Tasmania's Bioeconomy: Employing the Seven Capitals to Sustain Innovative and Entrepreneurial Agrifood Value Chains

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Abstract Tasmania, Australia's southernmost and smallest island state, depends strongly on its bioeconomy. Currently the farm gate production of Tasmania's bioeconomy contributes around 7.4% to the overall Gross State Product (GSP). This figure is considerably higher than for Australia, where the bioeconomy contributes 2.5% to the overall Gross Domestic Product (GDP). Based on this measure, Tasmania's economy is more in line with the economies of Brazil (5.7%) or New Zealand (7.2%). It is estimated that Tasmania's bioeconomy currently contributes 16–20% of overall economic output, when taking into account the economic impact of related value chains that reach from agricultural suppliers to retailers. Government policy for economic growth in Tasmania aims to build up this sector over the following decades. To achieve the stated growth targets, technologies must be combined with business capabilities in order to effectively and efficiently commercialize innovation while maintaining sound environmental practices. A technology-driven, irrigation-led transformation is currently underway in the state, turning Tasmania's bioeconomy into a highly knowledge-intensive sector of the economy. To fully realize the economic, environmental and social potential of investment in irrigation infrastructure, there must be similar investments in research, knowledge creation, marketing, value chain innovations and capability development.

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1 Introduction

The bioeconomy[1] underpins all economic growth and development. Without the development of agriculture over 10,000 years ago, the astounding transformational shift in human behaviour that resulted in the creation of our civilisations would not have been possible. Agriculture provided the foundation on which other sectors of our economies could develop and grow. The efficiencies created by agriculture—the ability to reliably feed growing populations with fewer and fewer farmers—meant that no society has ever turned away from agricultural practices (Leith and Meinke 2013). This situation is true despite a range of undesirable impacts brought about by the agricultural revolution [see Harari's (2011) comments on 'history's biggest fraud']. As a consequence of these efficiencies, the current contribution of the bioeconomy to large and highly developed economies is only about 1 to 3% of their GDP (Table 1).

The relatively low contribution of bioeconomy to the GDPs of developed nations is a direct result of the efficiencies created by agriculture. Efficient food and fibre production permitted labour resources to be deployed elsewhere; this, in turn, created new industry sectors that now dwarf agriculture's economic value. In other words: while the *relative* economic importance of agriculture has diminished over time, the strategic importance of the bioeconomy to sustain nearly eight billion people remains. Moreover, a renewed interest in the agrifood sector has important, underlying drivers: a secure food supply; sustainable production of healthy and safe foods, together with other attributes demanded by consumers; and, increasingly, a place-based need for a social licence to operate (Prno and Slocombe 2012).

The economic, social and environmental impacts of agriculture shape our societies. Important debates about the role of agricultural systems are part of political discourse everywhere. Controversies about environmental degradation caused by agricultural production, versus agriculturists as stewards for our managed landscapes, are everyday occurrences. It is the strategic importance of agriculture as a pillar of our societies that requires particular attention in terms of policy support for research, development and education.

Here we focus on the island of Tasmania, where proportionally the bioeconomy plays the most important role of any Australian state. We argue that Tasmania is a microcosm offering insights for other societies and economies striving for higher innovation and entrepreneurial potential that leads to more profitable and sustainable production of bio-based products. Tasmania's bioeconomy is presented and interpreted in relation to its history, geography and current socio-economic

[1] Here we use the definition by the European Commission that defines the bioeconomy as *the sustainable production of renewable resources from land, fisheries and aquaculture environments and their conversion into food, feed, fibre bio-based products and bio-energy as well as the related public goods. The bioeconomy includes primary production, such as agriculture, forestry, fisheries and aquaculture, and industries using/processing biological resources, such as the food, pulp and paper industries, and parts of the chemical, biotechnological and energy industries.*

Table 1 Percent of agriculture as a contributor to gross domestic product (GDP) based on farm-gate value as well as current population numbers for a range of countries (Australian Bureau of Statistics 2013; World Bank 2015)

Country	% of GDP	Population (million)	As of
UK	0.7	64	2013
Germany	0.9	81	2013
Japan	1.2	127	2012
USA	1.3	316	2012
France	1.7	66	2013
Netherlands	2.0	17	2013
Australia	2.5	23	2013
Brazil	5.7	200	2013
New Zealand	7.2	4	2010
China	10.0	1357	2013
Fiji	12.2	>1	2013
Indonesia	14.4	250	2013
India	18.2	1252	2013
Vietnam	18.4	90	2013
Papua New Guinea	36.3	7	2012

status. Opportunities and challenges associated with agricultural intensification and new irrigation infrastructure are then explored in terms of the need to address the resource stress nexus. Contemporary innovation systems and value-chain theory are used to frame the way forward, with theories-of-change, capitals accounting and entrepreneurial thinking introduced as tools to design and implement effective interventions and innovation platforms.

2 Wheels Within Wheels: Tasmania's Bioeconomy Within an Australian Context

Australia's agricultural farm gate production contributes about 2.5% to the annual GDP (Table 1; Australian Bureau of Statistics 2013; World Bank 2015). This contribution increases to around 12% or AUD$155 billion when accounting for the value-adding processes of food, fibre and other bio-based products. The value of all economic activities that support farm production includes farm inputs; food manufacturing; transport and logistics; wholesaling and retailing; and the food service sector (National Farmers Federation 2015). The farm gate contribution of 2.5% to Australia's GDP is at the higher end for a fully developed economy, indicating the importance of renewable, primary production for Australia's bioeconomy.

