknowledges that benefits can be accrued after that period but considers that these are captured in the 'residual value' of the asset at that time. "*It is therefore recommended to calculate residual value for extremely long-lived assets*" (IA op cit Table 33). "Residual value of assets is representing the future benefits that would be generated by an asset when its economic life is longer than the evaluation period" (Infrastructure Australia Assessment Framework 2018) and "... *forecasting over long time horizons will become increasingly uncertain*" (IA op cit).

This approach is generally consistent across Australian States in their equivalent BCDF. It is noted that IA can consider assessment periods of up to 50 years. Assuming predictions beyond 30 years can be realistic and accurate in amount and nature in dynamic markets, climate change and with the economic swings and uncertainty that have occurred over the last 50 years would seem optimistic, whether as actual costs and benefits or a residual vale.

IA recognises that all costs and benefits that go into a CBA are "*estimated forecasts of the future, meaning that there is risk of actual realised streams of costs and benefits deviating from expectations*" (IA op cit).

The main sources of risk for many public sector projects are noted below along with specific comments with regards applicability to dam infrastructure.

demand forecasts (and hence project benefits and some variable operating costs) that differ from expected

Network effects, where an asset is part of the network (e.g. an individual road) and decisions made elsewhere in the network impact on the project in question. It is also possible that the network is not considered at the time

Due to the nature of the discounted cashflow assessment, CBA tends to favour projects that can stage construction costs and yield benefits early in their economic life. It also suits projects where their economic life is similar to the assessment period. This is the antithesis of dam and associated irrigation projects which have a large number of upfront costs (construction, transition from one crop to another), lagged benefits (the benefits of the higher value crop which may take up to a decade to realise in the case of some citrus and nuts) and the economic life far exceeds the assessment period.

Transformative Changes and Benefits - "*Infrastructure projects can have significant land use impacts that are not easily captured in conventional CBA. For example, major transport projects, such as metro style train services, are often considered to be 'city shaping' because they influence where people choose to live and where businesses choose to locate on a large scale over time. For some projects, changing land use may be a primary objective of the project and being able to predict the degree to which they achieve this aim will then be important.*" (IA op cit)

This is the case with dam projects where land, not suitable for agriculture, can be made suitable for agriculture. This type of development can take years to reach optimum potential.

The ability to access more greenfield land for production is seldom considered. While water and land are constraints, if a water intensive industry (e.g. avocados) displaces a less water intensive industry (e.g. beef) in a location, other less water intensive industry (e.g. the sugarcane production) tend not to disappear, rather they move to less desirable land, often within the same geographic region. This creates an opportunity for additional dam infrastructure to be located in a similar location (in a separate catchment to the original dam), but with the ability to service marginal overlapping areas.

"*Attribution - often a change in both the regulatory environment and the infrastructure project are needed for the land use impacts to occur. In many cases, it may therefore be inappropriate for proponents to attribute all land use impacts to the project in question.*" (IA op cit). In the case of a dam, the water security is the critical factor for the benefits to be realised. If the regulatory framework was in place for agricultural production but water was not available, agricultural production could not proceed.

"Time *Dimension – approaches used for measuring land use should be able to consider over what time horizon the change is likely to happen. Often there may be a lag between an infrastructure project and its associated land use change.*" (IA op Cit).

This is a particular trait of dam infrastructure where the proposed change in land use might not have been possible prior to commissioning the dam and associated irrigation infrastructure. The nature of the land use might change because of opportunities that have arisen out of the original direct benefit. For example, MSF Sugar are now planting agave crops as an alternative feedstock to cane biomass for their Energy Cogeneration Plant at Arriga (Atherton Tablelands) within the Mareeba Dimbulah Water Supply Scheme (MDWSS). This cogeneration plant would not have occurred without the potential for sugarcane to be produced on the Tablelands (the initial feedstock), which would not have occurred without water for irrigation. The agave has a lower water demand than sugarcane and is expected to result in yielding water entitlements for use by other farmers.

"*Dependency means that infrastructure proposals should establish that the change in land use (i.e. any land use impacts) directly depends upon implementing the proposed infrastructure investment. …. Supporting material for dependency could include evidence of current or predicted capacity constraints on nearby infrastructure*" (IA op cit). Where agricultural production was not possible prior to irrigation, but possible after irrigation infrastructure, such dependency becomes readily apparent.

Wider Economic Benefits (WEB) – "*WEBs are improvements in economic welfare that are acknowledged but which have not been typically captured in traditional CBA…. The most significant (benefit) is agglomeration, the notion that similar firms are drawn towards the same location since 'proximity generates positive externality' (an effect of one party on another that is not a market transaction)*". The growth of a community with a largely agricultural based economy will create opportunities for other businesses to move into this region and economy. It also presents the opportunity for additional water security infrastructure to be developed proximate to the location as the associated infrastructure already exists in the region. The impacts on population – water security, a booming agricultural sector and up/down stream opportunities are likely to be significant drivers of settlement patterns.

Benefits Realisation Plan – "*…most jurisdictions have Benefits Realisation Plans as part of their standard business case templates. The timing of the subsequent reviews should depend on the type of infrastructure or asset class that is the subject of the review. Projects where it takes longer to realise benefits, or projects with a relatively long asset life (e.g. transport and water assets) should have a subsequent review undertaken approximately five years after delivery…A third review would consider the longer-term performance of the asset and may, in some cases, be undertaken up to 30 or 50 years after the project was delivered, depending on the asset type, to understand the success of the business case over the life of the asset.*" (IA op cit)

To date there is no evidence that this long-term assessment has ever happened. An ex-post review is unlikely to be undertaken (or remember to be undertaken) over a 50 year period and government departments with constrained budgets are unlikely to commission reviews of business cases (or their predecessors) from 50 years previously on the basis of relevance to the current market. The very action recommended as part of a government process, that could lead to a review of that government process, is stymied by other government processes. Were it to occur, this is expected to be supportive of the argument that over the economic life of these long- term assets, issues raised in the original business case are likely to have been superseded by a subsequent use that provides greater community value (or else the change would not have occurred).

The National Water Grid Authority (NWGA) was established in 2019 by the Commonwealth Government. The NWGA is designed to work with State and Territory Governments to identify, plan and invest in water infrastructure projects. The NWGA prioritises projects within its funding envelope with the highest net benefit taking into account economic, environmental and social impacts. It is expected that the NWGA will play a direct role in all major water security projects and bring a different perspective to assessing opportunities.

3.0 REVIEW OF LONGER-TERM BENEFITS

3.1 Summary

When an asset has a life of upwards of 150 years with a pattern of lagging benefits, trying to ascertain its benefits by considering an initial 30 year period, then trying to quantify the balance of future benefits by estimating a residual value by considering economic patterns that have occurred in the previous and current period; is going to be fraught with uncertainty and inaccuracy. Improvements in infrastructure, technology and business are disrupting the life cycles of current practices and creating opportunities that could not be considered, certainly within the constraints of a standard business case. These circumstances undermine the current processes used to assess whether dams should be constructed.

Dams are an essential building block for allowing regional communities to grow and expand in directions that might not be conceivable 30 years ago or in a way in 30 years' time that is inconceivable now. They provide a resilience for communities to adjust to events that could otherwise decimate the local economy or to take advantage of opportunities that can lead to prosperity through further growth and diversity within the local economy.

The growth of associated infrastructure around a dam can result in the dam's capacity becoming the limiting factor in the supply chain, holding back latent capacity in the rest of the chain. Co-location of dams and cross connection of supply can enable that latent capacity to be realised at a significant reduction in cost from having to develop separate associated infrastructure for a new dam located remotely from other existing dams.

The above factors lead to the conclusion that current practices for assessing dams are ill-equipped to identify and appropriately factor in all the benefits that can be realised from construction of a dam.

3.2 Provision of resilience

Engineers Australia's Queensland Water Management (2019) position paper noted that

"a changing future climate creates unexpected challenges to water management."

It recommended working towards a resilient water strategy for our future

"knowing that stronger resilience will be beneficial even if a future climate is more benign that it in today."

Climate predictions for Northern Australia tend to predict less consistency in traditional rainfall patterns but more extreme events when they occur. Based on these forecasts, a reliance on using rainfall onsite for agricultural production (in part or in full) could be catastrophic for farmers. Dams provide a buffer for harvesting high intensity events when they occur; and then distributing that reserve during drier periods of the cycle. Even if net rainfall decreases across the catchment, dams will provide a facility for catchment and release, a more resilient means of water management than relying on rainfall alone.

As dams have long-term operational lives, they can continue to provide economic benefit after their initial intended purpose might no longer be relevant. In the case of Tinaroo Dam, the primary product produced from the irrigation system has changed at least twice; from tobacco to sugarcane (broad acre cropping) to horticulture. It allows for changes in cultural and health practices, as was the down-turn and move away from tobacco to sugarcane; to opportunities to supply higher value crops to new markets (domestic and international) as has been the change from sugarcane to horticulture.

In short, the security of water supply for agriculture has provided a resilience to a regional economy to adjust to changes forced upon it and to take advantage of opportunities as they presented themselves due to improving supply chains and logistics.

3.3 Disruption of traditional product timelines

At the time of decisions being made to develop Tinaroo Dam over 65 years ago, the concept of refrigerated freight efficient vehicles, sealed roads to major freight markets, communications and marketing to overseas purchasers through the internet; and an international airport within 1.5 hours of the Tablelands would not have been considered. Improvements in infrastructure, technology and business linked directly or indirectly to dams have disrupted traditional means of production and business, giving rise to networking of business streams and reduction in times of bringing about productivity gains in established or new markets. It can be a case of timing as to whether existing infrastructure can aid in supporting the case for a dam or whether the dam aids in supporting the case for other infrastructure.

The impacts on flow-on industries are not typically considered in assessing dam business cases. For example, in the case study of the San Luis Dam in California, water investment enabled the production of grapes and olives, and localised production of wine and olive oil flowed from this. Further, a burgeoning premium wine and food tourism industry followed. In the case of Tinaroo, the replacement of low value 'bulk' crops, with high value 'premium' crops has led to the emergence of a premium transport sector where transport costs are linked to the potential value of loss of produce rather than just the direct cost of transportation.

What this indicates is that forecasting over periods of up to 30 years for long-life infrastructure is unlikely to identify the nature of and when higher value benefits can be realised from investment in the initial infrastructure. Attempts to quantify these benefits by estimating 'residual values' of the assets are also likely to understate the longer-term value.

3.4 Market Maturation

What is also becoming evident is that the period for product and market maturation, that is, identifying how best to exploit the available resources in irrigated agricultural areas, is shortening.

The ability to learn from the mistakes and successes of various regions is helping to shorten the period in which other regions can improve the economic advantages that their region has or can acquire if it has the basic resource – water security for agricultural production. The building blocks for the supply chain for producing and marketing higher value crops are evident and regional economies are developing the elements of infrastructure needed to achieve logistic chains that can deliver quality product to market for premium prices. What has taken the Tablelands nearly 50 years to ascertain and understand the value thereof, can be realised in 1-2 decades in locations with new access to water security. The Rookwood Weir in Rockhampton will become an example of this as improved water management techniques, better transport logistics and understanding of domestic and international markets will enable producers to focus on better returns sooner. Regions have learned to lever off the agricultural market into adjunct markets such as tourism and bio-medical research, providing both lower skill employment and higher value employment. The range of benefits are beyond what is currently being identified as achievable from dam infrastructure and linked into business cases.

However, this is following established patterns and established market trends. Current day business cases can consider the trends that did not exist 30 years ago; but are unlikely to consider the next wave of production and market opportunities. This might include by-products being used for sustainable energy generation to power production on farms, making them more self-sufficient; or opportunities to open new markets as Australian products are seen as safe and high quality food sources in a world where bio-security and product consistency become critical in food supply.

The reduction in these timelines between high initial capital cost and recognising higher financial benefits for the regions will assist in assessing business cases for dams, but they will still be disadvantaged in CBA compared to other major infrastructure which can be staged or has lower initial capital costs and earlier benefits realisation in the shorter term.

The case studies (four dam cases and one base case) that follow, use a range of different data sources. These are summarised in Table 5.1 below.

Table 5.1 Case study data sets

Case Study	"Before"	"After"	In test description
Base Case (Rockhampton)	QLD Year Books (ABS 1301.3), various between 1930 and 1970. Region: "Rockhampton," see map below which aligns reasonably well with the current Fitzroy NRM and the current Rockhampton SA4. This includes Rockhampton, Gladstone and the area to the west. Where possible, towns including Gladstone and Tamago which are clearly outside of the Rockhampton catchment have been excluded. Classes of products are typically high level, and there are measurements in tonnes/head not $. The classifications do not allow the split of tree crops, for example, into subcomponents e.g. avocados.	ABS 7121.0 Agricultural Commodities Australia, NRM for Fitzroy. More detail on agricultural products, however still in tonnes, not $. Workforce data (Census) workforce includes all of Rockhampton to Central Highlands LGAs.	Rockhampton region noting that this may mean slightly different things in different contexts.
Tinaroo Intervention	QLD Year Books, various between 1930 and 1970. Region: "Cairns map" is more Coastal than the study region. Classes of products high level and in weight/count not $. The classifications do not allow the split of tree crops, for example into subcomponents e.g. avocados.	ABS 7121.0 Agricultural Commodities Australia, SA4 for Cairns. More detail on agricultural products, however still in tonnes, not $. Cairns region SA4 chops off some of the western part of the Tablelands region. Workforce data (Census) on workforce includes all of Cairns, Mareeba and Tablelands LGAs.	Cairns or Tinaroo region noting that this may mean slightly different things in different contexts.
Wellington Intervention	WA Year Books, various between 1930 and 1970 Region: "South West Region," Which lines up reasonably to the Bunbury SA4, but includes Mandurah. Classes of products high level and in weight/count not $. The classifications do not allow the split of tree crops, for example into subcomponents e.g. avocados.	ABS 7121.0 Agricultural Commodities Australia, SA4 for Bunbury. More detail on agricultural products, however still in tonnes, not $. Bunbury region SA4 excludes Mandurah.	Wellington region or Bunbury used interchangeably noting that this may mean slightly different things in different contexts.
Copeton Intervention	NSW year book 1965, 'Northern Tablelands.' Poor data quality, fruit and vegetables not split.	ABS 7121.0 Agricultural Commodities Australia, New England and North West NRM.	Copeton region noting that this may mean slightly different things in different contexts.
San Luis	Old data largely unavailable.	Current data uses Merced County as 'economic' region. Wine data uses senate seat data for districts 14, 31-35.	San Luis region, noting that this may mean slightly different things in different contexts.

5.0 BASE CASE – ROCKHAMPTON

In order to make an informed inference regarding the impact of the water intervention and security of supply, there is a need to have a base case, to compare over a similar period that did not receive a similar intervention. Of course, this adds even more conflating factors to the analysis, so there is a need to control for these as much as is possible.

Rockhampton was chosen as the base case, for a number of reasons including inter alia:

- It has a relatively large agricultural sector (as do all of the case study locations).
- It has relatively low industrial base in the 1950s (when some of the case studies begin) which is comparable to the other regions studied.
- It has not received significant investment in agricultural water.
- It is in a regional location significantly separated from a capital city or another major urbanised centre (no 'halo effects', the region stands or falls on its own merits)
- It has multi-modal transport options for distributing product from the region (not disadvantaged in that respect)

Agricultural water use from the region's main water sources, including the Fitzroy River barrage, and the Alinga Dam appears to be modest. This infrastructure is largely targeted at supply of potable water for urban consumption. Accordingly, it is considered that this offers a reasonable base case.

Rockhampton, for the purpose of this case study, in order to match up with the available data from the 1950s has been defined as the Rockhampton plus Central Highlands LGAs. A portion of the Central Highlands LGA (around Emerald) has been removed from the agricultural results where possible to extract the Fairbairn Dam irrigation area from the results.

It is noted that the Rookwood Weir on the Fitzroy River has recently been approved for construction and based on its Business Case, is expected to bring significant benefits to agricultural producers in the region.

Figure 5.2 Rockhampton assessment area (Source: Labour market conditions in Rockhampton (July 2015), Australian Government Department of Employment)

6.0 CASE STUDY

TINAROO DAM

6.1. Tinaroo history and uses

The Tinaroo Falls Dam was completed in 1958 at a cost of $12 million (around $200m in 2020). The dam's initial purpose was to ensure continuity of water supply to a crop that was traditionally important to the Atherton Tableland region – tobacco. Today, the water of Lake Tinaroo supplies a diverse range of crops and also serves an important role in hydro-electricity generation for the local region as well as providing a range of recreational pursuits for the Cairns and Tableland regions.

The Tinaroo Falls Dam was built on the Barron River about 40 km inland from Cairns . From 2008 to 2013, $24.7 million was invested in a major Dam improvement Project which included the installation of active crest anchors, a dam crest wave wall, downstream protection works and raising the saddle dam.

Currently the Tinaroo Falls Dam four major purposes include irrigation for the Mareeba-Dimbulah Water Supply Scheme (MDWSS for irrigation), potable water supply, hydroelectricity, and recreation. The location of the Dam is shown in Figure 6.1.

