A longitudinal resilience comparison of Australian regenerative and conventional beef cattle production systems and the establishment of a set of guiding principles for Regenerative Agriculture in Australia

Lorraine Karen Smith Gordon

Master of Business Administration, University of New England

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Abstract

Agricultural land covers 55% of the Australian landscape, with grazing the dominant agricultural land use. Climate change's current and predicted impacts are driving innovations within the livestock sector toward carbon-neutral and nature-positive outcomes. Regenerative agriculture in Australia has become a fast-developing movement that offers an alternative to industrial and conventional agriculture to mitigate the effects of climate change. The aims of this research are twofold; 1) to determine if Australian regenerative beef cattle production systems are more resilient than conventional systems in a changing climate and 2) to develop a set of guiding principles for regenerative agriculture in Australia.

The research has a multi-disciplinary approach utilising mixed methods, including a longitudinal case study of beef grazing systems in Northern New South Wales, Australia that incorporates the environmental, social, and economic indicators required for a resilience framework. Using these results, a set of principles for regenerative agriculture unique to Australian conditions was developed and tested to produce a guide for achieving resilience in a changing climate. This research is significant as it fills a gap in the theory and practice of Australian regenerative agriculture.

The overarching arching objective is to examine if regenerative beef cattle production systems are more resilient than conventional beef cattle production systems in a changing climate and whether comparing these production systems highlights the need for a set of guiding principles for regenerative agriculture in Australia. There were two themes within the research; the first addressed the resilience of regenerative and conventional farming systems, with the methodology including a literature review, case study, longitudinal survey, and thematic analysis. The second theme sought to establish a set of regenerative agricultural principles for Australia utilising a literature review and quantitative survey approach.

This thesis found the beliefs, orientations, and behaviours of Northern NSW beef farmers differ between regenerative and conventional cohorts, including differences in management action, forward planning, and strategy. It identified economic, environmental, and social indicators that align with the Stockholm Resilience Framework and affect a farmer's ability to remain resilient in a changing climate. Regenerative farmers rate higher against this resilience framework than conventional ’farmers in drought conditions and a changing climate, meaning regenerative farmers and their farms are more resilient in maintaining diversity and redundancy, managing connectivity, managing slow variables and feedbacks, encouraging learning and participation, and broadening participation. It concludes by finding that implementing regenerative practices will assist producers in being resilient in a changing climate.

The research proposes a set of principles for regenerative agriculture to guide future farming practices and management decision-making. These principles are:

1. Be ecologically literate, think holistically, and understand complex adaptive systems.
2. See your landscape as a community that you belong to and work with.
3. Remain curious; seek transformative experiences and continuous learning.
4. Acknowledge and consider diverse ways of working with landscapes.
5. Engage in ecological renewal and make place-based decisions through monitoring.
6. Engage with First Nations people.
7. Understand that human cultures are co-evolving with their environments.

These principles have the potential to act as a guide for future farming practices and management decision-making with the understanding that farming practices will continue to evolve, as will our knowledge and understanding of working with ecological systems. The principles can assist farmers in navigating climate change and the associated economic, environmental, and social disruption and uncertainty. In addition, this thesis supports farmers' ability to capitalise on the opportunities that are presenting themselves through regenerative agriculture practices, including ecosystem service markets, carbon sequestration, and enhancing landscape health and biodiversity.

Certification

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this thesis are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

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Lorraine Karen Smith Gordon Date 28/11/2023

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Preface

This research has emerged as part of my long personal journey with rural Australia through agriculture. At the age of 14, growing up in the Western Suburbs of Sydney, I made the decision that I wanted to be a farmer. Lucky for me, I went to boarding school and therefore had several friends that lived in the country and came 'off the Land', I also had a very supportive mother and father. I thus began my journey into rural Australia through the vastness and harshness of outback NSW and QLD. By the age of 21, having gone to Agricultural College in Orange in Central NSW and taken out the College prize, (but on reflection, not really the wiser on how agriculture worked), I found myself through a set of unfortunate family tragedies (the death of my father and my aunt) managing 3000 acres (1215 ha) of prime, yet remote, cattle fattening country at Ebor in Northern NSW. This was the real beginning of my journey into building a relationship with nature and the landscape through farming. I started by soaking up the knowledge of my neighbours and advisors and ended up through trial and error, forging my own relationship with 'the Land'. A tough relationship that has presented incredible challenges and unbelievable heartbreak whilst at the same time making me highly resilient, incredibly connected to country, and feeling fulfilled in my chosen vocation.

It is this personal journey coupled with a quest for knowledge and understanding of the landscape in which I am so connected and its function that has led me to undertake this research. This need for higher-level knowledge to answer the many complex questions I have about farming systems, the long-term resilience of the landscape, eco-systems, and the people it supports. This quest has been heightened with a sense of urgency due to the complexities and challenges unfolding around climate change.

As both a farmer and student of agricultural practice, I have now been on this regenerative agricultural journey for some 38 years. As previously mentioned, I was running a 3000-acre beef cattle property by the age of 21. Not knowing the country, I absorbed all the local knowledge I could get my hands on, from my neighbours (of which I recall taking copious notes), government extension officers, soil and pasture consultants, field days, seminars, and workshops. In the 1990's my focus was most definitely on improving this 100% native, unimproved property so I could make a profit. When I first took over the property, the cattle were running through 55,000 ha's including the adjoining state forest and national park. The property had no internal fencing, little in the way of boundary fences, no cattle yards, no homestead, no improvements whatsoever. It had been part of a larger property settlement whereby the structural assets were on the sections my family did not inherit. I was 100% focused on clearing the timbered grassy woodlands, putting in improved pastures, and bringing it up to a working property that could compete with my neighbours and my farming peers. Looking back, I was caught up in the industrial paradigm of more and more inputs equals more profits, what I refer to as the farming treadmill. At some stage throughout this process, I began to become frustrated with the lack of progress towards my vision and the fact that I was a price taker for my product and couldn't set my own terms on anything. Within a few years, I ventured into farm tourism as a second enterprise and established a Beef Marketing Cooperative with the aim of having a larger voice when it came to the supply chain. Interestingly enough this group is still going today (some 35 years later). For this, developing an on-farm hydro system and other initiatives for the cattle industry, I was awarded the 1994 NSW Rural Woman of the Year and consequently secured a two-year scholarship with the Australian Rural Leadership Foundation. This would prove to be a life-changing experience for me. My thirst for knowledge and the burning desire to 'master my craft' in the early nineties as well as the added life progression of marriage and children was also a factor in my ambition to make a profit and 'get ahead'. Like many NSW New England graziers at the time, I was introduced to Holistic Farming through both Allan Savoury's 'Holistic Management' and Stan Parsons 'Grazing for Profit'. I undertook the 'Grazing for Profit' School with Terry McCosker in Toowoomba back in 1993. This was my first major paradigm shift when it came to farming. Interestingly, I have now undertaken 'Grazing for Profit' schools and 'Holistic Management' schools with my grown-up children. I believe that both 'Grazing for Profit' (which has a focus on cell grazing and now time-controlled grazing, a practice covered in more depth further on) and 'Holistic Management' (based on the concept of holism) were the birth of regenerative agriculture in Australia. However, at that time, they were not referred as regenerative agriculture.

My career journey has included leadership positions in regional tourism, agribusiness banking, and regional development, all of which have honed my perspectives and added to my skills and understanding of agricultural practice. In all of these roles, I would embed agricultural programs and bring in outside perspectives and approaches in doing so. I was constantly gravitating back to farming in one form or another. More recently I have been embedded in the University system, where as Director of the 'Farming Together Program', worked with some 28,000 farmers on their collaborative farming projects. The impact and scale of the project was unprecedented and various national awards flowed to my team as a result of its success. Building on the success of this program, in 2019, we formed the 'Regenerative Agriculture Alliance' which birthed the biggest movement in Australian Agriculture since the Industrial Revolution. Clearly, both society and farmers were ready for change and open to embrace a new style of farming.

I have dabbled in many forms of farming systems from conventional to cell grazing, holistic management, organics, and biodynamics, to time-controlled grazing, and now regenerative farming and carbon farming. All of these practices, I draw upon like tools in a toolbox.

My positionality and consequent focus on transformation through regenerative agriculture bring a particular frame to my thinking and analysis. Consequently, there may be an unconscious positivity toward regenerative agriculture as a pathway to agricultural transformation. This has been mitigated throughout the thesis by (1) creating a research plan in conjunction with my supervisors, who are not regenerative farmers and in fact are regenerative agricultural sceptics; (2) structuring my questions so they are open and not leading, reviewing these with my supervisors for accountability; and (3) ensuring that all texts are read in their context.

I hope this research will prove to be valuable and spur further work in this critical space. A space that I believe offers hope for future generations and the survival of our planet.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction: Global Crises and Regenerative Agriculture

1.1 Global environmental, social, and economic crises in the Anthropocene

According to the International Panel on Climate Change (IPPC) Working Group's Sixth Assessment Report, human-induced climate change has caused widespread environmental and socioeconomic damage, pushing nature and vulnerable people beyond the ability to adapt (Pörtner et al., 2022). The planet has moved into the Anthropocene, a period where the biosphere is shaped by humanity on both local to global scales, and humans are overstepping planetary boundaries, causing environmental and economic shocks and disturbances (Rockstrom et al., 2009a; Walker & Salt, 2006, 2012).

The world is unraveling with the increasing intensity of weather events such as heatwaves, droughts, fires, floods, and cyclones resulting in species extinctions, loss of kelp forests, mass human mortalities, glacier melting, and irreversible losses in terrestrial, freshwater, and marine ecosystems (Eddy et al., 2021; He & Silliman, 2019; McCarthy, 2001; Sage, 2020; Turner et al., 2020). These climate extremes have caused mass displacement and migration of people and species, affecting food and water security and causing malnutrition (Cattaneo et al., 2019). Countries such as Mozambique, Zimbabwe, The Bahamas, Japan, Malawi, the Islamic Republic of Afghanistan, India, South Sudan, Niger and Bolivia have been the most affected (Eckstein et al., 2021). As a result, The United Nations Conference on Trade and Development (2022) has established a global crisis response group urging action around food, energy, and finance, and the United Nations Department of Economic and Social Affairs (2023) has acknowledged multiple, inter-connected crises around food, energy, and war. The United

Nations Foundation (2023) has also highlighted the importance of adhering to international sustainable development goals as a key issue for 2023.

Agriculture, forestry, and fisheries are economic sectors vulnerable to climate change, which has adversely impacted agricultural productivity and farming livelihoods through weather variability, animal and plant diseases, and high input prices projecting many uncertainties (Bahri et al., 2021; Batrancea et al., 2020; Ozdemir, 2022). Aquaculture has been affected by ocean warming and acidification, with heavily depleted fish stocks in many areas (Pörtner et al., 2022). Poorer regions are more vulnerable to climate change due to poverty, governance challenges, limited access to services and resources, conflict, and a high reliance on agriculture, aquaculture, and forestry.

The physical and mental health and social well-being of humans have been affected by extreme weather events causing disease, cardiovascular and respiratory distress, and loss of livelihood and culture, resulting in increasing levels of depression and mental health issues (Caminade et al., 2019; Cianconi et al., 2020; Froese & Schilling, 2019; Romanello et al., 2021; Sesana et al., 2021; Wolf et al., 2015). Infrastructure such as sanitation, clean water, health services, transport, communications, and energy are becoming more vulnerable to climate change (Organization for Economic Cooperation and Development, 2022). Heatwaves and air pollution events have intensified in city areas and essential infrastructure has been compromised, with service disruptions severely affecting people's well-being. There have been losses of infrastructure, property, and incomes, with the most vulnerable of society often feeling the brunt of the devastation (Frame et al., 2020; Pörtner et al., 2022; Satterthwaite et al., 2020). The impacts on physical health, mental health, and social well-being from climate change are a real phenomenon (Clayton, 2020). Land use and conflicts over food and water continue to increase, with violent conflict occurring most frequently in regions vulnerable to the effects of climate change (Froese & Schilling, 2019; Gomez-Zavaglia et al., 2020).

Population growth leading to unsustainable extraction of natural resources, deforestation, and loss of biodiversity are affecting ecosystems and human's ability to adapt to a changing climate, even more so for Indigenous peoples who heavily depend on ecosystems such as the natural environment (Maja & Ayano, 2021; Verma et al., 2020). Only 15% of land, 21% of freshwater, and 8% of oceans are protected and sustainable management of land and oceans is lacking (Arneth et al., 2020; Pörtner et al., 2022). According to the World Wildlife Fund Living Planet Report, wildlife populations have fallen by 69% since 1970, with Australia leading the number of mammal extinctions due to climate change and habitat destruction (Almond et al., 2022).

According to the World Economic Forum's Global Risks Report, the Planet is experiencing a "climate action hiatus" and is unlikely to keep temperatures from increasing beyond 1.5˚C (World Economic Forum, 2023). Unless temperature increases can be held at 1.5˚C, landscapes, rivers, and oceans are predicted to continue to decline (Arias et al., 2021). Conflict and mass migrations of people are mostly driven by socioeconomic conditions and poor governance, and exacerbated by climate change (Abel et al., 2019; Podesta, 2019). Beyond 2040, the risks to human and natural systems will escalate and are dependent on mitigation and adaptation approaches undertaken now (Bustamante et al., 2019; Tang, 2019). Global warming is increasingly putting pressure on food production, weakening soil health and ecosystem services such as pollination, increasing pests and diseases, and reducing marine animal biomass (Gomez-Zavaglia et al., 2020; World Economic Forum, 2023).

Sustainable agriculture is critical to ending poverty and feeding a projected 9.7 billion people by 2050. According to the World Bank, three billion people in the world currently cannot afford a healthy diet and millions are eating insufficient food or unhealthy diets (The World Bank, 2023). Unsustainable agriculture has mostly been driven by unbalanced and unhealthy diets (Mehboob, 2023). Given agriculture affects the production of key greenhouse gases, sustainable agriculture has a significant role to play in addressing the global environment and socioeconomic crises stemming from climate change. Carbon dioxide, methane, and nitrous oxide are at record levels, with the annual increase in methane being the highest on record (The World Meteorological Organization, 2022). The livestock sector is the largest producer of anthropogenic methane emissions, producing one-third of all anthropogenic methane (Chang et al., 2021). In addition, grasslands under grazing regimes cover 25% of the global land mass and is the most extensive form of land use on the planet (Asner et al., 2004; Maestre et al., 2022). Grazing can have negative impacts on the environment and ecosystem function if not managed properly (incorporating suitable periods of rest) and has a major role in providing food security (Lai & Kumar, 2020).

Research into grazing systems investigating best practice for regenerating pastures and ecosystems whilst maintaining and improving production is essential (McDonald et al., 2019). Wider knowledge is required to understand the impacts of stock density (over-grazing and under-grazing referred to as low-intensity grazing) on the ecology of pastures, and the social-environmental implications of grazing practices. For example, over-grazing has resulted in entire pastoral districts being abandoned in areas of Southern Europe (Quaranta et al., 2020). In the United States, conventional grazing systems in rangelands have affected ground cover and water infiltration (Basche & DeLonge, 2019), ultimately impacting economic, social-ecological dynamics, and overall wellbeing (Bentley Brymer et al., 2020). Embracing regenerative agriculture (RA) and sustainable management practices will improve soil health, ecosystem biodiversity, landscape function, agricultural sustainability, and therefore food security (McLennon et al., 2021). Further, given that 60% of global agricultural land is grazed by some 360 million cattle, the livestock sector can play a key role in mitigating the effects of climate change (Beauchemin et al., 2020).

1.2 Australia's challenges in the Anthropocene

According to Australia's 'State of the Climate Report', it is estimated that Australia's climate has warmed by 1.47˚C since 1910 and sea temperatures have increased by 1.05˚C (Bureau of Meteorology and CSIRO, 2022). Since the 1950s, rainfall has declined by 15 - 19%, stream flows have decreased, extreme fire events have increased the fire season is longer, and snow occurrence and depths have decreased in the southwest and southeast areas of Australia. Oceans are more acidic and sea levels are rising, damaging coastal infrastructure and communities from compounding impacts (Bureau of Meteorology and CSIRO, 2022). In addition, Australia has a 22% rainfall variability next to its nearest neighbour across the Indian Ocean in Southern Africa which has an 11% variability putting the region at a 33% rainfall variability (Eckard & Clark, 2018) which increases its vulnerability. Australia is feeling the effect of the Anthropocene firsthand through the inundation of coastal areas along the east coast of Australia and large areas of agricultural land that face enormous risks and challenges. These climate challenges risk farmers' ongoing ability to farm and their economic, environmental, and social survival.

Sustainable management is critical for farm businesses given fifty-five percent of Australia is under agricultural land use, freehold pastoral land and leases make up 39.2% of land area in Australia, covering 325 million hectares of land, and 63% of Crown land is under leasehold (Australian Bureau of Resource Economics and Sciences, 2016, 2023). It is estimated that 61% of graziers use a grazing management system such as rotational grazing, and many sustainable land practices are now standard, with most farmers setting long-term ground cover goals (Coelli, 2021). Sustainable management is also vital, given that higher prices have driven growth in the livestock sector, with 70% of Australian agriculture output exported and 78% of beef exported (Weragoda & Duver, 2021). Australian farmers are managing climate, price variability, and significant risk, the effects of which vary from region to region. In addition, farmers face additional challenges in dealing with emissions from ruminant livestock in the form of methane consisting of 80% of CO2-e (carbon dioxide-equivalent), equating to around 22t CO2-e per unit of beef produced (Greenville et al., 2020) or 80 million tonnes (Ritchie et al., 2020). Given the significant role the livestock sector in Australia plays in contributing to enteric methane levels, farmers must assess strategies for reducing enteric methane levels (Beauchemin et al., 2020; Eckard & Clark, 2018).

The state of Australia from a triple-bottom-line perspective (economic, environmental, and social) closely reflects that of other countries. The Australian 'State of the Environment Report' (Department of Climate Change Energy the Environment and Water, 2021) highlights biodiversity loss and land degradation as critical issues that affect the well-being of communities and the economy. The indicators in this report document decreased biodiversity, increased numbers of threatened species, reduced soil health, increased competition for land resources in Australia, and the extensive clearing of native vegetation and invasion of non-native species. There is the opportunity to restore soil health through Regenerative farming practices and allow farmers to sequester carbon to reduce greenhouse gases on behalf of themselves and other industries (Daverkosen & Holzknecht, 2021; Khangura et al., 2023; Lal, 2020; P. Newton et al., 2020; Sahu & Das, 2020). To do this, an integrated economic, environmental, and social approach is required by livestock industries (Harrison et al., 2021). Practices that enhance the resilience of landscapes are critical to the future sustainability of Australian farming systems (Bennett et al., 2021).

In the 21st century, the most complex challenges facing humanity are biophysical in the form of climate change, transitioning to renewal energy, ocean acidification, overfishing, deforestation, biodiversity loss, nutrient pollution, etc. (Melgar-Melgar & Hall, 2020).

1.3 Response to the global crises impacting Australian agriculture

Globally, governments are implementing legislative changes to try and reduce greenhouse gases due to climate change. As part of the European Green Deal, the European Union (EU) has imposed a carbon-border tariff on imported goods, including steel, aluminium, cement, fertilisers, and electricity (European Commission, 2023). The New Zealand Government plans to introduce a farm-level levy on agricultural greenhouse gas emissions from 2025 (New Zealand Minstry for Primary Industries, 2023). Meat and Livestock Australia (MLA) has set a target to be carbon neutral by 2030 to ensure ongoing access to world markets (Witt et al., 2020). Agricultural emissions are currently estimated to be 16% of total greenhouse gas emissions; 81% is associated with livestock and 48% with beef alone (Bureau of Meteorology and CSIRO, 2022). It is anticipated that the expectations of the agricultural sector (and particularly on beef) to reduce greenhouse emissions will only increase (Marinova & Bogueva, 2019).

In June 2022, Australia agreed to reduce its greenhouse gas emissions to 43% less than 2005 levels by 2030 and move towards net zero by 2050 (Department of Climate Change Energy the Environment and Water, 2022). Current baseline projections (including federal, state, and territory policies and measures) indicate it is possible to achieve a 32% reduction on the 2005 levels by 2030, however, this could increase to 40% with additional methods. Significant changes are required in the electricity and energy sectors, and the agricultural sector needs to reduce emissions from methane (enteric methane from ruminant animals), nitrous oxide (from the use of urea and nitrogen fertilisers) and burning agricultural residue. The 2019 extensive Australian bushfires increased emissions (Shiraishi & Hirata, 2021); this was followed by the high rainfall of 2021-2022 and the corresponding widespread re-stocking that took place

(Kane, 2023). Beef cattle are the largest contributor to agricultural emissions and it is predicted that campaigners will turn their attention away from the fossil fuel industry and demand change from the livestock industry (AgTrade, 2023). According to the AgTrade Group, action is required and the narrative needs to change when it comes to what well-managed livestock can do for the environment.

The pressure to change to sustainable agricultural practices could potentially affect farmers' decisions to stay farming, particularly if overwhelmed with information, and potentially could cause structural changes within Australian agriculture (Mann et al., 2017). Further, the National Farmers Federation is referring to a national crisis in agriculture labour availability right across the supply chain (National Farmers Federation, 2022). In addition, the CSIRO and the Bureau of Meteorology have estimated significant drops in productivity to 2050 and beyond due to climate change, with data showing farm profits already reducing by 23% over the past 20 years due to climate events (Bureau of Meteorology and CSIRO, 2022).

The CSIRO has identified seven megatrends it sees as shaping transformation in the future, one of which includes adapting to climate change (Naughtin et al., 2022). Australia is highly vulnerable to the impacts of climate change. If the current trajectory continues and Australia is 3% warmer by 2040, ecosystems, food systems, health, and well-being will be severely affected. There is likely to be an escalation in heatwaves, bushfires, storms, and coastal flooding. In addition, the agricultural sector is likely to experience declining river flows, reduced water availability, heat stress on livestock, and increased erosion and invasive species, ultimately driving loss in profitability. Tipping points whereby a system moves to a significant and unstoppable stage of accelerated change, are already being experienced (Australian Academy of Science, 2021). Therefore, Australia, and particularly the agricultural sector, needs to be resilient in order to adapt to climate change.

1.4 Resilience and Regenerative Agriculture

The current dominant industrial-productivist agriculture does not reflect the principles of resilience. Resilience relates to the way that a system deals with disturbances or shocks. Most simply, resilience is defined as the ability to 'bounce back' (Vella & Pai, 2019). Resilience is 'the capacity of a social-ecological system to absorb disturbance, reorganise, and thereby retain essential functions, structures, and feedbacks' (Carpenter et al., 2012). The Stockholm Resilience Centre (Stockholm Resilience Centre., 2021) refers to resilience as the "capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop … It is about how humans and nature can use shocks and disturbances like a financial crisis or climate change to spur renewal and innovative thinking."

A paradigm shift from efficiency-driven industrial agriculture to resilience-focused eco-friendly agricultural approaches are seen as a pathway to adopting climate resilience practices that will support farms to be more resilient to droughts, floods, and other climate shocks (Bennett et al., 2021; Dong, 2021). There is a need to achieve a more sustainable and resilient Australian food and land-use system, with better socioeconomic and environmental outcomes compared to current trends (Navarro Garcia et al., 2023). Resilience principles are epitomised in RA farming systems, hence the adoption of these principles is critical to bringing humanity back within planetary boundaries (Gordon et al., 2022; Gordon et al., 2023). In addition, there are economic opportunities for farmers in environmental markets and the carbon sequestration space in the form of diversification and better income (Gosnell, Charnley, et al., 2020; Henry et al., 2012; White et al., 2021; White, 2022). Regenerative farming systems are underpinned by resilience in both an ecological and social context. However, economic resilience is also essential within regenerative farming systems and needs to be further explored (Baumber et al., 2020). Farming operates in a complex adaptive system (Bennett et al., 2021; Petersen-Rockney et al., 2021) whereby economic resilience does not exist without social and ecological resilience (Meuwissen, 2019).

1.4.1. What is Regenerative Agriculture?

Terra Genesis International refers to RA as "a system of farming principles and practices that increases biodiversity, enriches soils, improves watersheds and enhances eco-systems services" (Soloviev & Landus, 2016). According to US Academic, Professor Hannah Gosnell, "Regenerative agriculture is an alternative form of food and fibre production that concerns itself with enhancing and restoring resilient systems, supported by functional ecosystem processes and healthy, organic soils capable of producing a full suite of ecosystems services, among them soil carbon sequestration and improved soil water retention" (Gosnell et al., 2019a, p. 1)

Australian definitions have included "regenerative agriculture has emerged as an umbrella term for any agricultural activity that restores and enhances holistic, resilient systems. It can include many old and new practices. An agricultural practice is not regenerative when it discourages the evolutionary and self-organising potential of a living system" (Gordon et al., 2022, p. 1). It evolved in Australia from the training schools Resource Consultancy Services (RCS) and Holistic Management (HM), which stemmed from Stan Parsons and Allan Savory's work in South Africa and which recognised the impacts of large grazing animals moving quickly across a region on landscape function and health. A 1994 African article (Healthy Land and Water, 1994) stated Parsons and Savory worked together to bring ecology and economics to agriculture in Africa and later to Australia. Australian academic, Charles Massy captures this journey from Africa to Australia in his book entitled "The Call of the Reed Warbler" (Massy, 2020).

Since 2016, the RA Movement has been growing in Australia, but with little research on how to navigate, transform, and sustain farm management approaches and personal lives (Gosnell et al., 2019). It has been referred to by some as a community of practice (COP) moving towards a more sustainable agroecology approach (Cross & Ampt, 2017). The roots of RA are embedded in the concept of holism and HM practices (Gosnell, Charnley, et al., 2020), with the 'holistic paradigm' referred to as 'the next wave of sustainability' (Gibbons, 2020). It also has an alliance with other narratives such as agroecology, food sovereignty (Anderson & Rivera-Ferre, 2021) and permaculture practices (McLennon et al., 2021; O'Donoghue et al., 2022). Other research has examined RA from an agronomy perspective (Giller, Hijbeek, et al., 2021a), or in the context of circular economies (Schreefel et al., 2020; Velasco-Muñoz et al., 2021) or organics (Francis & Harwood, 1985; Andre Leu, 2020b).

RA is considered a key solution to agricultural climate mitigation, particularly through repairing soil health, water quality, vegetation, and land productivity, leading to carbon sequestration (Bossio et al., 2020; Lal, 2020; Schreefel et al., 2020; Toensmeier, 2016). RA can ameliorate the effects of flooding, drought, and erosion due to less runoff (Lal, 2020; Rhodes, 2017; Schreefel et al., 2020), and contribute to 'paradigm shifts' which encourage sustainable practices as part of that process (Gordon et al., 2022; Kassam & Kassam, 2021). Despite these positive contributions, there are challenges to RA's ability to mitigate climate change around adoption and questionable levels of carbon sequestration (Paustian et al., 2020; Ranganathan et al., 2020; Searchinger & Ranganathan, 2020) which has the potential to build resilience in agriculture.

1.4.2 What is resilience?

The Stockholm Resilience Alliance refers to resilience as "the capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions and continue to develop" (Stockholm Resilience Centre., 2021).

Resilience can have different meanings depending on the context, for example, we see the term resilience applied to healthcare (O'Sullivan et al., 2020), communities (McCrea et al., 2019), and disaster recovery (Parsons et al., 2021). However, resilience in agriculture incorporates all of these elements in a social-ecological context (Azadi et al., 2021; Tittonell, 2020) as well as an economic context (Meuwissen, 2019). Australia needs to look at the economic, environmental, and social indicators for resilience (the triple-bottom-line approach) if it is to adapt to a changing climate in the future. Subsequently, the term climate-smart agriculture has emerged which aims to incorporate economic, environmental, and social dimensions (O'Connell et al., 2019; Stockholm Resilience Centre., 2021; Venkatramanan & Shah, 2019).

To date, there have been no clear principles for RA in Australia to guide farming practices to ensure landscapes and farming families and communities can be resilient (Gordon et al., 2022). A legal or regulatory definition for RA is also lacking, with the literature largely referring to definitions based on processes and outcomes; this confusion around how RA is understood or misunderstood needs to be addressed (P. Newton et al., 2020). This will assist industry organisations who have intermittingly confused the difference between principles and practices such as Birchup Cropping Group, General Mills and Henly (Birchup Cropping Group, 2021; General Mills, 2020; Henly, 2021; McDonalds., 2023; Regenerative Agriculture Alliance, 2020) to accurately describe principles versus practices or outcomes and to understand that principles guide practices. Individuals can define the term RA as their knowledge of the space grows in their own purpose and context (Newton et al., 2020).

If Australia is to face the global challenges of climate change, environmental degradation, diminished biodiversity, and poverty, and allow farmers to thrive, we need to support agriculture that is regenerative and therefore resilient whilst remaining economically sustainable (Schulte et al., 2022). Given the lack of a clear understanding of principles as against practices or outcomes, a clear set of guiding principles is required to assist farmers' practices that can build resilience in a changing climate.

1.5 Research approach

This research is multi-disciplinary and includes economics, business, environment, and social sciences. Multi-disciplinary approaches have been used in various sectors including health (Duis et al., 2019), education (Briguglio, 2006), climate (D'Aloia et al., 2019) as well as agriculture (Ben Ayed & Hanana, 2021; Brenes et al.; Shah & Daverey, 2020; Soceanu et al., 2021). A mixed methods approach that uses both quantitative and qualitative data has been adopted for this research as a holistic approach to triangulate research findings. Mixed method approaches use multiple data collection methods to validate findings (Cameron & Miller, 2007). The mixed method approach has been chosen due to the holistic nature and complexity of the triple-bottom-line research and the need to examine in depth and obtain rich information that can’t be obtained if only using quantitative or qualitative analysis alone, allowing any unforeseeable insights to emerge from such a complex area (Almeida, 2018). Qualitative and quantitative approaches, allow the research to be triangulated utilising different conceptual frameworks, and methods for collecting the data, (observations, surveys, and interviews) over different times (Bamberger, 2012; Queirós et al., 2017). The research also took an exploratory design approach, utilising the quantitative data to complement and further test the written and verbal responses, with the intention to use the strengths of both methodologies (Tobi & Kampen, 2018). Note that due to the small number of farms captured in the overall case study (13-16), the quantitative data is limited whilst the number of data sets (100) obtained from each participating farm is extensive. Therefore, utilising both methods (qualitative and quantitative) is considered a complementary approach to test the qualitative responses and the researcher's interpretation of the results. The multi-dimensional nature and complex nature of holistic research therefore requires different research approaches to decrypt and understand it (Baran, 2016). Adopting a convergent parallel mixed method design uses pragmatism as a theoretical assumption (Creswell & Clark, 2017). By integrating the data, and cross-validating and triangulating to provide more accurate and robust results to confirm the findings from a single case study, assists the researcher in deeply and accurately understanding the phenomena or thinking underpinning the practices of the applicants (McKim, 2017; Ponterotto et al., 2013; Toomela, 2008).

Almeida (2018) highlights the disadvantages of using a mixed methods approach as difficulties in integrating quantitative and quantitative data, having methodological preferences, research projects being typically built to deal with quantitative data, and the time and skill involved. The challenges identified specifically for this research are identified as:

- Any discrepancies between the quantitative and qualitative findings may prove difficult to reconcile, and
- The additional time and expertise involved in analysing the data from different methodologies.

This research is underpinned by Systems Theory, which is considered an interdisciplinary study of systems as they relate to one another within a larger, more complex system. In this context, Systems Theory is referred to as Ecological Systems Theory (Guy-Evans, 2020). This approach recognises the complexity of the environment and the key concept that the whole is greater than the sum of its parts (Valentinov & Hajdu, 2021). Understanding the environment, people, and economics all operate within a complex adaptive system is key to designing more grounded and holistic studies in the field of agriculture (Phillips & Ritala, 2019). This research brings together socio-ecological systems with socio-economic systems. Ecological economics was originally developed 30 years ago to combine social and economic systems, aiming to form a new paradigm that included social and economic systems and moved away from conventional economics. It was an opportunity for transdisciplinary research to come together to advance science in the area of sustainability (Melgar-Melgar & Hall, 2020).

In this research, three methods are utilised as follows:

- A Literature review (encompassing beef systems, climate change, land degradation, value chains, resilience, and regenerative agriculture)
- A longitudinal case study of a group of cattle farmers in the New England region of Northern New South Wales, Australia comparing conventional and regenerative practices from a triple-bottom-line perspective, and
- A quantitative survey of an Alliance of farmers across Australia on the relevance of regenerative principles

The Literature Review evaluates the current literature to provide a broader framework around RA and climate change. It does not aim to highlight agreements or disagreements in the space as a form of Integrative review, but rather to highlight current gaps in knowledge (Neuman, 2006). Others have undertaken similar literature review approaches when studying existing literature in the sustainability space (Cordova & Celone, 2019; Martins et al., 2019).

The Longitudinal case study encompasses a group of cattle farmers in the New England region of Northern NSW, Australia. A longitudinal approach was taken to gauge farmer practices over the period in which significant drought was experienced. This approach captured farmers' thoughts and practices pre- and post-drought to gauge attitudinal and practice change. It is longitudinal in its approach because farmers were asked the same questions in 2016 and again in 2020. It refers to many units or cases across long periods and is time series in nature in that the same type of information was collected (Neuman, 2006). It is also considered a cohort longitudinal study as the case study group comprises a cohort of farmers from a similar location, consisting of 16 farming families in total. The case study had a triple-bottom-line approach as it focused on the economic, environmental, and social aspects of the farmers' lives. Triple-bottom-line approaches are an appropriate method for researching climate-smart agriculture and the environment (Venkatramanan & Shah, 2019).

The research also applied an Interpretive approach aiming to gain meaningful social action through observation and field research, which included on-farm visits and conversations whereby observations and records were made on farmers in their natural settings (Neuman, 2006). The surveys and site visits were later analysed using thematic analysis, picking up key themes in participant responses and conversations. Like other studies of farmers' views (Alexanderson et al., 2023; Balzani & Hanlon, 2020; Klerkx et al., 2019; Shi et al., 2019), this study focused on farmer's opinions, perceptions, knowledge, values, beliefs, and attitudes and "mined text" for keywords associated with a particular variable or question (Alexanderson et al., 2023; Lakshmi & Corbett, 2020). It used a coding system to capture the qualitative richness of responses as a set of rules to take verbal and descriptive content in the form of text into quantitative data (Neuman, 2006).

To support and triangulate the literature review and longitudinal case study, a national quantitative survey was undertaken surveying agriculturists with the same questions regarding their attitudes and beliefs on proposed regenerative agricultural principles that had been taken from around the world and applied to Australian conditions. Participants were asked to rate them on a Likert scale due to this method's ability to record the strength of agreement or disagreement and systematically asked to rank and make comments on the proposed principles. Quantitative research surveys are considered a practical adequate research method for gathering large data to give a specific measurement (Neuman, 2006; Stockemer, 2019). Likert scales are one of the most effective tools for data collection and one of the most fundamental and frequently used tools in research (Taherdoost, 2019).

Furthermore, a pragmatic theoretical perspective was undertaken to understand RA principles. Pragmatists agree that research should be contextually situated without being committed to any one philosophical position, instead using diverse methods to understand a given problem (Creswell, 2009). A mixed methods approach was used whereby both qualitative and quantitative data were utilised and interpreted based on the combined strengths of both, providing a clearer understanding of the research question than either approach alone (Creswell, 2014). The mixed method approach suited a holistic research piece. An interpretivist Approach was used for analysis whereby the researcher's perceptions and interpretations became part of the research (Creswell et al., 2006; Doyle et al., 2009; Gunbayi, 2020; Hendren et al., 2022; Hesse-Biber, 2010).

1.6 Aims, objectives, and research question

Given grazing predominantly occupies the vast majority of agricultural land use in Australia (Australian Bureau of Resource Economics and Sciences, 2016, 2023), and the livestock sector plays a critical role in mitigating the effects of climate change (Beauchemin et al., 2020), conventional and regenerative grazing systems were first examined through a longitudinal case study of beef grazing systems in Northern New South Wales, Australia. Given the urgency of mitigating the effects of climate change (Forster et al., 2020; Zurek et al., 2022), a set of regenerative principles were developed and tested via a large quantitative survey.

The overarching research question was: Are Australian regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate?

The objectives of this research were to:

- Determine the applicability of a specific resilience framework for Northern NSW beef cattle systems
- Identify the environmental, social, and economic indicators for a resilience framework for NSW beef cattle systems
- Identify the beliefs and practices of NSW beef cattle farmers in a changing climate, and
- Develop and test the principles for Australian regenerative agriculture

To address these objectives, the following research question and sub-research questions were addressed through the methods outlined in Table 1.1.

Table 1.1 Research Question Tree

<table>
<tr><td colspan="2">Overarching Research Question:

Are Australian regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate, and whether comparing these production systems highlight the need for a set of guiding principles for regenerative agriculture in Australia?</td></tr>
<tr><td>Sub-research questions</td><td>Methods</td></tr>
<tr><td>Theme 1 – Resilience of Regenerative and Conventional Farming Systems

1. Which beliefs and practices (leading to management decisions) are held by Northern NSW beef farmers in a changing climate, and how are these expressed?
2. What are the economic, environmental, and social indicators for a resilience framework, and how do the actions of regenerative and conventional beef cattle farmers align with the Stockholm Resilience Framework?
3. What conclusions can be drawn about the resilience of cattle production systems in Northern NSW?</td><td>Literature review

Case Study

Longitudinal survey

Thematic analysis</td></tr>
<tr><td>Theme 2 – Regenerative Agriculture Principles for Australia

1. What are the principles for Australian regenerative agriculture?
2. How are they relevant to Northern NSW cattle production systems in a changing climate?</td><td>Literature review

Quantitative survey</td></tr>
</table>

1.7 Structure of the Thesis

Chapter 1 provides an introduction, background, and overview of the reasons for the research and the approach that has been taken. It provides context on current environmental and socio-economic global challenges and the role Australian grazing systems can play to mitigate the effects of climate change and remain resilient and relevant into the future. It outlines the issues, the research approach taken, the aims, objectives, and structure of the thesis.

Chapter 2 looks at the current literature on global, national, and southern beef systems, and examines the drivers for practice change, including climate change, land degradation, and the effect of value chains on farm businesses. It also looks at issues around resilience from an environmental, social, and economic perspective, and sustainable land management practices in the form of RA, and highlights known and unknown gaps. Given Australia is a leading beef exporter, it is important to explore the resilience of beef production systems. The literature review focused on alternative beef production resilience in an ecological, social, and economic context. The literature review highlights the need for further comparative studies in alternative regenerative farming systems and the development of guiding principles to support practice change. The literature review provides the foundation for the empirical chapters that follow including Chapter 3 (A Longitudinal Case Study of Conventional and Alternative Cattle Grazing Systems in Northern NSW, Australia) and Chapter 4 (the Principles for Regenerative Agriculture in Australia).

Chapter 3 provides a comparative thematic case study of Grazing Systems in Northern NSW, Australia from a triple-bottom-line resilience perspective. The case study aimed to investigate the role RA plays in building resilient farming systems from a social, environmental, and economic perspective. It specifically examines if regenerative beef cattle production systems are more resilient than conventional beef cattle production systems in a changing climate. It applies a specific resilience model developed by the Stockholm Group of Scientists (SRAP) to determine if the model had a context in Northern NSW beef cattle production systems, and if the framework could be used to guide future decision-making by farmers in a changing climate. It also highlights the differences in both beliefs and practices of conventional farmers (CF) and regenerative farmers (RF).

In Chapter 4, a set of principles for Australian RA are developed as a guide for future practice and then validated. It assists people in developing an understanding of the differences between a set of guiding principles and specific practices. It highlights that principles and practices are significantly different and that definitions involve conjecture, can be misunderstood, and are often represented out of context. The principles offer guidance for achieving resilience in a changing climate. They can potentially become a common ground space for future discussion and discourse with the aim of achieving transformative change in Australian agriculture.

Chapter 5 provides a synthesis of the literature review, case study, and the principles findings. It provides further evidence from the existing published literature on the outcomes of the three areas of research.

Chapter 6 provides the conclusion, limitations of the study, and recommendations for future research.

Chapter 2: The Anthropocene, Regenerative Agriculture, and the Resilience of the Australian Beef Industry

2.1 Global Drivers of Regenerative Agriculture

This chapter aims to provide background into what is driving change in global agriculture and why the term regenerative agriculture suddenly emerged in Australia. Even though RA has been practiced globally under various synonyms since the 1970s, its popularity and research focus have risen substantially over the last five years. The logic underpinning this chapter is that RA has the potential to build resilience into farming systems in a changing climate, and suitable frameworks for building such resilience need to be found. This literature review chapter highlights several existing international and Australian resilience frameworks arguing their suitability for a triple-bottom-line comparison case study of beef cattle farming systems in Northern NSW. It also highlights the other alternative farming systems and their similarities and differences with RA. This chapter provides the necessary focus on existing beef production systems in Australia as background for the research that follows.