Australian farmers are amongst the most efficient agricultural producers in the world. Agriculture in Australia is a knowledge-intensive sector, characterised by a high degree of mechanisation, and increasingly, automation as a result of high labour costs and often extensive landholdings. These are consequences of Australia's

Table 2 Economic snapshot of the bioeconomy's contribution to each Australian state and territory, and Australia as a whole; 2013 data: Gross State Product (GSP), GSP per person, farm gate value of the bioeconomy (Australian Bureau of Statistics 2013)

	GSP ($ million)	GSP per person	Farm gate value of bioeconomy ($ million)	Bioeconomy's contribution to GSP (%)	Population (million)
TAS	24,191	47,222	1790	7.4	0.51
SA	94,210	56,674	4805	5.1	1.66
QLD	294,548	63,840	7953	2.7	4.61
VIC	333,393	58,682	8001	2.4	5.68
NT	19,860	83,828	338	1.7	0.24
NSW	471,354	64,098	6599	1.4	7.35
WA	252,999	102,232	2530	1.0	2.47
ACT	34,414	90,631	0	0.0	0.38
Australia (GDP)	*1,524,969*	*66,549*	*38,124*	*2.5*	*22.91*

biophysical conditions (a large and dry continent with high urbanisation and a low population density) and a market economy with little or no subsidisation.

Agriculture's contribution of 2.5% to the nation's GDP masks considerable variance across the eight Australian states and territories. Economic activities are unevenly distributed and each state's contribution to Australia's GDP varies considerably, as indicated by their Gross State Products (GSP; Table 2). The GSP of each state for the 2012/2013 financial year varied from 1% for Western Australia to 7.4% for Tasmania (excluding the Australian Capital Territory (ACT) of Canberra, where no primary production takes place). There are many reasons for this diversity that go beyond the scope of this chapter. The post-farm gate contribution of Tasmania's bioeconomy to the overall economic performance of the state is estimated to range between 16% and 20% (Bennett 2015), which is proportionally much higher than for any other state in Australia.

Agrifood products from Tasmania vary from traditional commodities based on dairy, beef, sheep, vegetables, wine, fruit (such as cherries, berries and nuts), oysters, abalone and salmon to rather unique produce such as leatherwood (*Eucryphia lucida)* honey, medicinal opium poppies (Tasmania produces about 50% of the world's medicinal opiates such as morphine, codeine and thebaine), pyrethrum (75% of current world demand for pyrethrum is serviced from Tasmania) and various essential oils.

Tasmania faces constraints in transporting commodities. It is separated from mainland Australia by Bass Strait, a 350 km wide and 500 km long, relatively shallow, but often rough stretch of sea (max. depth 83 m; average 60 m) with the central bathymetric Bass Basin 120 km wide and 400 km long (Jennings 1959). Bass Strait presents an barrier to the movement of perishable primary produce that requires the coordination of multiple modes of logistics to reach national or international markets. Two state-run ferries transport tourists and freight supplemented by a private freight service with an additional two ships. The more profitable tourists compete with freight during the summer and the service lacks economies of scale to reduce costs, making it as expensive to ship a container across Bass Strait as it is to move it from Melbourne to Scotland. In January 2016, the fragility of the service was illustrated when storm damage to port facilities temporarily reduced capacity of the state-run ferries by 60% at the peak of the harvest season.

3 Geography, Climate and Soils

Tasmania is comprised of about 68,000 km^2, roughly the size of Sri Lanka or Ireland and about twice the size of Taiwan (Fig. 1a, b). Located in the 'roaring 40s', between 40°S and 44°S, 144°E and 149°E in the Southern Ocean, Tasmania has a temperate maritime climate ideally suited for a wide variety of crops, pastures, livestock production and aquaculture. Mean maximum temperatures are 18–23 °C in summer and 9–14 °C in winter (ACE CRC 2010). Average annual rainfall ranges from 2700 mm in some highland locations (as a consequence of predominately westerly winds and orographic lift) to 450 mm in parts of the central midlands,

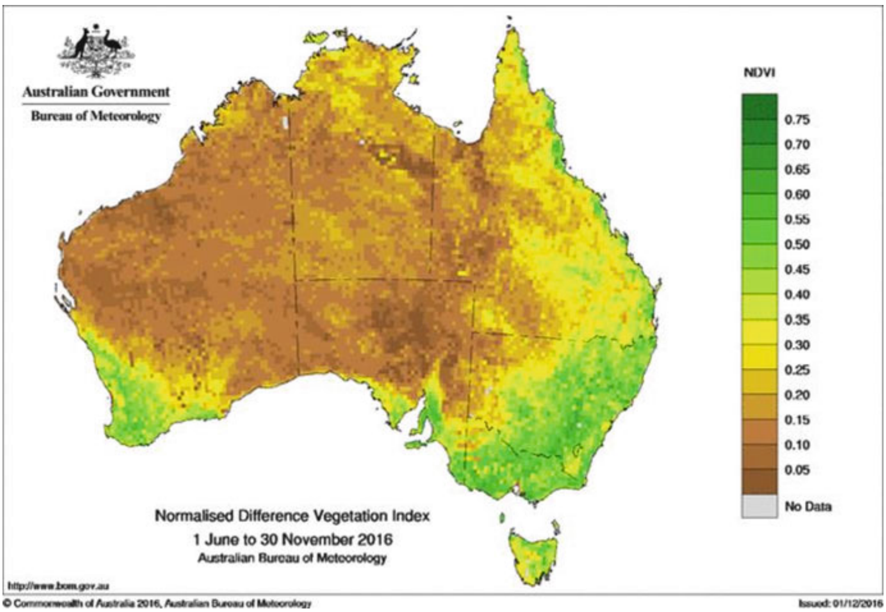

Fig. 1 Satellite image originally processed by the Bureau of Meteorology from the polar orbiting satellite NOAA—14 operated by the National Oceanographic and Atmospheric Administration (NOAA). (**a**) Normalised Difference Vegetation Index (NVDI) for the whole of Australia, six monthly average (1st June 2016 to 30th November 2016). The NVDI is a measure of vegetation