Figure 6.1: Surrounding LGA around Tinaroo Falls Dam

6.1.1. Irrigation for the Mareeba-Dimbulah Irrigation Scheme

The Mareeba-Dimbulah Water Supply (Irrigation) Scheme (MDWSS) covers approximately 112,000ha across the valleys of the Barron, Walsh and Mitchell Rivers and approximately 1097 customers including 800 separate farms. Water from the Tinaroo Falls Dam is gravity fed to these through a trunk network of 176 km, plus another 189 km of channels. The area under irrigation is approximately 27,000ha with a potential 53,000ha suitable for agriculture if adequate water supply were available.

Sugar Cane is currently the dominant crop, supplying to a MSF owned sugar mill in Arriga Flats. However, in the last decade there has been a significant move to perennial horticulture, which includes bananas, mangoes, citrus and avocados. Horticulture dominates the region in terms of dollar value of production.

Other water uses include crops such as grapes, coffee, tea, pineapple, lychee, pawpaw, custard apples and flowers, and irrigation of pastures for beef cattle fattening and stud breeding.

The MDWSS services four main sectors. Water allocations and usage across those sectors are indicatively shown in Table 6.1 below. Water entitlements for the available supply have been fully subscribed (in the case of agricultural – oversubscribed), however water delivered to the various uses averages at 68% and ranges from 44% to 72% usage of the allocated entitlement. Water entitlements are a valuable commodity and MSF indicated that some farmers hold more wealth in their water entitlements than their farms. Anecdotal reports suggest that due to current entitlements; demand on some properties is exceeding supply despite overall demand being less than total entitlements.

Table 6.1
Water Usage for the MDWSS 2016-2017 (Sunwater 2017 Annual Performance Report, October 2017)

Customer Segment	Water Available	Water entitlements	Water Delivered	Comments
Industrial	1,294ML	1,561ML	691ML	Barron Gorge Hydroelectric Power Station
Irrigation	152,169ML	151,202ML	109,135ML	Agricultural Uses
Urban	5,959ML	6,656ML	3,784ML	Supply for Dimbulah, Mareeba, Mutchilba, Tinaroo
Sunwater	45,002ML	45,005ML	25,308ML	Conveyance losses
Total	**204,424ML**	**204,424ML**	**138,918ML**	

Take up of water entitlements may vary seasonally and annually depending on rainfall over that year, whether market conditions are suppressing demand to produce some crops or in the case of the Barron Gorge hydro scheme, whether cost of producing power can be recovered by the sale of power in peak demand times. Availability of water and water allocation priority will also dictate whether a full or partial allocation can be drawn upon.

Allocation charges are set on an annual basis by Sunwater and can vary upon location and volume consumed.

6.1.2. National Water Initiative Pricing Principles

The National Water Initiative Pricing Principles require the full recovery of costs of water, through either an annuity method, or a building blocks method, which recognises capital, operational, and other costs.

To this end, the irrigation output of Tinaroo Falls Dam is managed under these principles and given the monopoly characteristics of the provider (Sunwater), these prices are managed by the Queensland Competition Authority (QCA).

6.1.3. Hydroelectricity

A 1.3MW hydroelectric power station is located at the base of the dam wall providing power to the adjacent township of Tinaroo. Timed releases from Tinaroo are also used to operate the Barron Gorge Hydroelectric scheme for power production during peak demand.

6.1.4. Recreational

Recreational facilities are predominantly provided by Tablelands Regional Council (TRC) with some private sector associated tourism related businesses. This includes activities such as fishing, boating, accommodation, restaurants, cafes and camping.

The Mareeba-Dimbulah Scheme consists of the Tinaroo Falls Dam, Lake Tinaroo and the Mareeba-Dimbulah Irrigation Area. Irrigation water is used for various fruit, general horticulture, sugarcane, tea-bushes and coffee. Urban water is supplied to Tinaroo, Walkamin, Mareeba, Kuranda, Mutchilba, Dimbulah and Yungaburra. Dam parameters are provided in Table 6.2.

Table 6.2 Tinaroo Falls Dam specification
(Emergency action plan – Tinaroo falls dam, Sunwater, 2019. Accessed from: http://data.dnrm.qld.gov.au/eap/tinaroo-falls-eap.pdf)

Description	Specification
Dam type	Mass concrete gravity dam
FSL	EL 670.42m
DCL	EL 674.11 m (Top of Kerb EL 674.31 m)
Dam height	41.48 m above downstream toe
Dam length	533.5 m
Historical recorded storage (as at 19/09/2012)	Max EL 672.74 m – Feb '99 Min EL 656.42 m – Dec '03 Max EL 671.34 m – Jan '11 (Post Spillway Upgrade)
Spillway type	Central uncontrolled ogee crest with baffle wall type dissipator
Saddle dam type	Earth Fill with a U/S concrete parapet wall
Embankment crest level	EL 677.0 m
Top of crest wall	EL 677.7 m (min)
Length	240 m
Embankment max height	6.6 m

6.2. Economic case

6.2.1. Case study data

The data for this project mixes historical Australian Bureau of Statistics products, (i.e. products from the 1940s, 50s and 60s) with data from more recent times. The data sources are summarised in Table 6 1. As can be seen from Figure 6.2 ABS Statistical regions circa 1940 - 1960, the statistical region referred to as "Cairns" encompassed an area surrounding the city of Cairns to north of Mossman, south of Ingham and west to Miranda Downs. Its main agricultural areas were on the coastal strip and the Tablelands.

Historically, sugarcane production was based along the coastal strip due to the higher rainfall in this area and the lack of appropriate water supply and lesser rainfall on the Tablelands area. Since the commissioning of Tinaroo Dam and the demand for other higher value land use on the coastal strip, the amount of sugar cane production on the Tablelands has increased as the amount of sugarcane production on the coastal strip has decreased.

There are a number of difficulties in matching up the data. Old data boundaries do not line up with current boundaries. Product categories do not match. Accordingly, references to this statisical region are rated as being for the Cairns (Tinaroo) region. However, there are some clear insights that can be made from using the best data available, and these will be considered below.

In all cases, agriculture has been defined to encompass crops, livestock and aquaculture.

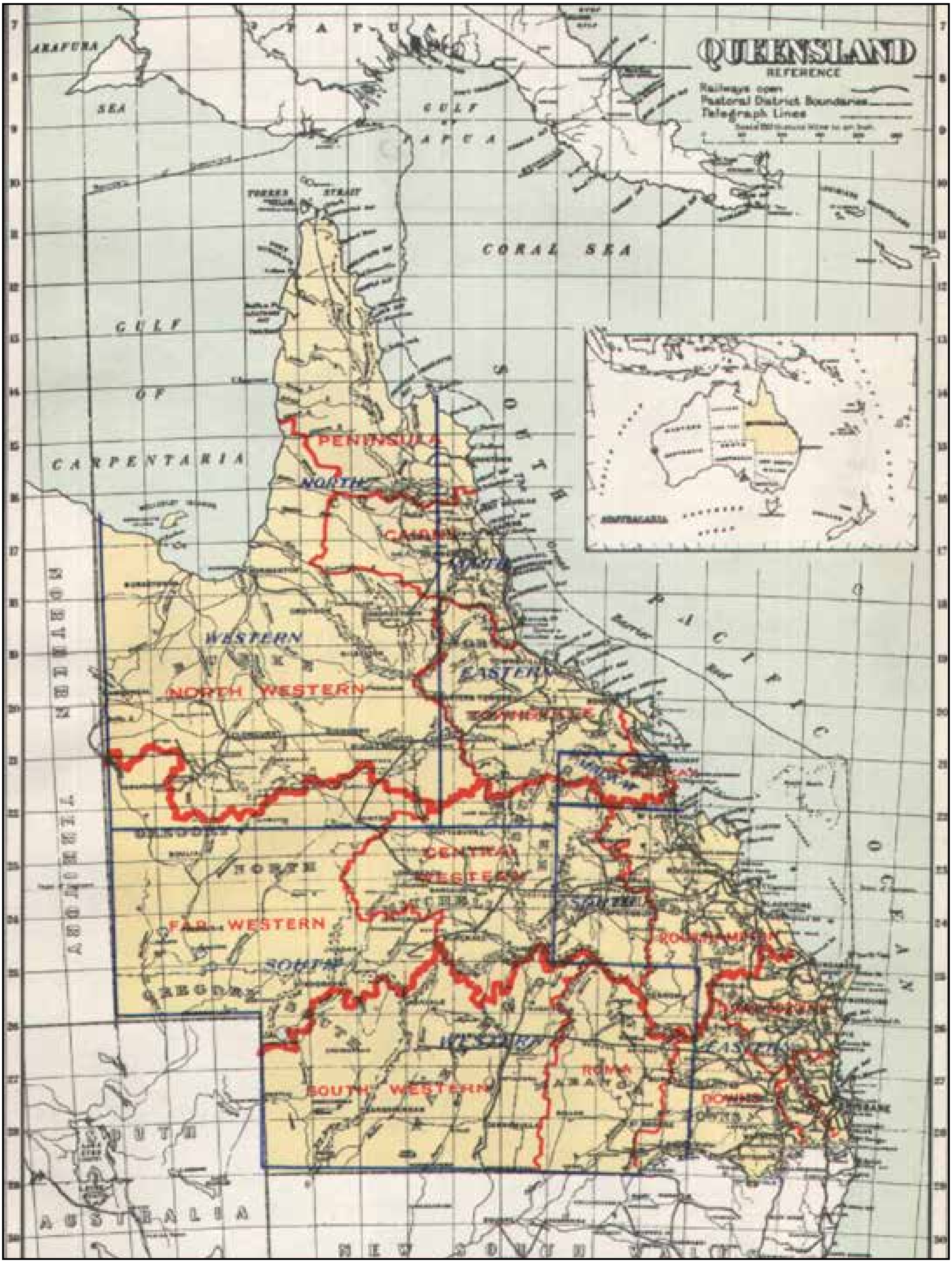

Figure 6.2 ABS Statistical regions, QLD circa 1940 - 1960 (source ABS)

6.2.2. Overview

The economic structure – based on industries of work – for the Cairns (Tinaroo) region, base case (Rockhampton region) and QLD as a whole are presented in Figure 6.3.

The Cairns (Tinaroo) region has a higher proportion of agriculture and accommodation and food services (tourism) and lower proportion of financial and professional services, relative to the state averages. The two largest sectors of the Cairns regional economy (like the QLD economy) are Health and Social Assistance, and Retail Trade. Cairns is clearly different to the Queensland average in that it is a tourism and agricultural region, borne out by it's shares of agriculture and accommodation and food workers. The agricultural component on the Tablelands is largely a direct result of the dam and associated irrigation scheme. The Tourism component for the Tablelands and Mareeba local government areas is considered related to the dam and the associated industries in the region.

Relative to Rockhampton, Cairns (Tinaroo) has a lower proportion of its economy employed in agriculture and mining, and a significantly higher proportion of workers employed in the services sector – including tourism, but also including more broad classes of high value service industries as shown in Figure 6.3.

Figure 6.3 Employment by region, Cairns region, Rockhampton region, QLD. (2016)

6.2.3. Population

Population growth in the two regions, Cairns (Tinaroo) and Rockhampton, has diverged significantly as indicated in Table 6.3 Population Growth, with Cairns (Tinaroo) growing by a higher compound annual growth rate (CAGR) at 1.3%, to Rockhampton's 0.7%.

Table 6.3 Population Growth

Region	1954	2019	CAGR
Cairns/Tinaroo	90,992	215,167	1.3%
Rockhampton	72,190	110,213	0.7%

6.2.4. The changing face of agriculture

6.2.4.1. Agriculture 1955

The agricultural production for the Cairns (Tinaroo) region before Tinaroo Dam was commissioned is reported in Figure 6.4, below. Note that the way that data was collected in 1953-54 means that there are difficulties directly comparing and contrasting the data (e.g. lb, to thousands of sheep). Notwithstanding, there are fairly clear takeaways from this comparison.

- Agricultural production in the Cairns (Tinaroo) region on the Tablelands was heavily geared towards tobacco and maize, with a relatively small beef and dairy industry.
- Agricultural production in Rockhampton was heavily geared towards grazing and cotton production. Note that the cotton production in the 1950s is an artefact of the region's geographic boundary stretching out past Emerald; which in later years was serviced by Fairbairn Dam. For 1955 this was unable to be removed completely.

The economic theory of comparative advantage suggests that regions will specialise in production of products where they have an abundant factor. The crops produced in both regions in the 1950s are relatively intensive for land use, but require relatively little water, or at least only require seasonal water.

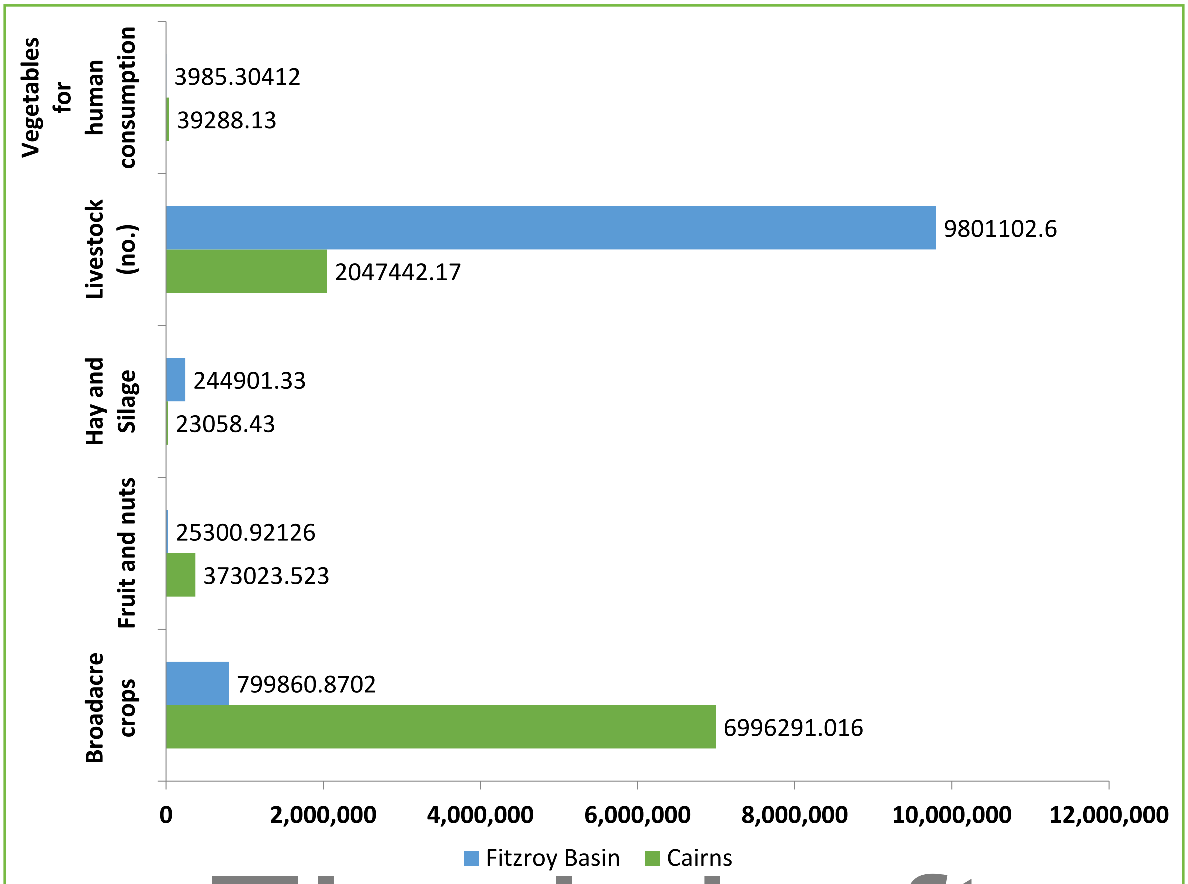

Figure 6.4 Regional Agricultural Production in Tonnes (Livestock in numbers)

6.2.4.2. Current Activity

The current agricultural production for the two regions is presented in Figure 6.6. The agricultural production of the area to the west of the Rockhampton region (the area near Fairbairn Dam and Emerald was able to be removed from this data set). While the data is unfortunately in tonnes (or head count for livestock), it shows a relatively similar pattern to the historical data, at least at the highest level. Livestock remains the dominant, and nearly only agricultural industry in the Rockhampton region.

There is a modest level of sugarcane farming, which is both used in sugar production, but also molasses which included as Hay/Silage to support the livestock industry.

For Cairns (Tinaroo) region, a Livestock industry still exists, but the dominant type of agriculture is broadacre crops.

There is also a significant share of tonnage for fruit and nuts (particularly given the high relative price of these products). Figure 6.5 breaks out this in some detail.