Worldwide, there is increasing concern about the impact of greenhouse gas (GHG) emissions on global warming. Many countries, governments, and corporations are working to reduce GHG emissions. In accordance with the Paris Agreement, Australia is facing increasing pressure to reduce its emissions and be carbon neutral by 2030 (Paris Agreement, 2015; United Nations Conference of the Parties 27, 2022). These concerns have become a major driver for changing the way we farm. It is therefore critical for agriculture and specifically the livestock sector to address GHG emissions in order to continue to have industry and community support and future market access (Dunn, 2021).

The livestock sector is responsible for three main GHGs – carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), with methane being the largest source of livestock emissions and contributing to approximately 80 - 90% of emissions in Australia (Dunn, 2021). Farmers are not just part of the problem, however, they may also play a role in providing solutions by sequestering carbon through vegetation, soil management, and adopting climate-smart agricultural best practice and climate-specific technology that reduce methane emissions (Panchasara et al., 2021). Carbon sequestration requires regenerative practices (Kenne & Kloot, 2019; Wiltshire & Beckage, 2022, 2023). Studies recognise the role RA plays in sequestering carbon and increasing soil health, but further research is also needed to understand how RA may also increase GHGs by retaining crop residues and adding compost or manure (Ranganathan et al., 2020; Tan & Kuebbing, 2023). Synergies between regenerative practices and resilience have been gaining attention (Zeunert, 2018), but in order to develop guidelines on best practice, further research is required to determine which aspects of regenerative farming increase the resilience of a system (Al-Kaisi & Lal, 2020; Khangura et al., 2023).

COP27 Food and Agriculture for Sustainable Transformation (2022), the SDG's sustainable agriculture metrics (Food and Agriculture Organisation, 2000), and the OECD's three key challenges facing agriculture being: feeding a growing population, providing a livelihood for farmers and protecting the environment, highlight issues that are driving the RA movement worldwide (Organization for Economic Cooperation and Development, 2023). Price Waterhouse and Coopers (PwC) highlight the Environmental Social Governance (ESG) trends for 2023 which include ethics, integrity and security, and resilience and transparency of supply chains (Price Waterhouse Coopers, 2023) and Collier FAIRR (a $7 trillion investor network focusing on ESG risks in the global food sector) (CollerFAIRR, 2023) is an example of the substantial philanthropic investment in scrutinising sustainability and international food chains in particular. These global drivers from international bodies and networks are putting greater emphasis on reducing emissions and being carbon neutral, driving agriculture to farm differently in an anthropocentric world increasingly shaped by climate change and biodiversity loss.

2.1.1 Climate change and biodiversity loss – a global problem and driver for change

As previously mentioned, the planet has moved into the Anthropocene, a period where the biosphere is shaped by humanity from local to global scales, and humans are overstepping planetary boundaries, causing environmental and economic shocks and disturbances (Rockstrom et al., 2009a; Walker & Salt, 2006, 2012).

Farmers are experiencing multiple natural disasters. For example, in North Eastern NSW, Australia, farmers went from drought to fires to floods and a global pandemic within five years (Nicholas & Evershed, 2021). These regular shocks and challenges test the resilience of farmers (including their mental and physical health) and the communities in which they reside (Cowie et al., 2019). These shocks and challenges are potential drivers for change, causing farmers to question the way they farm.

Agriculture is both a source and a sink of GHGs (Mehmood et al., 2022; Silva-Parra et al., 2021; Svensson et al., 2021; Zhang et al., 2022). If not managed to reduce methane levels, beef production will continue to significantly contribute to GHG emissions and the cattle industry is facing public pressure due to high methane emissions (Arango et al., 2020; Liu et al., 2021; McGregor et al., 2021; Reisinger et al., 2021; Resende et al., 2020; Suybeng et al., 2019). However, there is potential to sequester CO_2 in biomass and soils through carbon farming (Bai & Cotrufo, 2022; Das, 2019; Drexler et al., 2021; Gupta et al., 2020; Joshi & Singh, 2020; Mohanty & Singh, 2022; Rumpel et al., 2020; Yadav et al., 2023), and to reduce cattle methane emissions by using feed supplements (Arango et al., 2020; Min et al., 2020; N. Zhang et al., 2019b).

Over the years, there has also been conflict between humans and wildlife conservation (Van Eeden et al., 2018). If not conducted in an environmentally sustainable manner, beef production can threaten biodiversity by converting forested land to grazing land (Godfray et al., 2018; Machovina et al., 2015; Maxwell et al., 2016). In addition, beef significantly affects biomass, GHG emissions, and water use compared to other forms of livestock (Gerber et al., 2015; Hedenus et al., 2014). Consequently, many studies have recommended reducing beef production and consumption and developing beef alternatives (Hughes et al., 2011). Contrary to this approach, other studies focus on increasing beef production (Cusworth et al., 2022; Khangura et al., 2023). Some of these studies focus just on individual practices in a non-holistic context (Giller, Hijbeek, et al., 2021a), meaning the approach is atomistic and reductionistic and therefore incomplete. Other research focuses on feed additives, breed of cattle, government-subsidised insurance schemes, and education as the key to increasing productivity in a changing climate (Harris, 2020), with little mention of changing management practices to address GHG emissions, protect biomass, and reduce water use.

Globally, we are experiencing the breakdown of planetary systems (Campbell et al., 2017; Rockstrom et al., 2009a, 2009b). According to the Intergovernmental Panel on Climate Change and other recent studies (Intergovernment Panel on Climage Change, 2018; Shukla. P.R et al., 2019; Tollefson, 2018), the earth is currently on a trajectory to a temperature increase of 1.5 - 2˚C in Australia and 2 - 4.5˚C worldwide by 2040, with temperatures predicted to increase by 5.4˚C by the year 2100 if action is not taken promptly to address emissions. Approximately 30% of total GHG emissions derived from human activities are attributable to the food system, with 7.2Gt CO_2 equivalent per year from crop and livestock activities within the farm gate (Tubiello et al., 2021). It is critical to apply effective mitigation methods to livestock production in particular as these enterprises contribute around 14.5% of GHG emissions globally (Godde, 2020).

Agriculture, forestry, and other primary industry land use activities accounted for approximately 13% of CO_2, 44% of methane, and 81% of nitrous oxide emissions from human activities globally during 2007 – 2016, representing 23% (12.0 ± 2.9 $GtCO_2eq\ yr^{-1}$) of the total net anthropogenic emissions of GHGs. If emissions associated with pre-and post-production activities in the global food system are included, the emissions are estimated to be 21 – 37% of total net anthropogenic GHG emissions (Shukla. P.R et al., 2019). The total mitigation potential of crop and livestock activities is estimated to be 1.5 – 4.0 $GtCO_2$ eq year, including soil carbon sequestration, reductions in nitrous oxide emissions from fertilisers, and reductions in methane via improved manure and feed management (Intergovernment Panel on Climage Change, 2018). Agriculture can potentially reduce GHG emissions by applying best practice management with increased ecological literacy being the relationship between knowledge, environmental values, and ecological behaviour (Kamil et al., 2020; Maurer & Bogner, 2020) and utilising agroecological practices and principles (Bindraban & Rabbinge, 2012). There is increasing pressure on farmers to reduce their GHG emissions, which is seen as a driver for practice change.

2.1.2 Land degradation as a driver of practice change

The environmental impacts of industrial agriculture include carbon, methane, and nitrous oxide emissions, as well as the leaching of nitrates and phosphates into waterways and groundwater systems, and residual toxins from pesticides and herbicides (Auerbach, 2019). With the population projected to reach 9.7 billion worldwide by 2030, agricultural land availability and quality rapidly reducing, and climate change threatening food security, the global population faces significant challenges (Gomiero, 2008). *'The Global Land Outlook 2 Report'* released in 2022 by the United Nations Convention to Combat Desertification (van der Esch et al., 2022) found that 40% of Earth's land is degraded. The world's soils are continuing to deplete despite increasing levels of chemical fertiliser inputs, and soil phosphorus (P) loss from agricultural systems threatens to limit our future food production (Alewell et al., 2020). Given the predicted shortage of mineral P fertiliser, the future of food production faces significant challenges. In addition, the effects of overgrazing of livestock cause soil erosion, compaction, decreased infiltration, and thus increased runoff and consequent soil loss (Centeri, 2022; Li et al., 2019). This ongoing land degradation is a further driver for changing farming practices.

Some forms of low-input agriculture in less developed countries, for example, can also damage the environment through erosion (Borrelli et al., 2021). Compared to conventional agriculture low-input sustainable agriculture uses less energy, reduces CO_2 emissions, improves soil quality, increases carbon sinks, minimises water usage, preserves biodiversity, provides healthy, nutritious food to consumers (Gomiero, 2008), and facilitates agricultural sustainability (Sarkar et al., 2020). It is unclear whether organic agriculture can produce enough food to feed the world however and the potential implications of lower productivity need further examination (De Ponti et al., 2012).

There are measurable benefits to the environment if the use of chemical fertilisers, herbicides, and pesticides can be reduced through alternative management systems (Baweja et al., 2020; Koli et al., 2019; Kumar et al., 2023; Shoeb & Nahar, 2023). These benefits will be realised if farmers are convinced of the profitability of alternative agricultural systems. The estimated environmental and healthcare costs of pesticide use at recommended levels in the United States are around $12 billion every year (Pimentel et al., 2005).

On a global scale, the use of chemical fertilisers, herbicides, and pesticides in conventional agriculture can adversely affect environmental and human health (Baweja et al., 2020; Nayak et al., 2020; Tripathi et al., 2020; Warra & Prasad, 2020). Nutrients from fertilizer and animal manure have been associated with the deterioration of some large fisheries in North America (Frankenberger & Turco, 2003), and runoff of soil and nitrogen fertilizer from agricultural production in the Corn Belt has contributed to the "dead zone" in the Gulf of Mexico (Tallis et al., 2019). The National Research Council reports that the cost of excessive fertilizer use in America - that is, fertilizer inputs that exceed the amount crops can use - is $2.5 billion per year (Patel & Champaneri, 2020). Many modern agricultural practices can also contribute to the erosion of soil. The estimated annual cost of public and environmental health losses related to soil erosion and the threat to food security and ecosystem health and viability is alarming (Kopittke et al., 2019; Wuepper et al., 2020; Xie et al., 2020), with $26 billion in production lost worldwide as 75 billion tons of soil is eroded each year (Gupta, 2019).

In contrast, the introduction of farming practices such as no-till, intercropping (or mixed cropping) systems, and maintained vegetation cover can help preserve topsoil, enhance yield, and deliver environmental security in extreme weather events (Maitra et al., 2021; Ogle, 2019; Skaalsveen, 2019; Zhao, 2022). According to Patel and Champaneri (2020), integrated pest and nutrient management systems, and certified organic agriculture can reduce reliance on agrochemical inputs and make agriculture environmentally and economically sound. Evidence shows that sound management practices can reduce pesticide inputs while maintaining high crop yields and improving farm economics (Patel & Champaneri, 2020). Government programs in Sweden, Canada, and Indonesia have demonstrated that pesticide use can be reduced by 50% to 65% without sacrificing high crop yields and quality (Patel & Champaneri, 2020).

2.1.3 Value chains driving demand for carbon-neutral agricultural products

Increasingly, pressure from consumers and philanthropist organisations and international obligations are driving demand for carbon-neutral agricultural products and commodities that are environmentally sustainable and support biodiversity and animal welfare (Voora et al., 2022). The number of certification schemes worldwide for value chains with integrity and sustainability in their focus is growing (The United Nations Conference on Trade and Development, 2023; Voora et al., 2022). In Australia, Roots Regenerative (Paradigm Foods, 2023), Southern Cross Certified Regenerative Standard (Southern Cross Certified, 2023), and the Open Food Network (Open Food Network, 2023) are examples of certification schemes. According to Traldi, most studies of sustainability standards to date do not address all sustainability pillars and only 20% simultaneously measure economic, social, and environmental indicators (Traldi, 2021). On the other hand, some are more pragmatic in approach while being "scientifically validated, aligning with international conventions and providing consumers with an independent and trustworthy data source for product comparison" (Williams, 2019, pp. 15-20).

According to the 2019 Global Agricultural Productivity Report (Steensland, 2019), global demand for food and fibre will reach 10 billion people by 2050, requiring a 70% increase in food production (Food and Agriculture Organisation, 2022). Increasing competition for natural resources has resulted in 12 million hectares of agricultural land being lost annually, however, and 10 - 20% more water will be needed for water-scarce regions to sustain environmental flow requirements globally (Pastor et al., 2019). According to Canning (2022), increased climate variability and volatility will result in 20 - 40% of global food production being lost by 2050 due to climate change. In Australia, growing AgTech investment is predicted to reach AUD 100 billion by 2030 in an attempt to address some of these food production challenges

(Canning, 2022). If the agricultural sector is going to feed a growing population into the future, whilst responding to these drivers for change, it will need to build its resilience to climate change and therefore re-examine the way it practices agriculture.

2.2 Resilience and agriculture

2.2.1 Overview of resilience

To understand whether a specific practice might increase or decrease the resilience of a socio-ecological system, it is first necessary to define resilience. As previously mentioned, resilience relates to the way that a system deals with disturbances or shocks. Most simply, resilience is defined as the ability to 'bounce back' (Vella & Pai, 2019). Resilience is 'the capacity of a social-ecological system to absorb disturbance, reorganise, and thereby retain essential functions, structures, and feedbacks' (Carpenter et al., 2012). This definition focuses on social-ecological systems, however, and fails to encompass economic resilience. The Stockholm Resilience Centre integrates all three aspects, covering social, environmental, and economic factors referring to resilience as the "capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop" (Stockholm Resilience Centre., 2021).

Unlike Carpenter et al. (2012), the Stockholm Resilience Centre. (2021) incorporates social-ecological and economic factors when addressing resilience. But like Carpenter, the Stockholm Group of Scientists view humans and nature as strongly coupled to the point that they should be conceived as one social-ecological system (Stockholm Resilience Centre., 2021). There are virtually no ecosystems that people do not shape, and people rely on the ecosystems and the services they provide to survive (Stockholm Resilience Centre., 2021). The term social-ecological thinking and resilience are often linked in many sectors, including health, tourism, and agriculture (Armitage et al., 2012; de Garine-Wichatitsky et al., 2021; Liang & Li, 2020; Rotarangi & Russell, 2009; Stone-Jovicich, 2015).

When assessing the resilience of farming systems, Meuwissen et al. (2019) refer to robustness, adaptability, and transformability within a local agricultural context. Meuwissen et al. (2019) defines resilience in a farming system as "its ability to ensure the provision of the system functions in the face of increasingly complex and accumulating economic, social, environmental and institutional shocks and stresses, through capacities of robustness, adaptability and transformability" (Meuwissen et al., 2019, p. 1). Meuwissen's framework assesses resilience to specific challenges (referred to as specified resilience) as well as unknown and unexpected surprises (referred to as general resilience) using indicators, capacities, and attributes as measurements.

2.3 Resilience Frameworks and Triple-Bottom-Line Approaches

Resilience frameworks have become a key focus globally, given the challenges caused by climate change (Hynes et al., 2020). Resilience is also a key focus for Australians battling ever-increasing climate change challenges and coping with the COVID-19 pandemic. Farmers are experiencing increasing frequency and severity of natural disasters. For example, between 2017 and 2022 farmers in North Eastern NSW experienced drought, bushfires, floods, and a global pandemic (Nicholas & Evershed, 2021). Furthermore, the consequences of these disasters were acute; the drought from 2017 – 2019 was described as the worst drought in living memory (Miller & MacNeil, 2022; Shanahan, 2022), bushfires included the largest recorded forest fires in living history (Filkov et al., 2020), and flooding on the east coast of Australia was unprecedented (Rice et al., 2022). Such experiences challenge the resilience of individual farmers and their surrounding communities.

Some resilience research focuses on social and ecological resilience (Cowie et al., 2019; Kutzner, 2019; Mcleod, 2019), while other studies focus on economic resilience (Andrade et al., 2020; Snow et al., 2021; Steffen, Mallon, et al., 2019). In comparison, triple-bottom-line approaches place equal importance on social, ecological, and economic resilience (Negri et al., 2021). In holistic research and teachings, the whole presents differently than the sum of all of its parts (Ratner, 2012). Social, environmental, and economic approaches to decision-making have equal weight and importance when building resilience in both people and the landscapes they inhabit (Polkinghorne & Given, 2021). In other words, economic resilience does not exist without social and ecological resilience (Rudiarto et al., 2019). Current agricultural advice and practice in Australia still has a strong focus on economic resilience and increasing yields and profits (Chauhan, 2020; Figueroa-Rodríguez et al., 2019; K. Giller et al., 2021b).

Farms are complex adaptive systems, which means they have the capacity to self-organise and adapt based on past experience (past negative and positive events that have led to this point), non-linear behaviour (whereby there is no straight-line or direct relationship between an independent variable or dependant variable), and uncertainty (a state of unpredictability) (Budaev, 2019; Jagustović, 2019). For example, in an agricultural context, pasture species are constantly adapting according to climatic conditions. If there is a drought resulting in less ground cover and bare soil, the first responding plants after a drought are often weeds aimed at securing ground cover and protecting topsoil from eroding forces and using extensive deep penetrating root systems to break up the subsoil to improve drainage and creation (Moreau et al., 2020). Farms and the landscapes they occupy are considered complex adaptive systems in that they are entities with more than one connected or interrelated component whereby everything is connected and interdependent (Von Bertalanffy, 1968). Further, the vulnerability of complex adaptive systems to climate change, means important issues such as connectedness, feedback mechanisms, redundancy, and susceptibility of the individual components of a system need to be considered when assessing how sensitive a system is to exposure over time and if that system is able to adapt (Naylor et al., 2020). Triple-bottom-line approaches and resilience are often considered together (Aguiñaga et al., 2018; Hodbod et al., 2016; Meuwissen et al., 2019; Negri et al., 2021). Combining the two topics often causes confusion and lack of clarity on the practices that could advance both areas (Negri et al., 2021). However, the importance of integrating triple-bottom-line sustainability and resilience to improve both needs to be pursued to clarify concepts, synergies, and potential trade-offs (Negri et al., 2021). Examining economic, environmental, and social aspects with their complex interactions, achieves a deeper understanding of issues within a community, issues associated with food security, human health, socio-economic improvement, resource conservation, or ecological, economic, and social resilience (Aguiñaga et al., 2018). A multi-dimensional and integrative analysis is often required for example, in plant disease management (He et al., 2021). Full dimensions of systems functions and multifunctional perspectives to allow adaptive agricultural systems that can increase production, ensure food security and quality ecosystem services, respond to multiple shocks without collapse, and achieve triple-bottom-line sustainability, are required (Hodbod et al., 2016). Meuwissen et al. (2019) have effectively used triple-bottom-line indicators to describe resilience functions.

Overall, there is limited literature that directly combines triple-bottom-line measurements with resilience frameworks. This was acknowledged in a comparative overview of resilience frameworks by Schipper and Langston (2015), who found frameworks were influenced by conceptual entry points thus making comparisons difficult, there were gaps between resilience theory and indicators of well-being and development, and indicators did not always provide a clear picture of resilience.

Therefore, combining both triple-bottom-line (economic, environmental, and social) measurements against resilience frameworks can provide practical examples of the 'how to' necessary to achieve the markers of resilience identified by Meuwissen et al. (2019), for example, robustness, adaptability, and transformability. Further, combining triple-bottom-line measurements with resilient frameworks can test the efficacy of resilience frameworks and in addition, specific triple-bottom-line measurements can add meaningful examples to concepts that may be hard to grasp or understand. Triple bottom line measurements or indicators that capture in-depth detail, can give real meaning to the term resilience and ensure that information is not misunderstood or misused, and avoid it becoming meaningless.

Shammin et al. (2022) focus on community-based adaptation which embodies resilience principles to address the evolving and intensifying environmental threats in Southeast Asia and many other parts of the world. Shammin takes a holistic approach when it comes to the role of Actors (government, community, NGOs, DP's, private sector, researchers, media) and Enables (service, policy, knowledge, technology, and finance) (Shammin et al., 2022). Shammin et al. (2022) highlight the limitations to adaptation in reducing risk around GHG emissions due to constraints around resources and time to implement and scale up (Shammin et al., 2022). Meuwissen et al. (2019) highlight the issue with current assessment tools lacking transformability and needing to be addressed in a local context through mixed methods. Elmqvist et al. (2019) argues that resilience is more than recovering from disturbances, its subsystems need to be both adaptive and transformative at scale across time (Elmqvist et al., 2019).

In the case of graziers in Northern NSW, Australia, having a set of measurable and meaningful indicators that move them towards being resilient in a changing climate, is important. Having a framework in which the indicators can preside, provides overall structure and direction for farmers and land managers.

Whilst acknowledging that there are many resilience frameworks (R Biggs et al., 2015a; Elasha et al., 2005; Index, 2014; Nikpour & Ashoori, 2023; Rodin, 2014; Tyler & Moench, 2012; UNDP, 2013), the following sections look at the importance of combining triple-bottom- line measurements with resilience frameworks using four resilience frameworks (two international and two Australian) most relevant to Australian grazing systems in Northern NSW as examples. The four examples outlined in Table 2.1, demonstrate how specific triple-bottom-line indicators can provide further meaning to principles or frameworks. The four examples chosen were:

- The Stockholm Resilience Alliance Principles for Building Resilience (SRAP)
- Resilience Adaptation Pathways Transformation Approach (RAPTA) Cowie Version
- Resilience Adaptation Pathways Transformation Approach (RAPTA) Baumber Version
- Meuwissen's framework to assess the resilience of farming systems (MF)

A review of the literature showed that definitions of resilience and the indicators to measure resilience lack consensus and consistency are contested and context-specific (Cerè et al., 2017; Schipper & Langston, 2015; Serfilippi & Ramnath, 2018). Therefore, the rationale for considering the above four frameworks, is that they aligned with triple-bottom-line criteria relevant to Northern NSW cattle grazing systems and therefore were context-specific. This was important in that the triple bottom line indicators need to be relevant, easy to understand and measure, and important to Northern NSW graziers achieving their goals. The four resilient frameworks chosen could allow for further testing and significance of the frameworks against a specific set of triple bottom line criteria and measurements relevant for Northern NSW graziers.

RAPTA (Baumber et al., 2020; Cowie et al., 2019) had been utilised for a similar group of farmers in a region of NSW for similar purposes. Meuwissen et al. (2019) had identified the type of farming system and its location to be researched, the challenges being faced, functions including indicators to reflect functions, and assessing the performance of indicators, looking at resilience capabilities and attributes also aligned with the triple bottom line criteria.

The SRAP, RAPTA (Cowie and Baumber versions), and MF frameworks allowed for adaptation and transformability in a local context utilising triple bottom line mixed method approaches and were found to be applicable and relevant to the group of graziers in Northern NSW. Whilst the RAPTA studies had proven useful in an Australian context however, when compared to the SRAP framework, SRAP captured the essence more broadly of the other frameworks and in addition was relevant to a particular group of graziers in Northern NSW. In addition, the importance of managing connectivity and polycentric governance systems was more specific with SRAP. The differences and similarities between the frameworks have been summarised in Table 2.1. The following sections provide an analysis of the frameworks considered.

Table 2.1 Differences and Similarities between the Frameworks and Relevance to Northern NSW Graziers

SRAP (Stockholm Resilience Centre., 2021)	**RAFTA** (Cowie Version) (Cowie et al., 2019)	**RAFTA** (Baumber Version) (Baumber et al., 2020)	**MF** (Meuwissen et al., 2019)	**Examples of farm management practices relevant to the northern graziers**	**Relevant citations**
Maintain diversity and redundancy	Diversity and Redundancy	Reserves/ Buffers/ Redundancies/ Diversity	Robustness	Number of other enterprises and income sources, income security and equity levels, ability to retain staff, level of biodiversity on the farm	Kharrazi et al. (2020)
Manage connectivity				Tree belts, wildlife corridors, and nature strips, individuals and the family's connection to land and community	Estrada-Carmona et al. (2019)
Manage slow variables and feedbacks	Flexibility	Feedbacks	Adaptability	Adopting and taking up new practices more suitable to the environment, increased on-farm landscape monitoring, and information sharing between farming cohorts	Reinette Biggs et al. (2015a)
Understanding that social-ecological systems are complex adaptive systems	Self-organisation		Transformability	Grazing management practices such as being regenerative or not, utilisation of the holistic management framework for decision-making purposes	Jagustović et al. (2019)
Encourage learning and experimentation	Risk Intelligence	Monitoring/ information flows	Transformability	Furthering education, level of risk-taking or new ideas, level and depth of information sharing amongst peers, and monitoring systems in place	Chavas and Nauges (2020)
Broaden participation	Collaboration Social capital	Social capital		Social and Community Engagement / Mental Health	Thomas et al. (2020)
Promote polycentric governance systems		Management at the right scale		Ability to self-sustain without relying on larger governance systems	Thiel and Moser (2019)

2.3.1 Stockholm Resilience Alliance Principles for Building Resilience

SRAP defines resilience as 'the capacity to deal with change and continue to develop' but SRAP is unclear on what that process of adaptation and transformation looks like, for example, how does a system go from surviving to thriving? SRAP asserts that resilience exists within the context of the environment, and the environment and its inhabitants, including humans, are connected (Bengtsson et al., 2003). Members of the SRAP in 2016 agreed on seven principles for improving resilience (R Biggs et al., 2015a). These principles and definitions of their meanings from a farm management perspective are outlined as:

1. Maintain diversity and redundancy: Systems require several components that undertake the same function so that components can compensate for the loss of others. Each element reacts differently to change or disturbance.
   For example, the number of enterprises and income sources on a farm and the level of biodiversity within a landscape.
2. Manage connectivity: Managing the strength and connectedness between different system components and enable organisms to move from one area to another.
   For example: tree belts and wildlife corridors, nature strips. The individual and family's connection to their community.
3. Manage slow variables and balance feedback: Feedback is a two-way connector between variables that can give a negative or a positive result based on changing variables. It is a form of self-reinforcing feedback against dampening or ignoring it, which can be difficult to reverse.
   For example, observation of landscape changes and increased on-farm monitoring, allowing the adoption of practices more suited to the state of the environment.
4. Foster complex adaptive systems: Complex Adaptive Systems move away from reductionist thinking and accept that several connections are co-occurring, causing unpredictability and uncertainty.
   For example: adopting HM decision-making frameworks that improve landscape function.

5. Encourage learning and experimentation: Involves adaptive management, testing and evaluating alternative approaches, learning, and doing through testing. Learning as integral to decision-making and knowledge is incomplete.
   For example, continuous education and adoption of new ideas and information sharing amongst peers.
6. Broaden participation: Expanding depth and diversity of knowledge, broad stakeholder representation to assist with interpreting perturbations.
   For example: expanding one's social and community engagement, inviting all perspectives to address challenges.
7. Promote polycentric governance systems: Refers to 'nested institutions' operating under a set of rules across hierarchies for abiding by social engagement rules and collective action.
   For example, the ability to self-sustain without relying on larger governance systems.

As previously mentioned, agriculture has a key role to play in the period of the Anthropocene (Vanbergen et al., 2020). Agricultural production is essential to human well-being and feeding a predicted world population of 9 billion by 2050 (Fróna et al., 2019; Gerten et al., 2020; Serraj et al., 2019), therefore, its practices will play a significant role when it comes to environmental decline and its ability to support 10 billion by 2050. Currently, the focus is on increasing agricultural production efficiency; however, that may in the long term reduce agricultural resilience through soil degradation, increasing fragility to pest and disease outbreaks and climate shocks. What is required is a system that is both sustainable and resilient with many diverse solutions to enhance both adaptability and transformability (Bennett et al., 2014).

SRAP provides a framework for resilience which can be measured by combining triple-bottom-line sustainability indicators. As previously mentioned, the review conducted by Schipper and Langston (2015) highlighted that methods to measure resilience are both contested and debated, with the main criticism being that the measurements need to be context-specific, rely on adequate data to be accurate, and are difficult to apply in practice. Using SRAP in the context of a northern beef grazing case study can address these issues by providing a context-specific approach with access to adequate data (which can be used as meaningful indicators) based on the farming practices of the group who are used and comfortable with monitoring and evaluation using location specific indicators.

A critical review of global resilience models undertaken by Marin (2021) identified limitations in resilience models in general (including SRAP) in that they allow for resilience biases and underlying conceptions regarding territories. For example, questions in this review were raised around definitions of resilience and how it is defined, for example, is it defined in reference to a particular phenomenon? It also looked at the theoretical and conceptual frameworks and resilience networks that produced the model, from what discipline or field of study was it produced, the underlying belief systems, the practical implementation of proposed models, and the tools required for implementation. The review also considered the connection with initiatives and projects and its critical perspective to identify limitations to the use of the resilience model. Finally, the review also looks at interrelations and complex phenomena around which scales are used (Marin, 2021).

Others concluded that the Sustainable Development Goals (SDGs) and SRAPs are designed to guide program development and implementation, are closely linked and together, and can achieve the SDGs and community resilience (Eckstein et al., 2018; Elmqvist et al., 2019). Together they offer opportunities for integrative community-based climate change adaption at the grassroots level (Shammin et al., 2022). The Stockholm approach looks mainly at social-ecological aspects of resilience (Sellberg et al., 2020). More strategic integration with economics as a key attribute of governance could be included to assist in managing participation and polycentricity, as well as help to prioritise learning requirements, understand causality, and improve processes (Crépin, 2019). The adoption of capacities around robustness, adaptability, and transformability are critical if we are to move from a focus on robustness only (Meuwissen, 2019). Despite these shortcomings, the Stockholm approach is highly regarded and adopted as guiding principles (Sellberg et al., 2020). According to Meuwissen et al. (2019), more can be achieved when robustness, adaptability, and transformability are included to address the diverse challenges in farming systems (Meuwissen, 2019). Additional research is required to develop methods and tools to assess transformability (Herrera, 2017; Meuwissen, 2019).

Whilst recognising its limitations, SRAP has been used widely across the globe, including in urban landscape design, land use, and governance, when incorporating green and blue infrastructure (Borgström et al., 2021). SRAP's approach has also been utilised to develop sustainable and resilient food systems in Europe (Sellberg et al., 2020) and sustainable pathways for land use in Latin America (Rocha et al., 2020), for land use planning in the Amazon (Ruiz Agudelo et al., 2020), when examining the health of oceans in the context of climate change (Yadav & Gjerde, 2020), to mitigate flood disaster risk in Canada (Doberstein et al., 2019), and to foster climate change and community resilience in South Asia (Shammin et al., 2022).

2.3.2 Resilience Adaptation Pathways Transformation Approach (RAPTA)

RAPTA was developed to support the application of resilience concepts in the management of social-ecological systems in the United States (O'Connell et al., 2016). It was then adapted and used in a study by a group of Australian researchers in Central Western NSW, facilitating a holistic assessment of the social, biophysical, and economic impacts of carbon farming and improving the understanding of the opportunities, trade-offs, synergies, and risks of carbon farming (Cowie et al., 2019).

RAPTA encourages an integrative, holistic approach to identify critical linkages in the social-ecological system that may then become the focus of assessing the system's resilience. It also recommends the participatory development of management plans to enhance resilience, support adaptation, and facilitate transformation where required (Cowie et al., 2019). Therefore, it includes an economic context. The approach uses six general resilience factors derived from the social-ecological resilience literature:

1. Diversity – multiple recovery pathways following disturbance (Armitage, 2007). Examples include farm income diversity, biodiversity, and community economic diversity.
2. Redundancy – buffering the capacity of a system, including balancing feedback and slowing variables to prevent runaway changes. Examples include farm income, grazing viability, increase in INS (invasive native species), biodiversity benefit, soil/water benefit, and community income.
3. Flexibility – allows enterprise managers to adapt to new situations (Erol et al., 2010). Examples include grazing viability, invasive plant impact, and soil/water benefit.
4. Self-organisation – leaving space for elements of the system to re-organise following disturbance while maintaining fundamental relationships (Armitage, 2007). Examples include biodiversity benefit, soil/water benefit, and community income.
5. Collaboration – potential for enterprises and community stakeholders to work together for mutual benefit (Armitage, 2007; Erol et al., 2010). Examples include community income, absentee owners, and inequality.
6. Risk Intelligence – the uncertainty and risks a new activity may introduce (Erol et al., 2010; Opstal, 2009). Examples include information, sequestration uncertainty, seasonal variability, grazing pressure, fire risk, and absentee risk.

Qualitative explanations for scores were thematically organised around the six general resilience factors to provide nuanced, stakeholder-specific insight into indexed results. RAPTA's approach looks at people (dialogue, values, and vision), systems analysis, and options and pathways to action (O'Connell et al., 2019). It was supported by active learning (learning practices that build capacity for responding to rapid, unprecedented change) and adaptive governance (coordinating iterative, flexible, and responsive interactions). RAPTA's approach provided an integrating framework to conduct research and synthesise multiple sources of evidence to address complex problems. It has proven useful in an Australian context for designing and implementing sustainable futures, achieving "land degradation neutrality" and facilitating transformation into practices such as carbon farming (Cowie et al., 2019). It also embraces systems thinking and complex adaptive systems and addresses transformability (Nelson et al., 2020).

A similar piece of work looking at the social-ecological resilience of carbon farming in Central Western NSW was also undertaken using an adaptation of the RAPTA model (Baumber et al., 2020), looking at the co-benefits of carbon farming and the positive and negative ramifications of the practices for social-ecological resilience. The conceptual framework of this study is based on six enabling conditions for general resilience, also identified from previous research being – reserves, diversity, monitoring, scale, feedback, and social capital (Armitage et al., 2010; Carpenter et al., 2012; Erol et al., 2010; Walker & Salt, 2012).

Baumber et al. (2020) adapted RAPTA with several enabling conditions for general resilience:

1. Reserves/buffers/redundancies – Extra capacity that is held in reserve that can minimise the severity of a disturbance or enable recovery, e.g., capital, labour, water, organic matter, and social memory.
2. Diversity – Includes economic diversity, cultural diversity, biological diversity, and response diversity, i.e., having a range of pathways available.
3. Monitoring/ information flows - Capacity to gather information in a shared, transparent, and regular fashion.
4. Management at the right scale –Striking the right balance between (i) connectedness – maintaining connections to neighbouring systems and higher system levels to enable exchange, support, and replenishment; and (ii) modularity – enabling autonomous units

in which agility, responsiveness, and self-organisation are enhanced at the local level and threats are quarantined to stop them spreading.

5. Feedbacks – Maintain strong balancing feedbacks that push back against disturbance, as well as the capacity to interrupt reinforcing feedbacks that could lead to undesired runaway change.
6. Social capital – Includes effective leadership, trusted relationships between key stakeholders, collaboration, and reciprocity.

Baumber et al., (2020) found that carbon farming, depending on how it was implemented, had the potential to decrease the socio-ecological resilience of rangelands unless careful management and appropriate policy were in place. Baumber's study found that overall carbon farming aligned with enabling general resilience through increasing diversity of livelihood options, protecting habitat, soils (with ground cover), and biodiversity, and increasing biomass. Collecting new data could potentially improve decision-making. However, the way the policy of the ERF is, the value of the carbon could be at the cost of other eco-system areas and social capital due to the focus on economic self-interest (Baumber et al., 2020).

Baumber, like Meuwissen et al. (2019) concludes with the need for an adaptive approach with critical factors being monitored and modifications made to policy. According to Baumber et al. (2020), there are dangers in simplifying the ecosystem, landholder absenteeism, and community division which are just a few of the side effects of inflexible policy decisions. From a carbon farming perspective, there is a lack of empirical evidence and substantial uncertainty as to whether carbon farming can deliver ecosystem services of conserving biodiversity, increasing soil and water quality, and productivity, and delivering economic and social benefits to Indigenous communities. The approaches that could be applied to carbon farming to test carbon farming outcomes in Australia could be spatial modelling, benchmarking, environmental benefit indices, and indicators (Baumber et al., 2019).

2.3.3 Meuwissen's framework to assess the resilience of farming systems

Utilising mixed-method approaches, a European study undertaken by Meuwissen et al. (2019) found that increasing economic, ecological, and societal changes raised concerns about how farmers would cope with the shocks and stresses and, more importantly, transform their practices accordingly. Often, uncertainty and accumulating challenges associated with farming require three resilience capabilities: robustness, adaptability, and transformability (Meuwissen et al., 2019). The approach gathered quantitative statistics, econometrics and modelling, qualitative interviews, and stakeholder workshops for experiential and contextual knowledge to provide a more nuanced approach. Meuwissen's study found that the concept of resilience is multi-faceted and cannot be captured by a single method or indicator and that multiple and changeable functions must be examined along with internal and external interdependencies and potential shocks and stressors. Meuwissen came up with a framework that refers to specific challenges (specified resilience) and the farming system's ability to deal with unknown, unexpected challenges (general resilience), providing heuristic approaches to such uncertainties, surprises, and challenges. It unpacks resilience in relation to the resilience of what (a farming system), resilience to what (challenges), resilience for what purpose (function private goods or public goods), what are the resilience capacities (robustness, adaptability, and transformability) and what enhances resilience (diversity, openness, tightness of feedbacks, system reserves, modularity), utilising a top-down approach for specified resilience, and a bottom-up approach for general resilience.

Further, Meuwissen et al. (2019) found that some environments may have constraints when it comes to social and economic but opportunities around ecological resilience and vice versa. The focus on robustness, adaptability, and transformability can present a range of strategies with trade-offs and synergies (Meuwissen et al., 2019). For example, if a business enhances robustness, it may be at the expense of transformability or force adaptation and transformation on value chain members. Given the similarities between the various farming systems Australia has adopted from Europe, it serves as a relevant framework in an Australian context. Meuwissen et al. (2019) identified that further work needed to be undertaken in the transformability space (Meuwissen et al., 2019). Feindt et al. (2019) suggested that a deep structural bias toward retaining the status quo through current policies was more focused on robustness at the expense of adaptability or transformability (Feindt et al., 2019).

Herrera et al. (2018) argue that using multiple qualitative and quantitative assessment methods is essential to enhance the robustness of resilience findings while resilience attributes might be studied in isolation and that the complexity of farming systems requires an integrated consideration to capture the various synergies and trade-offs between attributes. However, this approach has some limitations in that collecting data on some indicators at a systems level, such as well-being, mental health, or species migration, is not necessarily captured in administration data (Herrera et al., 2018). In addition, supply chain influences and policy recommendations affect multiple levels beyond farming systems. It is also rarely one challenge but numerous incidences that affect risk at any time; focusing only on one measure would severely distort reality (Herrera et al., 2018). According to Creswell and Clark (2017), using multiple qualitative and quantitative assessment methods is essential to enhance the robustness of resilience findings. Meuwissen et al. (2019) state that researchers must realise that ‘principles’ and ‘frameworks’ can materialise in several ways depending on the context and the practices and present many variables and examples in unexpected forms.

Meuwissen (2022) identified through the SURE-Farm project in Europe several important findings:

- The need for resilience assessments that conduct stress tests on farming systems, including ranking the likeliness of perturbations.
- The relationship between resilience strategies and sustainability needs more attention, as it is possible for unsustainable farming systems to be viable (resilient).
- More research is required on transformative capabilities which are less understood, looking at past histories of transformations that involved modifications of systems function. An example of the type of research required could be that of Termeer et al. (Termeer et al., 2019).
- Resilience attributes in the economic, social, and ecological domains, require further analysis.
- More work is required on simulating transformative capabilities into a clear framework for guiding experiments.

When comparing these frameworks, having a clear definition of the differences between the conventional and alternative farming and grazing systems, their historical context, and their relationship to RA helps assess their resilience to climate change over time.

2.4 Conventional Agriculture and alternative farming and grazing systems

Conventional agriculture (CA) is a widely used term to encompass many forms of agriculture, referred to as a general acceptance of how farming should be carried out, commonplace agriculture, or falling outside of a circumscribed category and often used as a control group to compare with alternative agriculture. Some argue it is being weaponised (Sumberg & Giller, 2022). Weaponised in this context refers to using destructive practices on the landscape. In the context of grazing systems, it encompasses a mixture of set stocking and rotational grazing, utilising chemicals to control internal and external parasite infestations, vaccinations for animal health, and synthetic fertilizers, herbicides, and pesticides to improve pasture performance.

Since the early 1980s, interest has increased in farming systems that exclude or place minimal reliance on the use of artificial fertilizers and pesticides (Cesco et al., 2023; Goyal & Parashar, 2023; Ngegba et al., 2022). Some names given to alternative farming systems are organic (Willer et al., 2021; H. Willer et al., 2018), biodynamic (Brock et al., 2019), agro-ecology (Loconto & Fouilleux, 2019), conservation agriculture (Page et al., 2020), holistic (Dominati et al., 2019), and regenerative (Fenster et al., 2021; Gordon et al., 2023; Newton et al., 2020).

RA utilises a combination of existing practices to achieve 'landscape functions' (restoring ecosystem processes around community dynamics, water cycle, mineral cycle, and energy flow) and moves away from CA (O'Donoghue et al., 2022).

In contrast to CA, RA aims to shift farmers from a conventional paradigm of controlling one's landscape to higher levels of understanding when working with the environment (Massy, 2020). RA could therefore be summarised as a new paradigm and growing movement that is potentially transformative, overlapping with best practice from many farming systems and discourses, and an inclusive approach to enhancing ecosystems and landscape function (Gordon et al., 2022; Gordon et al., 2023).