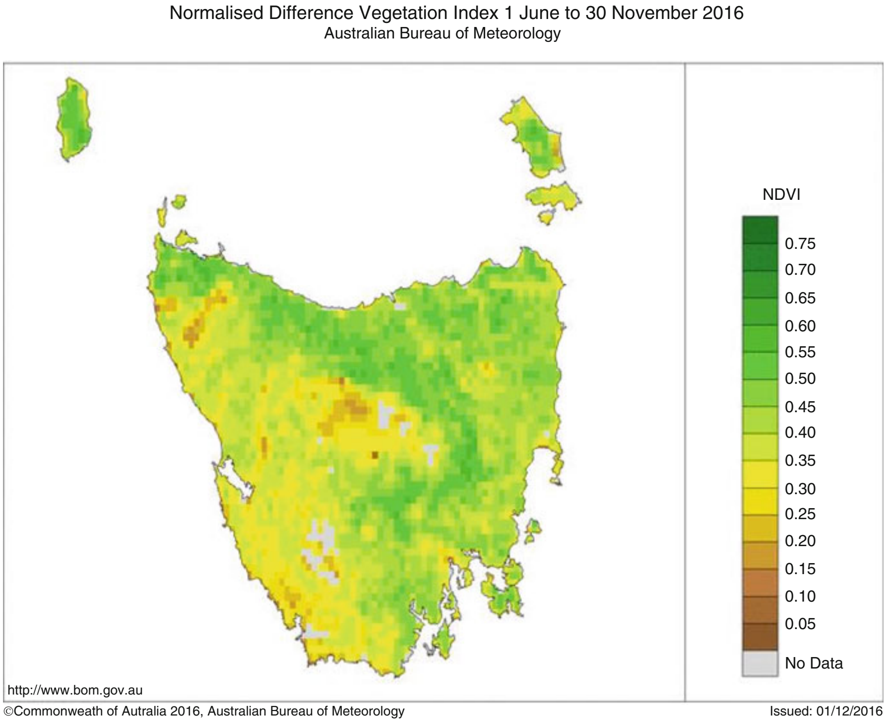

Fig. 1 (continued) cover and photosynthetic greenness based on satellite data, with cover ranging from highest to lowest. Tasmania is located to the south of the Australian mainland. Note the darker area with <25% plant cover—Australia is the driest inhabited continent on Earth, being 75% arid or semi-arid (Ummenhofer et al. 2009). (**b**) NDVI six monthly average (1st June 2016–30th November 2016) for Tasmania. The NVDI is a measure of vegetation cover and photosynthetic greenness based on satellite data, with cover ranging from highest to lowest. The *lighter* areas in the west and east are largely mountainous, forested or the uninhabited south west. National Parks, the Tasmanian Wilderness World Heritage Area, Reserved and Management Areas comprise about 45% of the state. The *darker* areas indicate the highest vegetation cover and photosynthetic rate, reflecting plant conditions in traditionally arable agricultural land in Tasmania

located in a rain shadow to the east of Tasmania's highland regions. However, these average values mask a very high degree of annual variability. Scott (1956) remarked that Tasmania's rainfall variability is greater than experienced in some other regions of the globe with similar climates such as the UK, British Columbia or the South Island of New Zealand.

Like the rest of Australia, Tasmania is strongly impacted by the El Niño–Southern Oscillation (ENSO) phenomenon, with most droughts associated with El Niño (e.g. 1914, 1965–1967, 1972, 1982–1983, 1997, 2002–2003, 2006 and 2015–2016) and floods associated with La Niña seasons (e.g. Bureau of Meteorology, http://www.bom.gov.au/climate/enso/lnlist/). In early 2016, Tasmania was in the grip of another El Niño drought following the hottest and driest spring on record (Australian Broadcasting Corporation 2015). By 2050, climate modelling suggests climate-induced increases in rainfall over Tasmania's coastal regions and reduced rainfall over central Tasmania and in the north-west (ACE CRC 2010).

Tasmania's soils are diverse due to its geological history and variations in climate, landscape and vegetation. The Tasmanian landscape is dominated by an old, erosion resistant geology that emerged about 650–1000 million years ago. Several periods of submersion under Gondwana's seas and metamorphic folding has produced rocks rich in mica and quartzite and other minerals that have been the basis for the mining industry of the west and north-west coasts. During the Tertiary Period, basins formed in the Tasmanian landscape as a result of the separation of Antarctica and the New Zealand sub-continent. This produced shallow soils on the hard dolerite hills of the Midlands and Derwent Valley in the south, and the unstable sandstone and mudstone-based soils susceptible to tunnel and gully erosion in the south-east and northern parts of the state.

Agriculture generally occurs on slopes of less than 20% below 300 m altitude in all areas of the state except the south-west wilderness region. The north-west and north-east of the state are characterised by igneous basalt and high annual rainfall (>750 mm), which has produced the characteristic brown or red ferrosol soils as well as deep, well-weathered, well-drained and friable soils that originally supported dense forests. Despite their rich colouration and apparent depth, the ferrosols are not highly fertile but provide an ideal medium for intensive cropping of vegetables, some berry and pome fruits, and the grazing of dairy and meat livestock (Scanlon et al. 1990; Doyle and Farquhar 2000; Sustainable Development Advisory Council 2002).

The rugged, incised topography and Tasmania's history of development (described below) have resulted in landholdings being relatively small (100–250 ha) in the fertile north and of marginal size for livestock commodity production in the central midlands, south and east despite gradual aggregation over the latter half of the twentieth century.

4 Some Historical Context

Tasmania was colonised by Europeans in 1803 as a penal settlement for Britain's overflowing prisons, leading to protracted confrontation and conflict with the indigenous population. Approximately 65% of the current population are descended from those convicts (Rubio et al. 2002). The average convict transported for life was freed within four years to make their own way, often thriving by their own efforts in an amazingly rugged landscape. When the transport of convicts ended in 1853, the eastern half of the state was developed on the public purse with government land grants, food for 3 years and free convict labour. Land grants were large as were the sandstone manors built by convict labour.

Until the mid-1850s, the rugged west and north-west were regarded as ‘waste-lands’ and used as a security buffer against the very worst criminals that had been sent to an isolated west coast penal settlement. By the late 1850s, the area was starting to develop through unofficial mining, forestry and agriculture to supply the Victorian goldfields. Finally, with government sanction, the north-west developed without the support of free convict labour and was relatively neglected by the newly established bi-cameral government, enduring cycles of boom and bust through the mid to late nineteenth and early twentieth centuries (Stokes 1969; Morgan 2003; Boyce 2008; Alexander 2010).