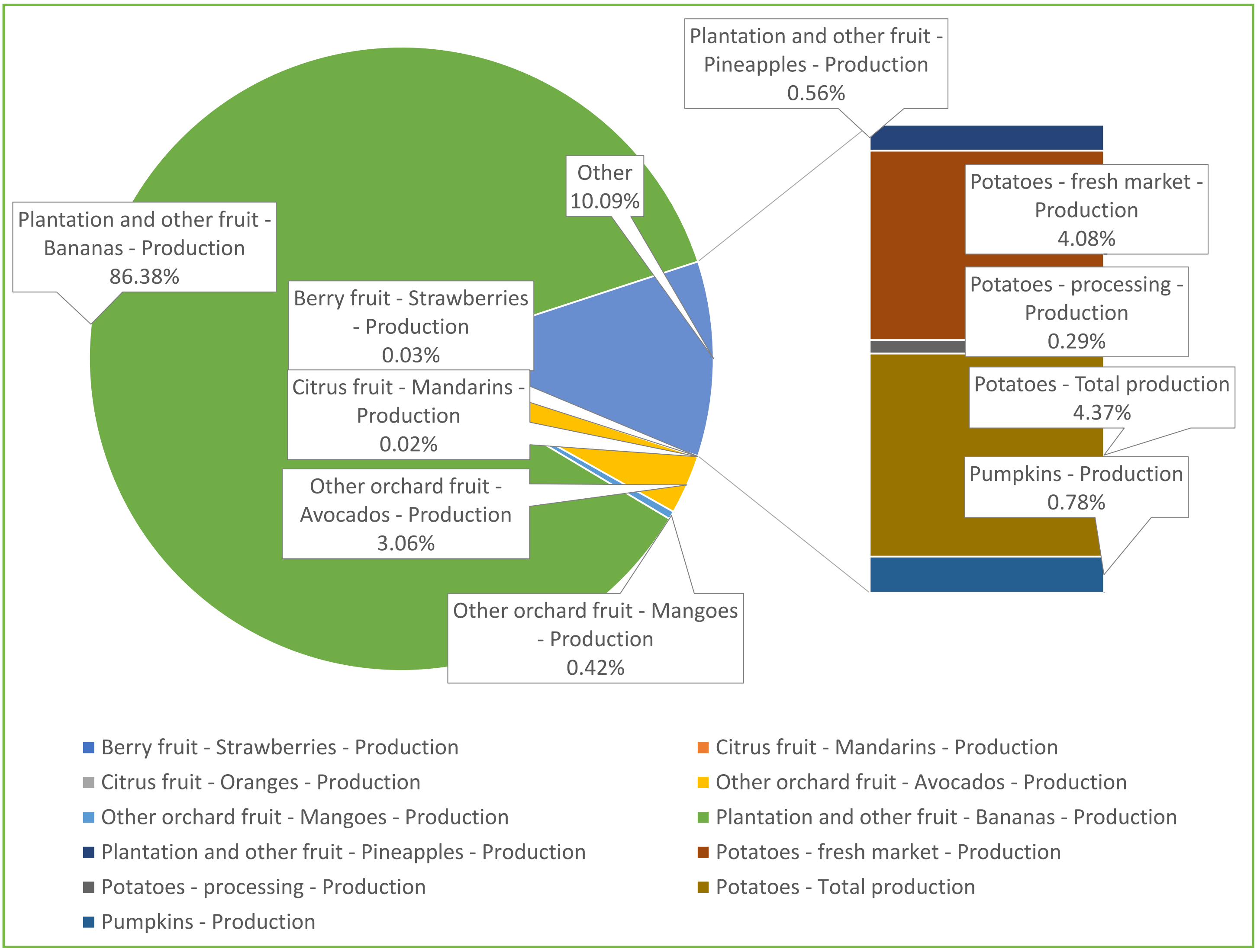

Figure 6.5: Cairns Agricultural production breakdown (tonnes) (2017). Produce less than 0.01% not shown for clarity.

Approximately 80 percent of the fruit production for the Cairns (Tinaroo) region is Bananas, but there is a significant share of avocados, pumpkins and pineapples.

Both Cairns (Tinaroo) and Rockhampton's agricultural sectors demonstrated path dependence in a lot of ways over the 60 years. In many ways the crops that mattered at the start of the period matter at the end. However, while there was virtually no meaningful change in the Rockhampton data, three significant things appear to have happened in the Cairns (Tinaroo) area.

- Tobacco (for a range of reasons) completely disappeared from the Cairns (Tinaroo) regional profile, and in its place, there has been a move to diversification of agricultural products.
- There has been significant growth in the production of fruit and vegetables.
- There has been evidence of the emergence of nuts (macadamias) in the Cairns (Tinaroo) agricultural sector.

While it is clear that Australia's transition out of growing tobacco was a strong driver to push the Cairns (Tinaroo) region out of tobacco, the ability of the region to pivot to higher value agriculture has been enabled by the climactic and soil conditions of the region. A further critical enabling factor is clearly the availability of a stable, reliable water source. Not only did the presence of the water infrastructure enable growth, it prevented a potentially significantly negative shock to the local economy (the closure of the tobacco industry) by making the local economy more able to make a rapid structural adjustment.

- In the absence of irrigation, the best available alternative would be a significantly less valuable agricultural land use.
- It is important to note that this pivot away from the tobacco crop occurred well and truly outside the 30 year time horizon for most dam infrastructure CBAs, suggesting the benefits of dams are long-lived.

6.2.4.3. Changing productivity of land

Figure 6.6 below shows the relative change in productivity for land in both the Rockhampton and Cairns regions over the last 60 years. Figure 6.6 estimates a 'per hectare' value of agriculture (excluding livestock) in 1955 and 2017. Due to the low confidence in 1955 price data, the series has been presented as an index, with Cairns (Tinaroo) productivity in 1955 as the baseline. It shows that Cairns (Tinaroo) agricultural productivity in 1955 was higher than Rockhampton, based on the relative strength of the tobacco and sugar crop relative to grains. The gap between the two regions grew significantly over the period to 2017 as Cairns shifted away from tobacco, and into the significantly more lucrative crops, such as avocados. The crop distribution in Rockhampton continued to focus on less water intensive,
less valuable crops – largely grains, including a significant share of these for animal consumption. This is not surprising given its minimal investment in water infrastructure.

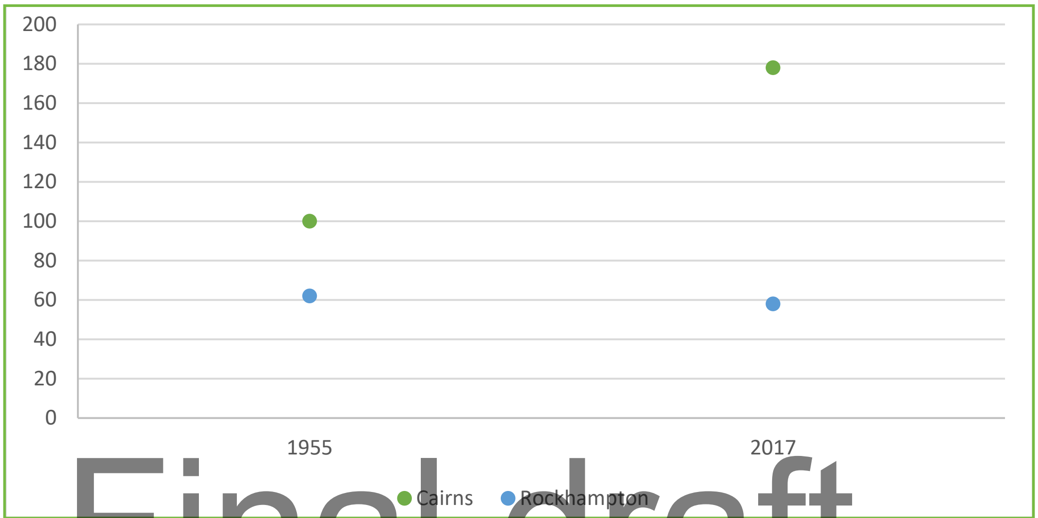

Figure 6.6 Changing agricultural productivity

6.2.5. Flow on impacts

6.2.5.1. Other industries in 1955

As shown in Figure 6.7, there was a relatively low level of manufacturing production across Cairns (Tinaroo) and Rockhampton in the 1950s. Cairns (Tinaroo) was dominated by a sugar processing industry, and Rockhampton by food (assumed to be meat) processing. Again, this makes sense based on the high volumes of sugar cane produced in Cairns and the high livestock volumes of Rockhampton.

Note that the sugarcane production in the Cairns Region occurred almost entirely on the coastal plan, which relied predominantly on natural rainfall, which supported the development of this industry long before irrigation was available in this region. Large scale sugar cane production on the Tablelands (Tinaroo region) was not commercially possible until Tinaroo Dam and the MDWSS was constructed. The production on the Tablelands was able to counterbalance the loss of production on the coastal plain due to urbanisation and kept a number of the local mills operating.

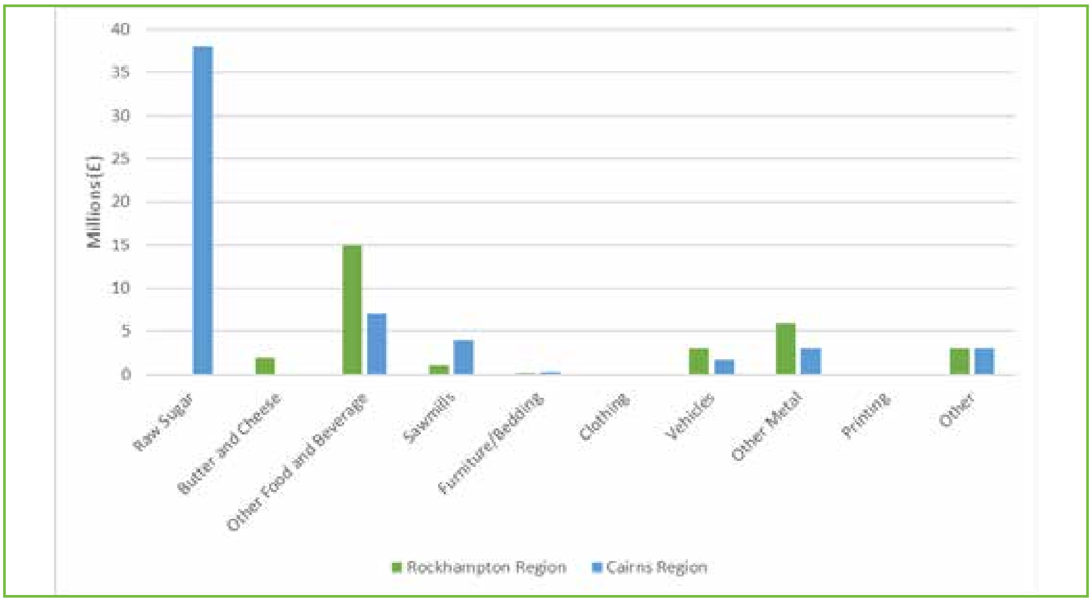

Figure 6.7 Cairns (Tinaroo) region & Rockhampton region manufacturing breakdown (circa 1950s)

A manufacturing breakdown for the Cairns (Tinaroo) and Rockhampton regions has been calculated by building a regional input output table for the Cairns (Tinaroo) region and the Rockhampton region. The shares of different manufacturers are presented in Figure 6.8 Manufacturing industry, 2017. There is definitely some path dependence, as in the agricultural sector for both regions. For example:

- Meat processing is the dominant manufacturing industry in Rockhampton. Consultation suggests that this is based on meat, not only from the region but from further afield.
- Cairns (Tinaroo) has a significant sugar manufacturing industry, further, there is evidence of a fledgling green energy sector using sugar waste (Bagasse) with MSF making a $75 million investment in a Green energy (Bagasse) plant in 2018.
- Cairns (Tinaroo) and to a lesser extent Rockhampton have metal manufacturing sectors.

More interestingly, and what was not picked up in the 1950 data, is the development of the 'other vehicles' (not cars) manufacturing sector in Cairns (Tinaroo). While it is tenuous to link this to water investment, it may be a function of a relatively strong economy, and some of this is linked to the strong agricultural sector. Cane and sugar syrup from the Tablelands have previously been both trucked and railed to coastal mills and ports for further processing and distribution. With further development of Arriga Mill, the practice of transporting sugar syrup has ceased and heavy rail transport of cane has ceased.

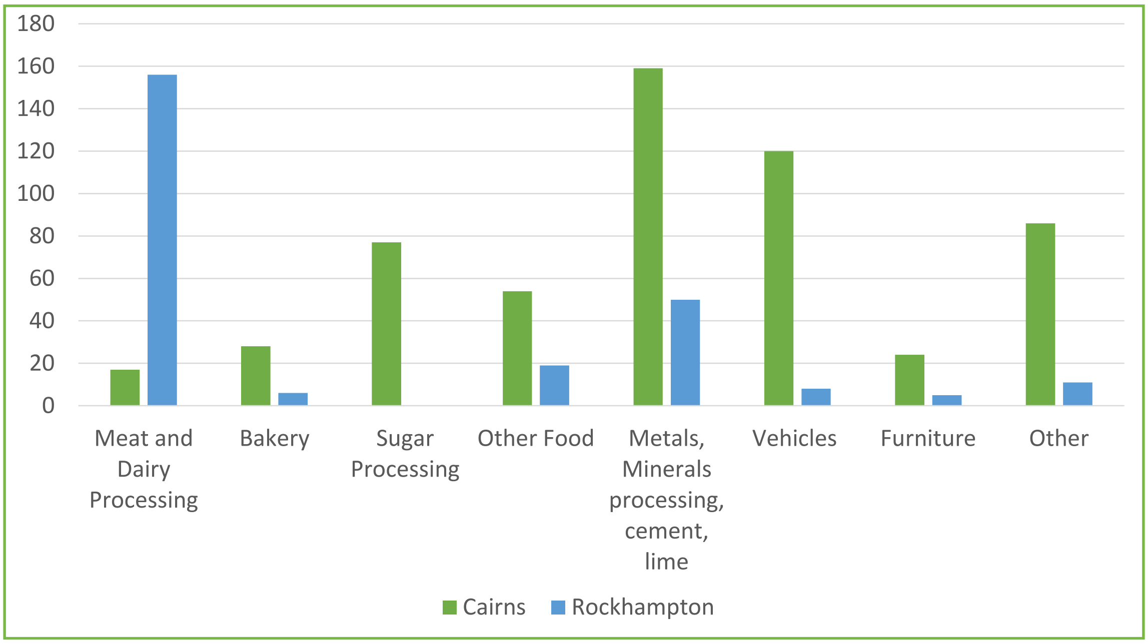

Figure 6.8 Comparison of manufacturing industry, 2017

6.2.6. Industrial/Commercial Benefits

The immediate downstream benefits of agricultural production in the Mareeba-Dimbulah Irrigation Scheme region include:

- Transportation logistics associated with moving produce to market. The two largest freight transporters on the northern Tablelands area are Blenners Transport and Lindsay Transport, both with depots based in Mareeba and each having approximately 50% of the interstate transport market from the Tablelands. Blenners opened a dedicated Mareeba depot 3.5 years ago after servicing the Tablelands from Tully for 32 years. That depot has been expended by doubling capacity each year from opening with business still being knocked back due to capacity constraints. Qube Transport is the largest Sugarcane transporter in the region.

The following information has been provided by Blenners Transport and MSF Sugar.

- Main products delivered by Blenners include Mangoes (Oct – Feb) - approximately 120,000t/season (estimated total Tablelands export approximately 240,000t/season)
- Avocados – 92,000t/season by Blenners, total Tablelands export estimated at 140,000t
- Bananas – over 2.5Mt/year total export estimated at over 30Mt
- Potatoes – over 35,000 t per season
- Local wages for these operations over $2.6M/yr reinvested in community, plus fuel and maintenance spend
- MSF's Arriga Mill, constructed in 1995, was the first sugar cane mill built in Queensland for 75 years. Between initial construction and the 2013 expansion, over $70M was invested into the Mill.
- MSF Bio Cogeneration Plant at the Arriga Mill has resulted in a further $75M+ investment in the plant and over $125M invested in the contributing farms. It is noted that the jobs created in the Cogeneration Plant are higher skilled and higher paying than conventional agricultural jobs and salaries. MSF will look to expand the cropping to provide the bio mass including Agave, which does not require irrigation, freeing up water for use on other crops in the area including sugarcane. Contractors, fabricators and materials are sourced locally where possible. MSF has flagged that were more water available, further investment would be possible.

While the majority of produce from the Tablelands is still consumed domestically, there is a growing percentage of select products that are being exported to primarily Asian markets either directly through Cairns Airport or indirectly through other Australian international airports. The recent State Government decision to help fund an (agricultural) Regional Trade Distribution Centre at Cairns Airport reinforces the view that the State Government recognises synergies that have developed through collocated infrastructure (though non-related in terms of business cases) and wants to support development of agricultural exports from this region.

6.2.6.1. Taxation impacts – irrigators

The taxation contribution of the irrigators in the Cairns (Tinaroo) region is shown in Table 6.4. Only Commonwealth taxes, have been considered.

Labour income tax, based on an average annual salary of $55,000 for agricultural labour is around $19m per annum. Low levels of average profitability in Australian agriculture (around 3%) yield $6m in annual taxes on business income. This is additional annual taxation revenue, not the whole revenue for the region. This is likely understated, as profitability with and without irrigation is likely different.

Table 6.4: Cairns (Tinaroo) region Government revenue, 2016

Revenue	2016
Labour income tax	$19m
Business income tax	$6m
Total	$25m

6.3 Case Study 1 Conclusion

What omissions would an ex-ante CBA have made? While the shift from low-value to high-value crops would be predicted using the CBA guidelines (although significantly understated), an ex-ante CBA would have significantly understated the value of the Tinaroo Falls Dam investment for a number of reasons.