Several studies have attempted to compare conventional and alternative grassland soil environments in these different grazing management systems (Bailey et al., 2019; Low et al., 2005; Scholefield et al., 1991), including a comparison of organic and conventional grassland grazing systems (Weil & Magdoff, 2004) and a comparison of conventional and holistic grazing practices (Ferguson et al., 2013). With the emergence of RA, these comparative studies have expanded into comparing CA and RA (Alexanderson et al., 2023; Ogilvy, 2018).

2.4.1 Regenerative Agriculture as an alternative farming and grazing system

RA has been referred to by Gosnell et al. (2019) as an alternative form of food and fibre production that enhances and restores resilient systems, supported by functional ecosystem processes, and healthy, organic soils. RA provides ecosystem services including soil carbon sequestration and improved soil water retention. RA as a global movement has transformative potential through the associated paradigm shifts that occur for farmers when it comes to how they manage their properties, farm businesses, and personal lives (Gosnell et al., 2019). Further, sustained transitions have occurred in Australia, whereby farmers are shifting from conventional practices to RA under the disguise of "good agricultural practice" (Giller, Hijbeek, et al., 2021, p. 1). Gosnell et al. (2019) refer to zones of friction and traction in transformation which can either impede or facilitate a transformation process.

RA achieves the best outcome for a specific environment, focusing on landscape function and regeneration (Massy, 2020). RA processes that support climate change mitigation do not necessarily preclude synthetic fertilisers and chemicals, however, they do aim to reduce or eliminate synthetic fertilisers, herbicides, and pesticides (Teague & Barnes, 2017; Waters et al., 2017). However, the various schools of RA (those with more ecological approaches to CSA) differentiate themselves regarding soil regeneration and larger more ethical elements (Rhodes, 2017; Soloviev & Landus, 2016). RA goes well beyond CSA in that it focuses on enhancing and restoring holistic regenerative, resilient systems through functional eco-systems processes and healthy soils.

As a farmer-driven movement that originated in the 1980s with the term being coined by Robert Rodale, RA has grown quickly in Australia since 2015, becoming somewhat of a 'soil revolution' supported by both producers and consumers alike who support niche markets and certification schemes (Montgomery, 2017). Soloviev and Landus (2016) identify various levels of RA; Level 1: Functional (regenerate soil, reverse climate change, best practice), Level 2: Integrative (earth as Eden, regenerative ecosystems, integrative design, and carbon farming), Level 3: Systemic (PRA, regenerative enterprise ecosystems, living systems frameworks), Level 4: Evolutionary (RA producer webs, regenerative culture, place and context sourced). Further, Soloviev and Landus refer to RA as an "Eco systemically vibrant, socially equitable, culturally diverse and spiritually meaningful global system of regenerative potential".

RA embraces many alternative farming practices and utilises the farming tools and techniques of several practices, as Jeffery (2017) identified in his "Soils for Life" work against 'agricultural scale' and 'ecological' impact (Jeffery, 2017). Like many alternative agricultural movements, RA integrates practices from Indigenous land management approaches such as rotational grazing, polycultures, intercropping, agroforestry, and biochar, amongst others (Sands et al., 2023). It has been criticised for continuing colonial patterns of adopting Indigenous practices without the relational values and worldviews that inform them (Sands et al., 2023). Indigenous people have not been properly recognised for their contributions, nor have they been able to participate fully in these agricultural movements, which raises issues of equity and power in RA (Layman & Civita, 2022).

According to Gordon (2019), depending on farm and farmer context, RA also integrates aspects of biodynamics (a closed, diversified ecosystem, utilising lunar cycles for farming activities (Steiner, 1993)), organics (organic matter applied through the use of manure, compost, animal by-products (Howard, 1940; Andre Leu, 2020b), permaculture (making use of by-products such as garden waste, table scraps for fertilizer and livestock food and designing environmentally sustainable farms and gardens (Holmgren, 2007; Mollison, 1988)), natural sequence farming (Fukuoka, 1978) and keyline farming (rural landscape design aimed at restoring natural water cycles and slowing down water by inserting barriers across creeks and swales in the landscape (Yeomans, 1993)), agroecology (ecological concepts and principles applied to farming (Altieri, 1995 ; Conway, 1985, 1987; Gliessman, 1990, 2001, 2007), holistic management (whole-farm business and financial planning, planned time-controlled grazing techniques (Butterfield et al., 1999; Gosnell, Charnley, et al., 2020; Savory, 1988; Savory & Butterfield, 2016)), conservational agriculture (promotes minimal soil disturbance but allows use of artificial chemical applications (Andersson & D'Souza, 2014; Hobbs, 2007; Hobbs et al., 2008)), and sustainable agriculture (protect environment and earth's natural resource base and maintain soil fertility (Dunlap et al., 1993; Gold, 1994; Velten et al., 2015).

RA farmers in Australia engage in many of these practices to promote deep rooted native perennial grasses and reduce bare ground (Doherty & Jeeves, 2016; Massy, 2020; Sherren et al., 2012), whereas CA relies on inputs such as superphosphate, pesticides, herbicides, the use of heavy machinery, and often encourages land clearing to eradicate native vegetation (Evans, 2016). Most Australian farms practice productivism as a form of agriculture (Australian Bureau of Resource Economics and Sciences, 2016).

Nine discourses for RA were identified in a review of 229 journal articles and 25 practitioner websites (Gordon et al., 2023). The discourses included: restoration for profit, big picture holism, regenerative organic, regrarian permaculture, regenerative cultures, deep holism, first nations, agroecology and food sovereignty, and subtle energies. The tensions between them and the absence of one clear definition make RA vulnerable to greenwashing, which can affect its transformative potential for climate mitigation. Greenwashing refers to deliberate corporate action with misleading elements aimed at deceiving ecologically conscious consumers and stakeholders (de Freitas Netto et al., 2020; Szabo & Webster, 2021), which leads to the development of legislation, regulation, standardisation, and compliance (Gatti et al., 2019) which often encompasses certification requiring third-party audit requirements.

The term 'regenerative agriculture' had many definitions and descriptions that were variously based on practices (e.g. use of cover crops, the integration of livestock, and reducing or eliminating tillage), outcomes (e.g. improving soil health, sequestering carbon, and increasing biodiversity), or combinations of the two (P. Newton et al., 2020). Further, Newton et al. (2020) concluded that it is beneficial for individuals to define RA for their own purpose and context and the diversity that presents across individual farm landscapes.

This is one of the main criticisms of RA is that it is untestable (in the form of a specific system of farming), difficult to define (as definitions change in parallel with the individuals deepening of ecological understanding) and confusing for upscaling and extension because it is so context specific. RA is difficult to define as a type of agriculture based on practice or outcomes and is best referred to as a "state" (restoring ecosystem function) or "a movement" to restore ecological function (O'Donoghue et al., 2022) or even a "social phenomenon, worldview or farming approach" (Page & Witt, 2022). The inability to define RA has left it vulnerable to strategic repurposing by diverse stakeholders (Sands et al., 2023). It is important to recognise the various agricultural sustainability discourses to avoid them remaining poorly defined and highly contested (Page & Witt, 2022) leaving them open to 'greenwashing'. As Page and Witt conclude, "If RA is to be meaningfully utilised as an approach to farming that drives improved environmental, social, and economic outcomes for individual farmers, their communities, and broader society, then there is a need to address gaps in present understandings, descriptions, and definitions of RA" (Page & Witt, 2022, p. 15).

RA is based on the concept of holism and finds its roots in several discourses (Gordon et al., 2023). Linnér and Wibeck (2020, p. 222) define "transformation as a radical shift in shared socio-cultural structures, as well as technological, economic, and ecological processors" and refer to RA as potentially transformative. The term RA was first used in 1980 and has elicited public interest in recent times, resulting in the dramatic growth of the movement and adoption of practices (Francis et al., 1986; Schreefel et al., 2020; Soloviev & Landus, 2016). RA differs from Organic Agriculture (OA) in that it does not prohibit the use of chemical inputs within a farming system however it does encourage constraints (regarding quantity and occurrence) to be applied where synthetic chemicals are used (Giller, R. Hijbeek, et al., 2021a). A core focus of RA is the rejuvenation of “the health, vitality and evolutionary capability of whole living systems” on a farm, thereby supporting the farm business for the longer term (Soloviev and Landua 2016). It is an approach to farming that aims to regenerate the natural functions of soil and landscape, increasing biodiversity through implementing a range of regenerative practices and reducing chemical inputs (Soloviev and Landua 2016). RA also focuses on the social and economic dimensions of food production systems that can build long-term social, economic, and environmental resilience (Schreefel et al., 2020; Soloviev and Landua, 2016). Regenerative practices have a positive effect on soil health and therefore have been found to have a higher nutritional value than conventionally grown plant and animal foods (Montgomery et al., 2022).

2.4.2 Sustainable Agriculture and why it is different than Regenerative Agriculture?

Like RA, defining sustainable agriculture (SA) has remained challenging and controversial. The Food and Agricultural Organisation refers to SA as “the management and conservation of the natural resource base, and the orientation of technological change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations (Food and Agriculture Organisation, 2022, p. 1). SA conserves land, water, and plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable” (Food and Agriculture Organisation, 2022, p. 1). Thus, SA can integrate several agricultural approaches and practices such as soil conservation, agroforestry, agroecology, mixed crop-livestock systems, rotational grazing, and organic farming (Slimi et al., 2021) and focuses on ‘preserving’ the environment (Sgroi, 2022). RA goes one step further, aiming to improve the landscape from its current state, repair the environment, and is outcomes-focused (Gordon et al., 2023; Gosnell et al., 2019; Grelet et al., 2021; O’Donoghue et al., 2022; Rhodes, 2017; Sgroi, 2022).

According to Gosnell et al. (2019), RA is more than “a suite of ‘climate-smart’ mitigation and adaptation practices supported by technological innovation, it involves other non-material factors such as culture, values, ethics, and identity. At the farm level, its transformational adaptation is often triggered by a crisis, an epiphany, and exposure to alternative pathways. It is a farmer-driven movement, whereby decisions to transition involve subjective factors such as feelings, emotions, virtues, and drivers. Environmental, economic, social/cultural, and personal/psychological factors often drive sustained adoption. RA transaction can support self-amplifying feedback loops based on ongoing experiential learning and increased consciousness of landscape and community (Gosnell et al., 2019). It is an approach to farming that goes beyond mainstream approaches to sustainable and climate-smart agriculture (CSA) therefore, it has a strong alignment with resilience principles, particularly due to its climate change adaptation and transformation qualities.

2.4.3 The relationship between Organic farming, Biodynamics, and Regenerative Agriculture

Rodale’s Regenerative Organic Certified (ROC) Standards (Rodale, 2023) use the United States Department of Agriculture Certified Organic standard as a baseline and add three major pillars of regenerative organic agriculture; soil health, animal welfare, and social fairness, into one certification. In comparison, OA refers to a farming system with regulations that ban agrochemicals such as synthetic fertilisers and pesticides, the use of Genetically Modified Organisms, and many synthetic compounds used as food additives such as preservatives and colouring. OA works with ecological systems to produce multi-functional benefits and avoids the use of inputs with adverse effects, such as toxic synthetic pesticides (Andre Leu, 2020a). OA has had sustained rates of growth worldwide, averaging 20 - 25% increased adoption per year since 1990. Its sustained growth has spread to 187 countries worldwide, covering some

72.3 million hectares of agricultural land managed by approximately 3.1 million farmers with global sales of over 106 billion euros (Willer et al., 2021). Since 1990, with increased public concern for the environment and food quality, the organic farming movement has gained consumers' attention and undergone increasing regulation from national and international bodies (Willer et al., 2018). The increased focus on soil health and its relationship to quality food grown organically has recognised the development of traditional organic farming methods and technologies (Patel & Champaneri, 2020). The terms RA and OA are often used interchangeably having similar objectives and practices (Giller, R. Hijbeek, et al., 2021; Schreefel et al., 2020a). There is also the discourse that believes that RA must also be organic in the form of regenerative organic (RO) (Rodale, 2023). In contrast, other discourses like "Restoration for Profit" advocate for reduced reliance on artificial herbicides and pesticides and reduced input costs (Gordon et al., 2023). RA utilises several practices (including organic inputs) to restore landscape function, whereas organics is a specifically defined practice that does not allow the use of artificial inputs (Rodale, 2023).

Biodynamics originated at the beginning of the 20th Century when experienced traditional European farmers were concerned that their animal, plant, and soil health was steadily deteriorating. From observation, the application of the then very modern chemical fertilisers did not solve declining farm health, nor did chemical application (treating symptoms instead of causes) address a farmer's lack of understanding of what was happening in their agricultural environment (Bradshaw, 2009).

According to Proctor et al. (2006), several farmers approached Dr. Rudolf Steiner in response to these questions and concerns, and in 1924 he presented a series of lectures of "The Spiritual Foundations for the Renewal of Agriculture", now more generally referred to as the "Agricultural Course." (Proctor et al., 2006). Here, practical steps farmers could adopt and develop, aimed to reverse the progressive degeneration they were witnessing. Steiner introduced the biodynamic preparations as a means of stimulating the whole farm organisation and its connection to what is above and below. He showed farmers how these preparations could be made from materials available on most farms. Biodynamic preparations are based on plant, animal, and mineral substances; the belief is that they are best applied in conjunction with the observation of cosmic rhythms to bring about healthy soil, plants, livestock, and, importantly, human beings. Biodynamic Agriculture (BA) is permeated by the principal philosophies inherent in all aspects of Steiner's work (Bradshaw, 2009; Proctor & Cole, 2004; Proctor et al., 2006).

Like organic farming, biodynamic farming uses no synthetic chemical fertilizers or pesticides and emphasizes building up the soil with compost and manures, controlling pests naturally, rotating crops, and diversifying crops and livestock. Unlike organic farmers, biodynamic farmers add eight specific preparations made from cow manure, silica, and various plant substances to enhance soil quality and plant life (Koepf et al., 1976). RA draws on both organics and biodynamic practices.

2.4.4 Holistic Farming and Regenerative Agriculture

The RA movement in Australia draws its roots from HM theory and practice (Gordon et al., 2022), and it could be argued that they are one and the same. However, as previously mentioned, RA incorporates several alternative agricultural practices not traditionally found in HM practices, including permaculture, organics, and biodynamics. Therefore, exploring the HM journey is important to understand how the regenerative agricultural movement has evolved.

The origins of holism can be traced to the early 1900s when Jan Christian Smuts coined the term, reiterating that nature functions in complex wholes, patterns, and relationships (Smuts, 1927).

HM is a systems-thinking approach to managing resources that was adapted by Allan Savory and Jody Butterfield in the 1960s for reversing desertification (Savory & Butterfield, 2016). The idea of holistic planned grazing began when Allan Savory, then a young wildlife biologist in his native Southern Rhodesia, set out to solve the riddle of desertification. Heavily influenced by the work of Smuts (1927) and Voisin (1959) and the ineffectiveness of mainstream science of the time, Savory (1983) concluded that the spread of deserts, the loss of wildlife, and resulting human impoverishment were related to a reduction in the natural herds of large grazers and the change in behaviour of those few remaining herds. Livestock could be substituted to provide important ecosystem services like nutrient cycling when mimicking those lost natural herds.

A new concept, the "holistic goal," (more recently referred to as the holistic context) was developed to provide an overriding direction to one's goals and objectives. Here, decisions were to consider immediate and long-term effects on ecological, economic, and social/personal well-being – areas not always considered in conventional decision-making (Savory & Butterfield, 1999).

Four fundamental ecosystem processes are acknowledged as undergirding all human endeavour – water cycle, community dynamics, nutrient cycle, and solar energy flow (Savory & Butterfield, 2016). Two new tools - animal impact and grazing - were added to this list by Savory. A simple filtering set of questions is used to determine whether the decision/action will move one closer to or away from the holistic goal. This approach assists in making decisions that are simultaneously economically, socially, and environmentally sound, both short-term and long-term (Savory & Butterfield, 2016).

The Savory and Butterfield (2016) Holistic Framework (a guide to management and decision-making), acknowledges that people work in whole situations in which people, their resource base, and money are seen as inseparable. The framework encompasses the following:

- The whole under management (decision makers, resource base, and money), the holistic context (statement of purpose, quality of life, and future resource base).
- Ecosystem processes (water cycle, mineral cycle, community dynamics, energy flow), Ecosystem management tools (human creativity, technology, fire, rest, living organisms, animal impact, grazing, money, and labour).
- Actions and decision-making (objectives, goals, tactics, strategies, policies, past experience, expert advice, research).
- Context checks (cause and effect, weak link – social/biological/financial, marginal reaction, gross profit analysis, energy money source and use, sustainability, gut feel),
- Management guidelines (time, stock density and herd effect, cropping, burning, population management).
- Procedures and processes (holistic financial planning, holistic land planning, holistic planned grazing, holistic policy development, research orientation).
- Feedback loop (plan, monitor, control, replan).

HM (also sometimes referred to as cell grazing, intensive rotational grazing, multi-paddock adaptive grazing, strategic planned grazing, and more recently time-controlled grazing) and planned grazing is based on minimizing overgrazing through always maintaining a high graze/trample recovery ratio on the land. According to testimonials and anecdotal evidence produced by practitioners in both the US and Australia, HM has restored degraded deserts and grasslands and reversed climate change through the impacts of large herbivores breaking soil crusts, trampling plants and soils to promote restoration, (Carter et al., 2014). A study undertaken in western North American landscapes, could find no peer-reviewed studies to support these claims. The study concluded that HM was not superior to conventional grazing systems in outcomes and that global greenhouse emissions are larger than the worldwide capacity of grasslands and deserts to store the carbon emitted each year. of this (Carter et al., 2014).

Grazing and animal impact are the two tools in holistic grazing systems that are unique to HM. Early references to the positive role of animals, at least in pasture management, are contained in Andre Voisin's *Grass Productivity*, first published in 1959 (A. Voisin, 1959). However, knowledge of targeted livestock grazing (another term for holistic grazing) is extensive and expanding rapidly according to a more recent study undertaken in 2019 (Bailey et al., 2019). The benefits of targeted livestock grazing as a proven tool for manipulating vegetation through defoliation or trampling can achieve ecological benefits when targeted grazing is applied properly. The study concluded that targeted livestock grazing does provide land managers with a viable alternative to mechanical, chemical, and prescribed fire treatments to manipulate grasslands (Bailey et al., 2019). Holistic Grazing has been shown to enhance grassland water infiltration (Döbert et al., 2021). Longer rest following early-season cattle grazing aids water infiltration and litter accumulation enhances water infiltration under adaptive grazing management (Döbert et al., 2021). The maintenance of hydrologic function on grazing lands is an important management objective to sustain forage production during low moisture supply, safeguard other ecosystem goods and services, and build resilience to a warming climate.

HM has generated much controversy as the use of large herding animals as a tool in land restoration and management, although in recent years, the controversy has subsided (Gosnell, Grimm, et al., 2020). Claims about HM improving productivity or soil carbon are referred to in some literature as unfounded (Hawkins et al., 2022). However, there is also literature that supports such claims of the high performance of agroecosystems from a multifunctional perspective (Hodbod et al., 2016). Benefits to soil carbon sequestration have also been identified (Frith, 2020; Lawrence et al., 2019; McDonald et al., 2019; Stanley et al., 2018).

In examining half a century of HM, Gosnell, Grimm, et al. (2020) concluded that "the way to resolve the controversy over HM is to research, in partnership with ranchers, rangeland social-ecological systems in more holistic, integrated ways. This can account for the full range of human experience, co-produce new knowledge, and contribute to social-ecological transformation". Further, any controversy is also complicated by the fact that "epistemic differences have proven intractable because they are rooted in the ontological difference between the hypothetic-deductive sciences and holistic knowledge practice" (Gosnell, Grimm, et al., 2020, p. 1).

According to a meta-analysis of HM Decision Making Frameworks based on triple-bottom-line approaches to managing complexity (Gosnell, Grimm, et al., 2020), multidisciplinary evidence emerges regarding the HM Framework's positive effects on ecological, economic, and social dimensions. For example, the feedbacks associated with daily monitoring drives adaptative and proactive management, increased profits associated with reduced inputs and income diversification, and social learning and community engagement. According to this meta-analysis, ruminant, hooved animals are an essential tool for regenerating grasslands. They have a role to play in the sequestration of carbon, removing CO_2 from the atmosphere and capturing moisture in the soil through their ability to stir up the seedlings in the ground with their hooves and speed up photosynthesis through controlled grazing techniques. Rotationally grazed, hoofed animals (through their herding effect and hoof impact) in healthy mixed species pastures are an essential management tool for the future (McCosker, 2000; McCosker et al., 2021; Savory, 1988; Savory & Butterfield, 1999). This is also commonly referred to as time-controlled grazing, cell grazing, or HM practices. In the simplest of terms, by grazing the top layers of pastures and grasslands, hoofed animals encourage the photosynthesis process to accelerate. Plant growth accelerates, and new plant shoots emerge, extending healthy root systems under the ground, creating humus that feeds soil fauna and microbes, and continuously building soil profiles (Savory, 1988; Savory & Butterfield, 1999).

Creating humus that feeds soil fauna and microbes also leads to carbon sequestration, which removes CO_2 from the atmosphere, thus reducing greenhouse gases and playing a major role in preventing the planet from overheating and the extinction of over 50% of all known terrestrial and marine species (Lehtonen et al., 2019). In addition, every percent of carbon that is sequestrated results in improved water-holding capacity (Acín-Carrera et al., 2013). Therefore, increasing our soil carbon is essential if we are to continue farming in drier conditions, with less water, in the future.

Holistic decision-making in grasslands builds on high-intensity, short-duration grazing to allow adequate recovery of grazed plants within a proactive, flexible, and goal-directed plan (Hodbod et al., 2016). Further, RA is recognised for its ability to build soil carbon and soil quality (Gosnell, Charnley, et al., 2020; Tan & Kuebbing, 2023; Wiltshire & Beckage, 2022). In summary, RA is strongly associated with HM through its triple-bottom-line approach to food and fibre production and its explicit attention to ecological, economic, and social/personal factors; therefore, because of this strong association, HM requires further critique.

2.5 The history of socio-ecological and economic research into Holistic Management and its relevance to Regenerative Agriculture

Holistic Planned Grazing (HPG) has yielded neutral/mixed views, leading to acrimonious debate (Sherren et al., 2019). Some reviews have shown it to have no effect or even reduce production (Hawkins et al., 2022), while other studies show benefits to both landscape function and pasture composition (Lawrence et al., 2019) and significant ecological and animal production outcomes, specifically around ground cover and animal productivity per hectare (McDonald et al., 2019). Others have linked the management of pastures for optimal forage, growth, and recovery coupled with improved animal foraging to increased soil organic carbon compared to continuous grazing systems (Stanley et al., 2018).

A meta-analysis of the available literature between 1972 and 2016, covering 75 data sets across five countries (Argentina, Australia, Canada, USA, and Zimbabwe) and examining both temperate and tropical grassland biomes, showed no difference in plant basal cover, plant biomass, and animal gain response, and therefore no impact on production (Hawkins, 2017) . Further, claims that HM can permit doubling the stocking rate without decreasing either plant or animal production (Savory, 1983), has been contradicted by much of the previous scientific literature (Briske et al., 2008; Hart et al., 1993; McCollum et al., 1999; Tainton N et al., 2013) but later supported by others (Teague, 2014; Teague & Barnes, 2017; Teague et al., 2015; Teague et al., 2013; Teague et al., 2011). The claims around HM's capabilities to reverse climate change through carbon sequestration were also controversial (Sacks et al., 2014). The concept that animals break 'soil caps' with their hoofs, incorporating urine, dung, litter, and seeds resulting in increased microbial activity and carbon sequestration is yet to be tested (Sacks et al., 2014). The study did conclude that few studies had considered HM across a gradient of nutrient and water availability or a range of animal densities. The study also highlighted the need for further research in the socio-economic aspects of HM (Sacks et al., 2014).

A study by Hawkins et al. (2017) found that when comparing rotational grazing (fast rotations with average 57-day rest periods, slow rotations with average 114-day rest periods, and flexible grazing based on the availability of green herbage) with conventional grazing across three different production zones, the intensive fast and flexible rotational grazing had greater herbage mass, ground cover, and pasture composition, than conventional grazing. Animal performance was on par with conventional grazing. Hawkins et al. (2017) concluded that how HM is managed, and the location has an impact on the efficiency of the approach, and more modelling is required to identify thresholds and test them in real-life situations. “We can neither dismiss HPG (Holistic Planned Grazing) claims nor claim that it will work anywhere” (Hawkins et al., 2017, pp. 62-63).

HM proponents point out that while HPG involves moving animals, that is where any similarity with rotational and other grazing approaches ends. Proponents of HM critique traditional experimental studies because they do not account for the focus on managing complexity (social, economic, and environmental) and neglect the important component of manager decision-making (Sherren et al., 2018), an aspect of HM that does not lend itself well to experimental design (Teague & Barnes, 2017).

Some studies (Hodbod et al., 2016) argue that adaptive multi-paddock grazing (another term for Holistic Planned Grazing) is a values-based triple-bottom-line approach (social, environmental, and economic sustainability) to decision-making in grasslands. It builds on high-intensity, short-duration grazing to allow adequate recovery of grazed plants within a proactive, flexible, and goal-directed plan.

A study by Gosnell et al. (2020b) of HM graziers in New South Wales, Australia compared conventional graziers’ perceptions and management actions, showing interesting results on **environmental perspectives** and priorities around biodiversity, both of which were higher with the HM graziers then with the conventional graziers. Also relative to this research are findings related to the **economic outcomes** of HM practices and the economic prosperity that results from looking after the health of the environment and ecosystem. Previous older studies such as Stinner et al. (1997) reported that 80% of the farmers they interviewed perceived increased profits since transitioning to HM, and 52% reported decreases of up to 40 – 60% in labour requirements in their operations, despite extra planning and monitoring required by HM. Other studies have similarly found that HM practitioners generate profit due to decreased costs of production and use of inputs (e.g., synthetic fertilizer, artificial weed control, and supplemental feeding of livestock), reduced animal health costs, and improved cattle conditions and product output such as milk and manure (Ferguson et al., 2013; Gadzirayi et al., 2007; McCosker, 2000; Sherren et al., 2012). Further, Ferguson found that holistic managers purchased less hay, feed, herbicides, and pesticides than their conventional neighbours, leading to greater economic stability (Ferguson et al., 2013). Holistic managers had a broader business philosophy and were more involved in off-farm investing than CF; therefore, they were less reliant on natural resources, trade, and climate conditions (Richards & Lawrence, 2009). Further, the holistic managers were well positioned to participate in the voluntary carbon market because soil carbon sequestration protocols aligned well with their principles and practices (Gosnell et al., 2011).

The research has moved on to attempts to compare regenerative practices with conventional approaches (Ogilvy, 2018; Teague & Barnes, 2017).

From an environmental perspective, holistic managers use less herbicide and pesticide (Ferguson et al., 2013; Sherren et al., 2012), burn pastures less (Alfaro-Arguello et al., 2010), and enjoy a higher energy yield ratio (Alfaro-Arguello et al., 2010) and more on-farm biodiversity (McCosker, 2000; McLachlan & Yestrau, 2009; Stinner et al., 1997). In addition, the practice of grazing and rest periods has increased water infiltration in grassland soils (Döbert et al., 2021). This is an important finding given the importance of hydrologic function in sustaining forage production in dry times. The paradigm of holistic managers focuses on working with ecological processes to build biodiversity and is radically different from CF, whose paradigm places little emphasis on ecological processes and biodiversity (Stinner et al., 1997). In Australia, holistic graziers in New South Wales were more focused on insects and animals and less concerned about weeds than their conventional counterparts. They linked biodiversity protection to their working landscapes, setting sections of their property aside for conservation (Sherren et al., 2012).

Several published studies have found that, if practiced appropriately, HM results in positive ecological outcomes. Specifically, **ecologically**, it can improve forage and livestock production (Teague & Barnes, 2017; Teague et al., 2016); reduce bare ground (Earl & Jones, 1996; Teague et al., 2011); improve stream and riparian health (Sovell et al., 2000); improve soil respiration, topsoil depth, organic matter, and overall soil health (Ferguson et al., 2013; McCosker, 2000; Stinner et al., 1997; Teague et al., 2011; Xu, 2018); improve soil–water content, water-holding capacity, and hydrological function (Earl & Jones, 1996; McCosker, 2000; Teague et al., 2011; Weber & Gokhale, 2011) and improve nutrient availability and retention (Teague et al., 2011).

Like RA, HM strongly emphasizes **social and psychological** well-being (McLachlan & Yestrau, 2009). Stinner et al. (1997) concluded that a decision-making process like HM could help empower individual farmers and farm communities and support quality of life. Social scientists have acknowledged links between human well-being and psychological resilience with links between ecological health and ecosystem resilience (Malmberg, 2013). HM practitioners' self-reliance comes from utilising the tools they coupled with honing their skills rather than relying on outside technology or artificial inputs for quick solutions. In other words, addressing the root cause of a problem and therefore enhancing their overall well-being.

Stinner’s research (1997) found that 91% of 25 HM practitioners interviewed “reported improvements in their quality of life because of changes in their time budgets.” They had more social and family time (McLachlan & Yestrau, 2009) and were no longer doing things they did not like to do (Stinner et al., 1997). HM philosophy underpinned systematic thinking necessary for successful adaption, increasing the adaptive capacity of holistic managers to cope with stressors and crises such as climate variability and market conditions (Gosnell et al., 2019; Sherren et al., 2012). Holistic managers were more accepting of risk, open to experimentation, and not trying to 'gain control' over the land working within the bounds of natural variability (Sherren et al., 2012).

All of the social science studies reviewed addressed the distinctive role of community in the HM approach to life, both for support in transition and persistence and as a source of social learning and ongoing innovation (Stinner et al., 1997). Networks build resilience through collective decision-making (De Villiers et al., 2014). This is especially important in rural areas experiencing depopulation and less opportunity for community interaction and innovation (McLachlan & Yestrau, 2009). In Australia, financial collaboration among cell graziers builds social capital and trust, leading to a new form of beef production (Richards & Lawrence, 2009).

The focus of ongoing research has turned to addressing resilience issues in farming systems, capacities, and attributes that assist with robustness, adaptability, and transformability (Meuwissen, 2019); approaching climate challenges from a resilience framework is compelling (Herrera, 2017). As RA grows as a significant movement and approach to farming, understanding and accepting different thinking, discourses, and world views will be essential to reach RA goals, communicate them, and measure their impact through increasing knowledge and understanding and therefore, evolving practices.

In examining the resilience of beef production systems in an Australian context, it is essential to understand the beef industry's position within the agricultural sector as well as the challenges and constraints the industry faces.

2.6 Beef Production Systems in Australia

Without significant change in the agricultural sector worldwide, human activities will continue to overstep planetary boundaries (Campbell et al., 2017; Rockström et al., 2016). As such, the agricultural sector has a central role to play in preventing further local and global environmental damage which threatens ecosystem functions. Agricultural land use covers 55% of the Australian continent or 427 million hectares, with livestock grazing as the dominant agricultural land use (Australian Bureau of Resource Economics and Sciences, 2023). Many sustainable land practices have become the standard for Australian farmers (Coelli, 2021).

Given livestock is the dominant agricultural land use in Australia, it is important to highlight the challenges it faces which can affect the sector's triple bottom line and its sustainability into the future. This section aims to provide background to some of the issues facing beef production systems that underpin resilience. The Australian beef industry services both domestic and export markets, which are experiencing high levels of demand. There are two types of production systems in Australia currently servicing these markets – the Northern Production Systems and the Southern Production System. Australia is a relatively small beef producer on a global scale, with a herd size of between 30 to 40 million, equating to 12 - 16 million tonnes of beef across 200 million hectares (Fordyce et al., 2023).

In 2020, 45,712 agricultural businesses were involved in the cattle industry in Australia (Meat and Livestock Australia, 2021). Cattle numbers were at 24.7 million head of cattle as of June 2019, with 11.7 million head of beef cows and heifers aged one year and over. Around 189,000 people are employed in the red meat industry, including on-farm production, processing, and retail. In 2018-19, Australia produced approximately 2.4 million tonnes of carcass weight (cwt) of beef and veal. In 2019, 3.0 million grain-fed cattle were marketed (feedlot turn-off), equating to 36% of all adult cattle slaughtered in Australia. The gross value of Australian cattle and calf production (including live cattle exports) in 2019–20 was estimated at A$15.1 billion (Australian Bureau of Agriculture and Resource Economics, 2020). Cattle are estimated to have contributed 23% of the total farm value of A$66.5 billion in 2019–20. Based on MLA estimates, domestic expenditure on beef was approximately A$7.8 billion in 2019, and Australians ate around 25kg of beef per person in 2018–19 (Meat and Livestock Australia, 2021). According to the MLA State of the Industry Report, Australia has approximately 2% of the world's cattle herd and is the 2nd largest beef exporter in the world behind Brazil. Exports in order of volume go to China, Japan, the US, South Korea, and Indonesia (Meat and Livestock Australia, 2021; United States Department of Agriculture, 2014).

Domestic demand has fallen since 2013-14, when Australians consumed 30.9 kg of beef and veal per head (carcass weight). Relative to other nations such as Hong Kong (80.6 kg/hd), Argentina (65.1 kg/hd), Uruguay (51.4 kg/hd), and Brazil (39.6 kg/hd), therefore Australia is by no means the largest consumer of beef globally. Subsequently, Australia exports a significant volume of beef (70.3% year ending June 2014 and 76% of its total beef and veal production ending June 2019). Australians spend 40% of their food bill on meat (Stoll-Kleemann & Schmidt, 2017) and they are the sixth-largest per capita consumers of beef in the world (Meat and Livestock Australia, 2021). However, statistics also show that the number of people who avoid meat in preference of a plant-based diet has been steadily increasing in recent years (Bogueva et al., 2017; Lea & Worsley, 2003; Lea et al., 2006).

There are several breeds utilised in Australia, depending on markets and climatic conditions. Angus, Hereford, and Charolais are prominent in southern Australia, and Brahman and Santa Gertrudis are in the north. The industry as a whole is disparate and fragmented, with many different players in the production chain. Corporate ownership is prevalent in the northern production zone, and the processing and feedlot industry is quite concentrated. The disease-free status and traceability of the Australian beef industry provide a competitive advantage at this point in time. However, there are increasing concerns around Foot and Mouth Disease and Lumpy Skin Disease coming into Australia, given both are already prevalent in Indonesia (Mutoyib et al., 2023; Zainuddin et al., 2023). Consequently, Australia is now gearing up its biosecurity systems and is on high alert, undertaking several modelling experiments and various preparations for any outbreaks (Kane, 2022; Manyweathers et al., 2022; Seitzinger et al., 2022; van Vuren et al., 2022).

The Australian cattle industry operates in a liberalised environment which has forced the industry to compete in international markets against heavily subsidised producers (Greenwood et al., 2018). Subsequently, the industry is continually researching ways to improve efficiencies of production. For example, there has been significant research undertaken on productivity improvements in the areas of genetics, pastures, and supply chains (Bell & Sangster, 2022; Jackson & Cook, 2022; Malau-Aduli et al., 2022; Sarker et al., 2022).

The Australian beef industry is currently dominated by production and processing facilities, which have developed to service export markets. There has been an ongoing strong influence from export market conditions and the increasing demand globally for beef as a high-quality product (Australian Bureau of Agriculture and Resource Economics, 2020; Greenwood, 2021). More recently, we have been experiencing the emergence of regenerative certification systems that pay a premium for grass-fed beef finished under regenerative farming systems (AgTrade, 2023; Open Food Network, 2023; Paradigm Foods, 2023; Southern Cross Certified, 2023).Wholesale values of beef are affected by movements in export returns, the overall balance of world supply and demand, trade barriers caused by diseases, and shortage of supply as a result of weather, feed availability/cost, and demand globally (Peel, 2021).

There is a trend towards increased value-adding and integration featuring wholesalers and specialty retailers (Spencer & Kneebone, 2012). The retail red meat industry is dominated by supermarket chains with contract growers and processors ensuring stability and consistent quality. Meat industry market research (Australian Bureau of Resource Economics and Sciences, 2023; Meat and Livestock Australia, 2021) shows retailers holding approximately 66 percent of the market, butchers 28 percent, with the remainder being independent food channels. Distribution is a direct supply from the processors to the retailers. Outside of the supermarkets, wholesalers play a central role.

According to the ABARES commodity report (2020), average sale yard prices in 2021–22 were forecast to rise by 12% to 702c per kg. Favourable weather conditions were expected to support continued herd rebuilding. Production was forecast to rise by 7% to over 2,000 kt, but cattle availability and labour shortage constraints are likely to continue. Australia's exports were forecast to rise by 3% to almost $10.1 billion in 2021–22.

2.6.1 Australian beef industry and the environment

In Australia, livestock accounts for 70% of greenhouse emissions, with Queensland contributing the most. Climate-smart activities will be needed to lower greenhouse emissions (Panchasara et al., 2021), and farmers have two main options if they are to retain their social license to farm livestock and therefore remain resilient:

1. Reduce crop and livestock emissions, and
2. Sequester carbon in soils and biomass

Temperate grasslands occupy 25% of the world and 70% of global agricultural land (Godde, 2020). Livestock grazing, dryland, and irrigated agriculture make up 55% of Australia's land mass; most of this land is under livestock production (ABARES, 2023). Given the substantial land areas involved with grasslands, grazing systems could be part of the mitigation strategy and a potential solution for reducing greenhouse gases.

Australian research has identified the key role of novel supplements, anti-methanogenic legumes, and rumen microbial manipulation in reducing methane levels (Black et al., 2021; Ridoutt et al., 2022). Novel ruminant supplements such as marine macroalgae (*Asparogopsis* spp.) at low dietary levels could significantly mitigate methane emissions in farming systems with improved productivity and no detectable impacts reported for animal health or meat quality (Davison et al., 2020). Research in reducing methane from livestock through the use of red marine macroalgae supplements, also known as red seaweed, has the capacity to reduce methane to negligible levels (Kinley et al., 2016), (Raven et al., 2002).

In addition, potential economic drivers to enhance carbon sequestration include emerging industries, such as Carbon Farming and Trading (referred to in Australia as Carbon Credit Units or ACCUs), and biodiversity credits and offset schemes (such as those managed by the New South Wales Office of Environment and Heritage through the Biodiversity Conservation Trust) (Yu, 2023). Australian companies (such as mining and construction companies) that clear native vegetation can offset their ‘footprint’ by paying another landowner to protect and manage biodiversity on their land through Biodiversity Stewardship Agreements (BSA). Managed by the NSW Biodiversity Conservation Trust (BCT), biodiversity credits and offset legislation support conservation on private land in New South Wales (NSW). These initiatives offer opportunities for NSW grassland livestock producers and have the potential to bring new enterprises and profits back into farming while protecting the natural capital and environment. However, more research and education are critical to give farmers the confidence to commit to these initiatives (Baumber et al., 2022; Baumber et al., 2019; Baumber et al., 2020; Burns, 2021; Cusworth et al., 2022; Giller, Hijbeek, et al., 2021a).

With the price of carbon continuing to increase and the threat of a carbon tax system to large corporations, carbon farming presents farmers with financial opportunities which will also assist with climate variability (Baumber et al., 2020; Hughes et al., 2019; Maraseni et al., 2021).

However, the limitations to adaptation in reducing risk around GHG include the uptake of carbon farming by Australians being slow due to compliance costs, opportunity cost of practice change, and commitment to 25 year permanence period (White, 2022), coupled with the lack of education, conflicting information, and confusion around the topic.

2.6.2 Australian beef farmer challenges

Australia is a substantial beef exporter despite its relatively small herd size compared to other countries. To date, it has a reputation for clean, green products and its disease-free status; however, this can change overnight with the threat of Lumpy Skin and Foot-and-Mouth diseases in nearby countries (Kane, 2022; Stanger & Bowden, 2022). Scientists at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) highlighted five major 'megatrends' that will affect Australian producers (Naughtin et al., 2022). A megatrend is described as a major trajectory of change that will have profound implications for the industry (Bindraban & Rabbinge, 2012). The response of the agricultural sector to these megatrends will determine its future. These megatrends include:

- A hungrier world – population growth driving global demand for food and fibre putting pressure on environmental assets
- A wealthier world – the emergence of a new middle class increasing food consumption
- Choosy customers – information-empowered consumers demanding particular ethics, provenance, sustainability and environmental accountability, or health attributes
- Transformative technologies – advances in food and fibre production and transport, and
- A bumpier ride – changes resulting from globalisation and a changing climate (Greenwood et al., 2018) testing overall resilience and ability to continue farming

Strong food and fibre demand from wealthier and choosier consumers, particularly in the Asian region, provides enormous prospects for export growth for Australian farmers. The global population will exceed nine billion by 2050, and food demand is expected to increase by around 77% (Lineham et al., 2012).