Tasmania’s recent history of European settlement exerts strong influences on the modern culture and recent development of the state. Tasmania is considered to be ethnically and socially homogeneous but suffers from highly parochial attitudes between the south, which hosts the seat of government, the north which has the wealth derived from agriculture, and the north-west which feels neglected and isolated from power. The origins of these attitudes can be traced to Tasmania’s history of development over a mere six to seven generations of European settlement. Parochialism drives contemporary expectations of government support and affects policy priorities for public development (Bonney et al. 2013b).

Historically, farmers have learned to cope on their small farms and the associated risk of boom and bust cycles by producing a range of commodities. Pre- and post-World War II there were long-term investments in the state’s fertile agricultural north by large multi-national food processors and marketers. Despite this investment, ‘mixed farming’ prevailed and opportunistic behaviour became entrenched as farmers used the leverage created from the threat of switching commodities and outlets to improve the prices they received. This led to Tasmania’s agriculture being largely focused on small-scale commodity production for processing, transactional spot markets and a deeply held commitment to opportunistic behaviour.

New agribusiness companies exacerbated this situation by developing a paternalistic protection of farmers as a means of maintaining their share of the raw material market, which has shielded farmers from the change imperatives brought by globalisation. This behaviour has reinforced the impression that current global pressures for change are ephemeral because throughout history the ‘busts’ have always been followed by ‘booms’. Farmers in Tasmania endeavour to ‘wait-out’ the downturns in anticipation of another upturn in economic conditions. However, in recent years, agribusiness companies have sporadically attempted to facilitate some change initiatives that have only been supported by a progressive minority of farmers.

Today, two thirds of farms employ the owner-operator only and are reliant on labour-hire contractors using international back-packers and itinerant labourers. Around 63% of Tasmanian farms have an estimated value of agricultural output (EVAO) of less than $150,000 and farm businesses rely on one or more family members working off-farm to survive. There are probably less than 1500 economically viable farms in the state and education levels are low relative to other industries, with around 5% of farmers having under-graduate qualifications and 15–20% having vocational certificate three or four qualifications (Australian Bureau of Statistics 2007).

A large proportion of the current generation of farmers are approaching retiring age. Consequently most are unwilling to change their current business models or consider alternative business structures or practices to achieve the economies of scale that would enhance their cost-competitiveness and enable access to new markets, develop innovative value-adding or new products (Bonney 2006, 2011). It appears that for some agricultural commodities the combination of farmer attitudes, demographic aging and processor paternalism has resulted in a transactional or resistant form of supply chain 'followership' in response to an increasingly transformational leadership by agribusiness and paradigmatic global change (Defee 2007; Bonney 2011). Transformational followership might sometimes be more important than leadership in developing adaptive, high performing value chains during times of rapid change (Defee 2007).

Given this history, the state's population has developed a highly resilient, independent but parochial culture, focused on gaining government support for their endeavours. To this day, despite in-migration, belief systems in Tasmania often manifest as an 'entitlement culture', risk averse and isolated, but with economically important pockets of entrepreneurship and innovation. Notwithstanding these constraints, the state's farmers are highly efficient in commodity production and technically advanced due to a history of high quality publicly funded research and extension. A welcome addition has been the more recent development of a large and innovative agricultural consulting sector (Bonney et al. 2013b, 2016).

Tasmania's bioeconomy is characterised by diversity as a consequence of its geography, history, climate and other geo-political factors. Its relatively small size, surrounded by the pristine waters of the Southern Ocean, and the distance from mainland Australia means that extensive agriculture based on low-value bulk commodities are generally not economically viable.

5 Tasmania's Awakening: Opportunities and Challenges

Tasmania is undergoing a phase of unprecedented intensification and transformation of its primary production sector by rapidly developing a reputation for high quality, often niche products, value adding, agri-tourism, fine food and beverages founded on a reputation for having "clean and green" food safety. A further increase in the profitable and sustainable production of these and other bio-based products requires entrepreneurism; functional, co-innovative and transparent value chains; innovative business models; proactive risk management; and knowledge creation and collaboration to achieve market access. Future prosperity in Tasmania requires transformational change that encompasses both the technical and social domains and focuses on delivering superior value to consumer segments.

Hence, the challenge for the future of Tasmanian agrifood producers encompasses overcoming the socio-cultural as well as geographic and economic constraints. Meadows (1999) identified that the most successful system interventions are those that jump the paradigm, change the mindset (values, attitudes, goals, structure), the rules of the system (incentives and dis-incentives), and/or the structure of information flows. The generational change that is currently underway in the industry offers the opportunity for new, non-traditional farmers, many not from Tasmania and often without any agricultural background. These new farmers bring new ideas, new attitudes, new ways of working, and new means of funding to address Tasmania's challenges. Tasmanian-born professionals returning to the state after careers elsewhere, and often for lifestyle reasons, are also shaping the state's future.

It is also incumbent on those who research and support the agricultural system to develop a new paradigm of engaging with industry through openness and responsiveness to develop new, practical systems-focused research outcomes that meet both business and educational needs. Modern approaches to agricultural innovation involve the development of an 'agricultural innovation system', a set of principles, analyses and actions that facilitate the identification, design and implementation of investments, approaches and interventions that promote innovation. Hence, consistent with systems theory, all relevant actors are affected by changes in the system (Ashby 1957; Von Bertalannfy 1968).

6 Adding Water Is Not Enough

Here we briefly outline some of these challenges using, by way of example, the current rollout of new irrigation schemes across Tasmania and in the context of current government policy. More than 150 GL of new irrigation water will be available when all the schemes become fully operational. Already irrigation contributes to approximately 60% of the gross value of agricultural production.