- The greatest benefit arising from Tinaroo Dam occurred well after the 30-year time horizon considered by most CBA frameworks and was the shift towards higher value crops after the wind down of the tobacco industry. The value of resilience to external factors (in this case the abandonment of the domestic tobacco industry) meant that the Cairns (Tinaroo) region could pivot towards high value crops, and the area may have benefited in the long term from a shock that would have been otherwise devastating to the region without access to irrigation (and government grants).
- The range of domestic and international markets available to producers on the Tablelands (and hence the value of the direct market and associated export economic activity and taxes) would not have been envisaged. Access to markets would have been primarily estimated by road and rail to southern domestic markets. The Bruce Highway was still unsealed in parts between Cairns and Brisbane at that time and was essentially single carriageway in each direction, resulting in longer travel times for produce and the inherent difficulty of growing crops with shorter transport life. The size of vehicles available to transport the produce was restricted by size and weight to far less than what is currently possible through the use of Freight Efficient Vehicles (FEVs). The Cairns Airport was at that time an aerodrome with very limited intrastate passenger service. There would have been no vision that it could become an international airport with flight times to south-east Asia that made export of some short-life agricultural products viable.
- The downstream benefits (e.g. higher wages and returns to capital in the transport sector) would not have been considered. However, as described in the sections above, these are significant.
- While modest in comparison to the Great Barrier Reef, an inland lake with tourist amenities only strengthens the appeal of the region to overseas visitors.

However, there are some features of the Cairns (Tinaroo) regional economy that mean these benefits have been able to be realised. For example:

- Access to an international airport and a significant port: even in 1954, around 10 per cent of the overseas cargo leaving Australia by sea left via Cairns
- Soil suitable for a range of crops
- A strong tourism industry, which supports the agricultural sector (with labour) and magnifies the tourism benefits of the dam investment.

The flaw in this process is that the impacts and benefits can only be identified within the realm of what is considered feasible at the time of assessment (potentially a 30-year time frame for infrastructure that will have a life in excess of 100-150 years. The ability to look forward and develop a robust argument for something beyond this time frame is constrained in that studies have not been undertaken with that specific purpose.

- The downstream benefits (e.g. higher wages and returns to capital in the transport sector) would not have been considered. However, as described in the sections above, these are significant.
- While modest in comparison to the Great Barrier Reef, an inland lake with tourist amenities only strengthens the appeal of the region to overseas visitors.

The rules for determining what can or cannot be included in the analysis would preclude such a speculative view despite evidence-based case studies that demonstrate that transformative growth is possible beyond the 30- year term of the assessment.

The purpose cannot consider how other pieces of infrastructure in a region can lead to synergistic effects and opportunities, to provide a renewal of purpose (or products) from the region it supports or provide an otherwise non-existent robustness to sustain a community through periods of rapid change in the face of a market collapse.

7.0 CASE STUDY

WELLINGTON DAM

7.1. Wellington Dam, History and uses

Wellington Dam is approximately 200 kilometres south of Perth and was initially constructed in 1933, then enlarged in 1956. While predominantly a source of agricultural water, the dam has served a range of functions including drinking water, industrial use and recreation. The increased salinity of the dam waters has led to the drinking water function of the dam being decommissioned in 2013. The Myalup-Wellington Water Project, a response to this increased salinity was added to the IA priority list in 2017, based on the identified significant economic benefits arising from this scheme. However, due to the perceived largely private benefits (to irrigators) of the investment, it was not clear that the project required public funding. It is currently on hold pending funding.

For the purposes of this case study, largely data for the Statistical Area Level 4 (SA4), 'Bunbury,' will be used to understand the catchment for the Wellington Dam. Refer to Figure 7.1, as noted in earlier sections of the paper, the 'Wellington region' will be used to describe this region. It is noted that this SA4 is well resourced by other water sources, however Wellington Dam was first, and in terms of agricultural use remains the most important.

Figure 7.1: WA Statistical boundaries, 1955

7.2. Collie River Irrigation District (CIRD)

The Wellington Dam takes flows from the Harris, Brunswick, Bingham and Collie Rivers. The dam provides an allocation of 85.1 gigalitres (85.1 GL) of water, of which 68 GL is allocated to the Collie River Irrigation District (CRID), which is shown in Figure 7.2 The Dam is administered by Harvey Water.

The region is a large agricultural producer and has a diversified production base. This includes beef and grains, and significant production of apples, citrus, stone fruits and olives.

Water allocations within the Collie River Irrigation District are managed by the Western Australian Department of Water and Environmental Regulation.

7.2.2. Hydroelectricity

The Wellington Dam also houses a hydroelectricity turbine, capable of generating 2 megawatts of electricity. The power station is located on the base of the dam wall.

7.2.3. Recreational

Wellington Dam is located within Wellington National Park and offers a range of recreational activities. This is largely managed by Parks and Wildlife (WA).

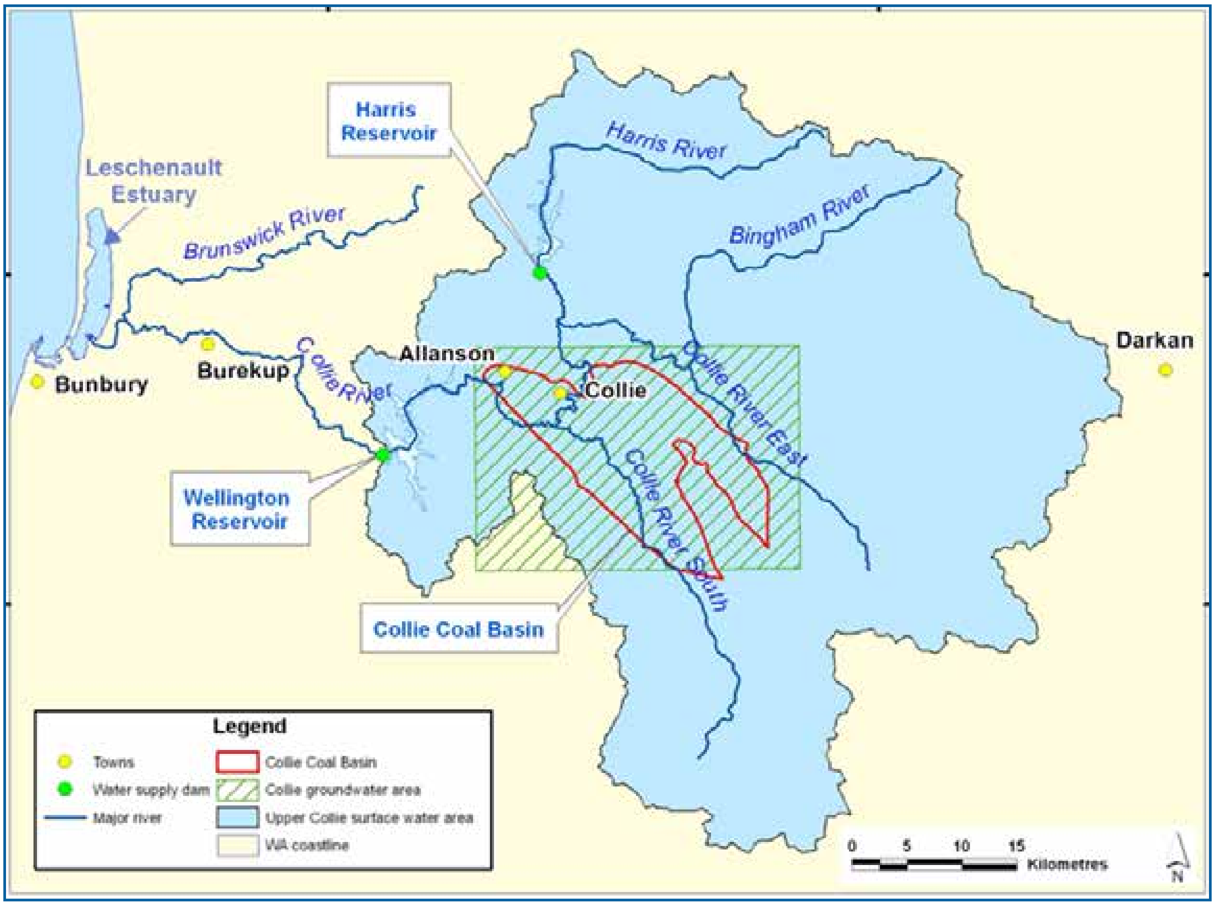

Figure 7.2: Collie River Irrigation District (Source: Government of Western Australia Department of Water and Environmental Regulation)

7.3. Economic overview

As noted previously, the region for the study in current terms is located within the Bunbury SA4. Data for the region follows.
The population growth relative to Rockhampton since the mid- 1950s is shown in Table 7.1. The region has experienced significant growth over the period since the Dam was, relative to Rockhampton, where no comparable intervention occurred. It is noted that there was a lag between when the dam expanded and the population spiked.

7.3.1. Population

The population of the study region has grown by around 700% in the last century, with growth from around 27,000 to nearly 160,000. At the time of the first dam intervention, population had risen to around 60,000. When the dam was upgraded, population had risen to around 70,000. It has had a strong growth rate since the 1970s.

Table 7.1: Population growth

Region	1954	2019	CAGR
Wellington	68,600	184,090	*1.8%*
Rockhampton	72,190	110,213	0.7%

7.3.2. Industrial base

The industrial base for the catchment is summarized in Figure 7.4, relative to the base case. The Wellington Region, Rockhampton Region and Western Australian economies are deconstructed by industry of employment, based on the number of jobs in each industry.

The Bunbury economy supports a substantially higher proportion of employment in the Agriculture Forestry and Fishing and Manufacturing industry, compared to broader Western Australia and Rockhampton. Like the rest of the state, it too has a large share of employment in Retail Trade and Health Care and Social Assistance, which are the region's two largest industries by employment. The Wellington Region, is significantly more heavily geared towards agriculture, forestry and fishing, and manufacturing employment than Rockhampton.

This reflects a significant agricultural sector, and downstream processing. Rockhampton overperforms in health care, education and public administration, which typically reflects a dearth of other industry.

Notably, the Wellington region performs better than the state average for Tourism.

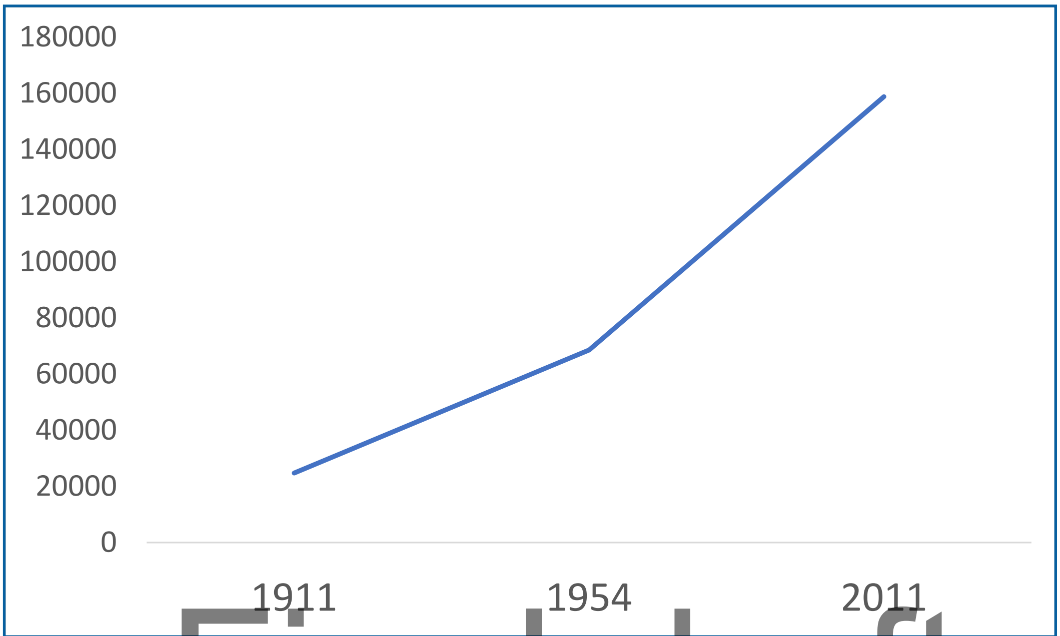

Figure 7.3: Population, Wellington Region, 1911 – 2019.

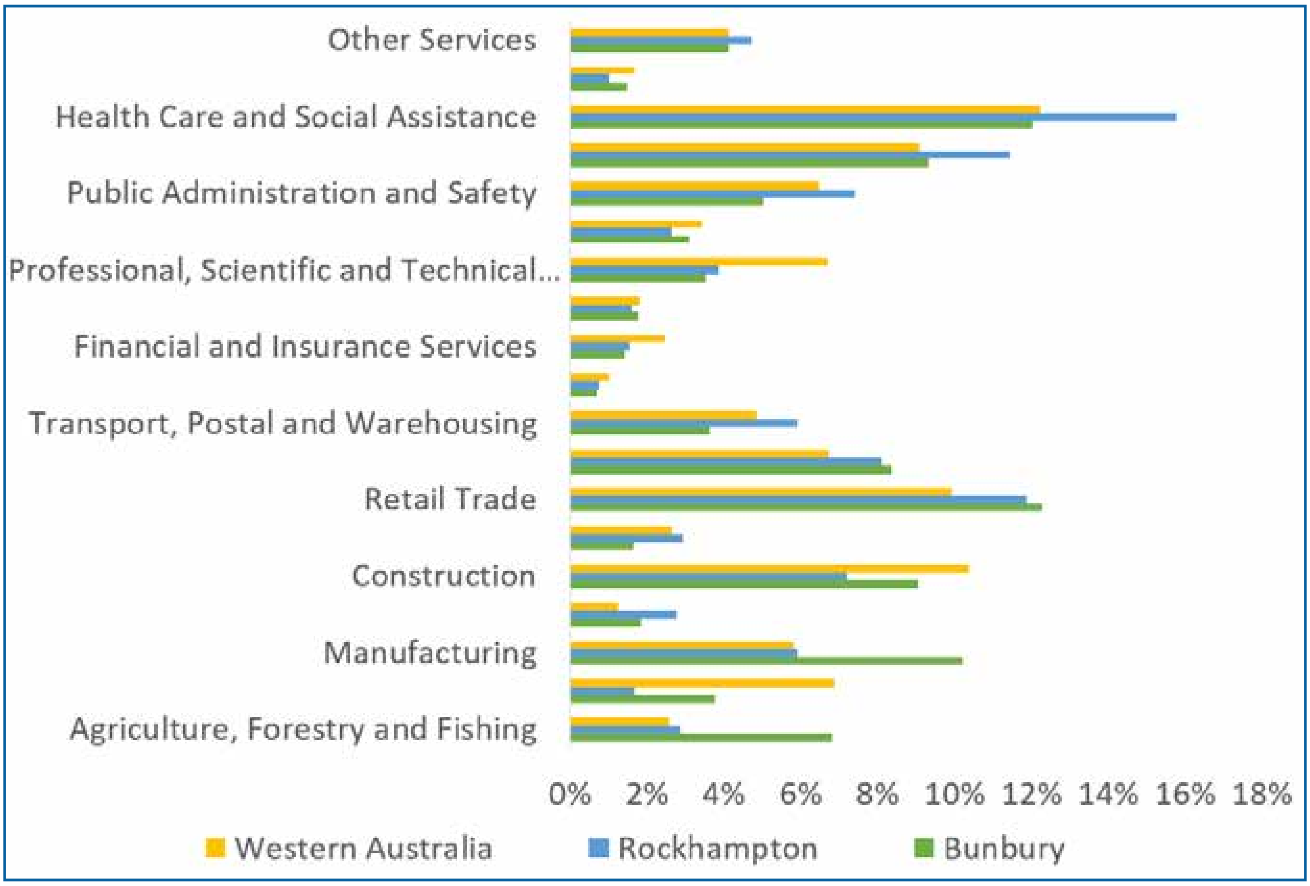

Figure 7.4: Industrial base, 2016, Bunbury (Wellington region), Rockhampton, Western Australia, share of employment by industry

7.4. Agriculture over time

7.4.1. Agriculture c. 1955

The agricultural profile of the Wellington Dam region in 1955, refer Figure 7.5, shows a relatively well diversified region, with focuses on three commodities. First, cattle (Beef and Dairy), and hay as an input into that production. Second, there was a significant potato crop, at more than 35,000 tonnes in 1955. Finally, there was significant apple production, at almost 25,000 tonnes.

There was also evidence of small-scale wine grape cropping, some stone fruit production, and general grain production.