Modern agriculture is becoming more knowledge intensive as agricultural systems and their management have become increasingly complex, underpinned by expensive capital investments, changing production technologies, volatile markets, social challenges, and increased regulation. Farming now employs various technologies and practices that require the continual assimilation and assessment of new knowledge (Kingwell, 2011; McKenzie & Williams, 2014; Oreszcyn, 2010). This increased complexity has placed new and additional demands on farmers existing knowledge and skills (Kingwell, 2011). Australian agriculture has a high proportion of small-scale owner-operated businesses with few employees and is classed as a skilled sector, with 70% of the industry working as managers, administrators, or professionals (compared to 40% for the national average) (Nelson, 2011).

2.6.3 Stagnating yields and declining equity levels

The profitability of Australian agriculture depends on how efficiently it uses resources and on the relative prices of Australian agricultural products (the terms of trade). The decline in the agricultural sector's terms of trade and the ratio of prices received for outputs relative to prices paid for inputs have both been important sources of pressure driving adaptation and change in Australian farmers. Like many other agricultural industries, profitability in the beef industry is highly variable and will be further affected by farmers ability to adapt to climate change (Adger et al., 2005; Harris, 2020).

The cyclical nature of the world beef markets and Australia's leverage to beef exports has meant that beef producer returns have been cyclical (Griffith & Alford, 2002). Australia's reliance on pasture-fed beef and the variable climatic conditions have resulted in profit variability. In recent years, however, there has been a strong global demand for clean green pasture-feed cattle (Zhongming et al., 2020). In 2002, the top producers received approximately 4.6% rate of return. This is changing dramatically since Free Trade Agreements were implemented in 2015. While there is a high demand for cattle worldwide, profits were at an all-time low during the 2016-2020 drought. There is a positive correlation between herd size and rate of return, however, and there are improved returns with sufficient scale, with the top 25% of producers with over 700 head of cattle receiving improved returns (Gleeson & Brittle, 2001). These farms also had superior production outcomes, such as lower death and higher branding rates. The percentage of the herd represented by females varies, with increasing resources going into valuable slaughter animals.

Corporate farms, while only representing 1% of the national beef herd in 2001, achieve efficiencies of scale and receive greater returns than family-owned farms (10% compared to 4% with family-owned farms). Since 2014, there has been a substantial increase in Corporate owned farms and foreign investment in farms (Sippel et al., 2017); this has been partly due to the loosening of the terms of trade with trading partners. These Corporate farms are also investing in the supply chain and vertical integration. While many family farms may have reasonably high ownership levels, they have aging farm owners and managers, reducing the uptake of technology and innovation, and face long-term challenges if succession is not addressed early. Higher farm equity does not correlate with more profitable businesses; the top 25% of beef production businesses, ranked by rate of return, tend to have lower equity levels. This may be due to having younger, more progressive managers who actively take up new technologies and have a greater focus on business performance (Gleeson & Brittle, 2001).

While the adoption of new technologies and adjustments in inputs has increased productivity and therefore profitability (Popescu et al., 2020; Radoglou-Grammatikis et al., 2020; Shafi et al., 2019), farmers are having to re-calibrate the way they farm. Ever-increasing inputs, for example, are not providing the same yields, which are plateauing. According to the State of the Climate report, annual average farm profits reduced by 23% over the past 20 years due to changes in seasonal conditions. CSIRO and the Bureau of Meteorology predict deteriorating on-farm productivity through 2050 due to climate extremes (Bureau of Meteorology and CSIRO, 2022). According to the latest ABARES 2023, farm incomes are easing as prices drop and inputs keep rising (Australian Bureau of Resource Economics and Sciences, 2023).

The quality of food can increase with reduced artificial inputs, and increasing crop yields will come from improved genetics and technology (Tester & Langridge, 2010). Fewer nitrogen inputs can achieve increased crop productivity if intercropping techniques are adopted. For example, a recent study by Wang et al. found that energy yields of sugarcane and soybean intercropping systems were up to 39% higher than in monocropping systems (Wang et al., 2020). Precision agriculture and smart farming technology that reduces GHG have been identified as key in retaining yields in climate change (Panchasara et al., 2021), assuming there are no soil constraints and carbon sequestration is available through cover cropping (Chahal et al., 2020). Manure has also been found to be better than synthetic fertilisers for increasing crop yields over time due to improved soil fertility (Cai et al., 2019; Zhang et al., 2020a). A global meta-analysis of the relationship between soil organic matter and crop yields showed that increasing soil organic carbon and reducing nitrogen fertilisers in maize and wheat resulted in increased crop yields (Oldfield et al., 2019). According to the Food and Agriculture Organisation (FAO), yields for major food crops (such as wheat and rice in France, Germany, the UK, and Japan) have not been increasing since 2000 (Food and Agriculture Organisation, 2000). Further whilst these yields have plateaued, total global pesticide production and imports have been increasing since the 1940s (Tilman et al., 2002), resulting in increasing inputs not corresponding with increased yields. Therefore, it is possible to achieve increased yields through reducing artificial inputs.

2.6.4 Selling methods and value chains

The Australian beef cattle industry comprises primarily small to medium enterprises and is spread across the continent, operating in a wide range of environments. Furthermore, the cattle industry is physically and culturally isolated from its primary customers (multinational meat processors) and its consumers (urban communities in Australia and overseas) (Economou, 2015). Given that cattle are considered a commodity whereby prices are set by market conditions, the industry is trapped in that it is a price taker rather than a price maker. In addition, there are fewer buyers because a market monopoly exists with JBS (‘Jose Batista Sobrinho’, the founder of the company) in Australia. Few processing facilities are left compared to the 1950s when many rural towns had their own meat works. It is difficult for producers to value add to their beef due to the many secondary cuts, skirts, and hides that also need to be marketed. Unlike meat products such as sheep, pigs, and poultry, which are more easily handled with less offcuts. The ability to navigate the ever-increasing compliance issues around selling beef to fewer buyers affects the profitability of the business and its economic resilience.

2.6.5 Government research and development extension policy

Nationally, Rural Research and Development Corporations (RDCs) are the Australian Government’s primary funding bodies for rural research and development (R&D) in Australia. The RDCs cover a broad spectrum of the agricultural, fishing, and forestry industries. In 2021, the research and development funds spent on drought mitigation provided an additional $38.5 million to the Drought Resilience Research and Adoption Program, taking the total investment to $117.3 million by 2023–24. An additional $60 million was allocated to the Farm Business Resilience Program and $31 million to the Regional Drought Resilience Planning Program. In addition, the 2021–22 Budget announced $196.9 million in new funding over four years to implement the National Soil Strategy (Department of Agriculture, 2021). There is now a significant focus on saving Australian soils and assisting rural communities to be more resilient in a changing climate. The 2019-20 Australia bushfires also contributed to the sense of urgency that was being felt across the country around Climate Change. Most agricultural commodity organisations, including Meat and Livestock Australia (Meat and Livestock Australia, 2019) and the National Farmers Federation (National Farmers Federation, 2021) have signed up to zero emissions by 2050 through their sustainability frameworks or policy documents, though precise details on how this will be achieved are lacking.

State and Territory governments have traditionally played a significant role in extension delivery but have reduced funding in recent decades due to budget pressures and changing priorities. Consequently, publicly funded extension declined an estimated 24%, and extension services from industry and private business providers have increased (Paschen et al., 2017).

2.7 Conclusion

Beef farmer resilience, defined by its capacity to deal with change and continue to develop in a changing climate (Stockholm Resilience Centre., 2021), needs to account for a triple-bottom-line perspective, incorporating equal emphasis on economic, social, and environmental approaches and outcomes (Negri et al., 2021; Rudiarto et al., 2019). Further research using holistic approaches is required to address complex problems in landscapes for social-ecological transformation (Hawkins et al., 2017). By drawing on the best practices of other alternative farming systems, RA may offer a 'best practice' approach to grazing land management and the opportunity to repair ecosystems and transform food production (Gordon et al., 2022; Gordon et al., 2023). Further research is required to determine which aspects of regenerative farming increase the resilience of a system (Al-Kaisi & Lal, 2020; Khangura et al., 2023). Therefore, long-term farming trials, which test various regenerative practices in different climatic conditions, could test aspects of RA that increase resilience.

RA is discursively linked to HM thinking and practice and encompasses triple bottom-line approaches (Gordon et al., 2023). Globally, beef production is a core contributor to the agricultural sector overstepping planetary boundaries (Campbell et al., 2017; Rockström et al., 2016), hence it is critical to explore resilience in the context of sustainable beef production (Navarro Garcia et al., 2023) and a northern beef grazing case study. Australia is a leading global beef production country/exporter, therefore the perfect context for exploring resilience in beef production systems. A paradigm shift from efficiency-driven industrial agriculture to resilience-focused eco-friendly agricultural approaches is seen as a pathway to climate resilience practices that will support farms to be more resilient to droughts, floods, and other climate shocks (Bennett et al., 2021; Dong, 2021). Farming systems are complex adaptive systems whereby economic resilience does not exist without social and ecological resilience (Budaev, 2019; Jagustović et al., 2019).

Analysis of current literature showed that definitions of resilience and the indicators to measure resilience lack consensus and consistency and are context-specific (Cerè et al., 2017; Schipper & Langston, 2015; Serfilippi & Ramnath, 2018).

The current dominant industrial-productivist agriculture has been referred to as extractive, privileging economics resource use efficiency over other dimensions (claiming it is necessary to feed a growing population), relies on high-input synthetic chemical pesticides and fertilisers, utilises large quantities of non-renewable fossil fuels, consists of monocultures, and consumes large quantities of water (Dong, 2021; Horrigan et al., 2002; Struik & Kuyper, 2017). While recognising and accepting that there is controversy, industrial-productivist agriculture does not reflect the principles of resilience as outlined in this review. Adopting these principles is critical to bring humanity back within planetary boundaries.

The literature mainly focuses on alternative beef production resilience in an ecological and social context; however, economic resilience is also essential to regenerative beef production systems. Hence, research into the resilience of regenerative beef production in Australia needs to come from a triple-bottom-line perspective.

This literature review has provided the foundation for the following empirical chapters: Chapter 3 (a longitudinal case study of both conventional and alternative farming systems in Northern NSW, Australia) and Chapter 4 (the Principles for Regenerative Agriculture in Australia).

Four resilience frameworks (SRAP, RAPTA (x 2), MF) were reviewed against the triple bottom line criteria identified for Northern NSW beef grazing systems and found to be context specific. Triple bottom line indicators applicable to Northern NSW graziers needed to be relevant, easy to understand and measure, and important to them achieving goals. The three resilient frameworks chosen allowed for further testing and significance of the frameworks against a specific set of triple bottom line criteria and measurements identified as relevant for Northern NSW graziers. The review highlighted the following observations that warrant further research:

- The significant challenges being faced by beef cattle and their production systems in Australia

- The limitations to adaptation in reducing risk around GHG, such as the slow reserved uptake of carbon projects by
- Additional research is required to develop methods and tools to assess transformability. Attributes that assist with robustness, adaptability, and transformability can be addressed through a mixed methods approach, and
- The need for longitudinal research that can gauge adaption and transformation through climate change events over time

The SRAP, RAPTA (Cowie and Baumber versions) and MF frameworks allowed for adaptation and transformability in a local context utilising triple bottom line mixed method approaches and were found to be applicable and relevant to the group of farmers chosen for a Northern NSW Grazing study. The RAFTA studies had proven useful in an Australian context however, The Stockholm Principles of Resilience (SRAP) was identified as the most suitable framework to apply to the case study as it captures the broad essence of the other frameworks, resonated with the relevant cohort of farmers, and provides a framework for resilience which can be measured through combining triple bottom line sustainability indicators. Using SRAP in the context of a northern beef grazing case study addresses the need to be context-specific, able to be applied in practice, and access to adequate data and meaningful location-specific indicators.

Having robust resilience frameworks and principles to guide farm decision-making will be essential to mitigate the effects of climate change. The practices will change over time as the knowledge and understanding of the environment are developed. Further, a guiding set of regenerative principles for farmers and land managers have the potential to facilitate adaptation and transformation in farming practices as new techniques and technologies become available.

Chapter 3: The New England NSW Case Study

3.1 Introduction

There has been controversy in studies comparing HM, from which RA grazing systems in Australia draw their roots, with conventional agriculture (CA) grazing systems (Briske et al., 2011; Sherren et al., 2019; Teague et al., 2013) and RA with CA (Francis, 2020; Giller, Hijbeek, et al., 2021a; McGuire, 2018). Most debate, according to a meta-analysis of HM undertaken by Gosnell et al. (2020b), was a result of epistemic differences between agricultural science disciplines. Epistemic differences have proven intractable because they are rooted in ontological differences between the hypothetical-deductive sciences and holistic practice.

A review of several studies examining adaptive multi-paddock grazing found that most studies choose simplicity over complexity, and control and replication over realistic context (Teague & Barnes, 2017). The scientific experiments that have critiqued rotational grazing (Briske et al., 2013; Briske et al., 2008) were found to be inconclusive due to the use of small paddocks, which were not comparable in size to properties using HM and therefore not realistic to real-time and space (Brunson & Burritt, 2009; Budd & Thorpe, 2009; Roche et al., 2015; Teague et al., 2013). In addition, the studies used pre-determined stocking rates and rotations for scientific integrity and repeatability but removed management of the social, environmental, and economic complexity in which the grazier usually operates (Brunson & Burritt, 2009; Budd & Thorpe, 2009; Kothmann et al., 2009; Roche et al., 2015). Therefore, it was concluded that previous studies did not undermine the Savory HM method (Bailey et al., 2019; Teague, 2014).

Some HM studies have argued that improved soil conditions associated with holistic planned grazing means that it is an effective approach to mitigating climate change through increased soil carbon sequestration (Neely et al., 2009; Rowntree et al., 2016; Teague et al., 2016). In addition, a meta-analysis comparing CA practices to alternatives found RA increased perennials and that cover crops increased infiltration rates (Basche & DeLonge, 2019). Further, the study concluded that practices that promoted ground cover and perennial root systems, improved soil structure.

Like HM, RA takes a holistic approach to decision-making and works with an understanding of complex adaptive systems (Gordon et al., 2022). There is little research directly referring to RA in this context, so similar research in HM, was relied upon. HM is increasingly used interchangeably with the term RA (Gosnell et al., 2019), and even the Savory Institute, based in the US (Savory, 2023), has embraced this newer terminology. RA practices claim to enhance ecological, economic, and social outcomes across farms and local communities, whilst positively impacting earth systems and transforming ecological complexity on farms (Colley et al., 2020; Elevitch et al., 2018; Gordon et al., 2023; Massy, 2020; Rhodes, 2012).

The current debate concerning RA versus CA focuses mainly on profitability (Ashton, 2018; Francis, 2020; Ogilvy, 2018). Overall, there is very little credible research on the outcomes of RA, and current research often criticises the practice from a single perspective, such as Agronomy (Giller, Hijbeek, et al., 2021a). To date, few researchers have compared RA and CA from a resilience perspective.

3.2 The Case Study: New England Tablelands, NSW

This case study aimed to contribute to existing research with a triple-bottom-line perspective, specifically examining whether Australian RA grazing systems are more resilient than CA grazing systems in a changing climate. The New England Tablelands of Northern NSW was chosen because it provided access to a group of farmers who represented a typical example of southern grazing systems in Australia and the variety of farmer-approaches therein. In this context typical refers to the stocking rate, types of farm enterprises, and land area.

For this research, non-conventional grazing practices were initially referred to as alternative practices when the research commenced in 2016. As the research evolved, the ‘worst’ drought in Australian history occurred, encompassing 2018 and 2019. This drought was followed by catastrophic fires in the case study region, never experienced at such ferocity and scale. These events have been referred to as the most severe droughts and fires in living history (Steffen, Hughes, et al., 2019). Parallel to these events was the greater emergence of the regenerative agricultural movement in Australia and mainstream recognition after the 2018/2019 drought; consequently, the alternative practice approach of this research morphed into a regenerative focus.

A case study of whole farm systems was used as the central methodology of this research to compare RA grazing systems to CA grazing systems in a major beef production region of eastern Australia. The research objective was to examine the practices of RA graziers in comparison to CA graziers in a specified region of Australia using a specific resilience framework - The Stockholm Resilience Alliance Principles for Building Resilience (SRAP). The case study covers environmental, social, and economic indicators, identifying the beliefs and practices of this group of Northern NSW graziers in a changing climate.

A longitudinal study was undertaken between 2016 and 2020 using a cohort of farmers in the same region and with similar climatic and soil conditions. To capture the influence of the various climatic events of the study period, and farmers management decision-making during these extreme climatic events, a longitudinal approach was necessary to capture the same questions at different times (Neuman, 2006). The collected data captured aspects of ecological resilience in a changing climate, and the intersections of sustainability, resilience, and wellbeing. This triple-bottom-line approach reflects the economic, environmental, and social aspects of farming (Venkatramanan & Shah, 2019).

The case study approach was adopted because many variables needed to be covered for this holistic piece of research, including an in-depth examination of farmers beliefs and management practices over time. In case study research, studies examine many in-depth variables of a few cases over time, mostly involving qualitative data, and is analytical versus enumerative (Neuman, 2006). In regards to farmer adoption of practice change, case study research delves deep into the decision-making processes that cause farmers to adopt or not adopt certain practices, and has been utilised both internationally and in Australia as a research tool (Brown, Batterham, et al., 2022; Bucci et al., 2019; Liu et al., 2019; J. E. Newton et al., 2020; B. Zhang et al., 2019a; T. Zhang et al., 2019c).

3.3 Study area, sampling design

Initially, 37 farms were chosen as potential participants for the longitudinal case study research who "self-described" as conventional, holistic, organic, or biodynamic. However, some of these did not wish to participate or their farms were not at a suitable scale to participate. As a consequence, the sample area did not end up including the Mid-North Coast region, remaining within the New England area of the Northern Tablelands. The study ended up researching 16 farming businesses in the New England region. The study area was further refined such that it stretched from Guyra in the Northwest, to Walcha in the South, and to Ebor in the Northeast, but left out the coastal areas from Dorrigo to inland Coffs Harbour, which are located in two very different Bioregions (groupings of similar vegetation, soil type, geography, climate). A Bioregion is a geographic area defined not by political boundaries but by ecological systems (Oneearth, 2023). The original case study sample area can be seen in Figure 3.1. These farms represented a mix of RA and CA grazing systems. Whilst farmers in the first instance 'self-described' their farming practice, this was validated against the regenerative style practices identified from the literature review. These practices included: the number and size of mob, the length of rest time for a paddock before re-grazing, the length of time cattle spent in a paddock, the length of pasture left after a graze, and the type of fertiliser inputs used.

The case study comprised farms with similar soil types and climatic conditions within a geographically contained area, with all farms within 100 kms. All farms had an average rainfall of above 800 mm per annum and were managing a minimum of 500 ha. Case study data collected in early 2016 (pre-2017-2019 drought) was compared to case study data collected from the same source in 2020 (post-drought and 2019 bushfires) using the same methodology.

Some participants were sourced through a network group of local 'Beef Marketing group producer members, and others through a 'Cost of Production' group. Other participants were chosen outside these groups to bring a different perspective, or because they represented diverse farming styles.

A total of 16 farming families participated over the period (2016-2020) comprising of mix of conventional and alternative. Some of the original farmers in the 2016 research were no longer farming and did not participate in the 2020 research. None of the conventional (CF) transitioned to regenerative (RF) over the study period. While initially there was an abundance of CF approached, some approached did not wish to participate in the research. Initially, there were fewer alternative and RF that met the specific size and location criteria available. They had to be found by adjusting the original geographical area chosen to provide adequate comparisons.

There were several on-farm visits involving CF and alternative farmers, which included semi-structured interviews based on the mail-out survey they had already completed. The

research participants were in the same group as in 2016 and formed the longitudinal study utilising similar questions and processes from 2016, again in 2020.

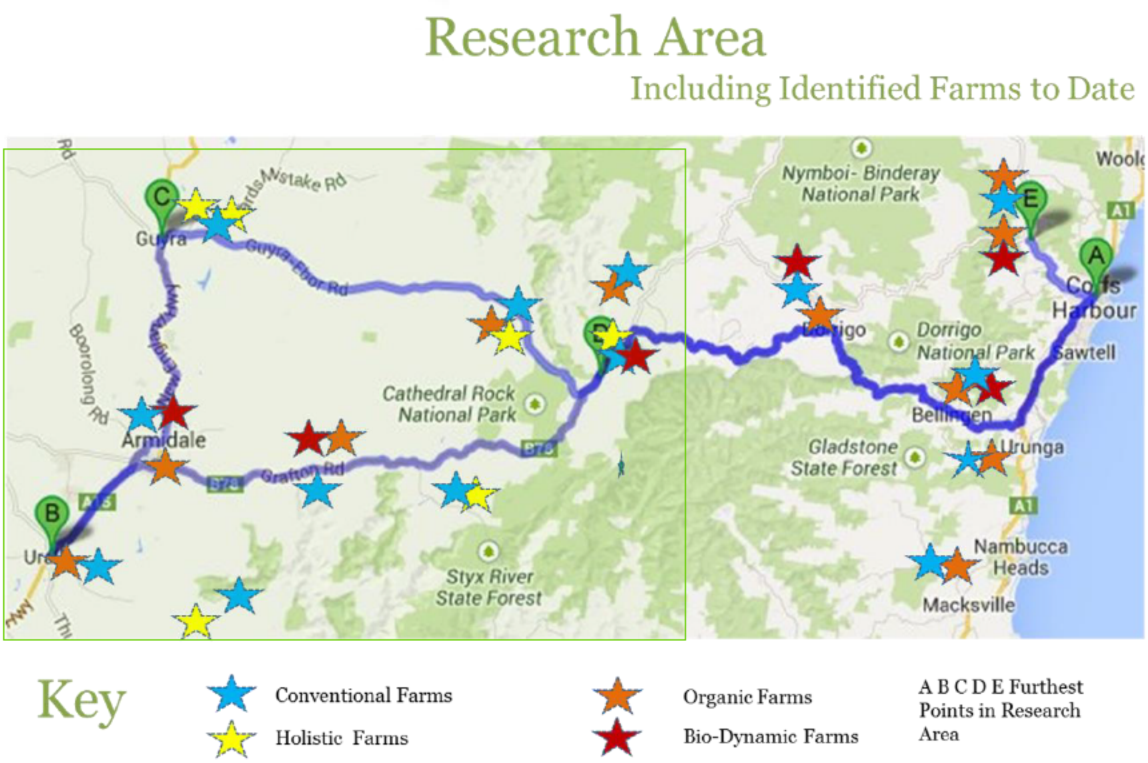


Figure 3.1. Original case study sample area in Northern NSW, was later refined to one bioregion to omit coastal areas (NB Holistic Farm means under holistic grazing management).

Participants' criteria for inclusion in the research:

1. Located within the study area in Northern NSW, Australia, with the boundaries being Guyra in the Northwest, Walcha in the South, Ebor in the East
2. Managed the property and were responsible for decision-making
3. Aged 18 or over
4. Production area of at least 500 ha
5. Have managed the property for at least three years
6. Participation in both the 2016 and 2020 research

Participants to be excluded:

1. Children (aged 17 and younger)
2. Farm managers with less than 12 months of experience on that property
3. Outside study area of Northern NSW
4. Employees who do not fit the category of either managers or owners of the property

5. Anyone suffering from mental incapacity

3.4 Research Question and Sub Questions

The overarching research question was:

"Are Australian regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate"?

To answer the overarching research, the following research sub-questions were explored:

a. Which beliefs and practices (leading to management decisions) are held by Northern NSW beef farmers in a changing climate, and how are these expressed?
b. What are the economic, environmental, and social indicators for a resilience framework, and how do the actions of regenerative and conventional beef cattle farmers align with the Stockholm Resilience Alliance Framework?
c. What conclusions can be drawn about the resilience of cattle production systems in Northern NSW?

3.5 Research Methodology and Approach

The research methodology included two Case Study Questionnaires in a Longitudinal Survey, with the data coded for use in Thematic Analysis. The Thematic Analysis extracted initial codes from the data, processed and classified the codes, combined the codes into overarching themes that accurately depicted the data, related the themes to the research questions and theoretical frameworks, defined the themes, and interpreted the results. A detailed explanation of this process and how the attribution was standardised is outlined in Appendix D. The case study nature of the data (effectively a small sample of 16 farms) occasioned the use of Thematic Analysis (Boyatzis, 1998), with the resultant coded data sets used both in qualitative and quantitative analysis and in the examination of the alignment of themes with the SRAP.

The research took a multidisciplinary mixed methods approach using qualitative and quantitative data methods. This convergent parallel mixed methods design allowed the results to be triangulated (Creswell & Clark, 2017; Dawadi et al., 2021). The reason for the approach was to obtain the depth of inquiry, and deeper insights from narratives from the qualitative approach and statistical insights from the quantitative data, with one method more suitable for answering some types of questions and vice versa and the strengths of one offsetting the weaknesses of the other (Plano Clark, 2017). The mixed methods research provided a complimentary complete picture. The qualitative and quantitative data whilst collected concurrently, were analysed independently with quantitive and qualitative analytical approaches (Creswell & Clark, 2017; Shorten & Smith, 2017). It used the descriptive case study, utilising observation and in-depth interviews as the central methodology, including quantitative data to support the qualitative approach. This research included response variables/outcomes measured around a resilience framework utilising economic, environmental, and social indicators. Explanatory variables for differences in profitability were identified. Variables such as institutional factors, premiums, supply chains, internal business dynamics, and constraints/opportunities, which were essentially linked to outcomes, were considered in the analysis.

The analysis does not facilitate cause-and-effect conclusions but uses measures of association within and between farm systems. The small sample size addressing many whole-farm variables lends itself to Thematic Analysis, which was employed.

Thematic Analysis included:

- Coding of the survey data according to emerging themes (refer to Appendix D)
- Crosstabs
- Correlations of 60 plus variables in a transposed dataset to compare farms,
- Radar graphs of qualitative aspects of patterns of codes, and
- Radar graphs of resilience principles and variables together

The Literature Review (Chapter 2) informed data collection for the Case Study, ascertaining which of many potential variables would demonstrate the contextual meaning of resilience. Like other literature reviews in the sustainability field (Cordova & Celone, 2019; Martins et al., 2019), it focused on addressing known knowledge gaps (Neuman, 2006). It brought together social, environmental, and economic themes to provide a holistic research approach, enabling comparisons of neighbouring farm systems. It also extended to issues related to a period spanning severe climate events which included drought, fires, and floods.

The Stockholm Resilience Alliance Principles (SRAP), also referred to as the Stockholm Group of Scientists Social-Ecological Resilience Principles' (R Biggs et al., 2015b; Stockholm Resilience Centre., 2021), incorporates the three performance dimensions: social, environmental, and financial used to triangulate the case study findings.

An outline of the methodology and research approach can be found in Figure 3.2.

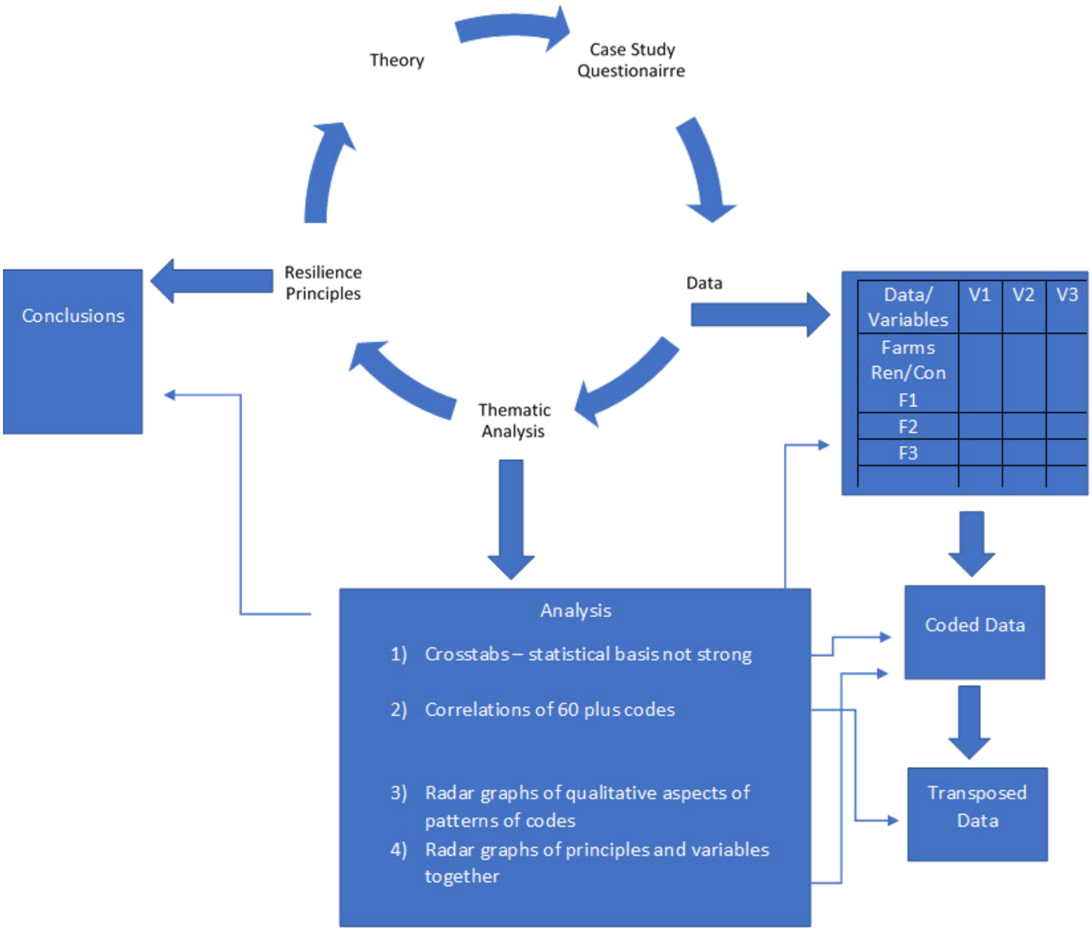


Figure 3.2. Research pathway and methodology flow chart.

Table 3.1 links examples of farm management practices and thinking used in the case study questionnaire with the resilience principles chosen for the research (SCAP).

Table 3.1 The Link between Resilience Frameworks and Farm Management Practices

Stockholm Resilience Alliance Principles (SRAP)	Examples of Farm Management Practices
1. Maintain diversity and redundancy	Number of other enterprises and income sources, income security and equity levels, ability to retain staff, level of biodiversity on the farm
2. Manage connectivity	Tree belts, wildlife corridors, and nature strips, individuals and the family's connection to land and community
3. Manage slow variables and feedbacks	Adopting and taking up new practices more suitable to the environment, increased on-farm landscape monitoring, and information sharing between farming cohorts
4. Understanding that social-ecological systems are complex adaptive systems	Grazing management practices such as being regenerative or not, utilisation of the holistic management framework for decision-making purposes
5. Encourage learning and experimentation	Furthering education Level of risk-taking or new ideas, level and depth of information sharing amongst peers, and monitoring systems in place
6. Broaden participation	Social and community engagement
7. Promote polycentric governance systems	Ability to self-sustain without relying on larger governance systems

3.5.1 Case study data collection

Data were collected in compliance with the University of New England's Research Ethics procedures (No: HE15-007 and HE20-161, see Appendix A for all Ethics forms in relation to this research). Data was entered into Excel Spreadsheets and stored in compliance with UNE data management protocols.

Both qualitative and quantitative data were collected in the farm survey using numeric, categorical, and open-ended questions. Similar to other practice-based survey approaches (Gonzalez-Mejia et al., 2018; Lekagul et al., 2020; Lowenberg-DeBoer & Erickson, 2019; Sulewski et al., 2020), the Researcher used key performance indicators (in this case Gross

Margins, percentage of tree cover or ground cover, pasture rest periods, etc.) coupled with a self-analysis rating on social indicators (such as mental and physical health).

Data collection was undertaken as a survey to gain extensive information on the property and its operations. Included in this detailed survey was data on the farm background and whole farm/household analysis. Farm characteristics were surveyed, including basic information on the property and family (e.g., number of hectares, number of years farming, numbers and classes of livestock, personal data on age, education, and gender, etc.), details on farming practices (e.g., type of system, number of animals in the mob, paddock size, graze/rest periods, soil fertility and annual health practices, etc.), identified resources and constraints (e.g., land area, soil, climate, labour, capital, available credit, DSE, etc.), as well as the aims and objectives of the farmer. For the most part, data consisted of recalled and self-assessed measures (see Appendix B & C for a detailed description of the survey and Appendix E, F and G for data collection procedures).

From the resulting coded datasets, scores for each farm were assembled by adding the relevant codes within thematic subsets. Normalisation on an interval [1-10] for each farm enabled the use of the variables and their combinations as plots in radar graphs and also facilitated correlation analysis. For each theme, scores were compared in the context of the principles of the resilience framework.
Table 3.2 corresponds the farm survey answers into economic, environmental, and social variables, adds in some relevant citations to the variables chosen to show their relevance and then shows how they connect to the overall principles of resilience (SCAP).

The research did not cover Principle 7. Promote polycentric governance systems, as all the cattle producers were part of the same formal governance systems in the context of regulation and policy and, no farmers were selling produce locally via self-generated value chains.

Table 3.2 Correspondence of Survey Data to: Economic, Environmental, and Social Variables, and Principles of Resilience

Resilience Principles	**Principle 1: Maintain Diversity and Redundancy**	**Principle 2: Manage Connectivity**	**Principle 3: Manage Slow Variables and Feedbacks**	**Principle 4: Understanding that Social- Eco-Systems are Complex Adaptive Systems**	**Principle 5: Encourage Learning and Participation**	**Principle 6: Broaden Participation**
Economic Variables						
No. of other enterprises on the farm *supporting other enterprises and overall farm profitability* (Alexanderson et al., 2023; Polyface Farms., 2023).	*					
Wages paid at a level above the minimum level specified in the National Award level *in relation to staff value and retention* (Francis, 2020).	*					
Higher yielding enterprises such as trading/fattening/finishing cattle v's breeding to turn off weaners, *with trading considered more profitable* (Francis, 2020; Williams, 2000).	*					
Use of supplementary feeds *which increases cost of production* (Ogilvy et al., 2018)	*					

Resilience Principles	**Principle 1: Maintain Diversity and Redundancy**	**Principle 2:** **Manage Connectivity**	**Principle 3:** **Manage Slow Variables and Feedbacks**	**Principle 4:** **Understanding that Social- Eco-Systems are Complex Adaptive Systems**	**Principle 5:** **Encourage Learning and Participation**	**Principle 6:** **Broaden Participation**
Amount spent annually on pasture improvement *which increases cost of production* (Ogilvy et al., 2018). *Also includes planting legumes and soil testing for nutrient availability to plant roots* (Cusworth et al., 2022; Horneck et al., 2011).	*					
Outside income earned off-farm *to enhance prosperity* (Alexanderson et al., 2023; Duong et al., 2021).	*					
Environmental Variables						
Overall biodiversity of pasture species *including perennials which can reduce acidity and provide erosion control against storms* (Alexanderson et al., 2023; Kemp & Dowling, 2000; Ogilvy et al., 2018). *No/minimum till allows for vegetation cover, as an armour against wind or rainfall erosion, whilst reducing methane and nitrous oxide. Improves physical, chemical*	*	*				

Resilience Principles	**Principle 1: Maintain Diversity and Redundancy**	**Principle 2: Manage Connectivity**	**Principle 3: Manage Slow Variables and Feedbacks**	**Principle 4: Understanding that Social- Eco-Systems are Complex Adaptive Systems**	**Principle 5: Encourage Learning and Participation**	**Principle 6: Broaden Participation**
and biology of soil including mycorrhizal fungi. Prevents loss of nutrients to and water to plants (Busari et al., 2015; Jansa et al., 2002; Ogilvy et al., 2018; Schnoor et al., 2011).						
Amount of native pasture mix *which are more resilient to Australian climate and drought* (Alexanderson et al., 2023; Department of Primary Industries., 2020).	*	*				
Amount of bushland tree belts/corridors. *Trees being cost effective for mitigating climate change, improves water and air quality, provides habitat and reduces wind erosion.* (Alexanderson et al., 2023; Griscom et al., 2017). *Trees enhancing nutrient and water cycling* (Kuyah et al., 2016).	*	*				
Use of environmental fertilisers v's artificial fertilisers *to allow natural process to adapt to local conditions,*		*	*			

Resilience Principles	**Principle 1: Maintain Diversity and Redundancy**	**Principle 2: Manage Connectivity**	**Principle 3: Manage Slow Variables and Feedbacks**	**Principle 4: Understanding that Social- Eco-Systems are Complex Adaptive Systems**	**Principle 5: Encourage Learning and Participation**	**Principle 6: Broaden Participation**
enhance resilience and reduce nitrous oxide levels (Colley et al., 2020; Rhodes, 2017; Scialabba & Müller-Lindenlauf, 2010).						
The overall percentage of tree cover on the farm**.** *Cost effective for mitigating climate change, improves water and air quality, provides habitat and reduces wind erosion.* (Alexanderson et al., 2023; Griscom et al., 2017). *Enhances nutrient and water cycling* (Kuyah et al., 2016)		*				
Time controlled/holistic grazing incorporating periods of rest *resulting in re-growth and increased species complexity and diversity* (McDonald et al., 2019; Savory, 1983; Savory & Butterfield, 1999; Savory & Butterfield, 2016)	*			*		
Social Variables						

Resilience Principles	**Principle 1: Maintain Diversity and Redundancy**	**Principle 2: Manage Connectivity**	**Principle 3: Manage Slow Variables and Feedbacks**	**Principle 4: Understanding that Social- Eco-Systems are Complex Adaptive Systems**	**Principle 5: Encourage Learning and Participation**	**Principle 6: Broaden Participation**
Amount of time allocated to community engagement (Brown et al., 2021; Ogilvy, 2018)	*		*		*	*
How often does a farmer test a new idea (Alexanderson et al., 2023; Caffaro et al., 2020)			*	*	*	
Farmer's commitment to continuing their education (Alexanderson et al., 2023; Gordon et al., 2022)			*		*	
Farmer's ability to cope with problems as they arise (Alexanderson et al., 2023; Jones-Bitton et al., 2020)			*			*
Farmer's outlook on life (Alexanderson et al., 2023; Brown et al., 2021)			*			*
Farmer's attitude to risk (Alexanderson et al., 2023; Duong et al., 2019; Sulewski et al., 2020; Wheeler et al., 2021)				*		

Resilience Principles	**Principle 1: Maintain Diversity and Redundancy**	**Principle 2:** **Manage Connectivity**	**Principle 3:** **Manage Slow Variables and Feedbacks**	**Principle 4:** **Understanding that Social- Eco-Systems are Complex Adaptive Systems**	**Principle 5:** **Encourage Learning and Participation**	**Principle 6:** **Broaden Participation**
Amount of time allocated to one's social life (Wheeler et al., 2023)						*
Farmer's assessment of their mental health (Brew et al., 2016; Brown et al., 2021; Ogilvy, 2018)						*
Amount of available leisure time (Contzen & Häberli, 2021)						*

3.5.2 Quantitative Research Approach

The Researcher used the following quantitative tools as an approach to the methodology:

1. Crosstabulations of categorical data
2. Correlations between farms, based on thematic codes and categorical data
3. Interpretive radar graphs of qualitative aspects of the patterns of codes
4. Radar graphs associated with correspondence with resilience principles

Data analysis was based on the farms’ performance and management characteristics. It measured economic, environmental, and social indicators such as financial performance/economics (e.g., in the form of activity gross margins per head, gross margin dollars per hectare, gross margin per labour hours and capital outlaid), marketing (e.g., systems used), environmental outcomes and natural resource management indicators (e.g., such as soil carbon, soil physics, community dynamics, etc.), and social outcomes/personal situations (e.g., community impacts, networks, purchasing of local resources, labour, and inputs).

Analysis of the survey included frequencies and percentages through a thematic analysis. Although the sample size was small, the extensive quantitative data obtained from the participant's questionnaire was analysed using the Pearson Correlation Coefficient (PCC) to measure linear correlations between two sets of data. It was determined to be appropriate for interval scales of 1-10 measuring the correlation between two variables (i.e., regenerative and conventional) as other agricultural and environmental studies have used similar approaches (Atagün & Aalbayrak, 2021; Geng et al., 2020; Heri et al., 2023; Oktan et al., 2022; Sadia et al., 2021).

The data included 56 economic, 12 environmental, and 32 social variables. Thematic analysis, eliminating variables for which few observations were recorded, and removing variables with overlapping interpretation elucidated 13 economic, 12 environmental, and 16 social variables. This data structure allowed for two sets of quantitative analyses.

First, crosstabulation analysis (SPSS Crosstab V1) was used to identify co-occurring actions or expressed beliefs and reported outcomes. The small sample size constrained the use of tests of statistical power. Nonetheless, numerous significant relationships were identified from groupings of observations in the crosstab tables, employing Chi-Squared (Greenwood & Nikulin, 1996) and Fisher's Exact tests (Bower, 2003).

Second, comparisons between whole-farm systems were examined by correlation analysis (Microsoft Excel, Correlations V1) between pairs of farms, using data from each emerging theme. This was achieved by transposing the data so that for each farm, a large number of variables (after processing, up to 78 variables) could be aligned for examination with the Pearson Correlation coefficient. Three such correlation matrices were produced, one for each theme.