The Tasmanian Government's AgriVision 2050 policy (Tasmanian Liberals, https://www.tas.liberal.org.au/sites/default/files/policy/Cultivating%20prosperity%20in%20agriculture.pdf) sets a substantial stretch target for Tasmania's bioeconomy, namely increasing the farm gate to an annual value of AUD$10 billion by 2050, up from AUD$1.8 billion in 2012/2013 (Table 2). Although this vision is underpinned by significant investment in irrigation infrastructure—about AUD$500 million of private and public funds have already been invested in new irrigation schemes—realising and sustaining the benefits will require substantial investment in knowledge infrastructure, innovation platforms, value chain approaches, benchmarking and monitoring. These efforts have already resulted in an increase of nearly 5% of agrifood exports from Tasmania in 2015 to a total value of $2.74 billion (Parliament of Australia 2016). In part, this is the result of the once-off increase due to the increased irrigation capacity (Fig. 2).

Continuous value adding is now required to keep up the momentum and to maintain the growth rates required for achieving the governments vision (Fig. 2).

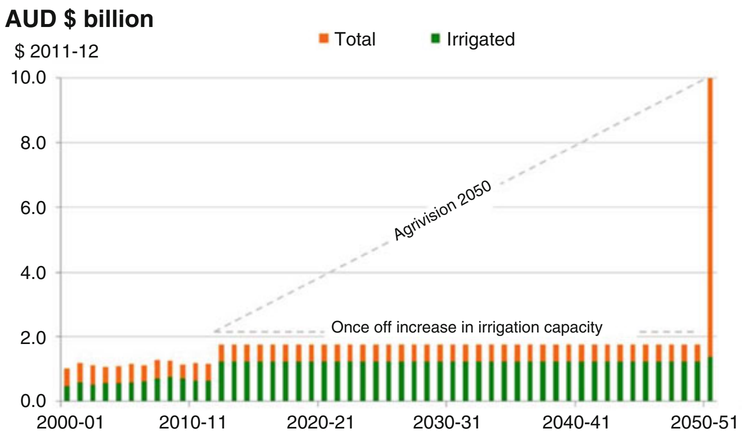

Fig. 2 Tasmania's research and innovation challenge: the AUD$10 billion target for 2050, commencing from the increase in irrigation capacity for 2010–2011. Innovation via research, development and expansion, in addition to increased irrigation capacity, is essential to facilitate investment and expansion in Tasmania's bioeconomy. Source: Tasmanian Government's AgriVision 2050 policy (http://bit.ly/1MxuovX) and R. Nelson, pers. com. 2015

This necessitates a dramatic increase in the value derived from each litre of irrigation water. For example, if 80% of the $10 billion target is to be achieved via irrigated agriculture, the value generated from irrigation water has to increase from currently AUD$3500 to $16,000 per mL of water. This would require an extensive step-change in productivity. But is that the only solution? Or, does the answer lie to a large extent in the agrifood system moving into a new paradigm of creating consumer value through advances in linked production, logistics and marketing into new, targeted niches around the world?

The obvious pathway for achieving such an ambitious vision is through applied and highly industry relevant research, development and extension. Researchers from multiple disciplines must work with industry, community and policy makers to achieve such a transformation. A key question for Tasmania is how such intensification can be economically, socially and environmentally sustainable. Using an Agricultural Systems Research (ASR) approach, industry experts, academics, farmers, policy makers and representatives of Tasmania's broader civil society are jointly investigating improvements in four key areas:

1. On farm systems (productivity, management systems, precision technologies, new crops and processes);
2. Business models and value chains (innovations, entrepreneurship and exporting);
3. Natural resource management (landscape health, ecosystem production, maintaining soil productivity, drainage, waterlogging, salinity, interactions between on-farm and landscape scale, biosecurity); and
4. Research, development, extension and education (arrangements and institutions, effective innovation, education and adoption).

The conceptual model 'just add water' is unlikely to result in the desired growth in economic development and value chain creation from irrigation. A value chain is comprised of linked businesses where the chain partners decide to co-innovate in order to create and deliver value for which their customers and consumers will pay a premium price (Bonney 2011). Entrepreneurial value chains must be created by aligning the strategic interests of knowledgeable and technically skilled farmers, input suppliers, value adding processors and marketers through public-private partnerships that are based on trust, shared values and co-innovation.

7 Systems Within Systems: Integrating Knowledge, Innovation and Entrepreneurship

Tasmania's situation exemplifies how modern agriculture and aquaculture are now high knowledge intensive systems that can no longer rely on single transformational innovations such as the ones that powered the green revolution of the 1960s and 1970s. Norman Borlaug's contribution to agricultural science and plant breeding at the time resulted in high-yielding, disease resistant crops that saved about a billion people from starvation. Borlaug and colleagues managed to find a very effective technological fix to overcome resource limitation. Much research, thinking, knowledge and insight went into the creation of these green revolution technologies resulting in an unprecedented increase in food production. Yet their application was relatively simple and little additional knowledge was required to deploy these technologies at farm level.

Now, during the first quarter of the twenty-first century, the challenge to our agricultural and food systems is different. This time it is not only about increasing yields per area. Instead the challenge is to increase productivity, rather than just production, but without additional resources and without negative environmental or social impacts. Today we are confronted with what the Shell Oil's scenario planning group (Shell Scenarios Team 2013; Bentham 2014) terms 'resource stress nexus (RSN)'. The RSN refers to increasing pressures on water, food, and energy resources to meet the demands of an expanding global population. These demands include rapid changes in consumer preferences requiring more of all three of these interlinked resources. The RSN impacts on food and energy production as well as the viability of urbanisation. All these sectors increasingly compete for the same resources.

Tasmania is uniquely positioned in the Australian bioeconomy to be able to exploit the RSN with abundant water, arable soils, and an economy based on a renewable hydro-electric power grid. Further, modern Tasmania is characterised by strong, cooperative partnerships across the research, education, policy and private sectors via a dynamic joint venture between the Tasmanian Government and the University of Tasmania. This vibrant partnership has led to the establishment of innovation networks that span the public and private sectors and serve as an example of institutional innovation (OECD 2016; Tasmanian Institute of Agriculture 2016). Tasmania's small but mobile population and accessible government foster this relationship and the science-government-industry interactions that are needed for effective, economy-wide research and development. The island's agrifood system provides an ideal platform that demonstrates the effectiveness of boundary organisations, i.e. small groups of committed scientists, policy-makers and industry leaders who are all concerned with translating science into action (Cash et al. 2003).