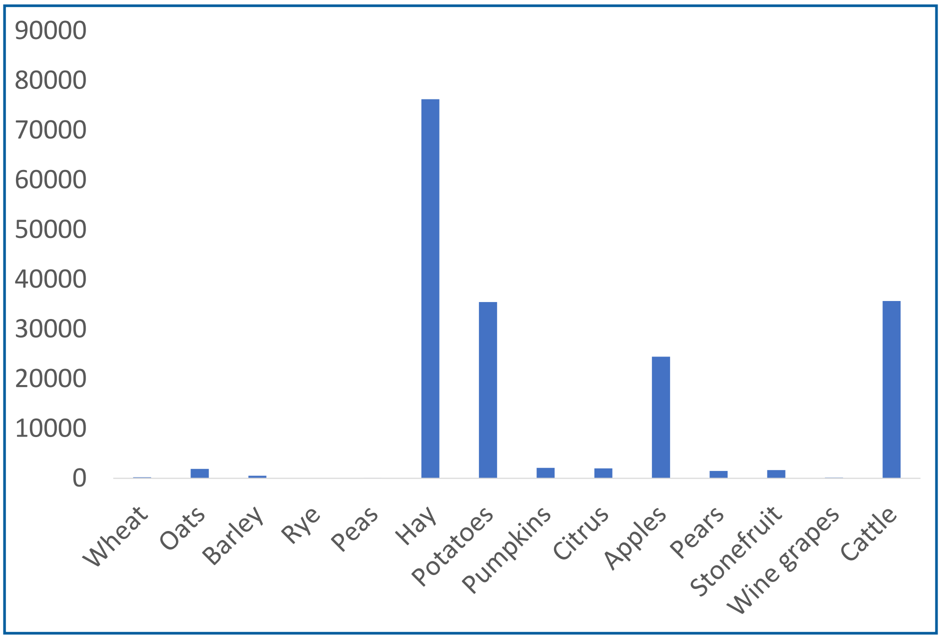

Figure 7.5: Agricultural commodities, Wellington region, (circa 1955)

7.4.2. Agriculture now

Agriculture in the region in 2017 is shown in Figure 7.6. The macro picture from 1955 remains largely the same. There is still a prevalent beef industry (and the feed/hay required to service it) and this has expanded. There have been expansions in the existing crops – oats, barley and potatoes. Interestingly, apple production has fallen but in its place there has been a shift towards higher value crops including wine grapes, avocados and olives.

7.4.3. Agricultural productivity

A comparison of Agricultural Productivity between the Wellington region and Rockhampton over 50 years is provided in Figure 7.7. Agricultural productivity is measured, using an estimate of the total value of production, divided by the amount of land used in its production. It is a partial measure, as labour inputs are not considered. Relative to Rockhampton, productivity was higher before the dam was built, and that gap has grown significantly in the period since the dam has been operational. This has been on the basis of both an increase in intensity of cropping, and a pivot to higher value crops, such as olives, grapes and avocados.

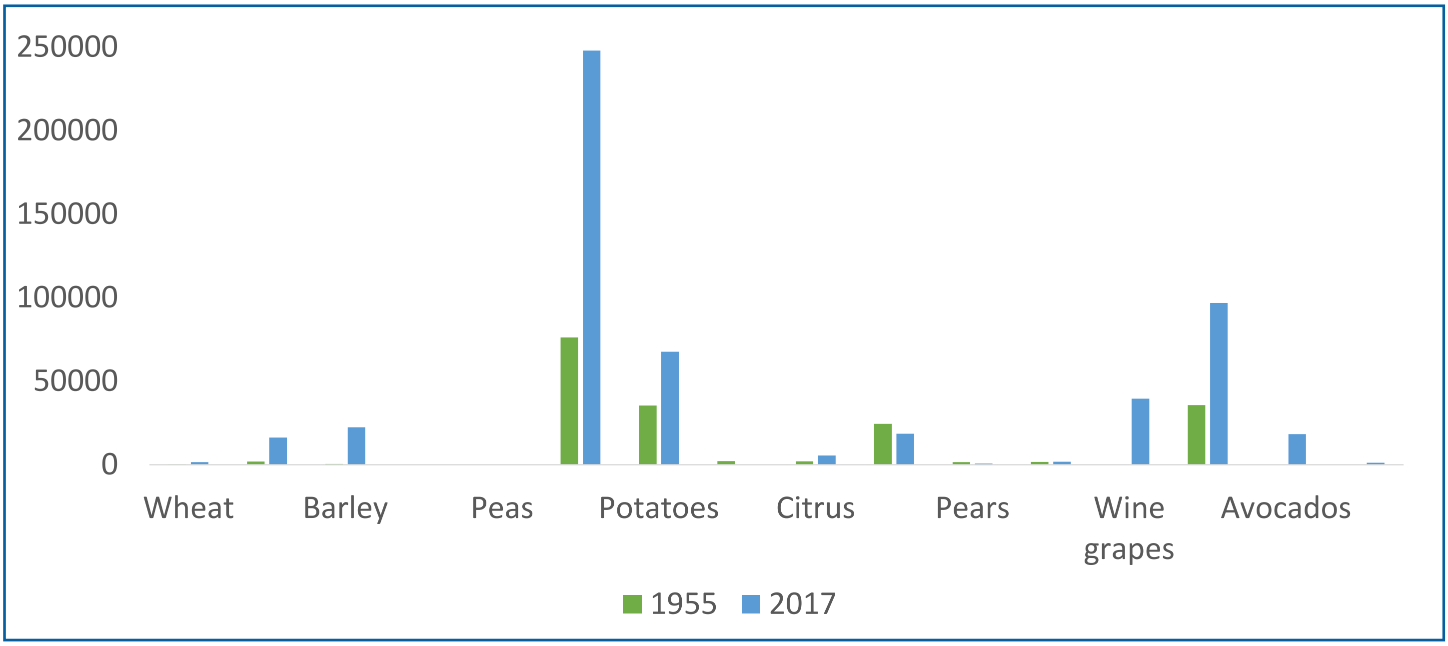

Figure 7.6: Agricultural commodities, Wellington region, 1955 2017.

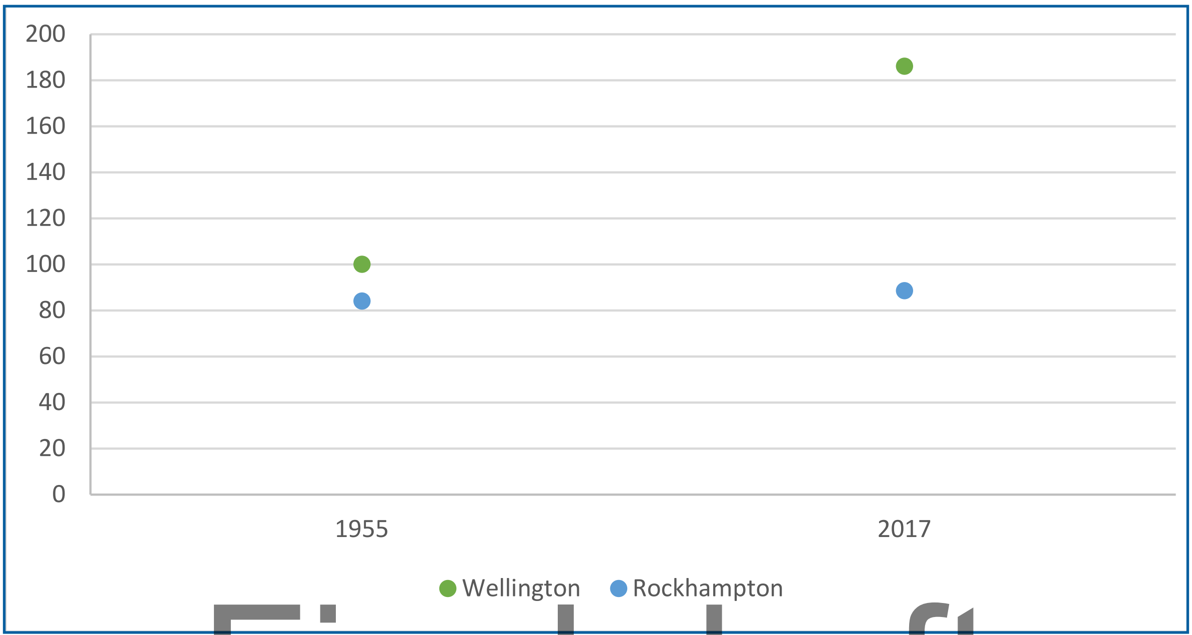

Figure 7.7: Agricultural productivity, Rockhampton and Wellington Region

7.4.4. Flow on impacts

The Wellington region has a significant sector that processes the agricultural product of the region. A detailed analysis of the jobs in the region shows that these are largely built on processing local minerals and local agriculture, as shown in Figure 7.8. ABS data shows considerable concentrations of workers:

- Undertaking meat processing
- Engaged in dairy, including milk, cheese and ice cream manufacture
- In bakeries, factory and otherwise
- In brewing, distilling and the manufacture of cordials and juice
- In the production of wine.

As such, the agriculture driven by the Wellington Dam can be seen to have made a significant impact on local flow on industries, supporting a diverse manufacturing sector.

7.4.5. Outcomes of consultations

This dam was constructed in the 1930s primarily as a jobs creation strategy following the Great Depression with an objective of providing water security to broad acre crops, primarily wheat. Over the last 70 years, the function of the dam and the market it has serviced has changed and broadened significantly.

Discussions with Harvey Water confirmed that while increasing salinity levels rendered the stored water unsuitable for direct human consumption, it was still viable for agricultural production. It was apparent that the increased salinity was negatively impacting the production rate for agriculture in the area and hence the recent project aimed at reducing salinity. It was interesting to note that the potential increase in agricultural production resulting from the decrease in salinity, demonstrated benefits sufficiently strong to carry a Business Case in favour of the works, but also to query whether government intervention was necessary or whether it could be delivered through the private sector. That strong CBA could be achieved as the sunk cost of the original dam was not considered in the analysis.

Harvey Water also identified that synergies existed across the co-located agricultural and mining sectors in the form of low- cost heating from the mining sector enabling green- house production of high value crops. Both sectors were possible because of the water security afforded by the dam.

A further benefit of the Wellington Dam was that water could be directed from this dam to the nearby Harris Reservoir, which boosted the local region's agricultural output beyond what it could have achieved as a standalone piece of infrastructure.

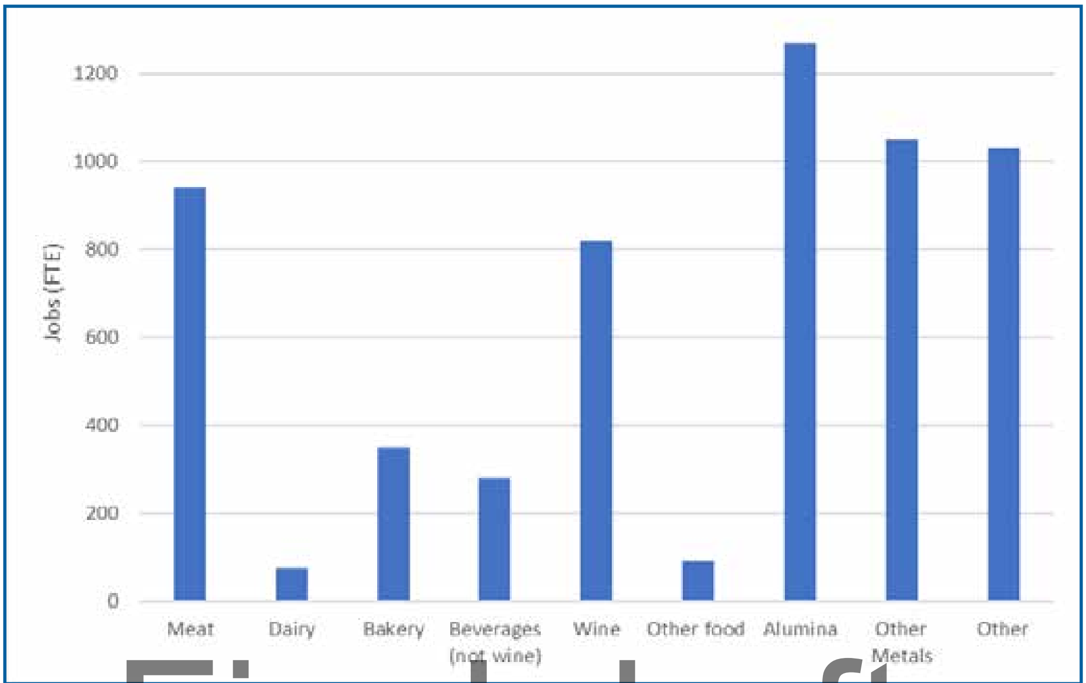

Figure 7.8: Manufacturing jobs, Wellington Region, 2016

7.5. Taxation

The taxation contribution of the irrigators is shown in Table 7.2 Federal Government revenue, 2016. Only Commonwealth taxes are considered in the assessment. Labour income tax, based on an average annual salary of $55,000 for agricultural labour is around $17m per annum. Low levels of profitability in Australian agriculture (around 3%) yield $8m in annual taxes on business income. This is additional annual taxation revenue, not the whole revenue for the region. This is likely understated, as profitability with and without irrigatiors is likely different.

Table 7.2 **Federal Government revenue, 2016**

Tax Description	2016
Labour income tax	$17m
Business income tax	$8m
Total	$25m

7.6. Case Study 2 Conclusion:

What would an ex-ante CBA have made?
traditional CBA undertaken in either 1930 or in the 1950s (at the time of augmentation) would have likely foreseen some increased agricultural productivity of the region due to the augmentation of the dam. The existing diversity of the region may have led to the prediction that either a shift towards higher value crops (e.g. more apples and less beef) or an intensification of the existing mix. Much, however, would have been missed or understated.

- There has been a shift towards crops that were not even considered before the water intervention. As tastes have changed in the community, and crops such as olives and avocados become more desirable, the ability to grow these in a water rich region is valuable and has been capitalised on in the Wellington region. This goes to the heart of inability to forecast trends in markets and production advances. It would have also been missed that short-term life, high value crops could be exported to international markets at premium prices, earning revenue for both the producers and various levels of government.
- The concentration of wine, olives and cheese has led to the development of a tourism industry, that would not typically have been forecast as the result of a dam intervention. It is not a traditional tourist industry based around water activities at the dam site.
- There has been development of local downstream processing and manufacturing clusters, across a broad spectrum of food and beverage. This employs more than a third of the manufacturing workers in the region.
- It would not have foreseen synergies between seemingly non-related industries that gave rise to new sections of production in the form of green-house agriculture.
- Given the level of engineering and technology at the time, it would not have foreseen the ability to 'share' water between nearby dams to provide broader water security than the immediate region of each dam.

Even a forecast for a CBA 30 years ago would have likely missed or understated most of the market trends and opportunities that actually arose.

8.0 CASE STUDY

COPETON DAM

8.1. Copeton Dam, History and uses

Completed in 1976, the Copeton Dam was constructed to improve agricultural production in the Gwydir Valley by increasing water flow (refer Figure 8.1). The dam is located on the NSW Northern Tablelands approximately 570km north of Sydney and 60km upstream of Bingara on the Gwydir River. Beyond agricultural irrigation the dam is used to supply water to Moree, Inverell and other surrounding towns, for recreation, environmental flows and flood control. In 2003 an additional spillway was constructed east of the dam wall. The 250m wide and 11m deep fuse plug spillway is used to control the flow of extreme floodwaters around the dam.

The dam is capable of generating 21 megawatts of hydroelectric power when water is released for summer irrigation, environmental flows and flood control. Copeton Dam controls the supply of water to users along the Gwydir River, Carole Creek, Moomin Creek and Mehi River and is the main irrigation storage facility in the Gwydir catchment. Parameters for the dam are provided in Table 8.1.