3.6 Results

3.6.1 Results of Quantitative Analysis

3.6.1.1 Crosstabulation

The overall analysis required bivariate comparisons to determine if any behavioural and technical issues occurred or did not occur together, by breaking it down into bivariate comparisons. For the most part, inference was limited from Chi-Squared and Fisher's Exact tests, due to the small sample. Kendall's Tau provided some statistical inference.

Table 3.3 Demonstrates that Kendall's Tau identified a statistical relationship ($p = 0.072$ so is significant at 10% level of test) whereas the other results suggested no statistical significance.

Statistics for each table were based on all the cases with valid data in the specified range(s) for all variables in each table. The Crosstab below shows a distinct difference in what RF pay their staff compared to CF. For example, eight RFs paid the Award or above the Award. In comparison, only two CFs paid exactly the award level out of a group of twelve farmers in total. The number of valid cases represents the number of farmers who answered the question which wasn't the full cohort.

Table 3.3 Example of Crosstabs Output and Supporting Statistical Tests

Conventional or Regenerative Farmer with Paying Australian National Award in 2016

Crosstab

Pay below the Award, The Award, or Over Award Rates
(As listed on the Australian National Award Levels)

	Below Award (0)	**The Award (1)**	**Over Award (2)**	**TOTAL**
Conventional Farmer (0)	1	2	0	3
Regenerative Farmer (1)	1	4	4	9
TOTAL	2	6	4	12

Chi-Square Tests

	Value	**df**	**Asymptotic Significance (2-sided)**	**Exact Significance (2-sided)**	**Exact Significance (1-sided)**
Pearson Chi-Square	2.222a	2	.329	.509	
Likelihood Ratio	3.085	2	.214	.345	
Fisher-Freeman-Halton Exact Test	2.271			.345	
Linear-by-Linear Association	1.941b	1	.164	.364	.182
No of Valid Cases	12				

Symmetric Measures

	Value	Asymptotic Standard Errora	Approximate Tb	Approximate Significance
Ordinal by Ordinal Kendall's tau-b	0.406	.187	1.797	.072
No of Valid Cases	12			

Table 3.3 shows the Crosstabs Chi Square combinations to highlight any statistical significance. In comparison, Table 3.4 shows combinations of economic variables to see if the combinations had some correlation. V9 (number of other enterprises on the farm) combined with V195 (outside income earned off-farm) shows 'some' statistical significance between the two variables.

Table 3.4 Combinations of Economic Variables

Variable No.	**Heading**	**With Variable No.**	**Heading**	**Results**
V9	Other Farm Enterprises	V135	Higher-Yielding Enterprises 2020	6/12 had both other enterprises and higher-yielding enterprises
		V194 and/or V195	Outside Income 2016 & 2020	5/14 75% of farmers income was 100% reliant on the farm in 2020
		V218 and V219	Rating Financial Situation 2016 &2020	6/14 as good
		V228	Coping with Problems	4/9 cope better
V135	Biodiversity of Pasture 2016	V160 and/or V162	Type of Fertiliser use 2016 & 2020	4/13 high biodiversity used organic, 4/13 with low biodiversity used artificial
		V160	Supplementary Feedings 2020	No pattern
		V162 and/or V164	Pasture expenditure 2016 & 2020	0/7 with high biodiversity spent on pasture
V115 & V127	Labour Award 2016 & 2020	V228	Coping with problems	Those paying the Award or above cope better with problems 5/9 2020

Variable No.	Heading	With Variable No.	Heading	Results
V135	Higher-Yielding Enterprises 2020	V167 & V168	Selling Costs 2016 & 2020	High-yielding enterprises (traders) had lower selling costs/head 4/8 in 2016; however, 3/7 had higher selling costs in 2020
		V172	High-Value Market	6/10 high-yielding (trading) enterprise also sold into high-value markets
		V173	Direct to Consumer	6/10 high-yielding enterprises didn't sell directly to the consumer
		V175	Forward selling/quotas	
V206 & V204A	Community Engagement 2016 & 2020	V210 and V211	Social Life 2016 & 2020	Correlate high community engagement with high social life and vice versa 5/10 both ways. 4/14 in 2020 had an average social life, and 4/20 had a good social life in 2016 and 2020. Community engagement in 2020 correlated high with social life at 6/14 also.
V214 & V215	Commitment to Continuing Education 2016 & 2020	V218 & V219	Rating Financial Situation 2016 & 2020	Correlation of 6/14 for 2016 and 7/14 for 2020.
V194 & V195	Outside Income sources for living costs 2016 & 2020	V218 & V219	Rating Financial Situation 2016 & 2020	2020 Correlation of 4/14 and 5/14 for those with no outside income sources rating financial situation high. 2016 showed similar 5/14 and 5/14.

Table 3.5 Further Example of a Summary of Cross Tabs Chi Square Test Comparisons

Variable	**Compared with Variable**	**Significance**	**Result**
Other Farm Enterprises	Income earned from off-farm sources in the year 2016	.458	Not significant
	Income earned from off-farm sources in the year 2020	.002	Significant result
	Higher-yielding enterprise such as trading or finishing in the year 2020	1.000	Not significant
	Self-rating of their financial situation in 2016	.735	Not significant
	Self-rating of financial situation in 2020	.577	Not significant
	Ability to cope with problems as they arise	1.000	Not significant
Amount of Supplementary Feeding in 2020	Biodiversity of Pasture mix in 2016	.920	Not significant
	Amount of native pasture mix in 2016	.480	Not significant
	Biodiversity of pasture mix in 2020	.722	Not significant
	Amount of bush in 2020	.253	Not significant

3.6.1.2 Correlation Analysis

The purpose of the Correlation Analysis was to assess the extent to which the farms in the dataset were similar or dissimilar in terms of:

(a) Conventional being like/dissimilar to other conventional

(b) Regenerative being like/dissimilar to other regenerative

(c) Regenerative being like/dissimilar to conventional

The data used was the coded dataset that emerged from the thematic analysis across a set of variables, each representing economic (EC), social (SOC), and environmental (ENV) themes, resulting in a set of selected variables for each category.

We then ran correlations between the farms. To do this, we transposed the dataset to present the farms as repeated observations on the data sets for EC, SOC, and ENV, enabling comparisons between farms. Judicious structuring of the results tables involved the self-described regenerative farms being grouped together, and similarly for the conventional farms.

Conscious of the low number of variables, a high correlation was arbitrarily set at 0.3. Any cells above 0.3 are coloured green for ease of description.

Correlations were undertaken involving transporting the data by comparing multiple variables for each pair of farms to see if there were similarities between the RF and their cohort of other RF, and similarly for CF and their cohort of other CF.

As shown below, (the green cells had a correlation > 0.3) there was a substantial correlation between pairs of RF. This was also the case for pairs of CF. An exception occurred for one CF (C3) who was moving towards a regenerative approach in 2016. However, this farmer had retired by 2020; therefore, no further data was collected. Correlations were most apparent for economic variables and appeared for farm comparisons within and between the two systems.

Correlation analysis for economic variables

In Table 3.6, comparisons are made between RF to measure if they are aligned/not aligned, and between CF to measure if they are aligned/not aligned, and between the two different cohorts.

However, in this example, a difference between RF and CF with green cells indicates a strong correlation (>0.3). High correlations are evidenced by common elements amongst the two subsets of case study farms (regenerative – the cases R1-R10 - and conventional - cases C1-C4). Differences between regenerative and conventional cases appear as low correlations (non-green cells). Please note that Farmer C3 admitted to moving towards a more regenerative approach, as indicated by the green cells below, but wasn't quite there yet.

Table 3.6 Economic Correlation Analysis

	R9	R8	R7	R6	R5	R4	R3	R2	R10	R1	C4	C3	C2	C1
R9	1.00	0.22	0.26	0.30	-0.18	0.11	0.10	0.34	0.79	0.16	-0.06	0.40	0.17	0.26
R8		1.00	0.66	0.73	0.34	0.60	0.05	0.90	0.33	0.66	-0.17	0.64	0.18	0.16
R7			1.00	0.78	0.20	0.64	0.35	0.62	0.35	0.60	0.15	0.61	0.15	0.26
R6				1.00	0.14	0.51	0.41	0.64	0.53	0.51	-0.17	0.49	0.17	0.16
R5					1.00	0.26	0.04	0.28	0.05	0.29	0.16	0.04	-0.01	-0.07
R4						1.00	0.30	0.53	0.25	0.53	0.34	0.80	0.17	0.49
R3							1.00	0.08	0.25	0.16	0.30	0.32	0.28	0.39
R2								1.00	0.30	0.73	0.05	0.67	0.27	0.35
R10									1.00	0.23	-0.01	0.31	0.30	0.27
R1										1.00	0.33	0.65	0.22	0.05
C4											1.00	0.20	0.33	0.33
C3												1.00	0.25	0.44
C2													1.00	0.21
C1														1.00

R = Regenerative farmer
C= Conventional farmer

Environmental Correlation Analysis

As indicated in Table 3.7, a less clear agreement pattern was present for the Environmental Analysis, as seen from the number of white grid squares in the top left and bottom right of the grid and unanswered data areas. Note that variables like tree cover and pasture biodiversity can be influenced by previous ownership and practice. Therefore, the data was less reliable and not necessarily reflective of current practice.

Table 3.7 Environmental Correlation Analysis

	R9	R8	R7	R6	R5	R4	R3	R2	R10	R1	C4	C3	C2	C1
R9	1.00	0.38	0.48	-0.24	-0.45	-0.16	-0.55	-0.03	-0.38	-0.49	-0.21	"n/a"	-0.21	-0.21
R8		1.00	0.18	-0.14	-0.40	0.29	-0.30	-0.31	0.30	0.00	-0.32	"n/a"	-0.32	-0.32
R7			1.00	-0.08	-0.27	-0.02	0.09	0.89	0.00	-0.29	-0.25	"n/a"	-0.25	-0.25
R6				1.00	0.91	-0.15	-0.17	0.16	-0.73	0.04	"n/a"	"n/a"	"n/a"	"n/a"
R5					1.00	-0.04	0.05	0.16	-0.73	0.23	"n/a"	"n/a"	"n/a"	"n/a"
R4						1.00	0.70	-0.20	0.52	-0.19	0.23	"n/a"	0.23	0.23
R3							1.00	0.37	0.77	0.03	0.38	"n/a"	0.38	0.38
R2								1.00	-0.22	0.21	-0.35	"n/a"	-0.35	-0.35
R10									1.00	-0.27	0.54	"n/a"	0.54	0.54
R1										1.00	-0.52	"n/a"	-0.52	-0.52
C4											1.00	"n/a"	1.00	1.00
C3													"n/a"	"n/a"
C2													1.00	1.00
C1														1.00

NB: "n/a*" means there was insufficient data to calculate.

Social Correlation Analysis

As indicated in Table 3.8, only a small agreement pattern was present for the Social Analysis between RF and RF, shown in the number of green highlighted boxes to the left of the table.

Table 3.8 Social Correlation Analysis

	R9	R8	R7	R6	R5	R4	R3	R2	R10	R1	C4	C3	C2	C1
R9	1.00	-0.01	0.08	0.08	0.26	0.54	-0.20	-0.05	0.82	0.04	-0.43	0.31	-0.10	0.49
R8		1.00	-0.03	0.39	0.31	0.01	-0.12	0.75	0.37	0.01	-0.13	-0.07	0.21	-0.12
R7			1.00	0.48	-0.30	0.01	0.32	-0.12	0.10	0.28	0.07	0.28	0.20	0.07
R6				1.00	0.04	-0.03	0.36	0.32	0.37	-0.10	-0.21	-0.11	-0.04	-0.18
R5					1.00	0.33	0.12	0.43	0.36	0.05	-0.03	0.05	0.07	0.10
R4						1.00	0.09	0.08	0.43	0.19	-0.05	0.65	-0.08	0.64
R3							1.00	-0.05	0.02	-0.11	0.10	-0.09	-0.11	0.10
R2								1.00	0.15	0.17	0.23	0.21	0.31	0.01
R10									1.00	0.12	-0.45	0.11	-0.23	0.42
R1										1.00	0.43	0.47	0.19	0.26
C4											1.00	0.32	0.17	0.18
C3												1.00	0.29	0.68
C2													1.00	0.00
C1														1.00

In summary

The results showed that overall, there was a pattern of positive correlation between farms that are conventional, with other farms that are conventional. There is an overall correlation pattern between regenerative farms and other regenerative farms. Overall, we did not observe a correlation between farms that were regenerative and farms that were conventional.

The results provide some quantitative support for results generated in the cross-tabulation analysis, which found some variation patterns associated with regenerative versus conventional farms but tended not to be statistically significant.

The reasoning behind using the Crosstabulations, Chi-Square, and Correlation Analysis on such a small group of farmers was to test and triangulate findings and outline a potential research approach for similar projects in the future that may a larger cohort of farmers to research. The results were included to show the process that the researcher went through, the rigorous testing of findings through several quantitative methods, and the fact that some of the methods produced results while others did not because of the small sample size. The researcher was more focused on demonstrating how she came to this conclusion through a mixed-method approach.

The results highlight the significance of the mixed method approach whereby the weaknesses of one method (quantitative in this case) can be mitigated by the strengths of another method (qualitative).

3.6.2 Results of Qualitative Analysis

The Thematic Analysis results were visualized using radar graphs (Figures 3.5-3.14). The Researcher chose to use a more qualitative approach to the study, returning to the original Thematic Analysis using radar graphs of patterns of codes and of the resilience principles and farm management practices together. SRAP added meaning to this research's findings from a resilience perspective.

3.6.2.1 Alignment of Economic observations with Resilience principle 1

While the resilience principles were initially constructed from an ecological and social perspective, it was clear that maintaining diversity and redundancy was also crucial in a farm business management context and therefore these variables were used to compare the findings of the economic variables. The units are represented as a score normalised to the interval (0,…,10.). The economic variables included only quantitative data, as against self-assessment responses, to avoid subjective, untested responses that may not be a true indication of the actual situation. Therefore, all the economic variables used were based on quantitative measurements.

Figure 3.3 depicts factors contributing to economic resilience in the regenerative and the conventional cohort of farmers according to the Stockholm Group's Principle 1. Maintaining Diversity and Redundancy:

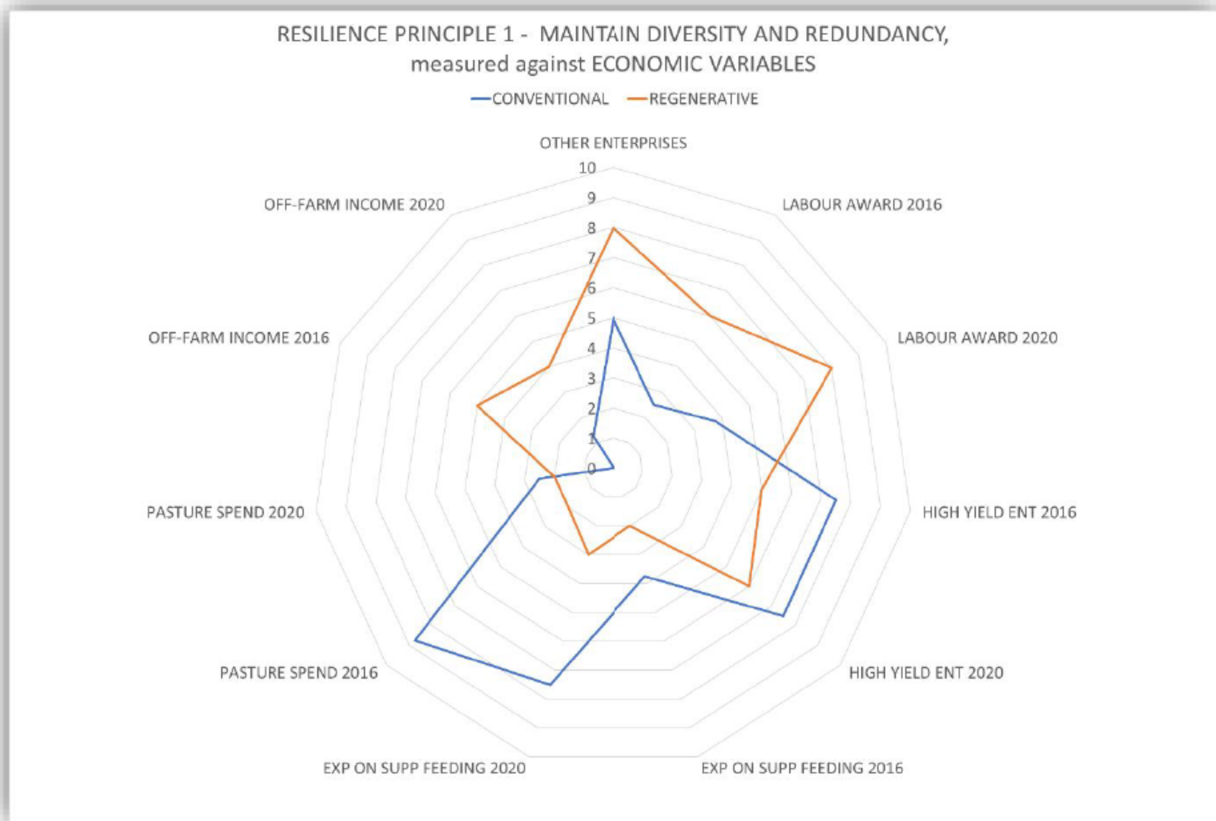


Figure 3.3. Resilience Principle 1 Maintain Diversity and Redundancy measured against Economic Variables.

As shown in Figure 3.3, CF tended to rely mostly on the income from the farm in 2016, moving to a slight increase in off-farm income (1.5) post-drought. RF had several income sources on and off the farm, with off-farm income scoring a 5 in 2016 and dropping to a score of 4 by 2020. CF also tended to focus on one enterprise only, focusing on the cost of production, as they were all members of a local Cost of Production group. RF tended to have more than one enterprise. Figure 3.5 depicts how RF had other enterprises, with a score of 8 as compared to a score of 5 for the CF (noting remained constant over the two years, so shown as one variable). CF were more likely to be cattle fatteners and traders than breeders. Most CF were traders across both years (scoring 7.8), and RF scored 5 for being traders in 2016, moving up to a score of 6 by 2020, post-drought and fires. In other words, half of the RF were Breeders in 2016, but only a quarter were Breeders by 2020. It is relevant to recognise that 'Trading' according to Barnes et. Al. (2021) and Grandin (2019a, 2019b) in most cases is a higher-yielding enterprise than Breeding. Other research has highlighted that flexibility to fluctuating pasture conditions makes trading cattle more economically stable (McCormick et al., 2021), whereas cow-calf breeding operations can be less profitable than trading (Browne et al., 2013). Therefore, this data was summarised under higher-yielding enterprise. When asked where they sold their livestock, CF sold into more profitable markets such as feedlots and finishing for Abattoirs, steering clear of sale yards. Most of the CF were members of a ‘Beef Marketing Group', which employed a full-time marketing consultant and resulted in higher premiums for their product, and/or a 'Cost of Production Group,' which gave them a constant focus on their variable input costs.

CF spent more money on hay, silage, grain, or agistment in both drought and non-drought years than RF. CF had a score of 4 for overall expenditure on supplementary feeding in 2016, moving to a score of 7.7 in 2020 due to drought years. In contrast, RF scored a 2 on supplementary feeding in 2016 and a 3 in 2020.

CF had slightly higher animal health costs when observed through the cost of production group's secondary data. Regarding pasture expenditure, CF were significantly higher than RF in 2016, with a score of 8.8 for overall expenditure compared to the RF score of 2. In 2020, the figure dropped substantially, with the CF dropping to a score of 2.5 and the RF increasing to a score of 3 for expenditure on pastures. RF paid higher per-hour rates to their employees overall than CF. In addition, even though all participants had between 1-4 FTE employees including family members, labour formed a higher percentage of RF overall costs. There was also a significant difference between RF paying above the Australian Government's Pastoral Award Wage (moving from a score of 6 in 2016 to 8 in 2020) compared to CF’ in both years (2.5 in 2016 and 3.8 in 2020). The reasons were not provided as part of the study.

When the case study conventional farmer 'F' was asked how many kilos of beef his farm produced in the drought year, he commented, "None, I made negative kilos of beef."

In contrast, case study, regenerative farmer 'D' commented, "I held them all and didn't require agistment, nor did I supplementary feed any of them.

Therefore, from an economic perspective, when considering diversity and redundancy as a form of resilience, RA farmers are more resilient for Resilience Principle 1.

3.6.2.2 Alignment of Environmental and Social Observations with Resilience Principle 1

The dominance of Environmental and Social Resilience in the findings of the regenerative farmer cohort over the conventional farmer cohort is apparent in Figures 3.6 and 3.7.

Figure 3.4 illustrates the factors contributing to resilience in the regenerative (orange) and the conventional (blue) cohort of farmers according to the Stockholm Group's Principle 1 - Maintain Diversity and Redundancy:

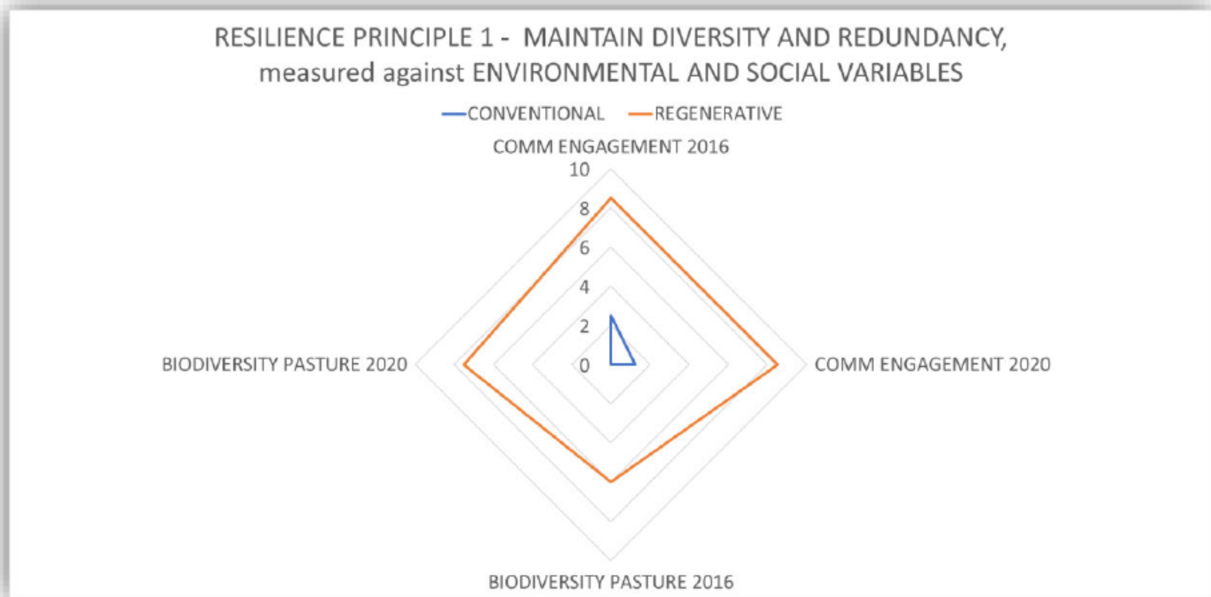


Figure 3.4. Resilience Principle 1 – Maintain Diversity and Redundancy, measured against Environmental and Social Variables.

As shown in Figure 3.4, RF had good Community engagement in both years, with a score of 8. Noting that a score of 1 is considered low, in 2016, CF rated their community engagement as low, which dropped from a low score of 1 to less than 1 post drought. For the purpose of this study, community engagement did not include professional memberships, incorporating professional advice to do with farming. Note, this radar graph is presented in even numbers increases to enhance visual so may show slightly different results from other graphs measuring the same variable with a different set of variables. However, the comparisons between the two cohorts remain relevant.

There were substantial differences in the biodiversity of pasture measured between the RF and the CF. The RF had scores of between 8-9 for biodiversity (6 species or more) compared to the CF with little biodiversity (5 or less). The Researcher measured the pasture's biodiversity using a metre-by-metre square and counted the number of different species in the paddock. This was in addition to the information provided by the farmer in the questionnaire. This was used to validate what the farmer had said, and it correlated in each of the cases.

3.6.2.3 Alignment of Environmental Observations with Resilience Principle 2

Figure 3.5 depicts factors contributing to Resilience in the regenerative and conventional (displayed as a blue dot) cohort of farmers according to the Stockholm Group's Principle 2.

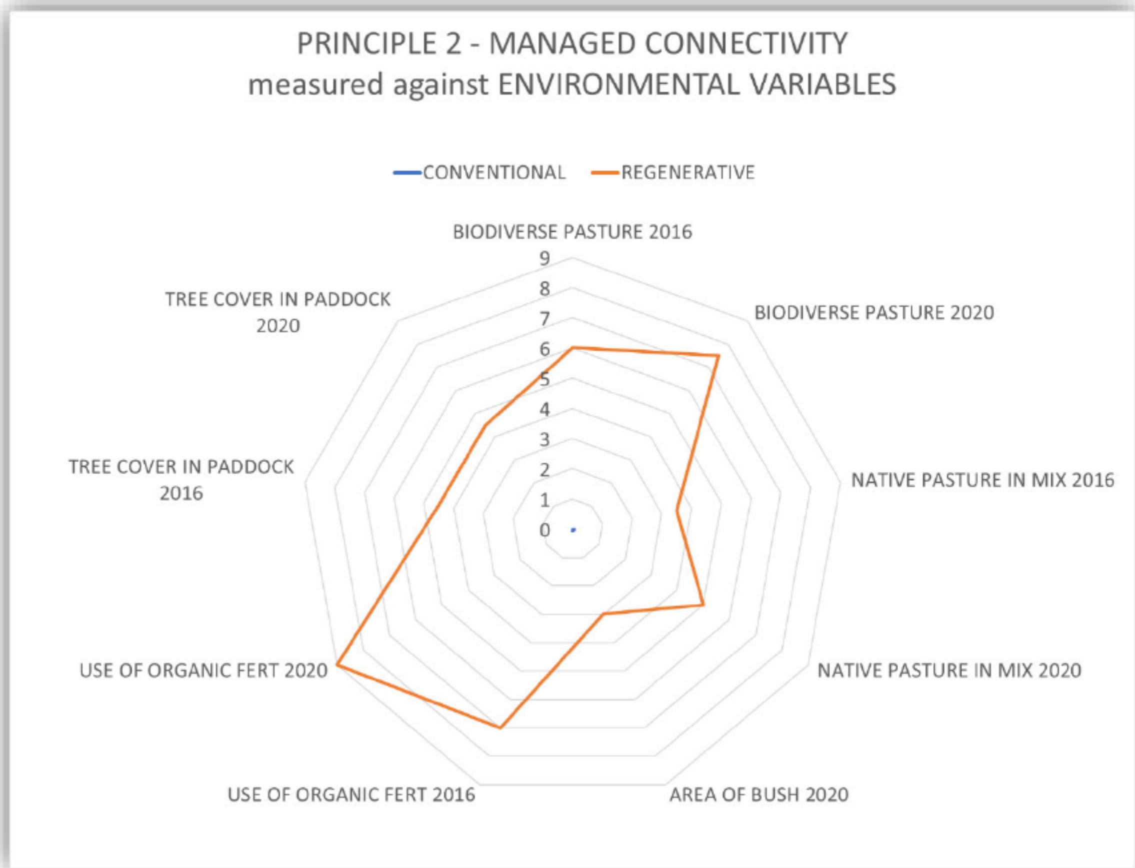


Figure 3.5. Resilience Principle 2 – Manage Connectivity measured against Environmental variables.

The area of bush was an added variable in 2020, however, there would have been no change in this measurement over the 4-year period, as bushland cannot be created in such a short time.

When managing Connectivity, RF had a higher proportion of tree cover on their farms (a biodiversity measurement). RF, on average, three times more bush and tree cover than their conventional counterparts in 2016, with a slight downward variation due to drought and fires in 2020. The CF scored less than 1 for bush or tree cover. It is important to note that this could reflect past practices, not necessarily current management practices. RF had a higher proportion of native pasture and fertilised native pasture than CF (biodiversity measurement). This made a substantial difference to ground cover in the drought years.

Nearly half of the RF had more native pasture than CF in 2016 and 2020. As previously mentioned, this was also the case for biodiversity in the pasture mix, with scores of 6 in 2016 and 7.5 by 2020. Most of the RF having a high level of biodiversity compared to the CF, who failed to register on the radar graph. The latter had little biodiversity in their pasture mix by 2020.

All CF surveyed had fully improved sown pasture. Only one regenerative farmer had fully improved pasture, and that is because they purchased a property that had been improved some years before their ownership. Most RF scored 8.5 for improved fertilised native pasture and valued such pastures for drought resilience. RF used more organic fertiliser applications than inorganic/artificial fertiliser applications. Most RF used organic fertilisers in 2016 (score of 8) and all (score of 10) in 2020, compared to zero use by CF in 2016 and 2020.

There was a distinct difference in fertilisers used by RF and CF in what they used to fertilise their paddocks. Other than one farmer in 2016, the balance of RF used only organic soil fertility agents. The secondary data from the 'cost of production group' showed that the RF spent an average of $53.11 per ha on pasture maintenance in 2016, dropping only to $40.15 in the 2020 drought. CF spent an average of $89.38 per ha in 2016, dropping to $70.75 per ha in the 2020 drought.

Note, that this radar graph is presented with a score out of 9 (not 10) as are some other graphs (Figure 3.7 and Figure 3.10) to enhance the visual, so may show slightly different results from other graphs measuring the same variable with a different set of variables. However, the comparisons between the two cohorts remain relevant. In addition, a zero score on this graph doesn't necessarily mean no bush or tree cover, native pasture, or use of organic fertilizers, just an insignificant amount for the graph to highlight.

3.6.2.4 Alignment of Environmental and Social Observations with Resilience Principle 3

Figure 3.6 depicts factors contributing to resilience in the regenerative and conventional cohort of farmers according to the Stockholm Group's Principle 3.

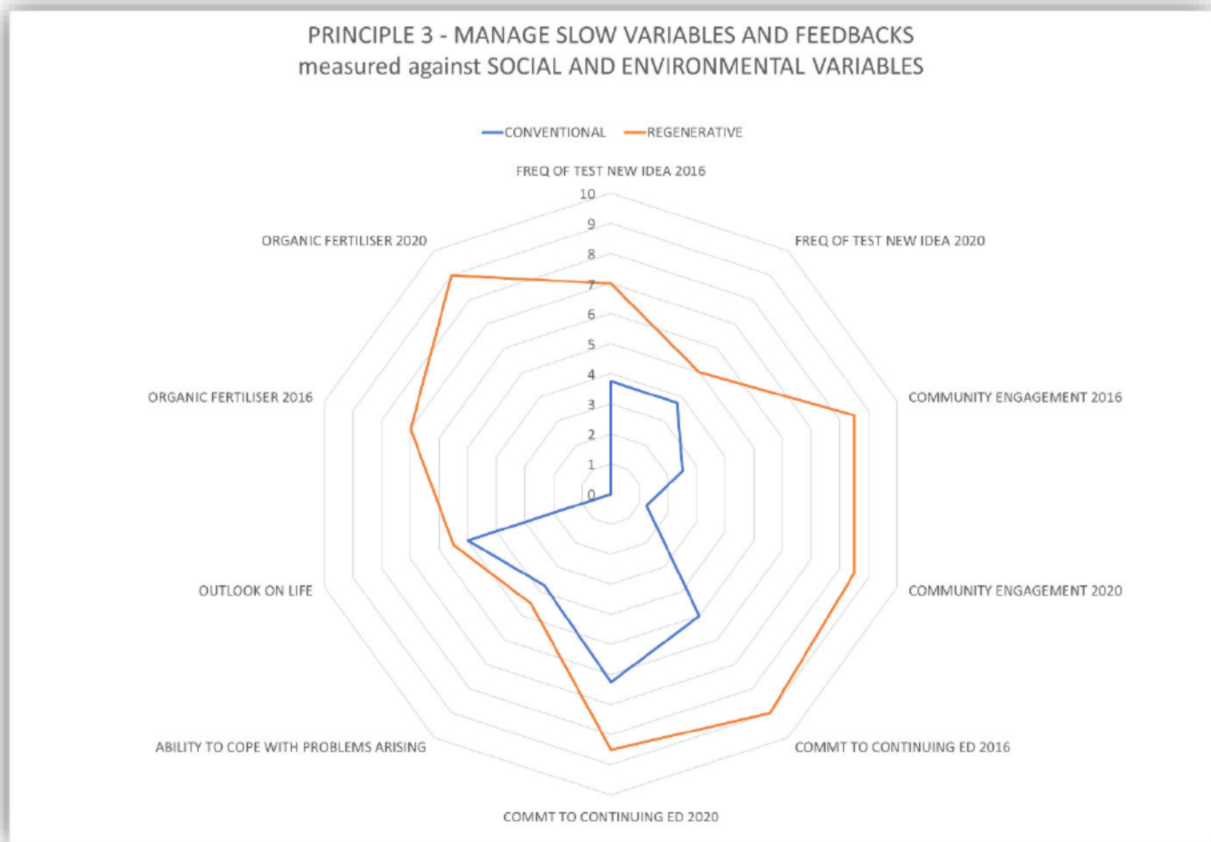


Figure 3.6. Resilience Principle 3 – Manage Slow Variables and Feedbacks measured against Social and Environmental variables.

RF were more open to testing new ideas and monitoring slow variables and feedback signs within their landscape. The testing of new ideas remained relatively constant for CF, scoring a 4 in 2016 and 2020, compared to RF which went from a 7 in 2016 to a 5 in 2020. This may have resulted from either their ideas tested in 2016 having worked, or because their appetite to try new ideas post-drought was diminished and they were focused on recovering and restoring post-drought.

RF placed more importance on continuing education, which remained constant. In comparison, CF increased their commitment to continuing education from a score of 5 in 2016 to 6 in 2020. Figure 3.8 indicates that most RF were more committed to continuing education than half of CF.

RF claimed to have higher community engagement and social life. The RF had higher community engagement than the CF in 2016 and 2020 post-drought and fires.

RF seemed to cope better with problems as they arose and had a more positive outlook. The ability to cope with issues as they arise and outlook on life were measures introduced in 2020 following the drought and tracked within a score of 1 for the two cohorts, with the RF being slightly more robust. This may be attributed to the community and social support networks, as they are often referred to in conversation. In addition, their understanding of complex systems was mentioned. One RF (Regen Farmer A) commented that "I go with the flow of what the landscape is telling me rather than try and change it." Another RF (Regen Farmer C) reminded me that as "a complex system, it was constantly adapting and self-organising." Therefore, "What is the point of worrying about it? Work with it". These comments were very different from those received from the CF, whose focus was very much on what the market was doing and the weather predictions, both of which were out of their control.

3.6.2.5 Alignment of Social Observations with Resilience Principle 2

Figure 3.7 depicts factors contributing to Resilience in the regenerative and the conventional cohort of farmers according to the Stockholm Group's Principle 2 - Manage Connectivity. It combines environmental and social indicators addressed previously (rather than just environmental) as connectivity affects both humans and flora and fauna.

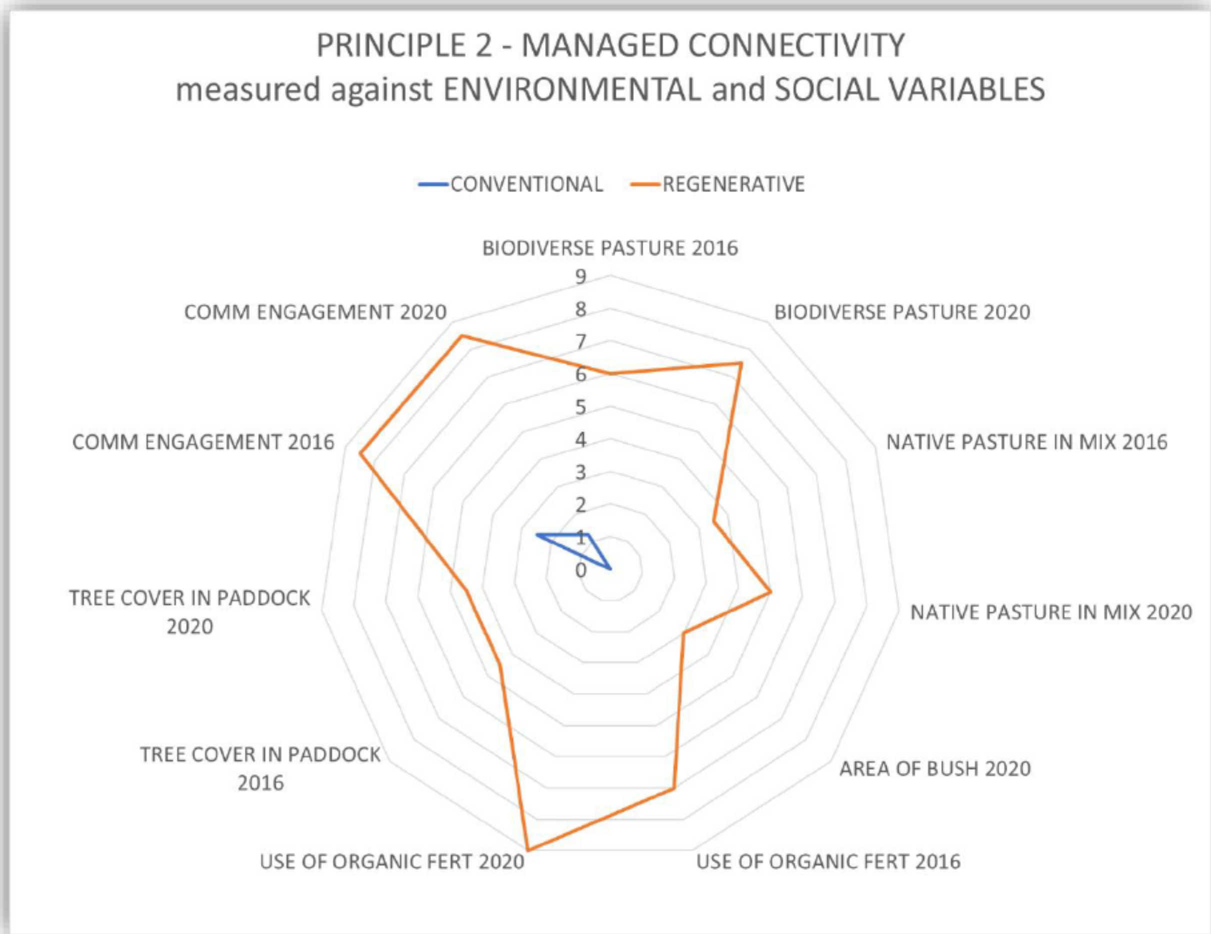


Figure 3.7. Resilience Principle 2 – Manage Connectivity measured against Social and Environmental Variables.

3.6.2.6 Alignment of Social Observations with Resilience Principle 4

Figure 3.8 depicts factors contributing to resilience in the regenerative and the conventional cohort of farmers according to the Stockholm Group's Principle 4 - Understanding that Social Eco-Systems are Complex Adaptive Systems.

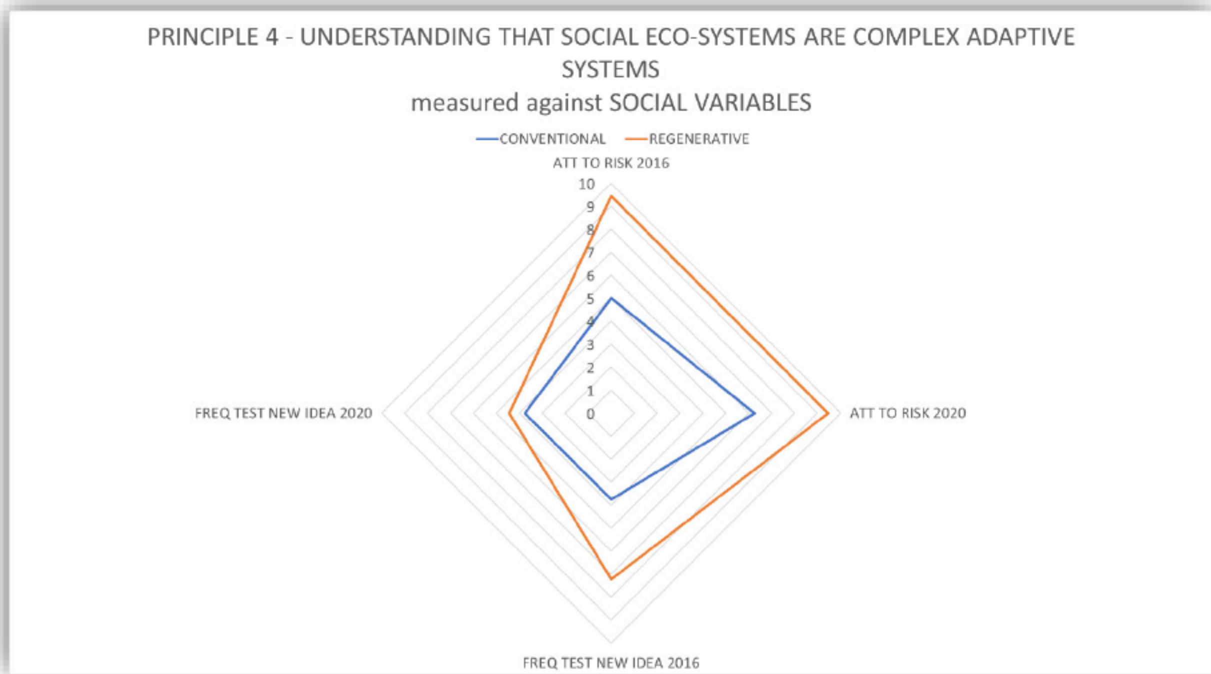


Figure 3.8. Resilience Principle 4 – Understanding that Social Eco-Systems are Complex Adaptive Systems measured against Social Variables.