Exploiting the RSN presents issues that go beyond production. There is a growing need to harness both bio-physical and social dimensions in system solutions that focus on increasing total economic yield for whole value chains. The locus of competition in modern value chains is increasingly shifting from single businesses to whole chains. Products are only as competitive as the whole chain that delivers them to a consumer. As a result, value chains are now regarded as recursive, interconnected networks that reflect the hierarchy of emergent properties in the overall food system (Collins 1999; Li and Wang 2007). Whilst they are frequently depicted as linear sequences of processes, it is now recognised that value chains are actually complex networks of relationships, both internal and external to the chain (Moore 1993; Lazzarini et al. 2001). These relationships assist the chain participants in acquiring the tangible and intangible resources needed to innovate, collaborate and compete, often simultaneously (Allee 2008; Fig. 3). A permutation of the value-chain network is the use of digital technologies to bring the consumer closer to the producer through novel marketing strategies, social media and/or direct investment by the consumer in business development. What could be more important for Tasmania's bioeconomy, given the island's sparse population and logistical challenges, than effectively managing value chain relationships and interdependencies?

Continuous innovation requires resources beyond the capabilities of a single farm. Hence, producers within chains are collaborating vertically to solve their shared problems and to exploit their opportunities. They are also collaborating horizontally with governments, research institutions and even their own competitors where they do not directly compete, and there is sufficient common interest. For example solving transport problems such as getting goods from Tasmania across Bass Strait to the port of Melbourne (Mason et al. 2007).

While food security is a fundamental driver, vertical and horizontal integration also serves to incorporate the unprecedented diversity in consumer demand and interest in food quality. The production, preparation and consumption of food is inextricably related to social identity. Food knowledge is entering a new era when diffuse, ill-defined and often misleading concepts such as 'organic', 'local', 'wild', 'sustainable', 'healthy' and 'national' are being influenced and are influencing global food consumption and hence the nature of production, transport and marketing (Rhea and Bettles 2012). The Asian food boom now has tangible, local and global impacts, with demand for some products (e.g. baby formula) outstripping supply (SBS News 2015). Geopolitics has put Australia at the forefront of these developments. Impacts such as increased demand are particularly noticeable in Tasmania due to its low population and high reliance on the agrifood sector.

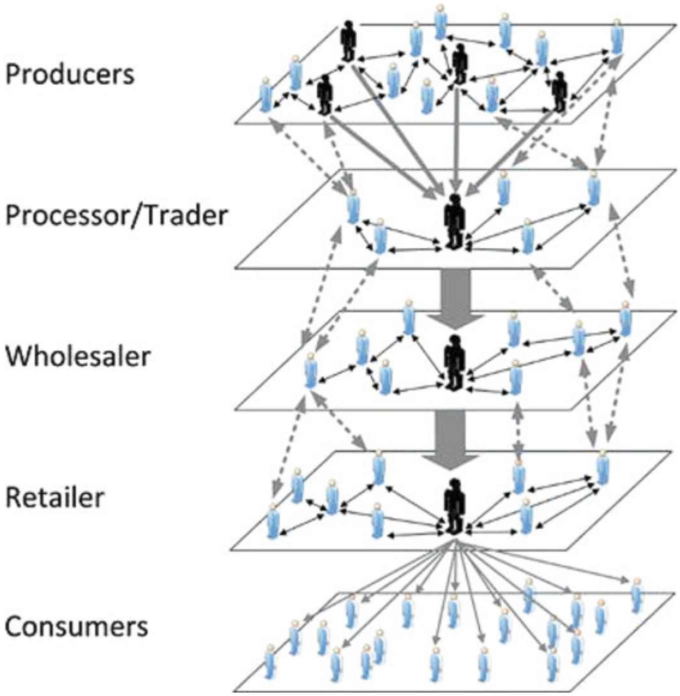

Fig. 3 A value chain network depicting the vertical and horizontal interactions between producers and consumers. Source: derived from netchain (Lazzarini et al. 2001); value network (Allee 2008); and business eco-systems concepts (Moore 1993)

Agricultural value chains will need more skilled intermediaries to foster knowledge flows and to build trust and productive relationships. Those seeking knowledge-based services will need to make active choices about why, how and what they access. In Tasmania the passive receipt of information and historical sense of entitlement to publically-funded services for private benefit will become increasingly uncommon. Attitudinal changes are inevitable. Institutional arrangements need to: (1) foster a more effective linkage between the research capabilities at the University of Tasmania and the needs of farmers, advisors, agribusinesses and communities; and (2) recognise that innovation in agriculture is facilitated through value chains that co-innovate for mutual benefit.

Innovation relating to Tasmania's bioeconomy requires an environment conducive to the interplay between society, producers and industry. The current needs of society are embodied in market choices, the regulatory environment and a social licence for agriculture. The practical needs and concerns of Tasmanian producers in securing markets and creating profit will ultimately influence receptivity to change and disruption. Agribusiness systems will be strongly shaped by information and innovation that influences the options available.

Producers themselves have aspirations and capacity that will affect the uptake of innovation. Such entrepreneurism requires the right attitude and skills from everybody involved in Tasmania's value chain. While some attitudes will and need to change, skills must also be developed. This relies on a supportive, accessible and inclusive education system that caters for all educational needs—from primary school to vocational training to associate, graduate and post-graduate qualification. It also requires a supportive and responsive policy environment that clearly articulates the Government's role in this process and helps to overcome a deep seated entitlement culture that has far too often stifled entrepreneurial spirit in Tasmania (West 2013).