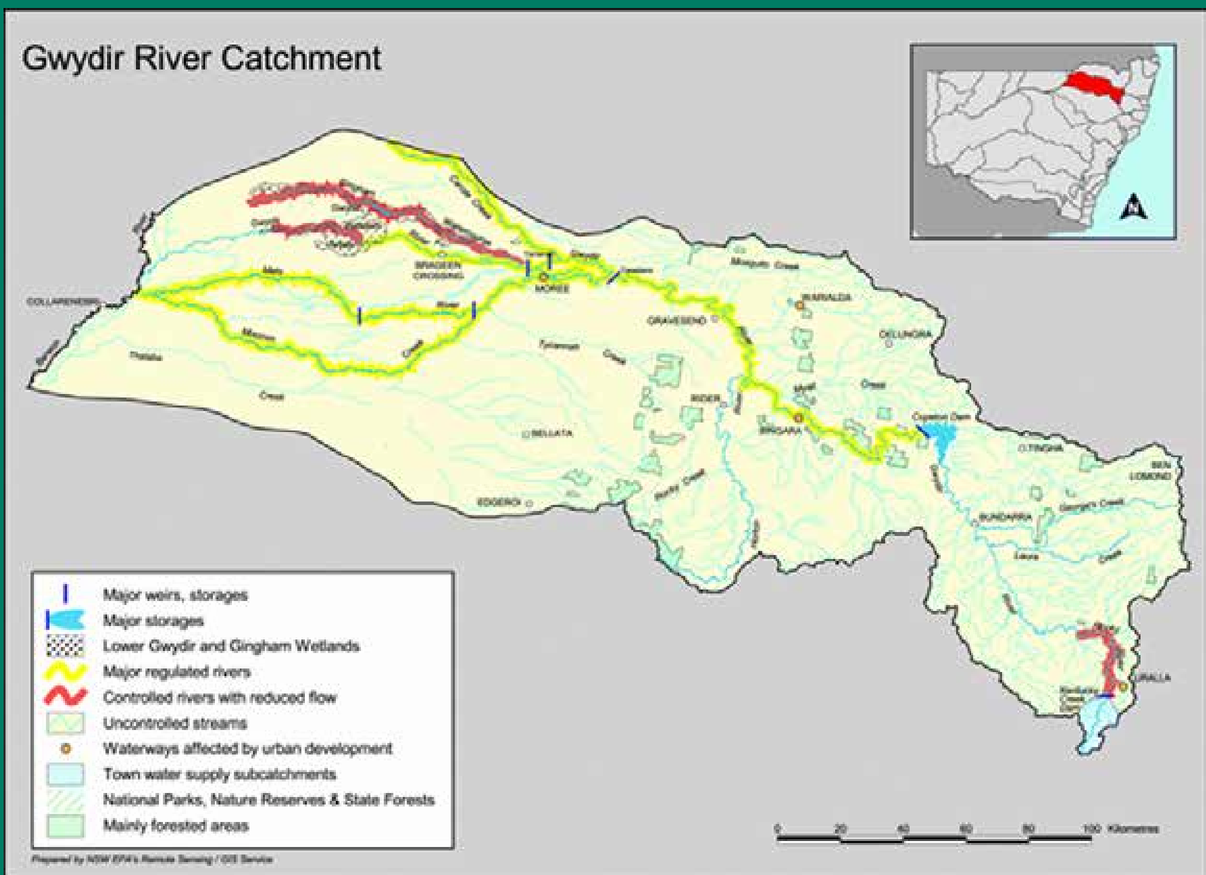

Figure 8.1: Gwydir River Catchment (Source: environment.nsw.gov.au)

Table 8.1: Copeton Dam specifications

Description	Specification
Dam type	Clay core and rock fill dam
FSL	560.43 m
Dam height	113 m
Dam length	1,484 m
Historical recorded storage (as at 19/09/2012)	Max: 7,932 ML – Jan '14 Min: 0 ML – Jul '11
Spillway type	Gate controlled concrete chute spillway
Spillway capacity	1,280,00 ML

8.2. Copeton Dam features

8.2.1. Water Licensing

The Gwydir Regulated Water Source licenses occur below the Copeton Dam and along the length of the river. Water access licensing requirements determine what share of the 718,000ML of regulated entitlements is dispersed. The accounting system, maintained by the NSW Government, helps to ensures a surplus account. The irrigation is controlled, through its designation of a regulated river, by the NSW Water Management Act 2000.

8.2.2. Hydroelectricity

AGL operates the 21MW hydro power station at Copeton Dam. Power can only be generated once water is released from the dam. Copeton has an average annual output of 35 GWh and the hydro electricity generated from Copeton is used to help meet peak customer demand.

8.2.3. Recreational

Copeton Dam hosts both recreational and accommodation facilities. Recreation activities are centered around the natural environment and include water sports, fishing and bushwalking. The accommodation consists of a holiday park which operates on Crown Land.

8.3. Economic Overview

8.3.1. Population

The population growth relative to Rockhampton since the mid-1950s is shown in Table 8.2. The region has experienced significant growth over the period since the Dam was largely finalised, relative to Rockhampton, where no comparable intervention occurred. Reliable population data for the period when the dam was commissioned has been difficult to obtain.

Table 8.2: Population comparison

Region	1954*	2019	CAGR
Copeton Dam	14,890	39,232	1.8%
Rockhampton	72,190	110,213	0.7%

*This year modelled due to low data quality in the 1970s

8.3.2. Industrial base

In comparison to Rockhampton, employment in the Copeton region shows a strong specialisation in the Agriculture, Forestry and Fishing industry sector. Both the Agriculture, Forestry and Fishing sector (refer Figure 8.2) and Manufacturing Industries account for a greater share of local employment in the Copeton region than in the base case, Rockhampton. Owing to its agriculturally based economy, the region supports a significantly smaller proportion of employment in the Financial and Insurance and Information, Media and Telecommunications industries. While Rockhampton and the region around the Copeton Dam are both known as beef regions, the region around Copeton Dam is an example of a very specialised agricultural economy, where more than 20% of the workforce are engaged in farming, more than 6 times the share for Rockhampton and almost 10 times the share for NSW.

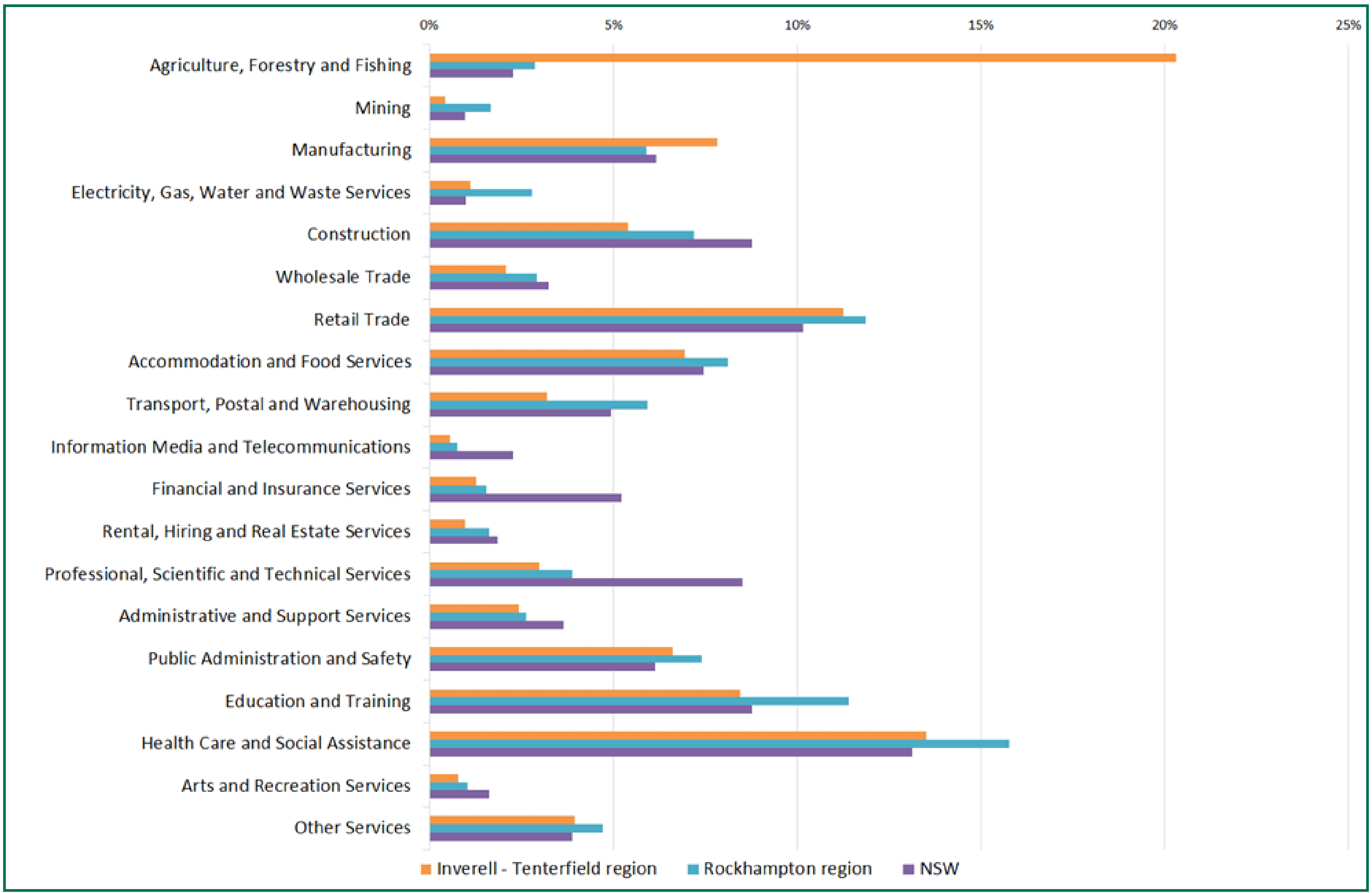

Figure 8.2: Comparison of employment by industry, Copeton (Inverell - Tenterfield region, Rockhampton region and NSW, 2017.

8.4. Agriculture

8.4.1. Agriculture c. 1965

As shown in Figure 8.3, the region prior to the water investment was predominantly geared towards the production of beef, at a relatively low intensity. There was a small tobacco industry, along with some citrus, wheat and sheep.

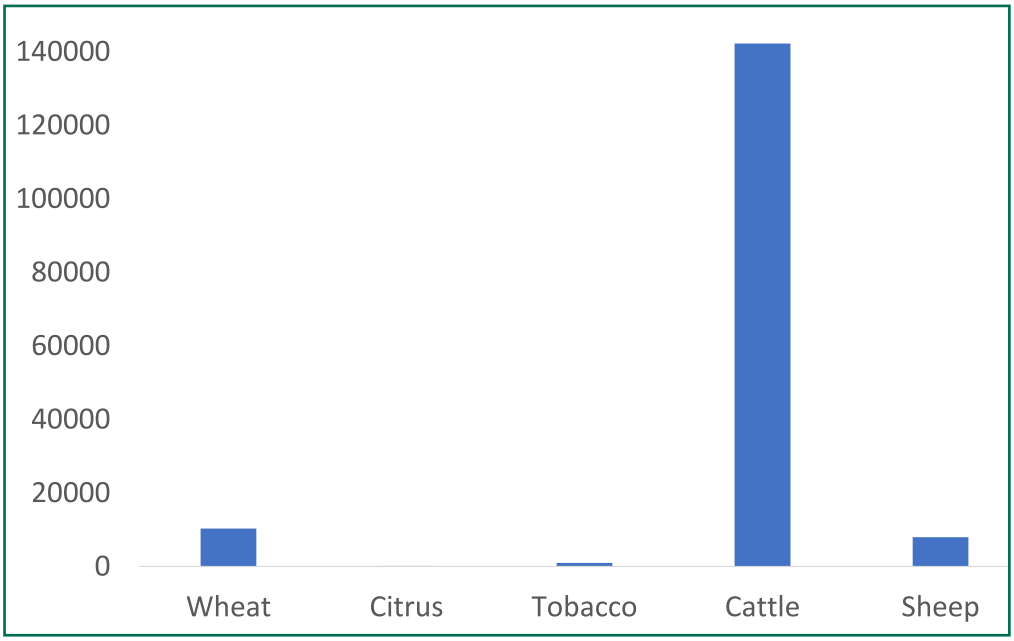

Figure 8.3: Agricultural commodities, Copeton region, 1965

8.4.2. Agriculture now

Figure 8.4 provides the comparison of agricultural production from 1965 and 2017. There has been an intensification of the region's predominant industry, beef cattle, which has increased by a factor of 3. At the same time, grain production has increased significantly. Tobacco, which was low scale, has disappeared and been supplanted by a large irrigated cotton industry. The region is also a significant producer of tomatoes.

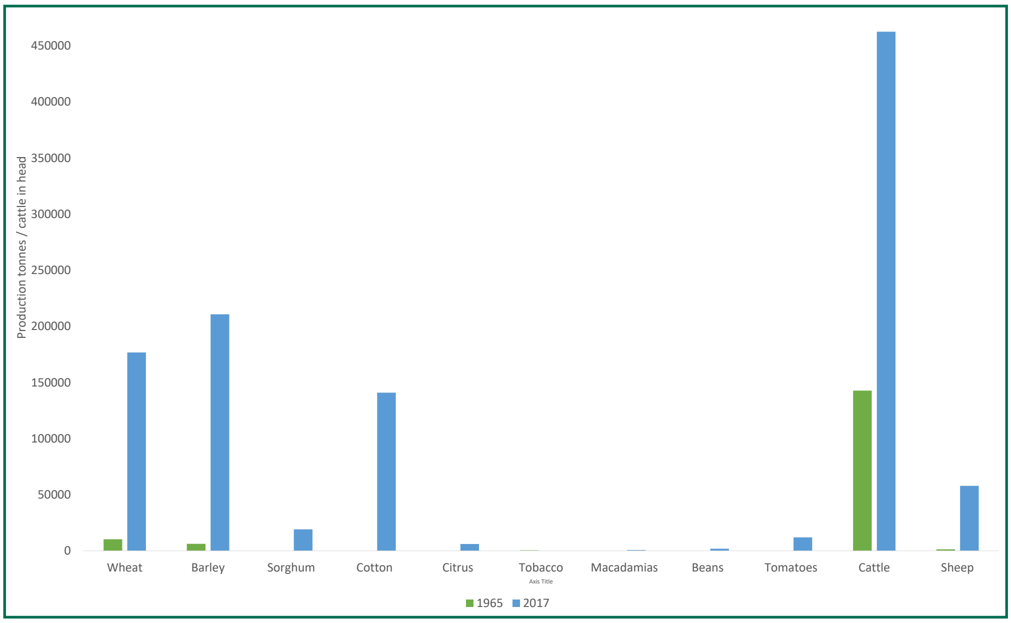

Figure 8.4 Agricultural commodities, Copeton region, 1965, 2017

8.4.3. Agricultural productivity

Agricultural productivity, as measured by product mix and shown in Figure 8.5, has grown significantly in the Copeton region, increasing by around 60 per cent over the period since 1965. This is in contrast to Rockhampton, a region that began the period with a very similar agricultural base, whose productivity measured in this way was largely constant.

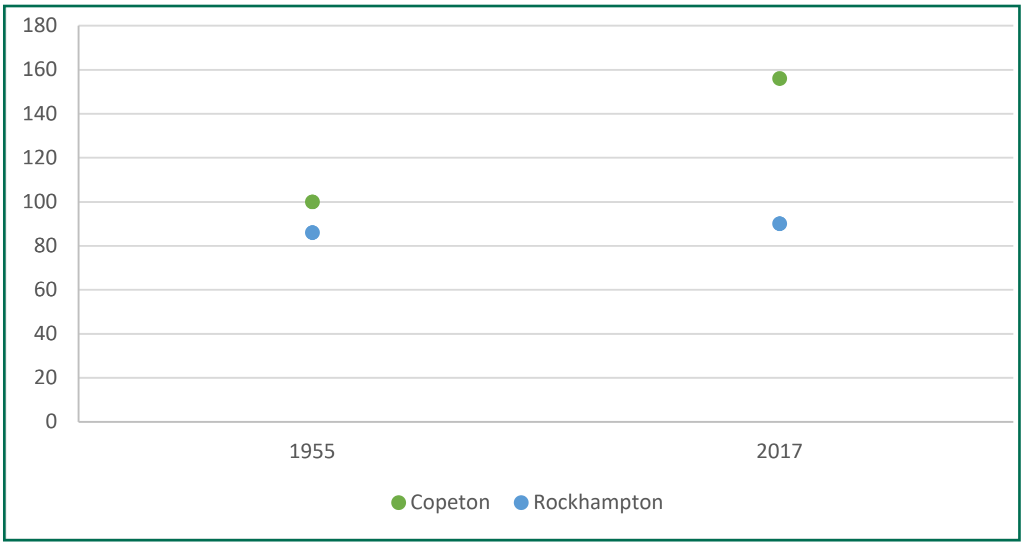

Figure 8.5: Comparison of Agricultural Productivity between Copeton Region and Rockhampton, 1965 and 2017.

8.5. Flow on impacts - manufacturing

The region's agricultural industry is mature and has enabled a local manufacturing industry to develop by providing processing and other services which are downstream of the broader agricultural supply chain. Manufacturing is 'overweight' as an employer in the region, relative to the state average, and chief amongst these manufacturing employers is the meat and meat processing sector, accounting for 61% of all manufacturing jobs.

Meat manufacturing dominates the local manufacturing industry because it has developed around the region's established grazing industry, particularly cattle. Meat processing has emerged due to the significant concentration of the cattle industry in the Copeton region which is a direct result of irrigation water. Other manufacturing sectors associated with the local agricultural industry include Printing and Printing Support Services, which are an auxiliary service in the packaging of meat products.