RF had a higher risk tolerance (attitude to risk) than CF. Figure 3.8 indicates that most RF had a higher risk tolerance compared to CF, with CF scoring a 5 for risk tolerance in 2016, increasing to 6.1 in 2020. In comparison, RF had a high score of 9.5 in both years. The RF' comfort with risk remained high in 2020 post-drought and fires, while CF increased their score slightly by 1. One conventional farmer, 'B,' said he would adopt a new idea or approach "Yes, once proven." RF 'A,' on the other hand, commented that "the concept made sense, so I decided to test it for myself on my farm." This demonstrates quite a different discourse regarding risk tolerance and attitudes.

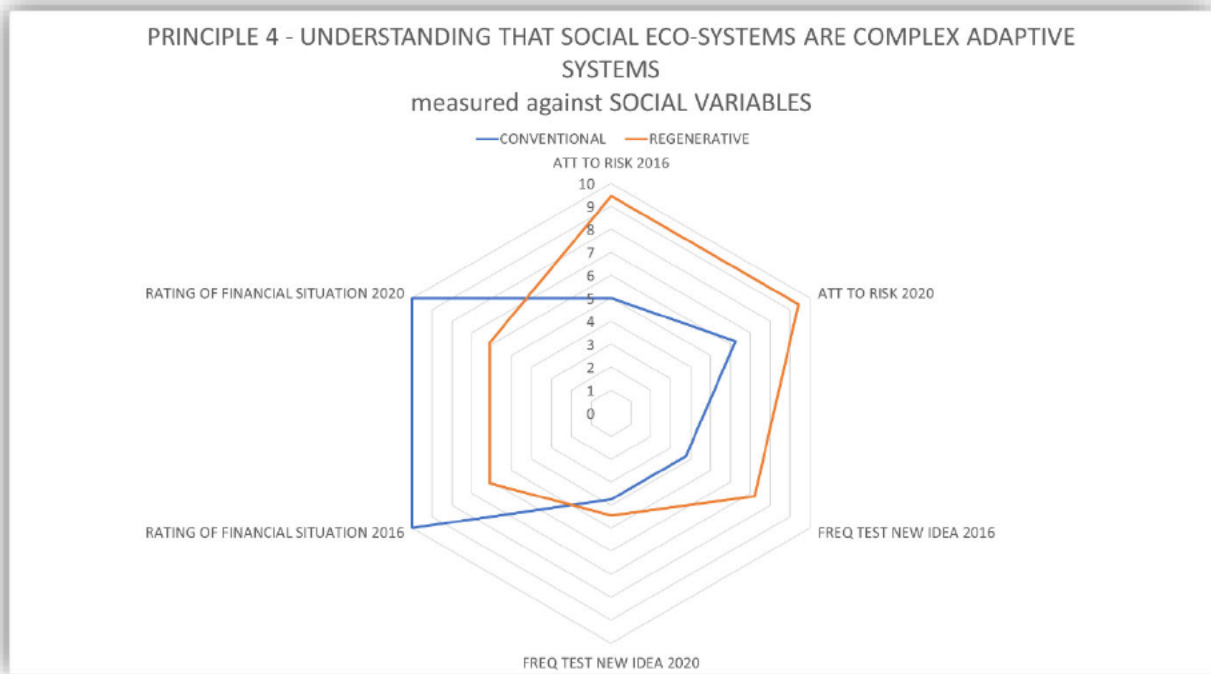


Figure 3.9. Resilience Principle 4 – Understanding that Social Eco-Systems are Complex Adaptive Systems measured against Social Variables, including self-assessment rating of their financial situation.

As indicated in Figure 3.9, CF rated their financial position as in better shape than RF. Interestingly, all CF rated their financial situation as solid, with a score of 10 in both years, compared to RF who gave a score of 5. The rating of one's financial situation is considered here as a Social Variable and not an Economic Variable because it was taken as a self-assessment rather than an economic measurement. Therefore, it comprised an element of mental well-being. It could be argued that the self-assessment strongly resembles the actual situation, but that would be an assumption that would require further testing, which was not undertaken in this study. Participants were uncomfortable disclosing their equity position in the farm and were more comfortable answering how they felt about their finances. Full disclosure of financial information is unlikely in surveys such as this one, and many factors contribute to this including privacy concerns, underlying financial structures, and historical issues such as inheritance. For this reason, the survey's financial elements focused on attitudes and expressions of the degree of satisfaction, rather than numerical measures.

3.6.2.7 Alignment of Social Observations with Resilience Principle 5

Figure 3.10 depicts factors contributing to Resilience in the regenerative and the conventional cohort of farmers according to the Stockholm Group's Principle 5 - Encourage Learning and Participation.

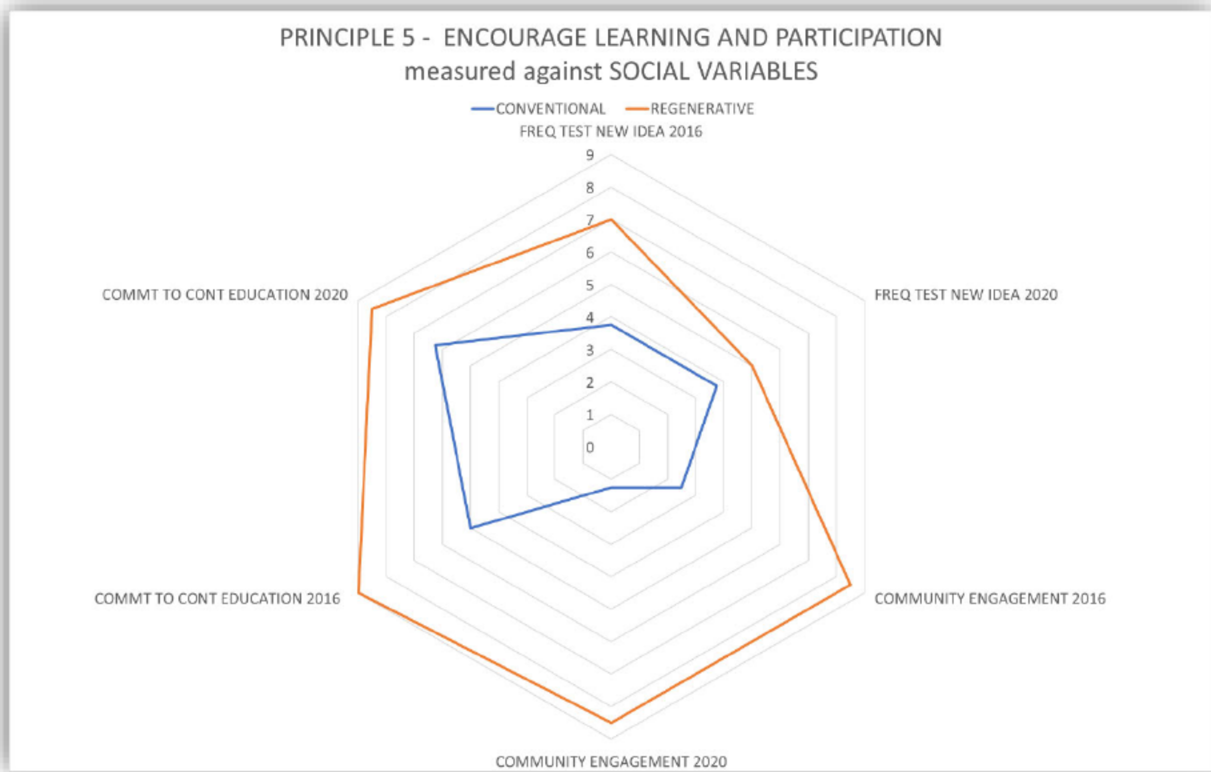


Figure 3.10. Resilience Principle 5 – Encourage Learning and Participation measured against Social Variables.

This Principle brings together several social variables, demonstrating that most RF has a high commitment to continuing education (scoring above 9.5) compared to half of the CF (4 score in 2016 and 5 score in 2020). RF had high community engagement (scoring a 9.5 in both years), compared to the CF in 2016 (2.5) and 2020 (dropping to 1.5) post drought and fires.

3.6.2.8 Alignment of Social Observations with Resilience Principle 6

Figure 3.11 depicts factors contributing to resilience in the regenerative and the conventional cohort of farmers according to the Stockholm Group's Principle 6. Broaden Participation.

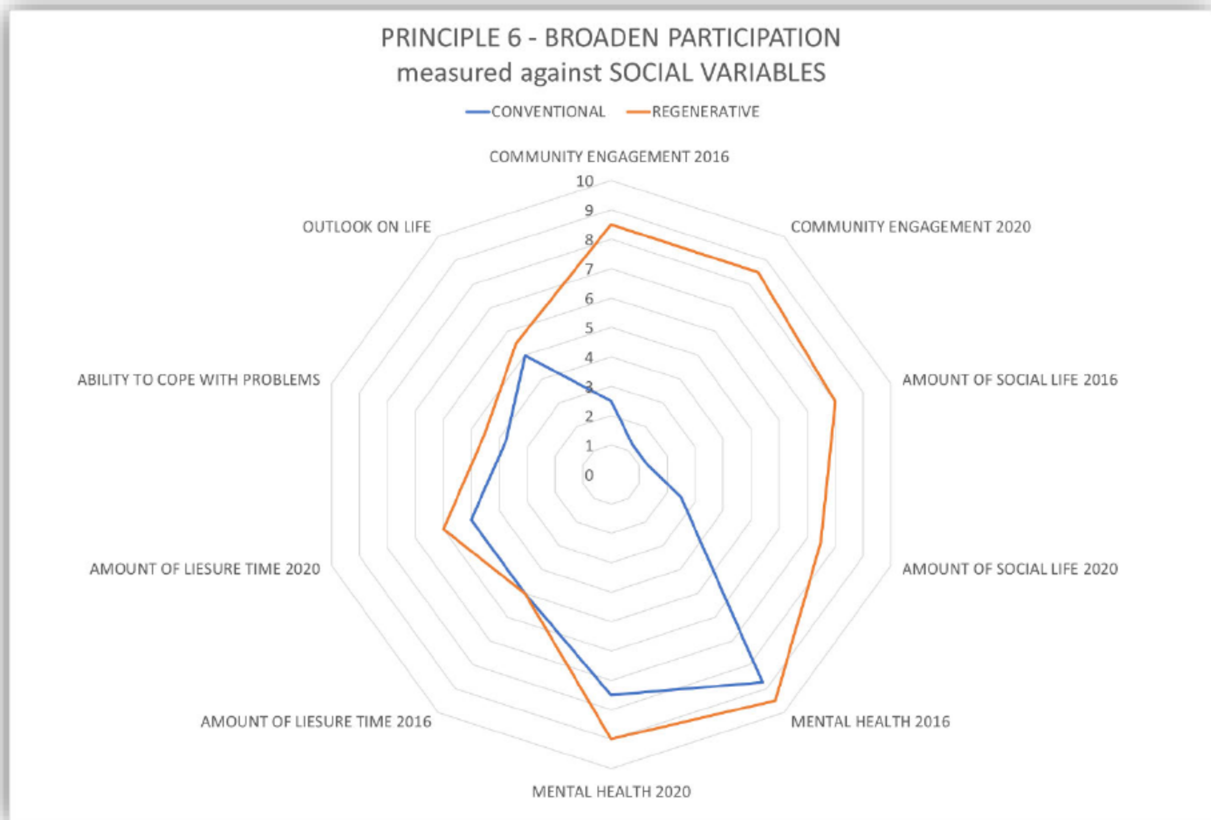


Figure 3.11. Resilience Principle 6 – Broaden Participation measured against Social Variables.

When taking several variables together, RF had high community engagement compared to CF in 2016 and 2020 post-drought and fires. Community engagement in 2016 and 2020 remained at a score of 8.5 in the regenerative cohort, compared to 2.5 in 2016 and dropping to 1.2 in

2020 for the conventional cohort. Similar observations were found regarding social life, except the regenerative cohort moved slightly downward from a score of 8 to 7.5 post-drought, and the CF moved up a score from 1.2 to 2.5 post-drought. The CF's increase in social life could be attributed to the amount of post-drought Government support programs and meetings that were put in place. The radar graph shows the RF moving strongly away from the CF in these two variables but being closely aligned regarding the amount of leisure time they had available and their mental health status. RF cope better with problems as they arise. RF had a more positive outlook on life.

3.6.2.9 Overall alignment of systems with Resilience Principles

If we collate all the variables (economic, environmental, and social) against the resilience principles as a summary radar graph (Figure 3.12), there are apparent differences between the RF and the CF against the Stockholm Resilience Principles. The RF rated higher against this Resilience Framework than the CF, meaning RF's resilience in a changing climate will be stronger. It is important to note that for this research, all the principles and the variables have been weighted equally, but they may not be equal in reality.

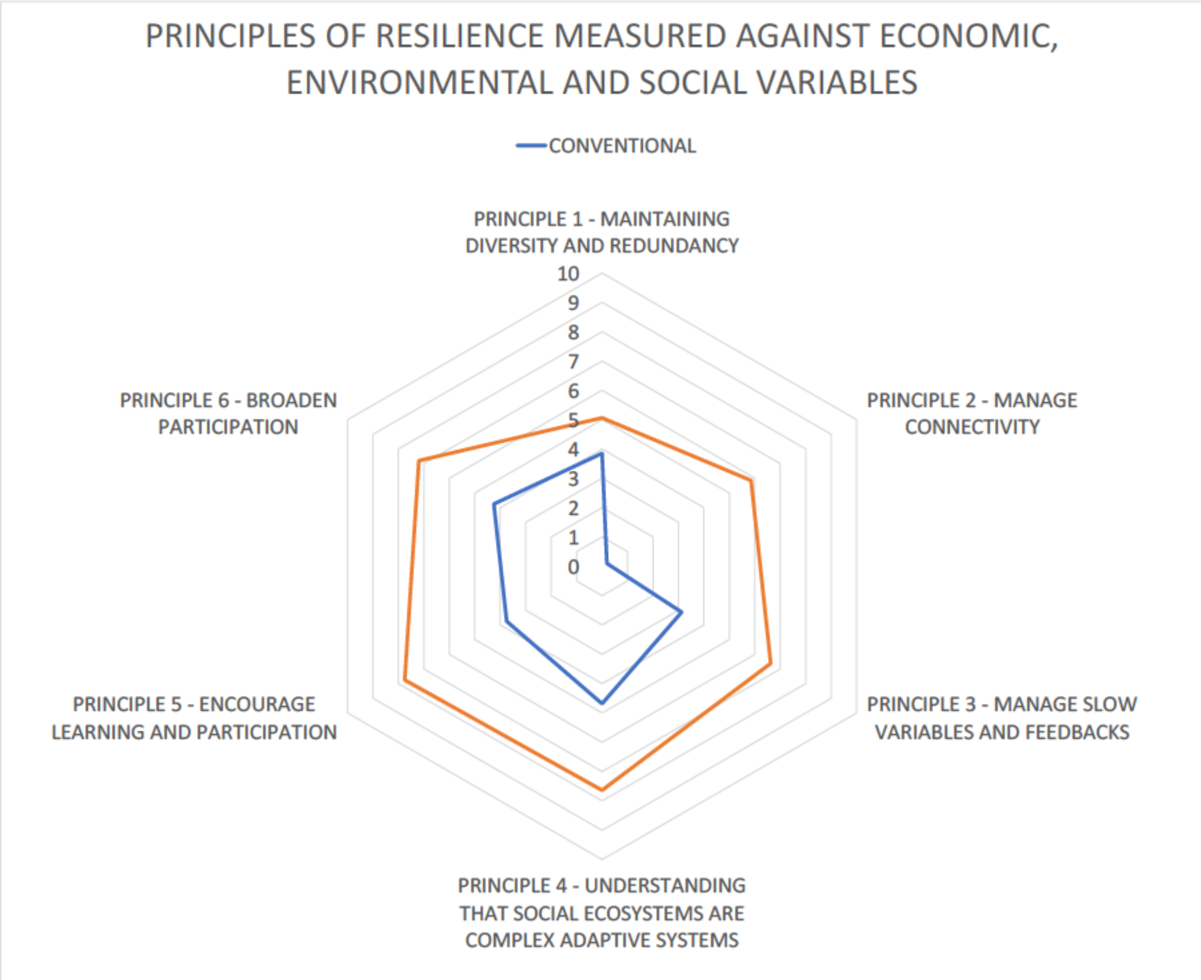


Figure 3.12. Principles of Resilience measured against Economic, Environmental, and Social Variables.

When comparing the two cohorts of farmers using the combined two years of data, Table 3.9 provides a summary of the findings against the resilience principles.

Table 3.9 A Thematic Analysis of the Link between resilience frameworks and the New England Case study findings

Resilience Alliance Stockholm Principles	Examples of Farm Management Practices	Relevance to New England Case Study Findings
1. Maintain diversity and redundancy	Number of other enterprises and income sources, income security and equity levels, ability to retain staff, level of biodiversity on the farm	• CF were more likely to be cattle fatteners and traders. CF also tended to focus on one enterprise only, focusing on the cost of production. • RF had more than one enterprise. • CF spent more on hay, silage, grain, or agistment in both drought and non-drought years than RF. • RF overall paid higher per-hour rates to their employees than CF. In addition, labour formed a higher percentage of their overall costs. • CF sold into more profitable markets, such as finishing for abattoirs and steering clear of sale yards. Where members of a Beef Marketing and/or Cost of Production Group, and therefore attracted a higher premium. While this is a social support network based on profitability, it notably lacked diversity of membership. • CF tended to rely more on 100% of their income coming from the farm. Regen Farmers have several income sources on and off-farm • RF had a higher proportion of native pasture and fertilised native pasture than CF (biodiversity measurement). This made a substantial difference to ground cover in the drought years. • CF rated their financial position as in better shape than RF. **CF scored 4/10, Regenerative scored 5/10**
2. Manage Connectivity	Tree belts, wildlife corridors, and nature	• RF had a higher proportion of tree cover on their farms (biodiversity measurement)

Resilience Alliance Stockholm Principles	Examples of Farm Management Practices	Relevance to New England Case Study Findings
	strips, individuals and the family's connection to land and community	**CF scored 0/10, Regenerative scored 6/10**
3. Manage slow variables and feedbacks	Adopting and taking up new practices more suitable to the environment, increased on-farm landscape monitoring, and information sharing between farming cohorts.	• RF had a higher usage of organic fertiliser applications (which affects water quality and microbes) than inorganic/artificial fertiliser applications. **CF scored 3/10, Regenerative scored 6.8/10**
4. Understanding that social-ecological systems are complex adaptive systems	Grazing management practices such as being regenerative or not, utilisation of the holistic management framework for decision-making purposes	• RF cope better with problems as they arise. • RF are more open to testing new ideas and has a better outlook on life. Noting that CF were more stressed about the drought, with obvious feelings of hopelessness that subsided as soon as it rained. In other words, their well-being was entirely dictated by the weather. **CF scored 4.8/10, Regenerative scored 7.8/10**
5. Encourage learning and experimentation.	Furthering education, Level of risk-taking or new ideas, Level and	• RF placed more importance on continuing education.

Resilience Alliance Stockholm Principles	Examples of Farm Management Practices	Relevance to New England Case Study Findings
	depth of information sharing amongst peers, and monitoring systems in place	**CF scored 3.8/10, Regenerative scored 7.8/10**
6. Broaden Participation	Social and Community Engagement	• RF had higher community engagement. • RF had more of a social life. **CF scored 3.1/10, Regenerative scored 7.1/10**
7. Promote polycentric governance systems.	Ability to self-sustain without relying on larger governance systems	• The research did not cover this aspect as all the cattle producers were part of the same governance systems and faced the same restrictions and limitations in producing a commodity **Not measured.**

3.7 Discussion

We employed Thematic Analysis in this case study to answer the following questions:

"Are Australian regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate"?

To answer the overarching research question, the following sub-research questions were explored:

a. Which beliefs and practices (leading to management decisions) are held by Northern NSW beef farmers in a changing climate, and how are these expressed?
b. What are the economic, environmental, and social indicators for a resilience framework, and how do the actions of regenerative and conventional beef cattle farmers align with the Stockholm Resilience Framework?
c. What conclusions can be drawn about the Resilience of cattle production systems in Northern NSW?

Coded results for the Thematic Analysis suggest that there was general agreement between regenerative cases and conventional cases in the Correlation Analysis for **economic variables.** General disagreement was found between most pairs of CF and RF.

This result could be attributed to input costs being lower for the RF and higher for the CF. This research showed RF spent less on supplementary feeding compared to the CF in 2016 and 2020 following the drought and fires. Regarding pasture expenditure, it was significantly higher for CF than for RF in 2016. In 2020, the figure changed and few RF or CFs spent money on their pastures. Similar studies have found that farmers generate profit due to decreased costs of production and use of inputs (e.g., synthetic fertilizer, artificial weed control, and supplemental feeding of livestock), and reduced animal health costs (Ferguson et al., 2013; Gadzirayi et al., 2007; McCosker, 2000; Sherren et al., 2012). Further, Ferguson et al. (2013) found that holistic managers purchased less hay, feed, herbicides, and pesticides than their conventional neighbours leading to greater economic stability.

RF used more organic fertiliser applications than inorganic/artificial fertiliser applications. Synthetic fertilisers can have a negative effect on soil health, including water quality and both soil chemistry and microbiology, such as Mycorrhizal Fungi (Bai et al., 2020; Baweja et al., 2020; Fenster et al., 2021; Kumar et al., 2019; Njuguna et al., 2020; Pahalvi et al., 2021; Paudel & Crago, 2021; Tripathi et al., 2020).

CF had slightly higher animal health costs when observed through the cost of production group's secondary data. Other research findings have found reduced animal health incidences in regenerative and holistic grazing systems (Fenster et al., 2021; Spratt et al., 2021). This research did not find any differences in the animal health costs as all farmers suffered from the same pests and parasites and needed to be treated similarly. However, it was discussed in conversations that the management responses differed slightly, as RF tended to fence off swampy riparian areas (a cause of Liver and Stomach Fluke infestations) and were more likely to treat systems (only animals showing signs of being unwell) rather than a ‘blanket’ standard drenching approach across all stock. While there were alternative options for breeders regarding parasites, both conventional and regenerative trading farmers were similar in their approaches.

Differing from Stinner et al. (1997), there was more spending on labour in a regenerative system. These findings showed a difference between RF paying above the average Award compared to CF in both years. This may be because regenerative employees with qualifications, skills and experience are difficult to find or that RF farmers place a higher value on having such qualifications and skills. Whatever the reasons (which are not captured in this study) there are assumptions regarding the amount of dollars RF spend on both labour and inputs such as fertiliser which required further testing. For example, farmer ‘D’ commented on the “large amount spent on correcting mineral deficiencies and feeding microbes, and employing good staff, in fact, three times that of their conventional neighbour”.

These findings differ to Stinner et al. (1997), who reported that 80% of the farmers they interviewed had perceived increased profits since transitioning to HM/regenerative farming, and 52% reported decreases of up to 40–60% in labour requirements.

There was no difference in profitability revealed in the Thematic Analysis. However, it suggested that income was more evenly spread when the drought years were considered, demonstrating more consistent returns for RF. Differing from Stinner's findings (1997), there was more spending on labour in a regenerative system.

The findings showed CF tended to focus on one enterprise only, focusing on the cost of production, as opposed to RF, which tended to have more than one enterprise. It also showed CF tended to rely more on 100% of their income coming from the farm, and RF had several income sources on and off-farm. This was a similar finding to that of Alexanderson et al. (2023), undertaken in the Eyre Peninsula in South Australia and the Western Australian wheatbelt of Australia, which found the RF had slightly higher levels of diversification in farming, which potentially could build economic resilience into a farming system (Alexanderson et al., 2023).

Alexanderson et al. (2023) found notable differences in education levels between RF and CF, with RF being more likely to have completed a degree, compared to the typical level of education being year 12 for the CF. In addition, knowledge areas around holistic grazing, soil constraints, perennial pasture establishment, and the role of remnant vegetation in supporting ecosystem function were higher in the RF compared to the CF, with concerns around loss of native plants, bushfire risk, and various soil issues, with soil biology seen as the most important indicator of soil health (Alexanderson et al., 2023). These research findings showed that the RF had a higher commitment to continuing education than the CF which may explain Alexanderson’s findings around RF increased landscape knowledge.

While taking up carbon farming was not explicitly covered in this study mainly due to carbon farming being in its early days of adoption in Northern NSW, the holistic managers were in an excellent position to participate in the voluntary carbon market because soil carbon sequestration protocols aligned well with their principles and practices (Gosnell et al., 2011). This is also the case for RF, as the practices they use are those that sequester carbon.

More significant disagreement between the RF and CF, and a less clear pattern of agreement, was present for the **Environmental theme.**

RF, on average, had three times more bush and tree cover than their CF. Nearly half of the RF had a high amount of native pasture compared to CF who did not have high amounts of native pasture in 2016 and 2020. This finding was also the situation for biodiversity in the pasture mix, with more than half of the RF having a high level of biodiversity compared to the CF who failed to register on the radar graph. The latter had little biodiversity in their pasture mix in 2020.

This finding concurs with similar studies that found more on-farm biodiversity in regenerative farming operations (McCosker, 2000; McLachlan & Yestrau, 2009; Stinner et al., 1997), setting sections of their property aside for conservation and having increased remnant vegetation (trees, grasslands, and wetlands) and tree planting (Alexanderson et al., 2023). Similar to Sherren et al. (Sherren et al., 2012), RF were more focused on insects and animals, less concerned about weeds than their conventional counterparts, and linked biodiversity protection to their working landscapes.

Earl and Jones (1996) and Teague et al. (2011) also found regenerative farming was associated with reduced bare ground and Sovell et al. (2000) found improved stream and riparian health, noting that enhanced stream and riparian health is a consequence of maintaining ground cover.

Bailey et al. (2019) found healthier rangelands in those that had used 'targeted livestock grazing' (also called time-controlled grazing/holistic grazing techniques).

Like Gosnell, Grimm, et al. (2020), this research showed adaptive and proactive management regarding environmental perspectives and priorities around biodiversity due to the feedback associated with daily monitoring. Most RF used organic fertilisers in 2016 and nearly all used them in 2020, compared to zero use by CF in 2016 and 2020. The results showed no evidence of less herbicide and pesticide use.

This differs, however, from the findings of Ferguson et al. (2013) and Sherren et al. (2012), who found HM cattle ranchers in the lowlands of Chiapas in Mexico used fewer herbicides, pesticides, and purchased inputs than CF. The CF in their study used extensive grazing, annual pasture burns, and frequent agrochemical applications, which threatened long-term biodiversity and productivity. However, it is important to note that pesticides were not prominent in all-grazing operations in this case study. Herbicides usage would mainly be used to control blackberries, for which there were no effective alternative methods other than peppering (a non-chemical method to clear weeds and animal pests by using the ash of the species to discourage the particular weed or pest from that environment) and use of goats. None of the RF had taken those options at the time of the study.

Improved soil–water content, water-holding capacity, and hydrological function found in other studies on regenerative practices were observed but not measured in this research (Earl & Jones, 1996; McCosker, 2000; Teague et al., 2011; Weber & Gokhale, 2011).

For the social theme, differences between the RF and CF were pronounced and widespread and included the social and community context.

The findings showed that RF had higher community engagement than CF in 2016 and 2020 post-drought and fires. Similar observations are found when it comes to social life. These findings support the existing research that shows the distinctive role of community in the HM approach to life and belief in the importance of community, forming support during periods of transition and persistence and as a source of social learning and ongoing innovation (Stinner et al., 1997). Stinner's research (1997) also "reported improvements in their quality of life because of changes in their time budgets." This means, like RF, holistic farmers had more social and family time (McLachlan & Yestrau, 2009) and that farmers were no longer doing things they did not like to do (Stinner et al., 1997).

This research showed that most RFs have a higher risk tolerance than CF. The testing of new ideas was higher in 2016 for the RF. It remained constant for the CF but decreased for the RF post-drought and fires in 2020. The reasoning was that approaches had worked, and RF farmers emerged from the drought in a better position than their conventional neighbours, primarily due to retaining more ground cover. Alexanderson et al. (2023) also found that CF were less likely to see risk as a challenge to embrace, less comfortable taking on risk or experimenting with new ideas, and less likely to be early adopters of new agriculture practices or technology. Almost all of the RF were open to new ideas, seeing their properties as an opportunity to test new ideas (Alexanderson et al., 2023) and depicting the importance of testing new ideas.

Like RF, Holistic managers have previously been found to be more accepting of risk, and open to experimentation, with their belief system including not trying to 'gain control' over the land, but working within the bounds of natural variability (Sherren et al., 2012). In addition, they liked to 'hone their skills’. Both Gosnell's and Sherren's research found that holistic thinking also increased farmers adaptive capacity to cope with stressors and crises such as climate variability and market conditions by providing the systematic thinking necessary for successful adaption (Gosnell et al., 2019; Sherren et al., 2019). Further, Stinner et al. (1997) concluded that "a decision-making process like HM can help empower individual farmers and farm communities and support quality of life."

In addition, holistic managers also used feedback associated with daily monitoring to drive adaptive/proactive management. A natural resource management (NRM) approach has been proven to have a positive impact on the quality of life of farmers, including their mental health and well-being and social connectedness, mainly through applying socioecological systems (SES) principles to guide their NRM activities (Brown, Batterham, et al., 2022).

According to Alexanderson et al. (2023), RF also accepted that humans are influencing climate change and believed fundamental changes are needed to ensure farming systems are more resilient, with many having already changed the way they farm, and primary producers should do all they can to reduce their emissions from farming activities.

Critics of RA, including Homes & Sackett (Francis, 2020), claimed that RA was “far less profitable than conventional agricultural systems managed by their clients, requiring much more land to generate similar profits.” Francis states that the research that Ogilvy cites was not a comparative analysis of a group of RF and CF, thus supporting the need for further research that looks at both production and margins for economic comparisons rather than either in isolation (Francis, 2020).

In addressing criticism by Francis and Director (2020) of Ogilvy’s paper (2018) and Ashton’s (2018) interpretation of it, this research sort to identify and address these criticisms by:

- Comparing like with like, i.e., neighbour with neighbour, with all producing the same product in a similar geographic location
- Utilising uniform data collection methods and questions for all farmers of both cohorts

Regenerative practices are being scrutinised, so the rigor of research approaches and subsequent questioning and triangulation of findings is essential. This will ensure the enhanced legitimacy of RA, which is crucial to addressing the Sceptic's concerns.

3.8 Conclusion

This Thematic Analysis utilised an International Resilience Framework (SRAP) to code the case study data and allow themes to emerge from the data, in order to ascertain what resilience themes, mean in the context of Australian grazing systems and triple-bottom-line outcomes.

In order to examine RA's role in building resilient farming systems from a triple-bottom-line perspective, this case study specifically attempted to determine if Regenerative beef cattle production systems are more resilient than conventional beef cattle production systems in a changing climate.

The case study thematic analysis revealed the following:

- The Resilience Framework (SRAP), as presented by the 'Stockholm Group of Scientists, provided a practical example of how farm management decision-making affects overall resilience, particularly in a changing climate when applied to Northern NSW beef cattle production systems.
- Therefore, the environmental, social, and economic indicators used for the case study purposes could be further utilised as a resilience framework for beef cattle production systems in Australia and act as a guide for farmers future decision-making in a changing climate, and
- Thematic Analysis identified substantial differences in the beliefs (i.e.: outlook on life) and practices (i.e., management decisions) of regenerative and conventional beef

farmers in Northern NSW, which could have significant implications in a changing climate.

The analysis, reinforced by Thematic Analysis, required a standardised set of variables suitable for averaging and combining, and for disaggregation. This required that identical weights be attached to each variable. This simplification can be removed by weighting for the purposes of further analysis. However, the more interesting aspect of this issue is the absence of evidence upon which to base such weightings, and it is recommended that future research address this.

Further, the results of this case study and the diversity in regenerative cattle grazing systems even across a small cohort of RF, highlight the need for a guiding set of RA principles for farmers and land managers. This could be beneficial to assist farm management decision-making and model adaptation and transformation in climate change.

Chapter 4: Principles of Regenerative Agriculture

4.1 Introduction

One of the biggest criticisms of RA is the lack of clear definition of what it is and scientific evidence around its benefits. Many claim it is “no different from sustainable agriculture, organic farming, and agroecology” and merely “Good Agricultural Practice” or a “new agronomic practice” (Giller, Hijbeek, et al., 2021a), while others have questioned its “extraordinary claims” (McGuire, 2018; Rowarth, 2020). Corporates like Homes Sackett have felt threatened by the claims and, understandably, have been quick to question data comparisons.

To differentiate itself from other practices and address the issue of having no set definition, this research seeks to change the paradigm of defining a practice to a new paradigm that understands the principles underpinning regenerative practices that will change and improve with our level of understanding of the environment over time. It also seeks to address the apparent ignorance of the criticisms in not understanding the human aspects and approaches that encompass regenerative thinking such as approaches to working with nature, rather than trying to affect or change it, transformative knowledge, and understanding of nature. Being specific about what practice is allowed or not allowed is not congruent with the thinking and approaches that set RA apart from other alternative practices. Critics like the group of agronomists (Giller, Hijbeek, et al., 2021) struggle to come to terms with the human elements and philosophical approaches to farming, concluding that it is “unlikely to deliver environmental benefits and increase food production.” Hence, this research assessed the resilience of various practices and how RF can approach their landscapes through guiding principles. This research aims to clearly define the guiding principles behind RA and provide credible definitions.

Over the last thirty years, many new farming practices have come and gone as our knowledge of RA has evolved. For example, farmers adopted minimum till cropping techniques in the eighties and shortly after, moved to no-till, which later progressed to 'no-kill no-till' in RA (Kassam et al., 2019; Lal, 2004). As identified in Chapter 2 (Literature Review) and the previous chapter (Chapter 3, New England Case Study), clear principles guiding regenerative agricultural farming practices in Australia are lacking. This continues to generate confusion regarding what RA entails (P. Newton et al., 2020). Industry organisations (Birchup Cropping Group, 2021; General Mills, 2020; Regenerative Agriculture Alliance, 2020) confuse principles and practices, as do academics (Khangura et al., 2023; Lal, 2020; Schreefel et al., 2020). Only a few authors have incorporated philosophical understandings, approaches, and social aspects of RA (Eckard, 2023).

As identified in Chapter 3, the case study farmers considered themselves practicing RA even when their methods were not regenerative. Farmers have requested a set of guiding principles to clarify what RA does and does not involve. In addition, when new practices emerge, or old practices are refined as new knowledge and technology emerge, a set of underlining principles is required to guide decision-making for individual bioregions or circumstances. It became apparent that establishing a set of guiding principles for regenerative agricultural practitioners in Australia will assist regenerative farming practices in the future to be more resilient and sustainable in a changing climate. As such, Chapter 4 aims to explore what the principles of RA (PRA) could look like for Australia and compare those findings with discourses of RA and the practices of the New England case study farmers.

In order to develop and test a set of principles and practices for RA unique to Australian conditions, the research findings were compared to two of the resilience frameworks outlined in the Literature Review (Chapter 2) - the 'Stockholm Group of Scientists' Social-Ecological Resilience Principles' (SRAP) (R Biggs et al., 2015b; Stockholm Resilience Centre., 2021) used in the New England Case Study (Chapter 3), and the 'Australian Group of Scientists Resilience Adaption Pathways and Transformative Approach (RAPTA)' (Cowie et al., 2019).

Examples of farm management practices in Northern Beef Cattle Systems taken from the New England Farming Systems Case Study findings (Chapter 3) were utilised as a practical example of a principle and, the 'Gordon Discourses' (Gordon et al., 2023) were included for further triangulation possibilities to gauge the principles' relevance as a resilient approach against a changing climate.

4.2 Research Question and Sub Questions

The overarching research question for this thesis was:

"Are Australian regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate, and does comparing these production systems highlight the need for a set of guiding principles for regenerative agriculture in Australia"?

To answer the second part of the overarching research, the following research sub-questions were explored:

1. What are the principles for Australian regenerative agriculture?
2. How are they relevant to Northern NSW cattle production systems in a changing climate?

4.3 Methods

A mixed methods approach was utilised to answer the following questions, encompassing:

1. A meta-review of grey and academic literature on regenerative agriculture principles
2. Analysis of key themes across this literature to inform the first draft of the principles

3. Informal testing via focus groups of a first draft of the principles with the regenerative agriculture network in Australia to inform a final draft for testing via a national survey
4. Testing the second draft of the principles via a national survey through the regenerative agriculture Australia network (See Appendix E) and analysis of the national survey results
5. Comparative analysis between the SRAP and the RAPTA Principles with the Australian Regenerative Agricultural Principles
6. Comparative analysis of practice management examples of the New England Case Study against the resilience principles and the regenerative principles
7. Comparative analysis of the Australian Regenerative Agricultural Principles and the various discourses outlined by Gordon et al. (2023) as potentially a 'common ground' starting point for collaboration in regenerative agriculture in Australia.

Qualitative and quantitative data were collected, utilised, and interpreted in order to provide a clearer understanding of the research question (Creswell, 2014). In a farming context, mixed methods address challenges encompassing holism, data scarcity, representativeness, and cost-efficiency (Lacostea et al., 2018). In addition, a pragmatic theoretical perspective was adopted to understand RA principles. Pragmatists agree that research should be contextually situated without being committed to any one philosophical position, instead using diverse methods to understand a given problem (Creswell, 2009). Further, this study utilised an Interpretivist Approach whereby the researchers' perceptions and interpretations became part of the research (Creswell et al., 2006; Doyle et al., 2009; Gunbayi, 2020; Hendren et al., 2022; Hesse-Biber, 2010). The mixed method approach was considered suited to holistic research as it emphasises the study of complex adaptive systems whereby the component parts are best understood in context and in relation to each other and the whole. It is concerned with complete systems rather than individual parts. It could be summarised as recognising, understanding, expressing, and explaining complexity (Polkinghorne & Given, 2021).

According to Moon and Blackman (2014), the three fundamental elements of social science research are ontology (what exists in the human world that researchers can acquire knowledge about), epistemology (how knowledge is created), and philosophical perspective (the philosophical orientation of the Researcher that guides her or his action). The ontological position taken in this research is that of a critical realist who "assumes that one reality exists but can never be understood perfectly because of basically flawed human intellectual mechanisms and the fundamentally intractable nature of phenomena" and, as such, "claims about reality must be subjected to the widest possible critical examination" to help in understanding reality as closely as possible (Guba & Lincoln, 1994). The epistemology is categorised as constructionist, as how an individual engages with and understands their world is based on their cultural, historical, and social perspectives, and thus meaning arises through interaction with community (Creswell, 2009; Crotty, 1998).

The results presented in the following section describe the emerging themes identified in the meta-review, developed definitions of RA practices, findings from focus group workshops on the principles, and results of the national survey of the principles.

Several key relevant publications were reviewed in constructing the first draft of the "Australian Principles for Regenerative Agriculture" (the Principles), including:

- The Rodale Institute's Seven Tendencies Towards Regeneration (Rodale & Rodale, 1989)
- David Holmgren's book Permaculture: Principles and Pathways Beyond Sustainability (Holmgren, 2007)
- Terra Genesis International's Levels of Regenerative Agriculture (Soloviev & Landus, 2016)
- The Routledge Handbook of Sustainable and Regenerative Food Systems – Regenerative Food Systems – A Social-Ecological Approach "Six Principles for Regenerative Food Systems" (Duncan et al., 2020)

- The Guardian's "Regenerative Agriculture Revives Farmland while Curbing Climate Change" six principles (General Mills, 2020).
- Gabe Brown's Principles, as outlined by Andrew McGuire of the Washington State University's Centre for Sustainable Agriculture and Natural Resources (McGuire, 2018)
- IFOAM Organics International's "The Four Principles of Organic Agriculture" (International Federation of Organic Agriculture Movements, 2022)
- Migliorini, P., Wezel, A. Converging and diverging principles and practices of organic agriculture regulations and agroecology. A review (Migliorini & Wezel, 2017)

The review highlighted similarities and overlaps in themes, as illustrated in Table 4.1. Economic, social, and environmental emerging themes were identified to inform RA principles. The complete list of emerging themes was:

1. Diversity and biodiversity
2. Ecological processes
3. Soil Biology and perennials
4. Fairness
5. Chemical use and decreasing inputs
6. Future generations
7. Collective knowledge, and
8. Continuously evolving

4.3.1 Principles for Regenerative Agriculture

An initial draft set of principles for RA (PRA) in Australia was created based on the meta-review of the international themes. These were presented, discussed, and refined with the following focus groups through a series of four round tables, webinars, Q & A's, and conferences in 2020 and 2021 as outlined below from participants of the various groups:

- The Regenerative Agricultural Foundation. Consisting of 20 leaders in the RA space coming together to form a Foundation. Discussed March 2020.