8 Solutions to Complex Problems: Innovation Platforms and a Theory of Change

Rural Australia and Australia's agrifood sector faces unique, complex problems that require development approaches emphasising endogenous or local rather than external interventions (Khisty 2006; Tomaney 2010) to address the 'wicked problems' (Rittel and Webber 1973) i.e. problems that can only ever be partially resolved. One approach is to use 'place-based' strategies that identify how the unique attributes of individual places determine the constraints, and the tangible and intangible assets that influence the development of comparative advantages and fosters innovation (Ryser and Halseth 2010; Woods 2012).

Traditional approaches have focused on economic analyses with little consideration of the non-traded, knowledge-based intangibles that may be used to construct regional advantage. A proportion of this knowledge is tacit, meaning it cannot be fully codified or documented. Taking such tacit knowledge into account could create meaningful government interventions that go beyond fragmented policies and simple 'place-branding', instead focusing on coordinated, holistic strategies that facilitate supportive, top-down, regional, whole-of-government policy support and community cooperation (Bachtler 2010). In particular, rural-urban networking and capacity have been found to be important to regional innovation (Dabson 2011; Pritchard et al. 2012) as long as the influence of individual values, beliefs and norms on adaptive behaviour in regional change are well understood and accounted for in the planning stage (Raymond et al. 2011). Long-term approaches that focus on innovation, facilitate the active involvement of stakeholders and develop human capital are essential (Tomaney 2010).

Innovation platforms are a critical success factor for constructive dialogues and capability development (Ekboir and Rajalahti 2012). They draw on networks of diverse public/private actors who voluntarily contribute the necessary resources and facilitate innovation. Such innovation platforms are often a consequence of effective boundary organisations forming action-oriented communities of practice (here we expanded the boundary organisation model discussed by Guston (1999) by including private sector actors as a third partner to the science—government model). A very practical outcome of innovation platforms is the construction of competitive advantages (McCall 2009; Eversole and McCall 2014) by creating business ecosystems. Bonney et al. (2016) advocated this approach based on Emery and Flora's (2006) seven capitals (natural, cultural, human, built, financial, political and social capital) as the basis for analysis and the development of a more entrepreneurial, innovative agrifood industry in Tasmania. The capitals framework is a typology to understand and analyse a community's fundamental building blocks of development from a systems perspective, and provides a lens to consider both the inhibitors and enablers of innovation in the agricultural sector.

Continuing research into regional agricultural entrepreneurship and innovation, that has compared seven Australian regions, suggests that there are similarities and differences in regional factors that drive innovation. Even the most common factors have a varying emphasis from region to region (Bonney et al. 2013b, 2015, 2016). The research also suggests that there is a sequential influence of capitals in 'place-based development' that moves from 'foundational' natural, cultural and social, to the 'enabling' political and financial capitals. When these influences align, they can create the human capital necessary to produce and deliver place-based products and services.

These broader systems approaches are particularly important as Tasmania experiences an entrepreneurial renewal with an emerging cultural tourism industry driven by the Museum of Old and New Art or MONA (Lehman et al. 2016; MONA 2016). Against the background of these cultural changes, a portfolio of new, agricultural-based ventures is also emerging. These ventures market high value, premium agricultural products such as organic farmed Atlantic salmon, ultra-fine wool, Wagyu and organic beef, artisan cheese, leatherwood honey, flowers, pyrethrum, pharmaceuticals, cherries, high quality whisky, gin and vodka, fine wines, craft beers and ciders.

We know from experience that more knowledge doesn't necessarily lead to better action; the 'know-do gap' within agriculture and food systems has been widely documented. For example, knowledge about the causes of diet-related diseases does not necessarily change peoples' eating habits. Behaviour change requires empowerment through shared knowledge and individual attitudes, and a supportive culture to convert intention to action (Fishbein and Ajzen 1975, 2010). Individuals must be given the capacity to actively contribute to their aspired outcomes (such capacity includes the availability, affordability and acceptability of, for instance, healthier alternatives). Empowerment leads to informed decision-making and in doing so creates value. Hence, empowerment can lead to well-reasoned action or in-action.

Cooke (2007), an architect of regional innovation systems in Europe, has suggested a framework for policy platforms to assist the development of 'constructed advantage'. It is a process of further developing existing social capital that produces not only product innovation but also local governance that enables innovation to occur. According to Cooke (2007) this involves a strategic focus on:

- **Economy**: proactively 'constructing' future sources of economic competitiveness in the region with: inter-firm interactions; integration of knowledge generation; and, both local and global business networks.
- **Multi-level governance**: seeking out governance mechanisms that support a proactive approach to the region's future by: alignment of stakeholder interests and management of expectations; strong policy-support for innovators; enhanced budgets for outcomes-focussed research; and vision-led, principled and ethical policy leadership.
- **Knowledge Infrastructure**: the active involvement of knowledge-based organisations in constructing advantage in the region through horizontal co-innovation solving shared problems.
- **Community and culture**: community and public, cultural orientation toward proactivity, entrepreneurship and innovation.

Coordination of these policy instruments in order to achieve desired outcomes is often one of the biggest challenges for an institution. This is where well-planned and effective interventions based on a theory of change (ToC) and effective foresighting can help.

The ToC approach is '... *a comprehensive description and illustration of how and why a desired change is expected to happen in a particular context ... it does this by first identifying the desired long-term goals and then works back from these to identify all the conditions (outcomes) that must be in place (and how these relate to one another causally) for the goals to occur ...*' (Centre for Theory of Change 2016).

In practice this can be achieved by strategic foresight which anticipates future events by articulating possible, plausible, probable and preferable futures as demonstrated for the rollout of irrigation infrastructure in Tasmania (OECD 2016). Foresight illuminates the implications of present actions thus helping to avoid problems and develops plans to achieve the preferred future (Voros 2003; Slaughter 2004). More importantly though, the process facilitates the development of anticipatory individual mental models and group cultures that enable an agility to cope with the environmental drivers, critical uncertainties and wildcards (low probability, high impact events) which drive their emergent future trajectory. In doing so, foresighting facilitates unified, coordinated action in a general direction with an ability to cope with the unexpected (Ingvar 1985; MacKay and McKiernan 2004). In this context, foresighting effectively becomes a 'construction of the future' (McCall 2009) rather than allowing serendipity to prevail or, more to the point, its antonym, zemblanity to dominate (i.e. situation where humanity constructs their own misfortune in the systems designed to avoid it; Giustiniano et al. 2016).