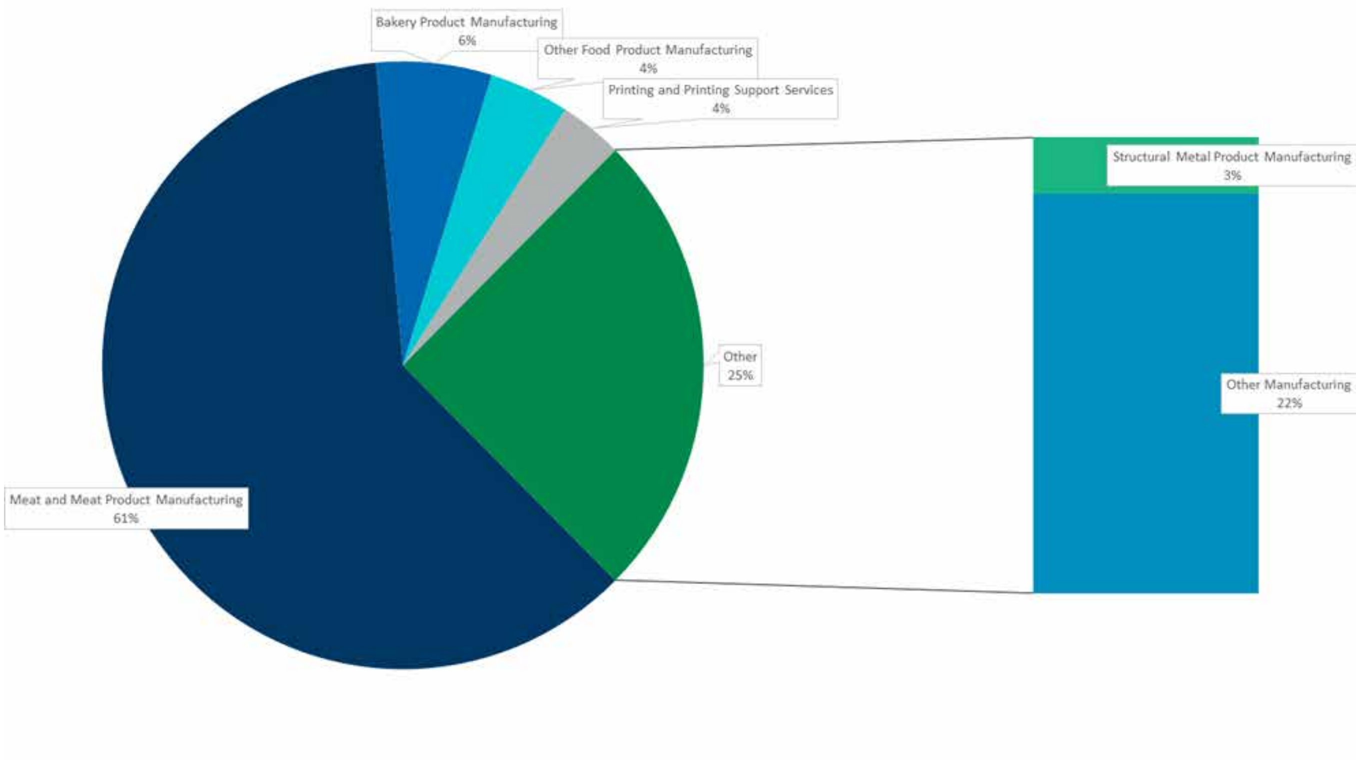

Figure 8.6: Manufacturing breakdown Copeton (2017)

8.6. Taxation

The Commonwealth taxation contribution of the irrigators is shown in Table 8.3. Labour income tax, based on the growth in employment and an average annual salary of $55,000 for agricultural labour is around $11m per annum. Low levels of agricultural profitability, Australia wide (around 3%) yield $12m in annual taxes on business income.

Table 8.3: Federal Government tax revenue, 2016

Tax Description	2016
Labour income tax	$11m
Business income tax	$12m
Total	$23m

8.7. Case Study 3 Conclusion

What would a ex-ante CBA have missed? A CBA undertaken in the 1960's would have predicted that the region would benefit, as it did from access to irrigation. A conventional CBA may, foresee that access to water would have supported the emergence of a cotton industry, as occurred.

The rapid growth of the cattle industry, and downstream processing would have been largely missed. Irrigation, and water security have allowed higher carrying capacity, and significantly higher head counts in the region. Further, the region's cattle industry has become so large, that manufacturing has sprung up around it, this would not be considered in a conventional CBA under the prevailing guidelines.

9.0 CASE STUDY

SAN LUIS DAM

9.1. San Luis Dam, History and uses

The San Luis Dam is approximately 75 km south-east of San Jose, located on the San Luis Creek in Merced County, California USA (refer Figure 9.1). It is an earth-filled dam with a 380-foot (116m) high compact embankment and a total storage capacity of 2.5 million cubic metres (2.5GL).

The San Luis Dam, built between 1963 and 1967, supplements the total supply of irrigated water to one-million acres of agricultural land in the San Joaquin Valley, while also providing water for urban and environmental uses.

Figure 9.1: San Luis Reservoir (Source: mavensnotebook.com

The San Luis Dam is an important piece of water storage infrastructure. Both the California State and Federal Governments utilise it as a storage facility and are entitled to 55% and 45% of its water, respectively. It supplies irrigated water to several San Joaquin Valley farms through the Federal Central Valley Project (CVP). The CVP stores and manages water through a network of twenty dams and reservoirs which deliver water to California's Central Valley.

The San Luis Dam also forms part of the California State Water Project (SWP), a drinking water management system administered by the State of California. The San Luis Dam, through the SWP, provides drinking water to many cities in Southern California, including Los Angeles. The San Luis Dam was built to augment the CVP and SWP water networks by increasing the water storage capacity. Dam parameters are provided in Table 9.1.

Table 9.1: San Luis Dam feature

Description	Specification
Crest Elevation	168.9m
Structural Height	116.4m
Hydraulic Height (Normal Operating Depth at Dam)	92.4m
Crest Length	5669.3m
Top of Active Conservation Pool (Elevation)	165.8m
Spillway Crest Elevation	165.8m
Top of Dead Storage Pool (Elevation)	83.2m
Streambed at Dam Axis	73.5m

The San Luis Dam, through the CVP and SWP water networks, supply the Westlands Water District (Westlands) with irrigated water. The Westlands is the largest agricultural water district in the USA and spans 600,000 acres across Fresno County, Kings County and the San Joaquin Valley . Construction of the San Luis Canal was completed in 1968 and has supplied water, crucial to the Westlands agricultural development. The region has significant water for a range of crops, including livestock and poultry, fruits and nuts, vegetables and grapes.

9.2. San Luis Dam Features

9.2.1. Hydroelectricity

The San Luis Dam has the capacity to generate hydroelectricity. The power plant generates power by releasing water through pump-turbines, the water flows from O'Neill forebays into the San Luis reservoir. The power plant has an installed capacity of 424 MW and stores it via pumping-generating.

9.2.2. Recreation

The San Luis Reservoir has three lakes which can host a range of recreational activities. The Reservoir is used for boating, sailing and angling. There are also facilities available for camping and picnicking.

9.3. Economic Overview

9.3.1. Population

The population growth relative to Rockhampton since the 1950s is shown in Table 9.2. The region has grown rapidly in population since the dam was built, with a compound annual growth rate almost 3 times larger than Rockhampton, where no comparable intervention occurred.

Table 9.2: Population comparison

Region	1954*	2019	CAGR
San Luis Dam	69,396	277,680	2.0%
Rockhampton	72,190	110,213	0.7%

*1950 for San Luis Dam region, 1954 for Rockhampton

9.3.2. Industrial Base

The industrial structure of Merced County is dominated by agriculture. Employment in this sector is almost 35,000 which is around 35% of the workforce of the county. Manufacturing, which is almost entirely food and wine processing accounts for another 9,000 individuals. There is also a reasonable proportion of labour employed in the trade and transport sectors, education and health sectors and in government. The 'leisure' sector is also an important contributor, employing around 6% of the workforce. Approximately 50% of the employment in this County is a direct or associated effect of the Dam.

9.4. Agriculture then and now

The agricultural profile of Merced County, where the San Luis Dam is located, has been influenced by its access to irrigated water. Figure 9.2 also indicates the movement away from lower value broad-acre agricultural production towards higher- value crops. In 1959, before the dam was constructed, Field Crops dominated agricultural output, accounting for 33% of the year's gross crop value. The County produced 368,007 tonnes of Alfalfa Hay in 1959, its largest field crop that year.

Alfalfa Hay is a very water efficient crop . Its roots stretch between 1-2m into the ground, allowing it to access water from deep into the soil. As such, this crop made sense prior to the dam's construction. Alfalfa Hay was consistently produced in large quantities as far back as 1939, the earliest record for agricultural production in Merced County. Prior to the construction of the dam, low rainfall (around 275mm p.a.) made more diverse agriculture impossible.

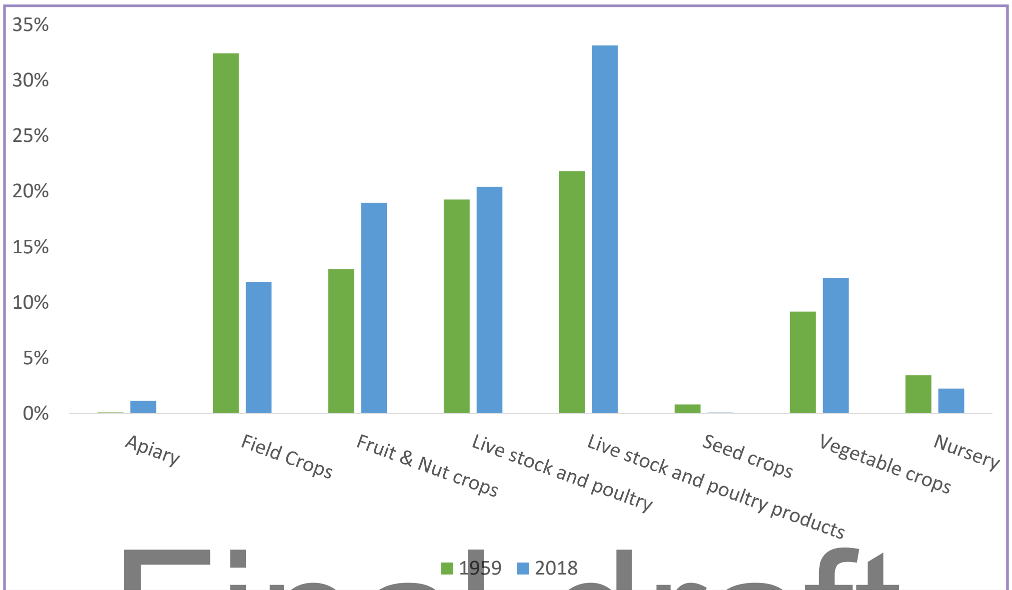

Figure 9.2: Crop share San Luis region, 1959, 2018

Since the dam construction Merced County has experienced a large increase in the agricultural production of fruit and nuts. Total almond production increased by more than 20 times between 1959 and 2018, with 174,593 tons of almond husks produced in 2018. Almond kernels were not accounted for in 1959 but in 2018, 91,410 tonnes were produced. Grapes for wine production also increased strongly up from 29,536 tonnes in 1959 to 129,956 tonnes 2018.

9.5. Flow on impacts

Food processing, using produce from the region is the most important flow on impact from the agricultural production generated by San Luis Dam. Data availability in the United States is not to the level that was available in the other case studies, however, there is evidence of a number of significant food production activities in the Merced County area as noted in Table 9.3.
The ability to commercially farm livestock has increased signficantly across cattle, sheep and poultry as shown in Figure 9.3.

Table 9.3: Merced County Food Production

Crop	Producer/Notes
Grapes	E & J Gallo, the world's largest family owned wine producer, with revenue of $5 billion/annum.
Poultry	Foster Farms, the world's largest poultry plant, with revenue over $2 billion/annum.
Frozen, Dried, Packaged and Vacuum packed fruits and vegetables	Dole – one of the largest food processing companies in the world with revenue greater than $4 billion/annum.
Milk/Cheese	A significant cluster of dairy producers, producing milk, cheese, powdered milk, condensed milk.
Nut processing	A significant cluster of almond, walnut, and pistachio processing firms.

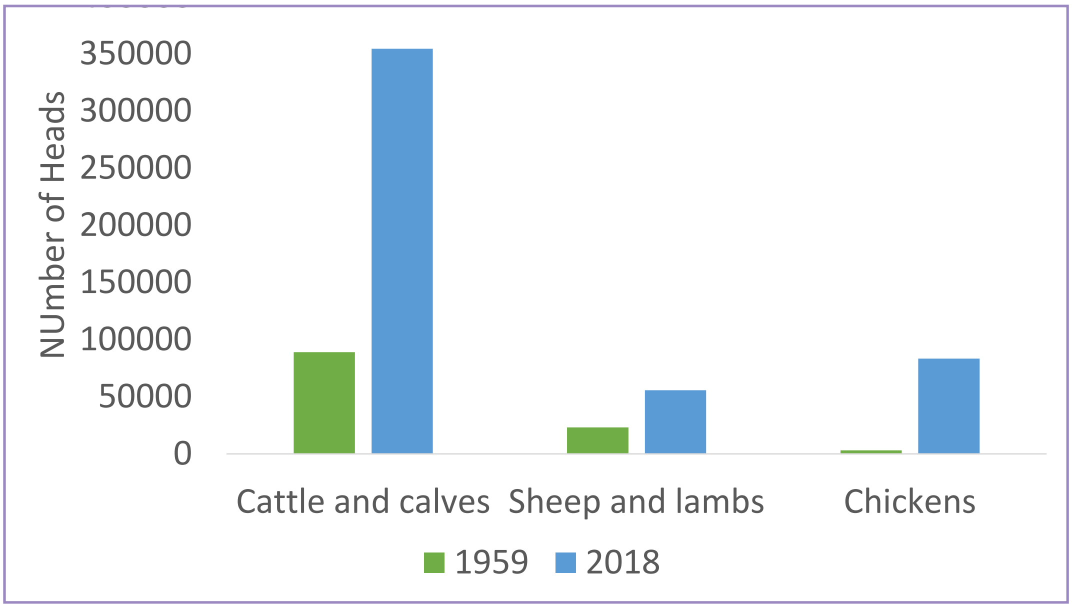

Figure 9.3: Livestock and Poultry counts, San Luis region, 1959, 2018.

As shown in Table 9.3, there are signficant flow on impacts, above and beyond those identified in other case studies.

- Grape growing in the region, which developed in the period since the construction of the dam has led to the emergence of a globally significant wine region, with the emergence of a wine cluster that includes a $5 billion/annum wine producer.
- The poultry farming in the region has spawned the world's largest poultry plant.
- The large scale, diverse production of fruits and vegetables has led to the development of a fruit and vegetable processing industry, led by a firm with more than $4 billion in annual revenue.
- There is also some evidence of a tourism impact of the dam, and of the wine and food produced in the region. Wine Tourism in California as a whole generated 23.6 million visits in 2019 and revenues of $7.2 billion. While the region immediately served by the dam is one of the lower profile wine regions (see Figure 9.4), there were over 300,000 visits to the region for 'wine tourism,' with revenues of over $80 million.

9.6. Case Study 4 Conclusion:

What would an ex-ante CBA miss? A CBA undertaken in the 1960's would have captured many of the benefits of the dam, but would have missed a number of critical areas. While it would be forecast that the area would shift to a higher productivity of agricultural product, as noted, due to the low rainfall (around 275mm), cropping of the type and density that currently exists would be beyond what could have been supported based on available information at the time. As such, a CBA would not be able to forecast these kinds of benefits. It is likely, however, that the sheer magnitude of the increase in agricultural production would be missed, as a forecast that this region would produce 8% of US agricultural output would be considered overly ambitious at the time of the study.

Further, the development of a significant food processing industry, that employs nearly as many individuals as the agricultural production itself, with global leaders across a range of crops, including wine, poultry and packaging would likely not have been captured by a CBA. In most cases, a CBA would be instructed not to forecast these levels of benefits, which would not occur in the absence of the water infrastructure for being beyond reasonable expectation at the time.

Finally, the emergence of a Tourism sector would not have been captured. In most dam case studies, even the direct recreational benefits are inadequately captured, let alone the emergence of a tourism industry, based around products produced as a result of the dam.