- The Regenerative Agricultural Alliance (scu.edu.au/regenerativeag). Membership of 13,500). First presented for discussion in July 2020.
- The Holistic Management Co-operative (landtomarket.com.au). Approximately 500 members in attendance at a conference were presented and asked for feedback. March 2021.
- The Institute for Ecological Agriculture (ecoag.org.au) Membership of 60. Discussed with Executive in November 2020.

The above groups were encouraged to openly provide feedback for group discussion or to personally provide feedback at the end of the presentation. In both cases, notes were taken, and consideration was given to the comments and various perspectives.

The participants were asked:

1. For each principle as outlined, do you agree with the principle as presented and its assumed meaning?
2. Is there any principle that does not fit our existing understanding and relevance to Australian conditions?
3. Do any of the principles make you feel uncomfortable?
4. If unsure or disagree, please explain why.
5. Have we missed a potential principle, and if so, what is it?
6. Any further comments?

Table 4.1 Emerging Themes of Regenerative Agriculture

Rodale Institute (Tendencies)	Terra Genesis	Gabe Brown	Duncan, Carolan and Wiskerke's	Mill's Guardian Article	IFOAM	Emerging Theme
Diversity of plants species, businesses, people, and cultures.	Holistic decision-making for specific systems change. Work with wholes, not parts. Connect farm to larger agroecosystems and bioregion	Increase biodiversity, Integrate livestock	Diversity in forms of knowing and being, Taking care of people, animals, and the planet	Maximise plant diversity	The health of the soil, plant, animal, human, and planet	Diversity and biodiversity (1 & 2)
Surface cover of plants, ending erosion hardiness and ability to withstand environmental, economic, personal, and cultural crisis. More perennials and other plants with vigorous root systems. Improvements in soil structure and water retention capacity and community life, increasing health and well-being.		Limit tillage and protect the soil. Maintain living roots in the soil.		Reduce soil disturbance. Keep soil covered. Each farm is different. Living root in the ground year-round	Ecology - working with living ecological systems and cycles, emulating and sustaining them	Covered soil and perennials (3)
	Non-linear, multi-capital reciprocity		Beyond capitalism. Commoning the food system	Integrate lives	Fairness to the common environment and life opportunities	Fairness (4)
No chemical fertilisers and pesticides affect people's health and well-being. Past systems of weed and pest interference. Nutrients more available for plants trickle up economies.						Synthetic Chemical use (5)
Deeper spiritual and meaning to life. Violence, crime, anger, fear, and hate are disrupted.	Unique, irreplaceable essence of each person, farm, and place		Accountable innovations, Long-term planning, and rural-urban relations		Care to protect current and future generations and the environment.	Future generations (6 & 7)
	Continually evolve agroecological processes and cultures. Agriculture shifts the world.					Continuously evolving (8)

Not all participants were RF many were CF's. Many were unsure of the movement, observing its growth and debating its relevance to them. Others, including many consultants, advisors, and academics, were defiant, highly critical, or indifferent.

A summary of the demographics of the respondents was as follows:

- 63% were farmers, with the balance being made up of consultants, advisors, agronomists, agricultural scientists, and public servants
- 55% were graziers, and 28% were mixed farmers
- 40% were first-generation farmers, and 42% had been farming for more than 20 years
- 36% derived 76% -100% of their income solely from farming
- 61% considered themselves RF, 33% considered themselves CF, with the balance being a mix of rotational farming, holistic, biological, organic, and bio-dynamic farmers
- 36% were located in NSW
- 60% were male
- 27% were aged between 51-60 years of age. 39% were 61 years or older
- 67% had a bachelor's degree, master's or Ph.D.

Feedback from the focus group testing resulted in a revised final draft of the regenerative principles (Table 4.2).

Table 4.2 Regenerative Principles 2021

Regenerative Agriculture Principles	Explanation
Be ecologically literate, think holistically, and understand complex adaptive systems	Appreciate how ecosystems behave in complex, adaptive, and often unpredictable ways. Consider how the landscape is nested within and interconnected with smaller and larger ecological, social, and economic systems.
See your landscape as a community that you belong to and work with	Your ecosystem is a community of species that you are part of. Do not try and control the members of this community but work alongside them.
Acknowledge and consider diverse ways of working with landscapes	There are many approaches to managing landscapes and be open to integrating them with your practice.
Understand that human cultures are co-evolving with their environments	People and landscapes are relational. We are co-evolving with our environments on a biological and cultural level. This requires adaptive thinking.
Engage with First Nations people	Be active in reconciling the trauma of landscapes and displaced communities. Share knowledge regarding working with landscapes.
Remain curious; seek transformative experiences and continuous learning	Be comfortable with the ambiguity that comes with not having all the answers, be open to paradigm shifts, adaptive thinking, and expanding your thinking.
Engage in ecological renewal and make place-based decisions through monitoring	Focus on and monitor landscape functions such as biodiversity, soil health, carbon sequestration, ground cover, water cycles, mineral cycles, and energy flow.

The final draft of the principles was presented via an online evaluation through 'Survey Monkey' (Appendix E) of the perceptions about the RA principles in the form of a Likert scale survey (do you agree or disagree on a scale of 1 – 10). Ethics approval was received from the University of New England Human Research Ethics Committee (Approval number: HE21-220. See Appendix A for all Ethics forms in relation to this research). The Survey commenced on the 7th of December 21 and finished on the 28th of February 2022. It was distributed throughout the RA Australia e-news network (13,000 email subscribers), which consisted of regenerative and non-RA, agricultural consultants, and people generally interested in the RA movement. The survey received 746 Australian responses in total.

The survey also ascertained the percentage of farmers to non-farmers. It asked the network to rate each of the seven principles with a score of 1 -10 (1 being strongly disagree and 10 being highly agree). Further, the survey asked the participants to rank the principles in order of importance to them. The results of the survey are presented in Table 4.3.

Table 4.3 Ranking of Principles of Regenerative Agriculture in order of importance according to the participants (746 respondents)

Ranking No.	Abbreviated Name	Principles of RA	Most important (out of 7 principles)	Agree with Principle (rated ≥ 7)
1	Ecological Literacy	Be ecologically literate, think holistically, and understand complex adaptive systems	5.65	89%
2	Humans as part of the landscape	See your landscape as a community that you belong to and work with	4.68	81%
3	Remain curious	Remain curious; seek transformative experiences and continuous learning	4.24	92%
4	Acknowledge Diverse Approaches	Acknowledge and consider diverse ways of working with landscapes	4.17	89%
5	Place-based Decisions Through Monitoring	Engage in ecological renewal and make place-based decisions through monitoring	3.98	91%
6	First Nations engagement	Engage with First Nations people	2.77	70%
7	Humans co-evolving	Understand that human cultures are co-evolving with their environments	2.51	76%

4.3.2 Practices for Regenerative Agriculture in Australia

As noted in the introduction to this chapter, practitioners and farmers consistently confused the practices and PRA and it was important to define the difference between the two terms. Principles should guide the movement and also help in the application of the practices (Migliorini & Wezel, 2017). As an example, ecological principles refer mainly to ecological aspects of sustainability, focusing on ecological systems, restriction of external inputs, limitation of chemical inputs, and adaptation to local conditions. In comparison, practices can include categories such as soil tillage, soil fertility, fertilisation, crop, and cultivar choice, crop rotation, intercropping, management of landscape elements and habitats, pest, disease and weed management, water quantity and quality, and agroforestry (Migliorini & Wezel, 2017). Jeffrey and Achurch (2017) outlined a set of practices to preserve the soil in Australia, which provided a foundation for considering practices within RA.

Building on Jeffrey and Achurch's initial list of practices, the set of practices outlined in Table 4.4 was constructed and then proposed to various industry groups throughout 2020 and 2021. This set of practices, as listed by Jeffrey and Achurch (2017), was presented as a PowerPoint presentation to the Regenerative Agricultural Alliance and various agricultural networks, including:

- The Birchip Cropping Group Webinar, September 2020
- Agri Webb Q & A, September 2020
- NSW Department of Agriculture, October 2020
- The Holistic Farming Conference in Albury, March 2021
- Dairy South Australia Conference, March 2021
- Zoom presentations and Q & As at the Sustainable Australia Initiative, May 2021
- Women in Agriculture Leadership Conference in Ballina, March 2022

Comments and feedback were requested from the workshops, presentations, and Q&A sessions. Questions and clarifications were taken at the end of the presentations and participants were invited to discuss further after the presentation and to provide any further comments. Notes of the questions and answers were taken and used to further refine the practices. Table 4.4 lists the practices agreed upon based on the focus group findings.

Table 4.4 Proposed Practices for Regenerative Agriculture in Australia

INPUTS • Applying organic composts, fertilisers and bio amendments, sourced locally • Encouraging natural biological cycles and nutrient retention • Reducing or ceasing synthetic chemical inputs
GRAZING MANAGEMENT • Implementing time-controlled planned grazing/holistic grazing • Using grazing management and animal impact as farm and ecosystem development tools • Self-herding and stress-free stockman-ship
BIODIVERSITY • Managing for increasing species diversity • Integrating enterprises • Feral animal and noxious weeds control
WATER • Constructing interventions in the landscape or waterways (such as leaky weirs) to slow the flow of water • Fencing off waterways & implementing water reticulation for stock • Rehydrating wetlands • Investing in revegetation
CROPPING • Multi Species Pasture cropping • Pasture sowing • Changing crop rotations • Incorporating green manure or under-sowing of legumes • Retaining stubble or performing biological stubble breakdown • No Kill and Cover Cropping • Controlled Traffic Farming

4.3.3 Comparison of RA principles with alternative resilience principles

The PRA were then compared with the SRAP (R Biggs et al., 2015b; Stockholm Resilience Centre., 2021), RAPTA (Cowie et al., 2019) and examples of farm management practices undertaken in the New England Beef Cattle Case study (Chapter 3). The aim was to test the efficacy of the PRA and its relevance to resilience and 'grassroots' practice. See Table 4.5 for the results, where it can be seen there were overlaps and synergies between the various principles.

Table 4.5 The Link between Resilience Frameworks and the Principles of Regenerative Agriculture

Resilience Alliance Stockholm (SRAP)	RAFTA Australian Resilience Framework	Principles of Regenerative Agriculture Research Findings	Ranking No.	Examples of Farm Management Practices in Northern Beef Cattle Systems
Maintain diversity and redundancy	Diversity and Redundancy Reserves and buffers Management at the right scale	Be ecologically literate, think holistically, and understand complex adaptive systems. (Ecological Literacy)	1	Number of other enterprises and income sources, income security and equity levels, ability to retain staff, level of biodiversity on the farm
Manage connectivity		See your landscape as a community that you belong to and work with (Humans as part of the landscape)	2	Tree belts, wildlife corridors, and nature strips, individuals and the family's connection to land and community
Manage slow variables and feedbacks	Flexibility Feedbacks	Acknowledge and consider diverse ways of working with landscapes (Acknowledge diverse approaches) Engage in ecological renewal and make place-based decisions through monitoring (Placed-based decisions through monitoring)	4 5	Adopting and taking up new practices more suitable to the environment, increased on-farm landscape monitoring, and information sharing between farming cohorts

Resilience Alliance Stockholm (SRAP)	RAFTA Australian Resilience Framework	Principles of Regenerative Agriculture Research Findings	Ranking No.	Examples of Farm Management Practices in Northern Beef Cattle Systems
Understanding that social-ecological systems are complex adaptive systems	Self-organisation	Be ecologically literate, think holistically, and understand complex adaptive systems. (Ecological Literacy) Understand that human cultures are co-evolving with their environments (Humans co-evolving)	7	Grazing management practices such as being regenerative or not, utilisation of the holistic management framework for decision-making purposes
Encourage learning and experimentation	Risk Intelligence Monitoring and Information Flows	Remain curious; seek transformative experiences and continuous learning (Remain curious)	3	Furthering education Level of risk-taking or new ideas, Level and depth of information sharing amongst peers, and monitoring systems in place
Broaden participation	Collaboration Social capital	Engage with First Nations people, share knowledge regarding working with landscapes. (First Nations engagement)	6	Social and Community Engagement
Promote polycentric governance systems				Ability to self-sustain without relying on larger governance systems

4.3.4 Further triangulation

Lastly, the developed PRA were compared with the work of Gordon et al. (2023) to see if any interesting further triangulation possibilities emerged. Gordon et al., identify, describe, and give meaning to nine distinct RA discourses:

1. Restoration for Profit – restoring soil health to increase productivity and profitability while reversing climate change
2. Big Picture Holism – looks at how everything is connected for sound management decisions and quality of life
3. Regenerative Organic – building on organic agriculture to regenerate soil health, animal welfare, and social fairness
4. Regrarian Permaculture – designing integrated farm systems that regenerate the land
5. Regenerative Cultures – spiritually rich and emotionally fulfilling regeneration, including place-based cultures
6. Deep Holism – ecosystems as inseparable from yourself
7. First Nations – what First Nations people have been doing for tens of thousands of years
8. Agroecology and Food Sovereignty – regenerating communities and having people democratically involved in the food system
9. Subtle Energies – working with the invisible dimensions to connect with the intelligence of nature and restore energy imbalances

Gordon found that 'tensions' between discourses may make RA vulnerable to 'co-optation and greenwashing' and possibly dilute the potential for RA to be transformative.

The nine discourses were compared to the PRA to determine how closely the developed principles aligned to Gordon’s definitions and beliefs around genealogy and holism, equity and power, and departure from conventional thinking. The approach was not to look for disagreement with the PRA but to gauge how prevalent or apparent the particular principle was in their language usage. Table 4.6 presents the findings of the comparative analysis between the PRA and the nine discourses (Gordon et al., 2023). Ecological literacy, remaining curious and place-based decision making showed a strong level of fit with the nine discourses identified by Gordon. The fit against the other discourses is not as strong. However, these results could be a starting point for further discussions to seek 'common ground' outcomes.

4.4 Results

In summary, the research findings indicated that the majority of participants agreed that **the Principles for Australian regenerative agriculture, in order of priority, are:**

1. Be ecologically literate, think holistically, and understand complex adaptive systems
2. See your landscape as a community that you belong to and work with
3. Remain curious; seek transformative experiences and continuous learning
4. Acknowledge and consider diverse ways of working with landscapes
5. Engage in ecological renewal and make place-based decisions through monitoring
6. Engage with First Nations people
7. Understand that human cultures are co-evolving with their environments

Further, the research findings confirmed a **current** set of **practices for Australian regenerative agriculture** (see Table 4.4).

Table 4.6 The Principles Alignment with the Nine Discourses

	1. Ecological literacy	2. Humans as part of the Landscape	3. Remain curious	4. Acknowledge diverse approaches	5. Place-based decisions through monitoring	6. First Nations engagement	7. Humans co-evolving
Restoration for Profit			*		*		
Big Picture Holism	*		*	*	*		*
Regenerative Organic	*		*		*		
Regrarian Permaculture	*		*		*		
Regenerative Cultures	*	*	*	*	*	*	*
Deep Holism	*	*	*	*	*		*
First Nations	*	*	*	*	*	*	*
Agroecology and Food Sovereignty	*	*	*	*	*	*	*
Subtle Energies	*	*	*	*	*		*

* Shows alliance to the seven regenerative principles

The Australian PRA supported a resilience framework. When the PRA were compared against two alternative resilience frameworks (Table 4.5) (SRAP (R Biggs et al., 2015b; Stockholm Resilience Centre., 2021) and the RAPTA (Cowie et al., 2019)), there were overlaps and synergies between the various principles. When triangulating the findings of the principles and practices of RA with the work of the SRAP and RAPTA, many synergies can be seen that support the Australian RA principles outlined in this research. This further supported the relevance of the PRA to act as a guide for a more resilient farming system in a changing climate.

Practical farm management practices of Northern NSW Beef Cattle Systems were overlaid with the resilience frameworks and the regenerative principles. The results provided examples of on-ground application and a resilience framework for Northern NSW beef cattle production systems. Specifically, all PRA aligned with six out of seven of the resilience principles. The sole principle that was not relevant to the study was 'Promote Poly Centric Governance Systems.'

Further, the nine discourses of RA (Gordon et al., 2023) also aligned with the RA principles (Table 4.7). They provided further clarity for the sector and the potential for a 'common ground' starting point for further discussion amongst the various discourses.

The principles and practices for Australian RA have been defined based on a moment in time. Therefore, they are iterative and adaptive in themselves. These principles may further evolve as we reach higher levels of understanding when working with nature and ecology, this will require adaptive thinking. The research reported here is contributing to this evolution.

4.5 Discussion

4.5.1 Lack of agreed definition for Regenerative Agriculture

In 2020, an analysis of the literature related to RA indicated that there was no legal or regulatory definition of the term 'regenerative agriculture' and since then, a widely accepted definition has still not emerged (P. Newton et al., 2020). There is also no universal agreement on what constitutes regenerative practices such as chemical inputs. Some, like the Rodale Institute in America, advocate for no chemical use (Rodale, 2023). In contrast, the Regenerative Agricultural Alliance in Australia, Resource Consulting Services, and Holistic Managers recommend reducing or ceasing synthetic chemical inputs (Savory, 2023). In comparison, organic agriculture is based on agreed standards and third-party audits, with no use of synthetic chemical inputs permitted.

4.5.2 Nine distinct discourses associated with Regenerative Agriculture

Once the PRA are understood, making decisions around climate challenges can become straightforward as the principles guide decision-making. Further, now that nine distinct discourses have been identified, the diversity of approaches to RA can be better understood and perhaps accepted (Gordon et al., 2023). If the various discourses are to integrate diverse forms of knowledge and embrace the complexity rather than simplify it to an agreed definition, then identifying a set of guiding principles is essential (Seymour & Connelly, 2022). Gordon et al. (2023) promoted the development of a 'Discourse Coalition', whereby diversity of the various discourses can come together to advance further discussion, around a ‘shared storyline’ (Hajer, 1995; Riedy, 2020). The PRA could be part of this ‘shared storyline’ that focuses on common ground, encourages discussion, and ‘refinement of these principles. Given the PRA in Australia, developed as part of this research, align well with the existing areas of discourse, these principles may form the necessary 'common ground' and building blocks required for fundamental industry transformation and potentially could pave the way for transformation in the agricultural sector by being used as a 'common ground' starting point. (Gordon et al., 2022; Hajer, 1995).

4.5.3 Certification versus Verification in Regenerative Agriculture

An ongoing challenge in the regenerative agricultural space is certification. Several corporate organisations (Nestle Ltd, Paradigm Foods Ltd, Australian Country Choice Ltd, Roots Regenerative Paradigm Foods Ltd) sought advice for certifying their products from the Researcher in 2021. 'Carbon 8' (Carbon8, 2019) in Australia attempted to certify RA, while 'Land to Market' (Land to Market, 2019) aimed to verify such practices. To date, the most successful certification program has been 'Roots Regenerative' www.rootsregenerative.com owned by Paradigm Foods (Paradigm Foods, 2023), who have combined self-assessment processes with verification and third-party certification. The certification is based on the participant undertaking certain practices.

RA consists of many ever-evolving practices that can be "verified." An example of this approach has been undertaken by the Australian Holistic Management Cooperative trading as ‘Land to Market' www.landtomarket.com (Savory, 2022). This group has a unique ecological verification program developed in conjunction with the Savory Institute, which recognises farmers holistic approaches to managing their farms. It is based on an outcomes-based protocol for verifying land regeneration. Ecological Outcomes Verification (EOVs) measure regeneration through a host of ecological indicators, including ground cover, water infiltration, biodiversity, soil carbon, and soil health.

A recent paper (Elrick et al., 2022) aimed to explore the learning opportunities for certification of RA based on the experiences of organic agriculture in Australia, and highlighted the somewhat bumpy journey experienced in the organic sector. Unlike the organic sector, RA does not aim to eliminate synthetic chemical use, but rather to minimise the reliance on synthetic inputs and maintain agricultural productivity while offsetting the climate crisis through emissions reduction and carbon sequestration. Social elements are also considered important in a regenerative context, including such elements as a focus on local food systems and family farming (Gordon et al., 2022).

Many are trying to find a way forward (Gardner et al., 2019; Regenerative Organic Alliance, 2022; Thurman, 2022). It seems verification is a more appropriate means of ensuring continuous learning, adapting to a complex adaptive system, and co-evolution. The likes of 'Land to Market' based on Alan Savoury's Ecological Verification System (EOV) align more closely with the principles outlined in this chapter.

Elrick et al. (2022) found mixed views among industry leaders regarding certification, stating that the RA industry must pay special care to the areas of "process," "governance" and "regulation" as well as "collaboration, support, and education." Many key informants expressed that a future RA certification model should focus on principles that support and help the producer to transition along a continuum of RA farming approaches and practices rather than imposing dichotomous rules (Elrick et al., 2022). In order to ensure checks were conducted and reduce potential 'greenwashing', this feedback recommended a regulatory body be established instead of a 'certification' model that is similar to the organic model, which is seen as black and white and punitive. This research hopes to further inform Elrick, Luke, and Stimpson's findings regarding certification, speaking to temporal aspects of the principles and practices that underpin RA including the ever-moving, changing dynamics and constant adaptation to change. Unless certification can find a way to embrace flexibility, adaptation, and transformation, it remains an unlikely fit for RA.

While the study of soil is a mature science, RA is not. RA promotes nature-based solutions to improve soil and landscape health and productivity while improving water and nutrient retention in soils across the farmscape (C. J. Rhodes, 2017). RA offers an opportunity to address many prevailing environmental challenges through restoring damaged landscapes (Francis & Harwood, 1985; Massy, 2013; Massy, 2020; Wahl, 2016).

4.6 Conclusion

RA is a fast-developing movement that offers an alternative to industrial and OA and contributes to mitigating climate change's effects. However, by its very nature, RA means different things to people depending on where they are on their regenerative journey and what discourse they belong to. RA is moving towards being accepted as 'best practice' in Australia. However, to become mainstream best practice, it needs a set of guiding principles to adhere to. Practices will evolve and improve, while principles will remain constant. This journey is similar to Sustainable Farming and the sustainability movement's challenges in defining sustainable agriculture and keeping its relevance in the 20th Century.

In this chapter, a set of principles and practices for RA, unique to Australian conditions, were developed and tested.

The principles outlined in this chapter offer guidance for achieving resilience in a changing climate. While not providing a specific definition for RA but finding 'common ground,' this set of guiding principles provide a step towards transformative change in Australian agriculture.

The key findings based on the results were:

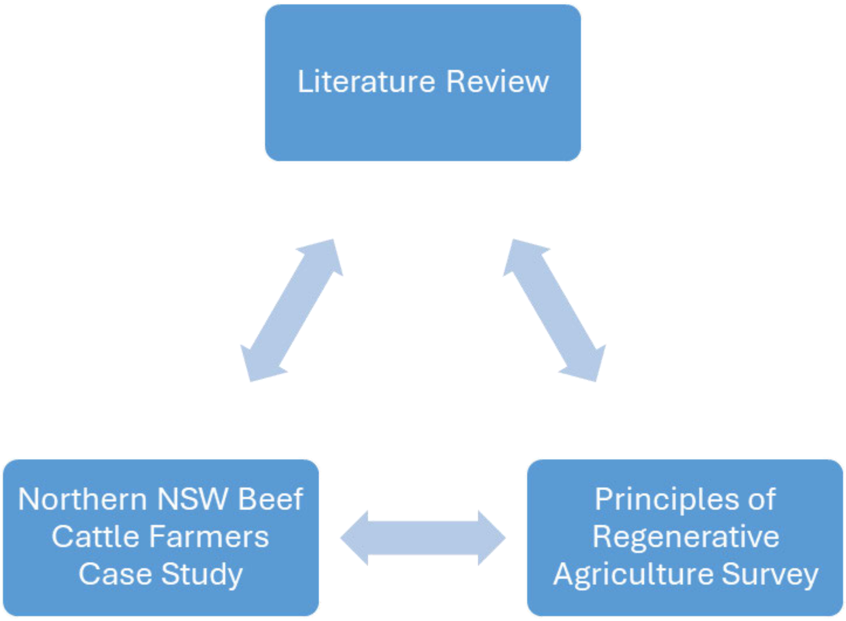
1. A set of guiding principles for Australian regenerative agriculture
2. A list of current practices for Australian regenerative agriculture

3. An alignment and synergy with the regenerative principles and that of the Stockholm Group of Scientists and Australian Group of Scientists Resilience Principles
4. A resilient framework applicable to northern NSW beef cattle producers

Chapter 5: Synthesis and Conclusion

5.1 Introduction

This chapter aims to synthesise and triangulate the findings of the literature review (Chapter 2), the northern NSW beef cattle farmers case study (Chapter 3), and the PRA Survey (Chapter 4) in order to test the efficacy of the research and address the over-arching research question and sub-research questions. The discussion will be presented under the two main themes of 'Resilience of Regenerative and Conventional Farming Systems' and 'Regenerative Agriculture Principles for Australia.' Table 5.1 provides an overview of the summary of the research questions into the two main themes. Following the discussion, the conclusions of the research are presented.



5.2 Theme One: Resilience of Regenerative and Conventional Farming Systems

The New England case study of graziers and their operations from an environmental, social, and economic perspective showed distinct differences between the two RF and CF cohorts.

While differences were apparent, what was the significance of these differences for farming in a changing climate in the future? To gauge the importance of the differences, they needed to be placed in the context of resilience in a changing climate. Farm management practices seen through the lens of the Stockholm Resilience Principles (SRAP) provided the meaning and context to view the findings of the case study from a resilience perspective. To determine the differences, the SRAP was triangulated across the New England Case Study results to align farm practice with resilience measures. The SRAP was narrowed down into practices and further narrowed into measurable variables (or indicators) in the context of New England grazing operations. It then took specific variables measured in the case study that matched general farm management examples and the SRAP. For example, the number of other enterprises or income sources directly measures a business's diversity and redundancy. Another example of the principle of diversity and redundancy is the number of enterprises, percentage of income from farming, payment levels for retaining employees, etc.

A further example would be the amount of tree or bush cover on a farm-related to wildlife corridors and nature strips that allow for connectivity for nature or people. The measured variable of placing more emphasis on continuing education relates directly to encouraging learning and participation as a resilience principle. The variable of having higher community engagement also is a direct measure of broadening participation as a resilience principle. See Table 5.2 for an overview of the environmental, social, and economic indicators for a resilience framework.

Table 5.1 Research Question Tree

Overarching Research Question Are Australian regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate, and does a comparison of these production systems highlight the need for a set of guiding principles for regenerative agriculture in Australia?	
Sub-research questions	**Methods**
Theme 1 – Resilience of regenerative and conventional farming systems Which beliefs and practices (leading to management decisions) are held by Northern NSW beef farmers in a changing climate, and how are these expressed? What are the economic, environmental, and social indicators for a resilience framework, and how do the actions of regenerative and conventional beef cattle farmers align with the Stockholm Resilience Framework? What conclusions can be drawn about the resilience of cattle production systems in Northern NSW?	• Literature review • Case Study • Longitudinal survey • Thematic analysis
Theme 2 – Regenerative agriculture principles for Australia What are the principles for Australian regenerative agriculture? How are they relevant to northern NSW cattle production systems in a changing climate?	• Literature review • Quantitative survey

Table 5.2 Environmental, Social, and Economic Indicators for a Resilience Framework

Stockholm Resilience Principles (SRAP)	**Farm Management beliefs, practices, management decisions (Indicators)**
1. Maintain diversity and redundancy	Number of other enterprises and income sources, income security and equity levels, ability to retain staff, level of biodiversity on the farm
2. Manage connectivity	Tree belts, wildlife corridors, and nature strips, individuals and the family's connection to land and community
3. Manage slow variables and feedbacks	Adopting and taking up new practices more suitable to the environment, increased on-farm landscape monitoring, and information sharing between farming cohorts.

4. Understanding that social-ecological systems are complex adaptive systems	Grazing management practices such as being regenerative or not, utilisation of the holistic management framework for decision-making purposes
5. Encourage learning and experimentation.	Furthering education, Level of risk-taking or new ideas, level and depth of information sharing amongst peers, and monitoring systems in place
6. Broaden Participation	Social and community engagement
7. Promote polycentric governance systems.	Ability to self-sustain without relying on larger governance systems

The case study results found that the actions (in the form of beliefs and practices, which lead to management decisions) of regenerative and conventional beef cattle farmers align with the SRAP. When a correlation analysis was undertaken, the results showed that, there was a pattern of positive correlation between farms that are conventional, with other farms that are conventional. There was an overall correlation pattern between regenerative farms and other regenerative farms. Overall, there was no correlation between farms that were regenerative and farms that were conventional. However, one farmer was transitioning towards a more regenerative approach and therefore aligned more towards the regenerative group.

A thematic analysis found that conventional and regenerative farms exhibit different beliefs, orientations, and behaviours. This variation is recognisable as differences in management action, forward planning, and strategy. The results provide some quantitative support for some variation patterns associated with regenerative versus conventional farms but tended not to be statistically significant. The thematic analysis, using radar graphs of patterns of codes and combining the SRAP and farm management practices, showed that the SRAP added meaning to the findings from a resilience perspective.

Examples of maintaining diversity and redundancy from an economic perspective concluded that RF have more enterprises and higher levels of off-farm income and provide higher pay to their employees. The CF focused on higher-yielding enterprises (e.g., cattle trading v's breeding) and spent substantially more on pastures and supplementary feeding. Similar economic findings were found by other researchers when it came to decreased costs of production and reduced inputs by RF, such as synthetic fertilisers, herbicides, supplementary feeds, and animal health (Ferguson et al., 2013; Gadzirayi et al., 2007; McCosker, 2000; McCosker et al., 2021; Sherren et al., 2012; Teague & Barnes, 2017). Higher profitability of RF during drought years, as claimed by Ogilvy (2018), was considered; however, there was a lack of specific data to substantiate the claims. There was a slight difference in animal health costs in both the case study regenerative and conventional trading systems revealed in the secondary data; however, there were no significant differences due to the case study farmers being located in the same geographical area and therefore having similar worm and parasite infestations and, mostly being traders, not having the time period to breed immunity to such diseases. However, other researchers found reduced animal health incidences in regenerative farms (Fenster et al., 2021; Spratt et al., 2021).

The case study found that RF paid their employees slightly higher than the Award rates, however, no reason for the difference was provided This may be because regenerative employees with qualifications, skills, and experience are difficult to find or that RF farmers place a higher value on having such qualifications and skills. Other research has claimed decreases in labour costs of up to 60% since transitioning to RA, however, this study could not substantiate this (Stinner et al., 1997). Socially, the case study RF had much higher levels of community engagement, and from an environmental perspective, they had significantly higher levels of biodiversity in their pastures. Similar claims of the ecological health of pastures were observed by Ogilvy, Teague, and Ferguson (Ferguson et al., 2013; Ogilvy, 2018; Teague & Barnes, 2017).

Examples of managing connectivity from an environmental perspective included the case study RF having more pasture diversity, including higher levels of native pastures in their pasture mix, higher levels of both tree and bush cover, and the use of significantly more organic fertiliser inputs, which can contribute to environmental outcomes such as improved stream health. Higher levels and concentration of on-farm biodiversity in regenerative farming operations were also found by other researchers (Alexanderson et al., 2023; McCosker, 2000; McCosker et al., 2021; McLachlan & Yestrau, 2009; Sherren et al., 2012; Stinner et al., 1997). From a social perspective, the case study RF had much higher levels of community engagement. This supports Stinner's research (1997) on the distinct role of community in HM approaches as a source of social learning and ongoing innovation. Examples of managing slow variables and feedbacks from a social and environmental perspective included the case study RF testing new ideas more often, having a higher commitment to continuing education and higher community engagement, also observed by Alexanderson et al. (2023). The case study RF were marginally better at coping with problems as they arose and having a positive outlook on life. While beyond the variables measured in this research, other researchers have observed reduced bare ground (Earl & Jones, 1996; Teague et al., 2011) and improved stream and riparian health (Sovell et al., 2000) from RA. Overall healthier rangelands were observed by Bailey et al. (2019) from the use of holistic/regenerative grazing techniques.

In a social context, the case study RF more frequently tested new ideas and had a higher appetite for risk. Alexanderson, Gosnell, Sherren, and Stinner (Alexanderson et al., 2023; Gosnell et al., 2019; Sherren et al., 2012; Stinner et al., 1997) also found more acceptance of risk and openness to experimentation and the adaptive capacity to cope with stress by RF due to the decision making processors of holistic farming and working within complex adaptive systems of variability. While the case study RF had a higher appetite for risk, testing new ideas, and continuing education, they rated their financial situation as lower than their conventional peers. Community engagement was also substantially higher in the case study regenerative cohort than in the conventional cohort. Socially, community engagement, amount of social life, and mental health were all higher in the case study RF. This echoes similar findings of Ogilvy (2018) work in outlining the improved overall wellbeing of RF compared to CF. This research found that both the RF and CF had a similar outlook on life, ability to cope with problems as they arise, and amount of leisure time.

5.3 Theme Two: Regenerative Agriculture Principles for Australia

As a result of the Literature Review (Chapter 2) and the Quantitative Survey (Chapter 4), seven principles of regenerative agriculture for Australia were identified as follows:

1. Be ecologically literate, think holistically, and understand complex adaptive systems.
2. See your landscape as a community that you belong to and work with.
3. Remain curious; seek transformative experiences and continuous learning.
4. Acknowledge and consider diverse ways of working with landscapes.
5. Engage in ecological renewal and make place-based decisions through monitoring.
6. Engage with First Nations people.
7. Understand that human cultures are co-evolving with their environments.

When triangulated, the research demonstrated a connection between the SRAP, the PRA for Australia, and the farm management practices of the New England conventional and regenerative graziers (Chapter 3).

5.4 Significance of the Research

This research fills a gap in the theory and practice of Australian RA through an applied Australian case study inclusive of qualitative and quantitative data followed by a national survey. Exploring the practices of RA through a case study method ensured a measure of 'like with like,' in the form of neighbour with neighbour, in the same geographical location, through a set of measurable variables comparing regenerative and conventional farm practices. This was followed by a quantitative national survey to test the proposed PRA for Australia. The significance of the research was to ensure that regenerative practices could be identified in the context of farmers remaining resilient and relevant through these changing climate conditions and being able to 'adapt' and 'transform' with climate change. Using the resilience framework of the SRAP provided the overall lens to view farm management practices and inform the development of the PRA for Australia, which provided a means of informing current and future Australian regenerative farm practices. This is important given the immense challenges Australia is experiencing from climate change increasing in the intensity and number of major climatic events, which affects agri-food supply chains, people's mental and physical health and wellbeing, and the environment. These are complex combinations of factors that affect the ability of farmers to "bounce back" and continue to 'adapt' and transform' to a changing climate while continuing to produce quality food and protect the environment for future generations of farmers.

5.4.1 Current Practices for Australian Regenerative Agriculture

The research has outlined a comprehensive list of current practices for Australian RA around inputs, grazing management, cropping, biodiversity, and water. For example, regarding agricultural inputs RA adopts organic inputs and bio amendments, sourcing its inputs locally (where possible), moving away from a reliance on synthetic fertilisers and chemical inputs, and encouraging natural biological cycles and nutrient retention.

Grazing management is a crucial component for RA with the implementation of holistic decision making and time-controlled planned grazing techniques that utilise animal impact as a farm and ecosystem development tool. There is also a high focus on stress-free stockmanship and overall animal health.

RA cropping systems focus on multi-species cover cropping or pasture sowing, no-kill, not till, incorporating green manures or the under-sowing of legumes, stubble retention for biological breakdown, and controlling farming traffic. These cropping practices aim to protect topsoil by keeping it constantly covered, increasing carbon sequestration and, therefore, water-holding capacity.

Biodiversity is highly encouraged through increasing species diversity within pastures and adjoining vegetation and trees. RA integrates farm enterprises to build diversity within the system and overall farm stability. Water is sometimes captured through interventions in the landscape, such as leaky weirs to slow water flow, fencing off waterways and rehydrating wetlands, and investing in revegetation. There is a high focus on soil health and carbon sequestration to capture water and less of a focus on rainfall. In other words, it is not how much rain falls but how much rain the landscape captures as against losses from runoff or evaporation.

5.4.2 Principles for Australian Regenerative Agriculture

The research went one step further with the additional survey to ascertain a set of principles for Australian RA to guide future Australian farm practices to be resilient to climate change. The "guiding set of principles" are relevant to Australian farming landscapes and seek to assist Australian farmers in making ongoing decisions based on the complexities around a changing climate. Having a guide to follow that shapes their decision-making into the future will result in more informed, considered decisions based on evidence that has been considered in a holistic context. Combinations of events cause stressors on people and their environments, rather than single issues. Addressing complex issues holistically rather than looking at problems in isolation from other factors will lead to more resilient farming systems.

The principles and practices for Australian RA have synergy and alignment with that of the SRAP and the RAPTA and offer a starting point for further discussion and research by identifying areas of 'common ground' whereby various agricultural discourses can converge. Future challenges for the RA movement include a more thorough understanding of what RA means to different people in the context of their environment and level of ecological knowledge in the absence of a widely accepted definition (Newton et al., 2020). The other challenge will be to accept the various discourses and differences of opinion that exist within the regenerative agricultural movement and to avoid the apparent divisions that have formed in other alternative farming practices (Gordon et al., 2023).

Avoiding 'greenwashing' (Szabo & Webster, 2021; Vollero, 2022) is important for RA. There are various opinions associated with certification (Elrick et al., 2022); however, certification of RA is not congruent with the Principle of RA for Australia of "co-evolving with the environment and seeking transformative experiences and continuous learning."

The research findings of the principles and practices of RA for Australia can act as a guide to navigate these challenges and, in doing so, support farmers to capitalise on the extraordinary opportunities that present themselves through regenerative practices such as ecosystem service markets and enhancing landscape health and biodiversity. There are substantial economic and environmental opportunities associated with carbon; however, social license issues, equity of eligibility, land management rules, and fairness of distribution may threaten large-scale uptake for climate change mitigation (Baumber et al., 2022). Carbon Farming has the potential to achieve climate change mitigation, socioecological resilience, improved soil health, and biodiversity conservation if the right policy mechanisms and land policy principles are in place (Baumber et al., 2022; Baumber et al., 2020). Economic, social, and environmental areas must be examined holistically, with an understanding of complex adaptive systems, when looking at separate yet interrelated factors that affect the resilience, adaptation, transformation, and sustainability of agricultural systems (Talukder et al., 2020). It is considered that the Earth has entered the geological time scale referred to as the Anthropocene, where humans have had a direct effect on the health of the planet with a more integrated relationship needed between humans and the rest of nature that requires a radical shift of thinking to avoid devastation (Marshman et al., 2019).

Transitioning to RA for climate change mitigation will require more than ‘climate-smart’ practices and ‘AgTech solutions’ (Gosnell et al., 2019). It will require a systems approach to managing landscapes and communities and a shift in culture, values, and ethics at a community, regional, national, and global scale if we are to adapt and survive (Gosnell et al., 2019). It will require “a paradigm shift in farming, led by farmers, to respect and work with the environment rather than downgrading it” (Burns, 2020; Dipu et al., 2022). It will also require acknowledgment of the drivers and barriers to adopting RA practices and the support mechanisms required as a viable means of producing food sustainably. Economic and consumer priorities will play a large role. Beef production faces the challenge of trade-offs between economic and environmental objectives, which are interpreted differently towards global sustainability objectives. There is an opportunity to shift production areas, improve feed composition and undertake credible land restoration for emissions reduction, understanding that there may be the cost of production trade-offs as part of the adaption that needs to happen (Castonguay et al., 2023). Castilla-Rho and Kenny (2022) suggest that understanding RA can assist land managers in tuning agricultural practices to the Earth's cycles and systems and state it will take a thorough understanding of biophysical processes and complexity, underpinned by values and beliefs to enact potential solutions. In addition, addressing problems associated with socio-ecological systems involves an understanding of human behaviour and how it can hinder or help in transformation (Kenny & Castilla-Rho, 2022).

5.5 Conclusion

The following section will present the conclusion of the research as responses to each sub-research question to ultimately answer the overarching research question.

5.5.1 Which beliefs and practices (leading to management decisions) are held by Northern NSW beef farmers in a changing climate, and how are these expressed?

The beliefs and practices held by Northern NSW beef farmers were dependent on whether they were CF or RF. Specifically, the research found:

- CF are more likely to be cattle fatteners and traders. CF also tend to focus on one enterprise only, focusing on the cost of production. RF had more than one enterprise.
- CF spent more on hay, silage, grain, or agistment in drought and non-drought years than RF.
- RF pay higher per-hour rates to their employees than CF, and labour forms a higher percentage of their overall costs.