Hence, stakeholder engagement must happen at the onset and, ideally, throughout the development process to generate additional means and ends. A useful entrepreneurial method is effectuation logic (Sarasvathy and Venkataraman 2011) in which actors use the status quo ("what I know, who I know, and who I am") as a starting point for the creation of a preferred, new future. Adaption of this method to policy making in Tasmania suggests that policies become most effective when they are co-created with stakeholders allowing a preferred future to emerge as contingencies are leveraged and new partnerships are created.

Effectuation consists of five principles (Society for Effectual Action 2016):

1. "Bird-in-Hand" or always start with the means you can control;
2. "Affordable Loss" to control the downside risk by using partners and pre-committed stakeholders to co-create a policy draft;
3. Using wildcard surprises in policy to create a new insight into systems dynamics and then use this to create new policy opportunities;
4. Co-create a policy draft via strategic conversations with stakeholders willing to put "skin in the game" and risk financial, political, and reputation loss; and,
5. A "Pilot-in-the-plane" approach based around a philosophy that the future is created rather than predicted and as such can be shaped to create a better future for all.

Effectuation leads to a divergent and expanding effectual cycle that is recursive, dynamic and flexible, and that results in both new outcomes and new means. It takes into account the dynamic of messy, human interactions and relationships that exist in real life (Bonney et al. 2013a).

In summary, methods such as strategic foresighting and effectuation logic allow people to think ahead and consider, model, explore, create and respond to future eventualities. The process includes questioning ingrained assumptions and (often limiting) beliefs that underpin current strategy. Usually behaviour change only occurs once a series of pre-conditions are met. Particularly in group settings, practice change is contingent on positive experiences for any change in participants' knowledge, attitudes, skills and/or aspirations (KASA). KASA-level change is regarded as a pre-requisite to practice change.

The effectiveness of these methodologies was acknowledged by the OECD's Observatory for Public Sector Innovation as part of their 'Stakeholder Engagement for Inclusive Water Governance' series (OECD 2016). In this series the OECD has recognised the leadership of the Tasmanian Government and the Tasmanian Institute of Agriculture, a boundary organisation that conducts extensive stakeholder consultations across a broad range of local actors (business, service providers, farmers, civil society, etc.). In response to three divergent foresighting scenarios, the team established well-defined and agreed irrigation research priorities supported by all stakeholders. This research and development (R&D) coalition is now delivering the knowledge infrastructure needed to compliment hard investments in water resource infrastructure. The coalition also needs to establish how Tasmania can avoid the problems that have historically plagued irrigation: salinization, water logging, erosion and the over exploitation of water resources.

In pursuing food security as a pillar of Tasmania's bioeconomy, we need to recognise that there are top-down constructs that will be shaped and influenced by policy and institutional settings. In the end, however, embedded food-systems will be implemented by farmers, agri-business leaders and processors pursuing economic ends. Non-food products could play an increasingly important role in Tasmania's bioeconomy as the current examples of medicinal alkaloids and pyrethrum production already demonstrates. Technological disruptors such as synthetic biology and the use of microbes to produce plant-derived chemicals will further test the adaptive capacity of the agrifood sector. This will be an area of rich social narrative, and in the process, norms, values and world views are and will be challenged and nearly every proposed 'solution' is likely to be contested at some level (Leith and Meinke 2013). Trade-offs will be inevitable, and compromises will have to be reached, particularly in instances where a farmers' economic viability is often driven by short term gains that can compromise their long term sustainability. There will be a need to resist short term solutions that more readily attract resourcing than longer, but more sustainable approaches.

Tasmania's bioeconomy is a microcosm that offers insights for other societies and economies in transition. The ability for Tasmanian agricultural value chains to be innovative and entrepreneurial is derived from its natural capitals such as its land and water resources. Effective innovation (OECD 2005) that creates and commercialises "new or significantly improved product (good or service), process, new marketing method or a new organisational method in business practices" strongly depends on such natural capital and needs to be paired with adequate human, financial, and social community capital. While Tasmania's natural capital requires appropriate governance and protection (e.g. sound and enforced environmental protection laws and effective biosecurity measures), the cultural and human capitals require development and nurturing. For Tasmania this means a particular emphasis on improved levels of education in order to overcome some of the deeply ingrained cultural impediments to sustainable development. A focus on education and its governance is critical for an island that has a worryingly high rate of functional illiteracy and welfare dependency (Rigney 2013).

9 Conclusions

Over the last decades Tasmania's bioeconomy has moved from a situation where knowledge came embedded in the inputs delivered to the farm (e.g. hybrid seeds, mineral fertilisers, etc.) to a situation where farmers now need to be highly skilled, knowledgeable, technologically savvy and digitally connected if they want to partake in the bio-based revolution that is taking place. Opportunities abound but engagement and investment decisions are not simple, markets and value chains are globalised and production methods are more scrutinised which determines market access. The challenges ahead will increasingly be characterised by technical complexity, uncertainty, a mix of social, economic and biophysical drivers, abundant data and information of variable quality. Contested issues among diverse stakeholders will create additional challenges.

Tasmania can have a very bright and vibrant future. With good governance of all the components that make up Tasmania's agriculturally-based value chains, the island may get close to the vision articulated by Government in 2015: a more than fivefold increase in the value of Tasmania's bioeconomy by 2050. To make this future a reality, the relevant actors need to first imagine it. The community need to agree on what they want and then jointly figure out and commit to pathways that will get them there. Arguably, the age of business-as-usual with occasional change management is over, necessitating structures that enable on-going adaptation, knowledge and risk management. Tasmania has all the ingredients and tools for this task, especially the natural capital and human potential. Here we have outlined some of the well-tested principles and approaches to research, industry development, knowledge creation and policy development that can achieve the desired vision, create acceptable compromises, build socio-economic resilience and, ultimately, create a better future. All we need to do is make it happen.

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