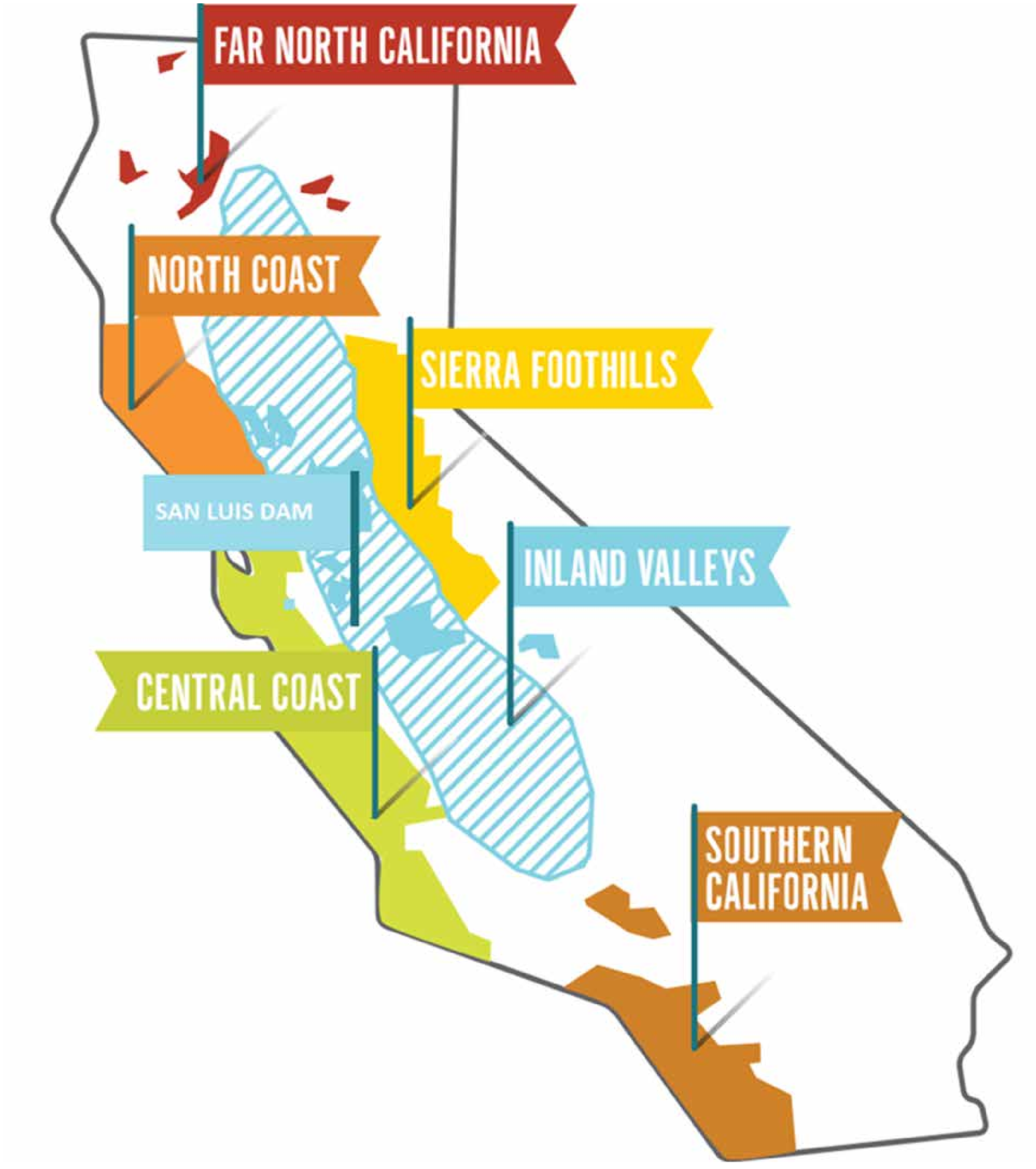

Figure 9.4: San Luis region, and California's v wine regions. (Source: discovercaliforniawines.com)

10.0 WHAT DO THE CASE STUDIES INDICATE

10.1. Water security providing flexibility and resilience

While the primary purpose of most dams remains unchanged from when the concept was conceived, the products produced from the security of water can change a number of times during the life of the dam and with that, the value of benefits derived from the infrastructure. Over the study period, particularly in the case of Tinaroo Dam (one of the longest established dams), there has been an evolving use of water for producing higher value agricultural products. The nature of agricultural produce, how that produce could be transported to market and what/where those markets are located have altered dramatically in the cases of Tinaroo Dam, Wellington Dam and San Luis Dam. This has been supported by other infrastructure developed in or adjacent the regions, which was identified in each of the Case Studies. In most cases, the level of development was beyond what would or could have been accepted at the time of the original Business Case (particularly the San Luis Dam). In all cases, the fundamental requirement for the agricultural production has been security of water.

10.2. The role of dams in supply chains

The understanding of supply chain linkages, the broader world economy and quality of produce from Australia has created opportunities that would not have been considered reasonable or creditable 60 or even 30 years ago. They represent a maturation in the strategic planning of assets and how to use them to maximise utility.

Infrastructure that supports agricultural production around dams can be augmented to provide additional capacity for agricultural production in the region at a lesser cost than providing that supporting infrastructure in a new location. It therefore seems prudent to co-locate dams where risks associated with dams can be mitigated. This would include siting the dams in different catchments to offset risks due to local climatic changes. This has proven successful in the Wellington Dam being used to augment the Harrison Dam and the dams around San Luis Dam allowing surrounding industries to draw on the total water security on the region.

The Wellington Dam and San Luis Dam case studies indicate that where dams can be co located in a regional context; where allied infrastructure has already been developed; the second dam could show a reduced timeline for recognising benefits and custom its business case. The regional approach can enable increased community benefits and synergies. This is the equivalent of seeking to create an integrated supply chain from the outset, rather than just a single link in a chain.

10.3 Ex-poste reviews

The current process for approving dams using a Business Case has been in place for approximately 10 -15 years in various formats. CBA Analysis has been used for assessing projects for longer, but the current level of rigour, including P50 and P90 estimates has only been around for 20-30 years. Over that period, there has been little published data on ex-poste reviews of dams to determine the accuracy of Business Case assumptions and financials. While IA advocates for a review at 50 years for long-life assets such as dams, there is no available data that indicates that such a review has been undertaken to assess the results.

It is considered unlikely that many governments or government departments would consider the cost of such a study warranted given the demand for funding for Project Assessments for proposed projects. This negates the opportunity to learn about longer term benefits that can be attributed to long-life infrastructure such as dams and accordingly, to improve the decision-making process. This review process is included in CBA Guidelines because it is acknowledged that the lag between outgoing costs associated with the infrastructure and the benefits to be derived can occur over decades.

The project assessment framework recommends potentially deferring decisions to allow more time to refine what could be possible for each dam site. The very nature of lead time for dam projects means that it is extending out the period before benefits can be generated and the nature of the benefits could be changing or lost (due to other locations capturing market share).

It was apparent in some of the case studies that further major infrastructure investment in the region could be proven up, because the sunk cost of the original infrastructure was not considered in the later Business Case, however the benefits flowing from the original investment were contributing to the CBA either directly or indirectly.

10.4. Cost Recovery Policy for Dams

One of the objectives of the National Water Initiative pricing principles (2004) is to provide *"principles for recovery of capital expenditure to provide guidance to water service providers on asset valuation and cost recovery for urban and rural capital expenditure".*

This is further defined as commitments to water pricing

"to promote efficient economically efficient and sustainable use of water infrastructure assets … to give effect to the principle of user-pays and achieve pricing transparency in respect of water storage and delivery in irrigation systems and cost recovery for water planning and management; and avoid perverse and unintended pricing outcomes".

The Principles for recovery of capital expenditure are complex and can vary upon assumptions made about where to draw a 'line in the sand' pertaining to past investment decisions. It is acknowledged that this process is seeking an equitable outcome for tax payers by targeting a user-pays system.

Its practice ties into the process for determining the price point for water in business cases for proposed dams. For new assets, *"charges will be set to achieve full cost recovery of capital expenditures".*

The position in Queensland appears different based on the Department of Agriculture and Fisheries (DAF) Qld Agricultural Snapshot 2018 which noted

"In principle, water users are charged for all operating costs (including depreciation) for the supply of water. The Queensland Government does not require any return on its capital invested; water infrastructure is considered an important economic development service to the Queensland community. Many irrigators pay lower prices than this, supported by a community service obligation payment. These prices are phasing upwards to full cost recovery, but price paths have been frozen until 2019 to support transfer of some of SunWater's irrigation channel schemes to local ownership."

10.5. Sovereign Security

Recent changes in global situations such as international pandemics and changes in policies by foreign governments have acutely raised awareness of the need for providing for a strong domestic capacity and national security in terms of food and pharmaceutical production. It has been an alarm to reconsider what is 'business as usual'. In Australia, considering expected climate changes, providing security for food and pharmaceutical production means providing water security, which in turn means providing for water storage. Given the long lead times for achieving water storage, particularly in the form of dams, there is no ability to 'pivot' as a rapid reaction
to a developing situation. It requires a proactive approach. However, having a dam in place, can facilitate more rapid changes in downstream and associated infrastructure and business activities. The case studies have shown how important water security is to agriculture productivity.

The QCA Report noted

"Where legislation or government directions specify a particular equity or other social goals, reference to economic efficiency impacts would provide an estimate of the cost of pursuing the broader public interest matters. That is, economic efficiency provides a reference point when other goals are considered".

It is suggested that the approach to water security for the nation and allocation of funding for water security should be considered in a similar way to that of allocation of budget for Defence. Conventional approaches for business cases would be focused on comparisons of options for providing capability rather than competing for funding against the wider infrastructure demand. In this way, security and capacity needs would be guaranteed and funding allocation would be focused on achieving the greatest value for investment dollar. This would support the notion that cost recovery could be considered along the 'beneficiary pays' principle while still providing for a form of direct recovery through a water charge.

10.6. What improvements could be made?

10.6.1 Sole Project Focus

The current process for analysis focuses on the individual project and its direct costs and attributable benefits. This fails to recognise the inter-connectiveness of the primary infrastructure (the dam) with the surrounding community(s) and how that infrastructure becomes an anchor point for regional development. A strategic overview for the region, incorporating a co-operative model would help to develop an understanding of how a dam would act as a driver to support direct and indirect markets and how synergies could be exploited between the dam and other non-related infrastructure.

10.6.2 Disruption in the Market

The longer-term dam sites have shown an evolution of the produce they support and markets they service. These changes are largely due to improved technology and market frameworks. The rate of change is increasing, as it is being seen in numerous industries and markets. Development will tend to happen faster than it has historically, and 'disruption' will play a broader role in 'what is possible'. This rate of change does not fit within the current conventional assessment guidelines. The current long lead times for development of dams do not allow for them to respond quickly to be a part of a solution that is evolving quickly, if it is not already in play.

11.1. Cost Recovery in Business Cases

The market sounding component of the business case is aimed at identifying the target purchasers of water from the proposed dam and their inclination towards a price point for the purchase of water. Based on a number of studies within Australia, urban water consumption demands appears to be relatively inelastic. However, Bulk Water appears to have a significant price elasticity as espoused by potential water users. This might be in response to trying to 'downplay expectations as to what price could be charged' or alternatively based on what the water user can understand as the price point for their products in the current market.

Regardless, attempts through a Business Case to match a water charge based on recovery of either the full capital cost of the water infrastructure or even the operating costs, will likely lead to a proposed cost that the market would indicate it cannot accept – hence undermining support for a positive BCA in a business case for dams.

11.2. Alternatives Cost Recovery models

The conventional approach to cost recovery adopted for Business Cases is the 'User Pays' model, where those obtaining a direct benefit from the service are charged for that service such that the provider can recover up to 100% of costs. In the case of dams, there are various types of uses for the water and cost recovery would be based around allocations to the various sectors (e.g. irrigation verses power generation verses environmental flows) and costs associated with those allocations.

The Queensland Competition Authority in its "SEQ Retail Water Long-Term Regulatory Framework – Pricing Principles – Part C (September 2014) noted that

"The 'beneficiary pays principle' may also be considered in determining who should pay for a particular service. Beneficiaries may include individuals that are not direct users or customers."

What these case studies indicate is that the economic benefit of the dams is spread more broadly than just the immediate water users. In pursuing a 'user pays' approach to capital and operational cost recovery, it is potentially understating the broader group of beneficiaries and trying to burden those directly using the water.

In the case studies, it indicates that the broader aggregation of non-direct users or customers that achieve some benefit from the asset can be at a regional, state or federal level. Given that the beneficiaries are so broad, there should be a cost component of the infrastructure that the State and Federal Governments accept as the mechanism for broadly dispersing the costs to beneficiaries.

12.0 CONCLUSIONS FROM CASE STUDIES

The case studies support previous arguments that dams have transformative impacts on agricultural regions.

DAMS PROVIDE RESILIENCE AND OFFER THE ABILITY TO PIVOT WHEN CIRCUMSTANCES CHANGE.

The tobacco crop, which was a feature of the region around Tinaroo provided a significant income for local farmers for decades. Following the shift in Australian regulatory policy away from domestic growing of tobacco, the irrigated farmland of the region was able to pivot towards other lucrative crops, including avocados.

The recent Covid-19 pandemic has reignited debate at a national level as to the need for Australia to be self-sufficient across a number of key markets including food production. Given the long lead times associated with dams, water security for food production cannot be pivoted quickly in response to critical or pending critical emergencies. It becomes a matter of national and state government strategic concern for safety and security in the broader public interest.

DAMS ALLOW GROWTH IN AGRICULTURAL PRODUCTIVITY EITHER THROUGH DIVERSIFICATION OF CROPS, AND/OR INTENSIFICATION OF CROPS.

The agricultural change in the region, relative to Rockhampton is shown in Figure 12.1. As shown, the San Luis region improved in both intensity and diversification of crop following the dam's construction, while others (e.g. Copeton) increased in one area predominantly.

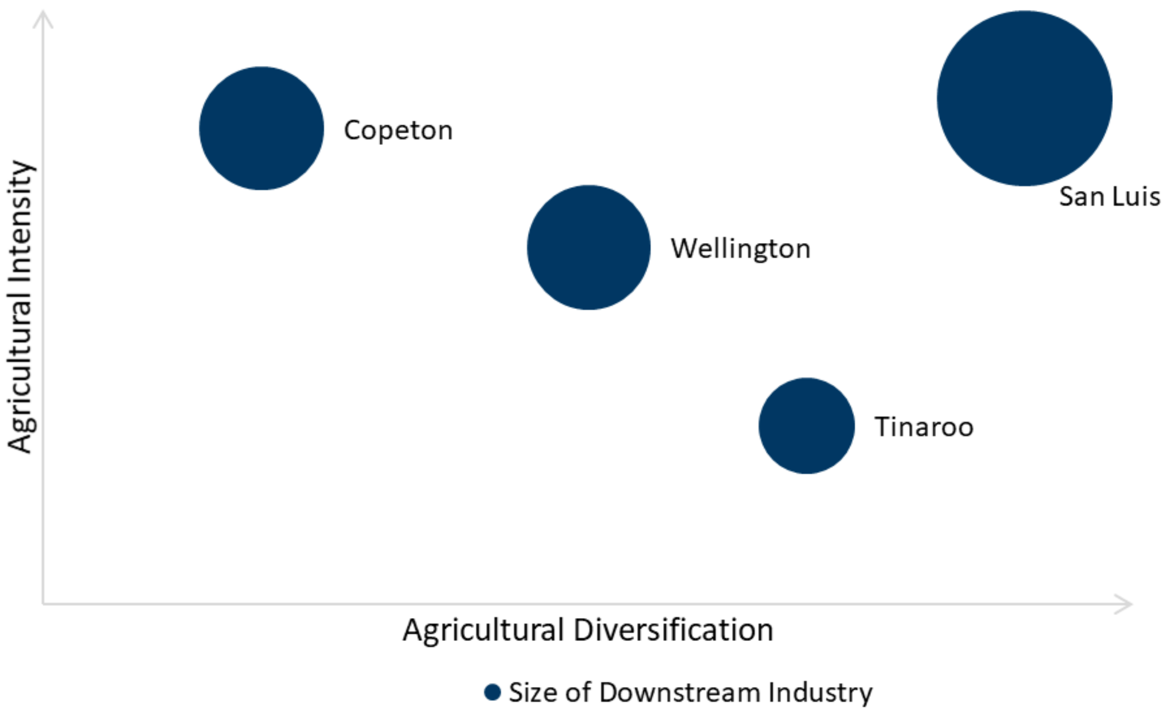

Figure 12.1: Agricultural change, relative to Rockhampton

The impact of this diversification/intensity is shown in Figure 12.2. The Australian regions that received a dam intervention have enjoyed significant growth in agricultural productivity, over a long period. Productivity has been relatively flat in Rockhampton, the base case.

The case studies showed that downstream industries evolved largely in the regions that received investments in water infrastructure.

- There was modest evidence of downstream processing in the Tinaroo region, through sugar processing.
- There was evidence of meat, dairy, grain and wine industries in the Wellington region.
- There was evidence of a beef 'hub' in Copeton, based on agricultural specialisation and intensification.
- There is evidence around the San Luis region of one of the world's premiere food processing regions, using irrigated crops from the region.

DAMS CAN GENERATE SIGNIFICANT DOWNSTREAM INDUSTRIES

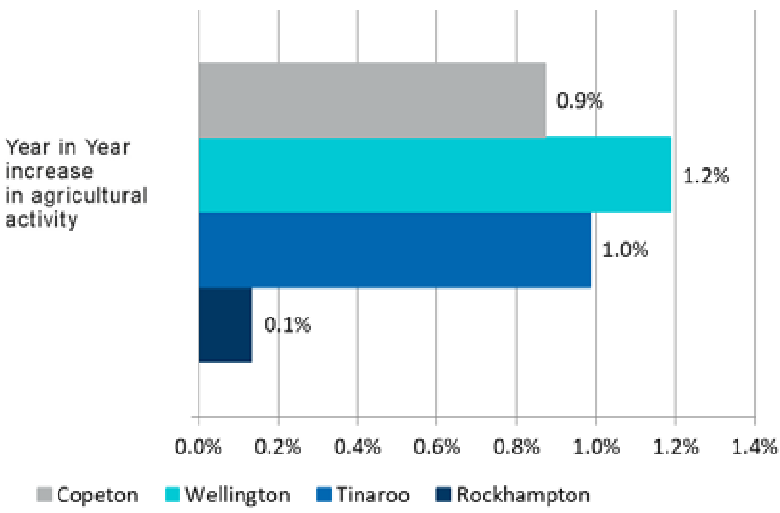

Figure 12.2 Change in agricultural productivity, CAGR

THE BENEFITS FROM DAMS EXTEND WELL OUTSIDE A 30 YEAR HORIZON

Each of the case studies demonstrated that the major regional economic benefits were occuring beyond the 30 year period from the dam commencing construction.

The benefits are typically of a nature that would have preluded them from being considered in a CBA if undertaken during their planning stages.

SOURCES

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- NRMMC (Natural Resources Management Ministerial Council) National Water Initiatives pricing principles, 2010
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- *International sources to be added*

PERSONAL CONVERSATIONS WITH

- Professor Allan Dale – Professor of Tropical Regional Development, JCU (Cairns)
- Mr Jeff Schrale – ANZ (Cairns)
- Mr Gary Murphy – MSF Sugar (Mareeba)
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