- CF sell into more profitable markets, such as finishing for abattoirs, steering clear of sale yards, were members of a Beef Marketing and/or Cost of Production group, which attracted a higher premium (while this is social support network was based on profitability, it notably lacked diversity of membership).
- CF tend to rely more on 100% of their income coming from the farm. RF have several income sources, on and off-farm.
- RF have a higher proportion of native pasture and fertilised native pasture than CF (biodiversity measurement), resulting in a substantial difference to ground cover in drought years.
- CF rate (and therefore believe) their financial position as in better shape than RF.
- RF have a higher proportion of tree cover on their farms than CF (biodiversity measurement).
- RF use organic fertilizer applications more (which affects water quality and microbes) than inorganic/artificial fertiliser applications.
- RF cope better with problems as they arise compared to CF.
- RF are more open to testing new ideas and have a better outlook on life. Noting that CF are more stressed about the drought, with obvious feelings of hopelessness that subsided as soon as it rained with their well-being being affected by the weather.
- RF place more importance on continuing education than CF.
- RF had higher community engagement and social life than CF.

5.5.2 What are the economic, environmental, and social indicators for a resilience framework, and how do the actions of regenerative and conventional beef cattle farmers align with the Stockholm Resilience Framework?

The research identified the economic, environmental, and social indicators for a resilience framework for Northern NSW beef farmers that align with the SRAP as follows.

The economic and environmental indicators for maintaining diversity and redundancy are:

- The number and type of other enterprises and income sources
- The level of income security and equity levels

- The amount of expenditure on hay, silage, grain, or agistment
- The ability to retain staff and the level of pay
- The number of marketing options for selling produce
- The level of biodiversity on the farm, and
- The balance of native and improved pasture mix and amount of species diversity

The environmental indicators for managing connectivity are:

- The amount of tree cover
- The presence of tree belts, wildlife corridors, nature strips, and
- Individuals and the family's level of connection to land and community

The environmental indicators for managing slow variables and feedbacks are:

- The adoption of farming practices more suitable to the environment and climate change, such as using organic inputs, adopting no-kill/no-till farming
- The adoption of on-farm landscape monitoring
- The level of information sharing between farming cohorts
- Having monitoring tools in place to gauge when to de-stock, and
- Having fenced-off/protected waterways and wetlands

The social and ecological indicators for understanding that social-ecological systems are complex adaptive systems are:

- The adoption of the holistic management framework for decision-making purposes, and
- The adoption of time-controlled/planned grazing management practices, with adequate rest periods and stock density

The social indicators for encouraging learning and experimentation are:

- The amount of ongoing education and training
- The amount of risk-taking or trying new ideas
- The level and depth of information sharing amongst peers, and
- Having monitoring systems in place

The social indicators for broadening participation are:

- The amount of social and community engagement, and
- The connection to First Nations people and knowledge

The economic indicators for promoting polycentric governance systems are:

- The ability to self-sustain without relying on larger governance systems
- Having circular economies in place, and
- Having local, state, and federal governance systems

5.5.3 What conclusions can be drawn about the resilience of cattle production systems in Northern NSW?

The thematic analysis concludes that CF and RF exhibit different beliefs, orientations, and behaviours. This variation is recognisable as differences in management actions.

When all the economic, environmental, and social variables were collated against the SRAP and displayed in the form of a summary radar graph (Figure 3.14), there were some apparent differences between the RF and the CF. RF rated higher against this Resilience Framework than CF, meaning RF were more resilient in a changing climate when it came to maintaining diversity and redundancy, managing connectivity, managing slow variables and feedbacks, encouraging learning and participation, and broadening participation.

The resilience of beef cattle production systems in Northern NSW needs to be looked at from an economic, environmental, and social perspective, understanding that without environmental resilience, there are no long-term positive economic outcomes. Without ecological resilience, social systems, including human wellbeing, break down, as do entire economies. Therefore, the resilience of Northern NSW cattle production systems is no different than other social-ecological systems when overlayed with a resilience framework such as the SRAP. Farmers beliefs, practices, and management decisions enormously impact the ability of themselves, their families, and their landscapes to remain resilient in a changing climate. Implementing regenerative practices for Northern NSW cattle production will assist producers to be resilient in a changing climate. Conventional approaches are not as resilient in drought conditions and a changing climate.

5.5.4 What are the Principles for Australian Regenerative Agriculture?

The research identified the principles for Australian RA as follows:

1. Be ecologically literate, think holistically, and understand complex adaptive systems
2. See your landscape as a community that you belong to and work with
3. Remain curious; seek transformative experiences and continuous learning
4. Acknowledge and consider diverse ways of working with landscapes
5. Engage in ecological renewal and make place-based decisions through monitoring
6. Engage with First Nations people
7. Understand that human cultures are co-evolving with their environments

5.5.5 How are they relevant to Northern NSW cattle production systems in a changing climate?

The RA principles can act as a guide for future farming practices, management decision-making, adaptation and transformation in climate change. While farming practices (and humans) continue to evolve and improve our understanding and knowledge of working with our ecological systems, what is currently considered ‘best practice’ now may not be in the future. The principles, however, will remain constant and assist farmers in navigating climate change and the associated economic, environmental, and social disruption and uncertainty it brings. While humans are co-evolving with the environment, learning to be ecologically literate, remaining curious and thinking holistically, acknowledging and considering diverse ways of working with landscapes, and having guidelines on how to navigate such change are critical if we are to remain resilient in the future. We will need to engage in ecological renewal and with the assistance of First Nations knowledge to help us navigate a very different future.

5.5.6 Are Australian regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate, and does a comparison of these production systems highlight the need for a set of guiding principles for regenerative agriculture in Australia?

When all the variables (economic, environmental, and social) were collated against the SRAP, there were apparent differences between the RF and CF. The RF rated higher against this Resilience Framework than the CF, meaning RF resilience in a changing climate will be stronger.

A set of guiding RA principles can assist farmers in navigating climate change and the associated economic, environmental, and social disruption and uncertainty it brings. The RA principles can inform future farming practices management decision-making and support adaptation and transformation to climate change.

5.6 Limitations and Future Research

5.6.1 Limitations of this research

The case study research was limited in that it included only one case study with a small sample size of participating farmers (13 - 16 over the period) representing a particular bioregion of Australia (New England in Northern NSW). Even though there were many variables measured

(100, later reduced to 60), the small sample size of participants affected the quantitative analysis, hence the use of a mixed methods approach, so as not to rely on just a quantitative approach. The need to use several research methodologies addressed concerns raised around integrating the data, cross validating the data to provide a more accurate and robust result in confirming the findings from a single case study consisting of a limited number of participants. For example, with the crosstabulation, for the most part, the inference was limited from Chi-Squared and Fisher's Exact tests due to the small sample, and Kendall's Tau provided only some statistical inference. In the correlation analysis, the results provided quantitative support for results generated in the crosstabulation analysis, which found some variation patterns associated with regenerative versus conventional farms, however, these results tended to not be statistically significant. Subsequently, the methodology moved to a qualitative approach utilising the thematic analysis to allow themes to emerge from the data and radar graphs to depict patterns of codes, adding meaning to the research from a resilience perspective.

The researcher acknowledges personal biases obtained from a long journey of transformation from conventional to regenerative farming and how these biases might influence the framing of the research questions, the methodology used, and the interpretation of the results. To address this, the researcher adopted a mixed-method approach, triangulating the results to ensure robustness and a thorough critique of the findings. In addition, the researcher in addressing potential biases focused on the research questions, the methods, and the results to ensure objectivity.

Great care should be taken in interpreting the differences between the two groups as being either regenerative or conventional. As the research has highlighted, there are nine identified regenerative discourses in Australia and a spectrum of transition from conventional practice towards regeneration. Identifying where a participant farmer sits on this spectrum can be polarising and divisive and at the very least not constructive towards inclusiveness and resilience in a changing climate.

Future research could include case studies in each agroecological zone in Australia, cross-cutting different agricultural sectors, and jurisdictions to obtain a more representative sample of Australian agriculture. In order to capture climate impacts, such research would still require a similar approach in comparing neighbour to neighbour, under the same climatic conditions, using a longitudinal and triple-bottom-line perspective to capture climate impacts.

It is important to note that for this research, all the SRAP and the farm management variables were weighted equally, but in reality, they may not be equal. It would also be difficult to examine them in isolation from each other, as all are required to achieve the long-term resilience of a system.

5.6.2 Future research recommendations

The need for further research on grazing management strategies and identified best management practices for grazing systems has been identified (McDonald et al., 2019), highlighting, for example, the improvements to ground cover and animal production per hectare from incorporating rest into grazing systems and, outlining the need for further studies into the benefits to overall biodiversity.

According to Quaranta et al. (2020) in Southern Europe, "under grazing is the main driver of pasture degradation and resilience requires a wider knowledge about the impact of practices on the ecological characteristics of pastures and an improved understanding of complex socio-environmental interactions underlying the adoption of such practices," providing further support for this research approach as well as its global application. Importantly, Quanranta et al. note that “ecological–economic imbalance, ultimately meet neither market demands nor ecosystem services…” and highlighting the need for “further investigation into a comparative analysis of livestock trajectories in different local contexts … with the final aim to gather an evidence-based support for sustainable management of grazing farmland” to avoid community abandonment of what is traditionally seen as rural grazing land.

Gosnell, Charnley, et al. (2020) also refer to the need for research in partnership with ranchers and graziers through more holistic and integrated approaches for social-ecological transformation. In addition, Gosnell concludes previous agricultural research was inhibited as these studies were based on the industrial paradigm, which was reductionist and narrow, focusing on generic specific criteria. Like others with previous debates around organics versus conventional agriculture (Shennan et al., 2017), the researcher welcomes the approach to framing the discussions around management systems but also seeks to expand the discussion further, incorporating management thinking and approaches, recognising discourse, and seeking common ground.

Gosnell, Charnley, et al. (2020) also outlines the need for more studies examining how farmers shift their approach to managing their properties, farm businesses, and personal lives — concluding that “transitioning to RA involves more than a suite of ‘climate-smart’ mitigation and adaptation practices supported by technical innovation, policy, education, and outreach. Rather, it involves subjective, nonmaterial factors associated with culture, values, ethics, identity, and emotion that operate at individual, household, and community scales and interact with regional, national, and global processes”. Their findings are important if we are to adopt strategies to transition to climate-smart RA.

Gordon’s research (2023) identifying the nine distinct discourses in the regenerative agricultural space and its potential as a conceptual framework for further discussion through their concept of a 'discourse coalition' provides an additional opportunity for this research around the PRA. Potentially using the 'Principles of Regenerative Agriculture' to start transformative conversations amongst the various discourses. Their paper also highlights the need to hold the complexity of the term without "resorting to over-simplified and restrictive definitions."

Khangura et al. (2023) have also recommended long-term farming systems trials comparing regenerative and conventional farming systems to build knowledge to make informed decisions to achieve resilience against climate change. Like others, Khangura struggles with the lack of definition hampering the research and fails to define the difference between principles and practices. According to Khangura et al., scientific evidence is mounting that RA practices restore soil health, sequester carbon, prevent soil degradation, and produce nutritionally rich food in dryland agriculture and that further extensive research is required to develop regionally specific regenerative agricultural approaches.

McLennon et al. (2021) advocate for both permaculture and RA and the benefits they bring to improving soil health, ecosystems, biodiversity, agricultural sustainability, and food security. Combining RA and sustainable practices with digital agriculture, artificial intelligence (AI), or machine learning (ML), according to McLennon, will benefit the future of agriculture and the planet. McLennon et al. support more robust, holistic research to ensure 'socio-economic' benefits and increase farm productivity to cope with climate change. Others have highlighted RA's potential to restore soil health, water quality, and biodiversity (Massy, 2020).

Burns (2021) suggests that understanding the potential strengths of regenerative farming and its claims with academic rigor can result in 'strategic climate innovation,' stating that farmers are currently leading the educating of other land managers on how to farm beyond conventional, industrial, and ‘capitalists farming’ systems to avoid degrading natural systems in pastures and rangelands.

Agricultural practices that enhance water infiltration and encourage water cycling in farming systems were identified by Basche and DeLonge (2019) as critical. Identifying and researching which agricultural practices enhance water cycle processors, water availability, and decrease runoff are important areas of future research. Basche comments that conventional farming practices leave bare soil vulnerable to degradation, and despite interest in infiltration rates, further research across a range of practices is required that encourage perennials for water infiltration, soil biology, nutrient cycling, and impacts of droughts and floods, with a focus on alternative farming systems rather than individual practices is required. This will help farmers mitigate the effects of climate change.

While researchers focus on greenhouse accounting frameworks for beef (and sheep) properties (Dunn et al., 2021) and even carbon-neutral beef for the Australian beef sector (Mayberry et al., 2019), farmers are beginning to focus on how to reduce their emissions and sequester carbon. They also focus on their livestock grazing techniques to enhance ecological processes around nutrient and water cycle and energy flow (Bailey et al., 2019). Bailey, et al. have highlighted the need for more research in this space as an alternative to mechanical and chemical manipulation of grasslands.

Ferguson and Diemont’s (2013) comparison study looking at the sustainability of holistic and conventional cattle ranching in Mexico, including interview and field observations, against economic, social, and environmental indicators also highlights the need for further triple bottom-line research concerning ranching (grazing) and the environment.

Another meta-analysis (di Virgilio et al., 2019; McDonald et al., 2019) conducted in the space has found increased ground cover, animal production, increased plant biomass, ground cover, animal weight gain, and production per hectare compared to conventional continuous grazing techniques. Further research on ecological and animal production trade-offs associated with different grazing strategies in the form of the duration of rest compared to graze time, which can affect species diversity and richness, is recommended.

Mosier et al. (2021) went one step further than this research in measuring both carbon and nitrogen levels by comparing neighbouring conventional and regenerative/holistic farms (referred to as adaptive multi-paddock (AMP) grazing). Their research concluded that AMP grazing had 13% higher carbon (C) and 9% more soil nitrogen (N) than the conventional sites to a 1m depth. Recognising that this sort of measurement was not in the scope of this particular research, this approach warrants further research in an Australian context, particularly given the current focus on climate change mitigation.

The complexity of agricultural systems requires holistic approaches to develop a set of indicators to facilitate agricultural sustainability into the future (Talukder et al., 2020). Brown et al. (Brown, Batterham, et al., 2022; Brown, Schirmer, et al., 2022) in their research found increased well-being in RA farmers due to increased farming self-efficacy and being able to manage for a range of outcomes and adapt to change through “holistic planning and monitoring” and “prioritising landscape regeneration”, concluding that RA may support long-term adaptation to climate variability due to RA’s potential to increase psychological wellbeing resources through self-efficacy and how essential it was too long term economic, environmental, and social sustainability. Therefore, a set of well-being indicators to track, compare, and measure could be an addition to the resilience framework developed in this thesis.

Research in New Zealand also identified a set of RA principles within the farm systems not dissimilar to the findings in this research (Grelet et al., 2021). They also proposed using leading indicators around well-being, economics, and resilience. The recommendations were outlined to inform and support the transition to RA, including highlighting successful case studies, longitudinal, large-scale, comparative approaches, looking at socio-economic factors with sufficient replication, and bringing in natural capital increases or decreases. A combination of benchmarked metrics was suggested.

Grassroots experimentation in RA has been identified as an opportunity to assist society's sustainability goals (Dipu et al., 2022).

5.6.3 Future challenges

The future challenges will include a more thorough understanding of what RA means to different people in the context of their environment and level of ecological knowledge and accepting that there is no widely accepted definition (Newton et al., 2020).

The other challenge will be acceptance of the various discourses and differences of opinion that exist within the regenerative agricultural movement and to avoid history repeating itself and the apparent divisions that have formed in other alternative farming practices (Gordon et al., 2023). In other words, "acknowledge and consider diverse ways of working with landscapes."

Avoiding 'greenwashing' by major corporations, will be an ongoing challenge. The corporate world continues to capitalise on consumers' concerns and is seeking certification, which can have elements of greenwashing, and to date, no authorised body is actively addressing the issue. There are various opinions associated with certification (Elrick et al., 2022). From a regenerative agricultural perspective, in light of the regenerative principles outlined in this research, certification is not congruent with the principle of "co-evolving with the environment and seeking transformative experiences and continuous learning," only specific practices can be certified, not the term regenerative itself.

Many are surging a way forward through these challenges (Gardner et al., 2019; Paradigm Foods, 2023; Regenerative Organic Alliance, 2022; Thurman, 2022). Most importantly, the challenge is how to continue to produce quality, nutritious food to sustain the human race while protecting our environments from climate change, including avoiding unsustainable farming practices, food shortages, water shortages, environmental pollution, and soil degradation (Massy, 2020). This research hopes to act as a guide to navigate these challenges and, in doing so, set farmers up to capitalise on the extraordinary opportunities that present themselves through ecosystem services, carbon markets, and enhancing landscape health and biodiversity.

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Appendix A: Ethics Approvals

Human Research Ethics
Research Services
University of New England
Armidale NSW 2351
Australia
Phone 02 6773 3715 **humanethics@une.edu.au www.une.edu.au/research-services**

HUMAN RESEARCH ETHICS COMMITTEE

MEMORANDUM TO: A/Prof Paul Kristiansen, Prof Oscar Cacho (EMPRO), Prof Derek Baker, Dr Jacqueline Williams and Ms Lorraine Gordon
School of Environmental and Rural Science

This is to advise you that the Human Research Ethics Committee has approved the following:

PROJECT TITLE: Evaluation of the Principles of Regenerative Agriculture

APPROVAL No.: **HE21-220**

COMMENCEMENT DATE: 25 November, 2021

APPROVAL VALID TO: 30 November, 2021

COMMENTS: Nil. Conditions met in full

The Human Research Ethics Committee may grant approval for up to a maximum of three years. For approval periods greater than 12 months, researchers are required to submit an application for renewal at each twelve-month period. All researchers are required to submit a Final Report at the completion of their project. The Progress/Final Report Form is available at the following web address: http://www.une.edu.au/research/research-services/rdi/ethics/hre/hrec-forms

The NHMRC National Statement on Ethical Conduct in Research Involving Humans requires that researchers must report immediately to the Human Research Ethics Committee anything that might affect ethical acceptance of the protocol. This includes adverse reactions of participants, proposed changes in the protocol, and any other unforeseen events that might affect the continued ethical acceptability of the project.

In issuing this approval number, it is required that all data and consent forms are stored in a secure location for a minimum period of five years. These documents may be required for compliance audit processes during that time. If the location at which data and documentation are retained is changed within that five year period, the Research Ethics Officer should be advised of the new location.

[redacted]

Bethany Ayers
HREC Secretary
Research Ethics Officer

Ethics Office
Research Development & Integrity
Research Division
Armidale NSW 2351
Australia
Phone 02 6773 3449
jo-ann.sozou@une.edu.au www.une.edu.au/research-services

HUMAN RESEARCH ETHICS COMMITTEE

MEMORANDUM TO: Prof Oscar Cacho, A/Prof Paul Kristiansen, Prof Derek Baker, Dr Jacqueline Williams & Ms Lorraine Gordon

UNE Business School

This is to advise you that the Human Research Ethics Committee has approved the following:

PROJECT TITLE: A longitudinal study looking at the resilience of regenerative beef cattle grazing systems in Northern NSW.

APPROVAL No.: **HE20-161**

COMMENCEMENT DATE: 13 October, 2020

APPROVAL VALID TO: 13 October, 2021

COMMENTS: Nil. Conditions met in full

The Human Research Ethics Committee may grant approval for up to a maximum of three years. For approval periods greater than 12 months, researchers are required to submit an application for renewal at each twelve-month period. All researchers are required to submit a Final Report at the completion of their project. The Progress/Final Report Form is available at the following web address: http://www.une.edu.au/research/research-services/rdi/ethics/hre/hrec-forms

The NHMRC National Statement on Ethical Conduct in Research Involving Humans requires that researchers must report immediately to the Human Research Ethics Committee anything that might affect ethical acceptance of the protocol. This includes adverse reactions of participants, proposed changes in the protocol, and any other unforeseen events that might affect the continued ethical acceptability of the project.

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[redacted]

Jo-Ann Sozou
Secretary/Research Ethics Officer

Ethics Office
Research Development & Integrity
Research Division
Armidale NSW 2351
Australia
Phone *02 6773 3449* **Fax** *02 6773 3543* **jo-ann.sozou@une.edu.au www.une.edu.au/research-services**

HUMAN RESEARCH ETHICS COMMITTEE

MEMORANDUM TO: Prof Oscar Cacho, Dr Paul Kristiansen, Prof Steve Walkden-Brown, A/Prof Lewis Kahn & Mrs Lorraine Gordon

UNE Business School

This is to advise you that the Human Research Ethics Committee has approved the following:

PROJECT TITLE: The sustainability of conventional and alternative beef cattle grazing systems in the high rainfall areas of Northern NSW

APPROVAL No.: HE15-007

COMMENCEMENT DATE: 29 April, 2015

APPROVAL VALID TO: 29 April, 2016

COMMENTS: Nil. Conditions met in full

The Human Research Ethics Committee may grant approval for up to a maximum of three years. For approval periods greater than 12 months, researchers are required to submit an application for renewal at each twelve-month period. All researchers are required to submit a Final Report at the completion of their project. The Progress/Final Report Form is available at the following web address: http://www.une.edu.au/research/research-services/rdi/ethics/hre/hrec-forms

The NHMRC National Statement on Ethical Conduct in Research Involving Humans requires that researchers must report immediately to the Human Research Ethics Committee anything that might affect ethical acceptance of the protocol. This includes adverse reactions of participants, proposed changes in the protocol, and any other unforeseen events that might affect the continued ethical acceptability of the project.

In issuing this approval number, it is required that all data and consent forms are stored in a secure location for a minimum period of five years. These documents may be required for compliance audit processes during that time. If the location at which data and documentation are retained is changed within that five year period, the Research Ethics Officer should be advised of the new location.

[redacted]

Jo-Ann Sozou
Secretary/Research Ethics Officer

Appendix B: Farm Survey 2016

Farmer Survey

Please ensure that the main decision makers on the property are the one's answering this survey. Thank you.

Background Information

* Required

1. **Name of participants**
   Please put christian name and surname of main decision maker.

   ____

2. **What is the name and address of your property? ***

   ____
   ____
   ____
   ____
   ____

3. **How many years have you been farming on this property?**
   Please also include in your answer how many years farming in general.

   ____

4. **What is the legal structure of your farm?**
   Check all that apply.

   - [ ] Sole Trader
   - [ ] Partnership
   - [ ] Company
   - [ ] Family Trust

5. **What is the size and tenure of your property in hectares?**
   If you have a couple of properties which are operated together then include them as long as they are over 200 hectares and receive 800 mm or more in rainfall.

   ____

6. **How many paddocks to you have in total?**

7. **What is the percentages of improved pasture as against native pasture or bush?**
   Please list all three and the percentages adding up to 100% next to them.

8. **What percentage of your property is used for commercial cattle grazing on pasture?**
   This includes both unimproved and improved pasture and fodder crops. Please list % improved, % native, % bush, % fodder.

9. **What other enterprises do you have on your property?**
   This might include: cropping, sheep, tourism, pigs etc

10. **What is your age bracket in years?**
    Mark only one oval.

    - 20-30
    - 31-40
    - 41-50
    - 51-60
    - 61-70
    - 70 plus

11. **What is your gender?**
Mark only one oval.

- ( ) Male
- ( ) Female

12. **What is the level of education reached?**
Mark only one oval.

- ( ) School Certificate or High School Certficate
- ( ) Tafe Certificate or Diploma
- ( ) University/Bachelor Degree
- ( ) PhD
- ( ) Other

13. **What farm records do you currently keep?**
Check all that apply.

- [ ] Cashflow Actual
- [ ] Cashflow Budget
- [ ] Gross Margins per enterprise
- [ ] Profit and Loss
- [ ] Balance Sheets
- [ ] Livestock breeding records
- [ ] Pasture records such as pasture feed budgeting
- [ ] Weight gain records and animal performance
- [ ] Stock movements and trading accounts
- [ ] Chemical usage and treatments
- [ ] Other

14. **Average annual rainfall over the past 3 years in millimetres**
Please list 2013, 2014, 2015 separately if available.

____
____
____
____
____

Farmer Survey continued

Farming Practices

15. **What type of farming system do you operate under?**
You may tick more than one box if you utilise a number of different systems. To qualify for Cell Grazing you would need to use charts for moving stock otherwise you would tick rotational grazing. To qualify as an Organic or Biodynamic Producer you would be either certified or moving towards certification.
Check all that apply.

- [ ] Conventional Grazing
- [ ] Rotational Grazing
- [ ] Holistic Grazing/Cell Grazing
- [ ] Biological Farming
- [ ] Organic Farming
- [ ] Biodynamic Farming

16. **If operating a number of different farming systems in different paddocks, please list the percentage of the system in relation to the whole farm.**
As per the farming systems ticked above.

____

____

____

____

____

17. **What year did you begin this type of farming system**

____

18. **For the last 2 years, how many head of cattle would you typically run in a mob in March/April?**
Please note you may be asked to fill in a more detailed Livestock Schedule at a later date.
Mark only one oval.

- ◯ Les than 50
- ◯ Between 50-70
- ◯ Between 70-100
- ◯ Between 100-120
- ◯ Between 120-150
- ◯ 150 or more

19. **For the last 2 years, how many head of cattle would you typically run in a mob in September/October?**

Please note you may be asked to fill in a more detailed Livestock Schedule at a later date.
Mark only one oval.

- Les than 50
- Between 50-70
- Between 70-100
- Between 100-120
- Between 120-150
- 150 or more

20. **What is the average size of your paddocks?**

Mark only one oval.

- 1-5ha
- 5-10ha
- 10-15ha
- 15-20ha
- 20-30ha
- 30-40ha
- 40-50ha
- 50 ha plus

21. **What is the number of paddocks in each of the above categories?**

In relation to the size of the paddocks as above.

Farmer Survey Continued

Farming Practices

You may be required to show a your grazing charts as an example.

22. **On average, how long would you keep a mob in the same paddock in March/April?**
Mark only one oval.

- 1-3 days
- 3-6 days
- 7 days or more
- 2 weeks or more
- 2 weeks - 1 month or more
- 1 month or more
- No planned rotation

23. **On average, how long would you keep a mob in the same paddocks in September/October?**
Mark only one oval.

- 1-3 days
- 3-6 days
- 7 days or more
- 2 weeks - 1 month
- 1 month or more
- No planned rotation

24. **If different classes are treated differently please list.**
In relation to how long you keep a mob in the same paddock.

25. **On average, how long do you rest your paddocks in the summer months?**
Mark only one oval.

- 0-1 week
- 1-2 weeks
- 2 weeks - 1 month
- 1-2 months
- 2 or more months
- No rest

26. **On average, how long do you rest your paddock in the winter months?**
Mark only one oval.

- ( ) 0-1 week
- ( ) 1-2 weeks
- ( ) 2 weekls - 1 month
- ( ) 1-2 months
- ( ) 2 or more months
- ( ) No rest

27. **On average, how high do you like to leave the grass in the paddocks?**
Mark only one oval.

- ( ) Eaten right down before moving the cattle
- ( ) Approximately 10cm in height
- ( ) Stubby bottle height (21 cm)
- ( ) Knee high

28. **What sort of soil fertility practices do you utilise over the past 3 years?**
Please list all types of fertiliser application including type, how often (spring, summer, autumn, winter) and the rate of application per hectare, as well as the proportion of the property it was applied to. You may required to submit a fertiliser application table if you don't have one.

29. **What sort of animal health practices do you undertake?**
Please include all drenches, vaccines and supplements, number of applications over 12 months, and the rates for the different classes of stock. You may be required to submit a chemical usage and treatment table.

30. **What are the main parasites and diseases you have experienced under your particular farming system?**
Please include parasites and diseases such as worms, liver fluke, lice, mastitis etc. What class of animal and % of the animal was infected? What % mortality was associated with each disease? You may be required to submit a parasite and disease table.

Farmer Survey

Resources

31. **What is the predominate soil type on your property?**

32. **What are the minimum and maximum temperatures in summer?**

33. **What are the minimum and maximum temperatures in winter?**

34. **Do you get frosts?**
Mark only one oval.
- None
- 1-10
- 10-60
- 60 plus frosts per year

35. **Do you grow fodder crops to finish your cattle?**
Mark only one oval.
- yes
- no

36. **If yes, how many hectares do you have under fodder crops?**

37. **What sort of fodder crops do you grow?**

38. **Do you do crop/pasture rotations?**
Mark only one oval.

- yes
- no

39. **List the top 5 weeds currently on your farm.**
Please rank in order of importance from 1 being important to 5 being less important.

40. **List the top 5 animal pests currently on your farm.**
This may include wild dogs, worms, ticks, lice etc.Please rank in order of importance from 1 being important to 5 being less important.

41. **List the top 5 cattle diseases currently on your farm.**
Please rank in order of importance from 1 being important to 5 being less important.

42. **Have your weeds increased or decreased over the last 3 years?**
Mark only one oval.

- Weeds have increased
- Weeds have decreased
- Remained the same

43. **Have your animal pests increased or decreased over the last 3 years?**
Mark only one oval.

- Pests have increased
- Pests have decreased
- Remained the same

44. **Have your animal diseases increased or decreased over the last 3 years?**
Mark only one oval.

- Diseases have increased
- Diseases have decreased
- Remained the same

45. **What percentage of timber covered areas do you have?**
Mark only one oval.

- 50% or higher
- 25-50%
- 25% or less
- none

Farmer Survey Continued

Labour

46. **Number of full time employees.**

47. **Number of part time employees.**

48. **Number of casual staff.**

49. **Number of contractors.**

50. **Of the above, how many are local people from your nearest town/village?**

51. **Of the above how many are family members?**

52. **How many outside volunteers?**

53. **How many unpaid family members?**
These might include family members who take a cut of profits instead of a wage.

54. **What is the average wage range for your employees on a per hourly basis?**
Mark only one oval.

- less than $20/hr
- $20-25/hr
- $25-$30/hr
- $30-$35/hr
- Above $35/hr
- volunteers

Farmer Survey Continued
Capital and Credit

55. **What percentage of your income is sourced off farm?**
Mark only one oval.

- 100%
- 75%
- 50%
- 25%
- none

56. **What is your current farm debt level on a scale of 1 -10?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Low amount of debt	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	High amount of debt

57. **What are your existing sources of capital?**
Check all that apply.

- [ ] Income from farm
- [ ] Income from outside sources
- [ ] Family loans
- [ ] Bank/Building Society/Credit Union loans
- [ ] Livestock Agent loans
- [ ] Shareholder equity/capital injections
- [ ] Other

58. **What is your level of debt in the property expressed as a percentage of capital?**

___

59. **What is your level of equity in the property, expressed as a percentage of overall capital?**

___

60. **What is your level of equity in your stock, expressed as a percentage of the overall value of your stock?**

___

Farmer Survey Continued

Livestock

You may be required to submit a Livestock Reconciliation Schedule.
You may also be required to submit a Marketing Table for your various classes of stock.

61. **What are the types of livestock being sold over the last 3 years?**
Check all that apply.

- [ ] Cows and Calves
- [ ] Weaners
- [ ] Yearlings
- [ ] Steers 160-340kg
- [ ] Steers 240-420kg
- [ ] Steers 240-460kg
- [ ] Heifers
- [ ] Young cattle - heavy feeder steers
- [ ] Young cattle 15 - 20 months
- [ ] Vealers

62. **What were your livestock numbers as at December 2015 ?**
Please include: bulls, cows, calves, weaners, yearling steers, yearling heifers, grown steers, grown heifers in your answer.

63. **What was the income from each of your various cattle enterprises?**
The amount you sold each class of stock for before costs of producing them.

64. **How much did you purchase the above stock for?**

65. **What was the 2015 cost of transporting the above cattle to your property?**

66. **What were your 2015 livestock and vet costs?**
This may include preg testing, 5 in 1 vaccines, drenching, lice treatment and vet visits. Please list the various treatments seperately.

67. **If you grow fodder crops, what was the 2015 cost of growing this crop?**

68. **Which cattle enterprise was the fodder crop used for?**

69. **How much did you spend in 2015 on hay, grain or silage (supplementary feeds)?**

70. **How much would you spend in 2015 on pasture maintenance?**
This includes both fertiliser, mineral applications and pasture seed. Please list the various applications and costs separately.

71. **What was the 2015 cost of selling your livestock?**
This would include freight, MLA levy, ear tags, LLS Rates

72. **Where do you sell your cattle?**
Check all that apply.

- [ ] Saleyards
- [ ] Direct to the local butcher
- [ ] Farmers markets
- [ ] Direct to restaurants
- [ ] Abbattoirs
- [ ] Export
- [ ] On-line
- [ ] Supermarkets
- [ ] Direct to restockers
- [ ] Through local beef producer marketing group
- [ ] Other

73. **What if any quotas, contracts, premium arrangements do you have in place?**

74. **With the above, what is the price per kg that you get for the various markets?**

75. **What are the benefits of selling via this system?**

76. **What are your reason's for choosing this particular selling system?**

Farmer Survey Continued

Aims and Objectives of the Farmer

77. **How would you rate out of 10, the importance of having a profitable farm?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Low importance											High importance

78. **How would you rate out of 10, the importance of improving your property for capital gain purposes?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Low importance											High importance

79. **How much is your farm a "way of life" or a "lifestyle choice"?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not about lifestyle											All about lifestyle

80. How would you rate your attitude to risk?

This could be in relation to trying something new such as a new enterprise, new ideas or a change in direction.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
I don't like to take on risk	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	I feel comfortable taking on risk

81. How often would you test a new idea?

Mark only one oval.

- ⬭ Constantly
- ⬭ Occasionally if it makes sense
- ⬭ Only when scientifically proven to work
- ⬭ Only when I can see the results for myself

82. How comfortable are you with long term debt?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not very comfortable	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Doesn't worry me

83. How comfortable are you with seasonal debt?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not very comfortable	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Doesn't worry me

84. What percentage of your family's living expenses are dependent on farm earnings?

Mark only one oval.

- ⬭ 100%
- ⬭ 75%
- ⬭ 50%
- ⬭ 25%
- ⬭ none, we have enough off farm income to cover living expenses

85. **What are your objectives/aims for your farm?**

86. **What are your objectives/aims in life?**

87. **What keeps you awake at night?**

Farmer Survey Continued

Social outcomes and personal situation

88. **How would you rate out of 10, your family relationships in general?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Poor	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Excellent

89. **How would you rate out of 10, your community engagement in general?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Poor	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Excellent

90. **How would you rate out of 10, your social life?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Excellent

91. **How would you rate your comittment and action when it comes to continuing education for yourself?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Excellent

92. **How would you rate your financial position?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Excellent

93. **How would you rate your physical health?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Excellent

94. **How would you rate your mental health?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Excellent

95. **How would you rate the amount of leisure time you have?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very little	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Plenty of time out

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Appendix C: Farmer Survey 2020

Lorraine Gordon
UNE Business School
University of New England
Armidale NSW 2351

Phone: 0417 317 390
Email: lsmith26@myune.edu.au

Farmer Survey

Basic information

1. Name of participants
Please put Christian name and surname of whoever is answering this survey

Click or tap here to enter text.

---

2. What is the name and address of your property?

Click or tap here to enter text.

---

3. What is the size of your property in hectares?

Click or tap here to enter text.

---

4. How many years have you been farming on this property?

Click or tap here to enter text.

---

5. What is the legal structure of your farm?
Check all that apply

☐Sole Trader
☐Partnership
☐Company
☐Family Trust

6. What percentage of your property is used for commercial cattle grazing on pasture? *This includes both unimproved and improved pasture and fodder crops*

Click or tap here to enter text.

---

7. What is your age bracket in years?
Mark only one box.

☐ 20-30
☐ 31-40
☐ 41-50
☐ 51-60
☐ 61-70
☐ 70 plus

8. What is your gender?
Mark only one box.

☐Male ☐Female

9. What is the highest level of education reached?
Mark only one box.

☐ School Certificate or High School Certificate
☐ Tafe Certificate or Diploma
☐ University/Bachelor Degree
☐ PhD
☐ Other Click or tap here to enter text.

10. What farm records do you currently keep?
Check all that apply

☐ Cost of Production
☐ Cashflow Actual
☐ Cashflow Budget
☐ Gross Margins per enterprise
☐ Other Click or tap here to enter text.

11. Average rainfall over the past 3-5 years *Mark only one box.*

☐ Less than 800 mls
☐ 800-1000 mls
☐ 1000-1200 mls
☐ 1200-1500 mls
☐ 1500-2000 mls

Farming practices

12. What type of farming system do you operate under?
You may tick more than one box if you utilise a number of different systems. To quantify for cell grazing you would need to use charts for moving stock otherwise you would tick rotational grazing. To quantify as an organic or biodynamic producer you would be either certified or moving towards certification.
Check all that apply.

☐ Conventional Grazing
☐ Rotational Grazing
☐ Holistic Grazing/Cell Grazing
☐ Biological Farming
☐ Organic Farming
☐ Biodynamic Farming

13. Number of years using this type of farming system?
Mark only one box.

☐ 1-3
☐ 3-5
☐ 5-10
☐ 10-15
☐ 15 plus

14. a) For the last 2 years, how many head would you typically run in a mob in March/April? *Mark only one box.*

☒ Less than 50
☐ Between 50-70
☐ Between 70-100
☐ Between 100-120
☐ Between 120-150
☐ 150 or more

b) How many mobs would you be running in March/April?

☐ 1 mob
☐ 2 mobs
☐ 3 mobs
☐ 4 or more mobs

15. a) For the last 2 years, how many head would you typically run in a mob in September/October?
Mark only one box.

☐ Less than 50
☐ Between 50-70
☐ Between 70-100
☐ Between 100-120
☐ Between 120-150
☐ 150 or more

b) How many mobs would you be running in September/October?

☐ 1 mob
☐ 2 mobs
☐ 3 mobs
☐ 4 or more mobs

16. What is the average size of your paddocks?
Mark only one box.

☐ 1 – 5 ha
☐ 5 – 10 ha
☐ 10 – 15 ha
☐ 15 – 20 ha
☐ 20 – 30 ha
☐ 30 – 40 ha
☐ 40 – 50 ha
☐ 50 ha plus

Farming practices

17. On average, how long would you keep a mob in the paddock in March/April?
Mark only one box.

☐ 1 - 3 days
☐ 3 - 6 days
☐ 7 days or more
☐ Depends on rainfall and size of the paddock.

18. On average, how long would you keep a mob in the paddock in September/October? *Mark only one box.*

☐ 1 - 3 days
☐ 3 - 6 days
☐ 7 days or more
☐ Depends on rainfall and size of the paddock.

19. On average, how long do you rest your paddock in the summer months?
Mark only one box.

☐ 1 week
☐ 2 weeks
☐ 1 month
☐ 1-2 months
☐ 2 or more months

20. On average, how long do you rest your paddock in the winter months? *Mark only one box.*

☐ 1 week
☐ 2 weeks
☐ 1 month
☐ 1-2 months
☐ 2 or more months

21. On average, how high do you like to leave the grass in the paddocks? *Mark only one box.*

☐ Eat right down before moving the cattle
☐ Approximately 10cm in height
☐ Beer can height
☐ Knee high

22. What sort of soil fertility practices to you utilise?

a) Please list all types of fertiliser application:

Click or tap here to enter text.

---

b) How often would you apply the above fertiliser?

Click or tap here to enter text.

---

c) At what rate would you apply it?

Click or tap here to enter text.

---

23. What sort of animal health practices do you undertake?
Please include all drenches, vaccines and supplements, how often and the rates.

Click or tap here to enter text.

24. What are the main parasites and diseases you have experienced under your particular farming system?
Please include parasites and diseases such as worms, live fluke, lice clostridial, mastitis, pesti etc.

Click or tap here to enter text.

Resources

25. What is the predominant soil type on your property?

Click or tap here to enter text.

---

26. What are the minimum and maximum temperatures in summer?

Click or tap here to enter text.

---

27. What are the minimum and maximum temperatures in winter?

Click or tap here to enter text.

---

28. How many frosts do you get in an average year? Click or tap here to enter text.

---

29. Do you grow fodder crops to finish your cattle?
Mark only one box.

☐ Yes ☐ No

30. If yes, how many hectares do you have under fodder?

Click or tap here to enter text.

---

31. What sort of fodder crops do you grow?

Click or tap here to enter text.

---

32. Do you do crop rotations?
Mark only one box.

☐ Yes ☐ No

33. List the top 3-5 weeds currently on your farm.

Click or tap here to enter text.

---

34. List the top 3-5 pests currently on your farm.

Click or tap here to enter text.

---

35. List the top 3-5 diseases currently on your farm/found in your cattle.

Click or tap here to enter text.

---

36. Have your weeds increased or decreased over the last 4 years? *Mark only one box.*

☐ Weeds have increased
☐ Weeds have decreased
☐ Remained the same

37. Have your pests increased or decreased over the last 4 years? *Mark only one box.*

☐ Pests have increased
☐ Pests have decreased
☐ Remained the same

38. Have your cattle diseases increased or decreased over the last 4 years? *Mark only one box.*

☐ Diseases have increased
☐ Diseases have decreased
☐ Remained the same

39. What percentage of timber covered areas would you have? *Mark only one box.*

☐ 50% or higher
☐ 2550%
☐ 25% or less
☐ None

Labour

40. Number of full-time employees.

Click or tap here to enter text.

---

41. Number of part time employees.

Click or tap here to enter text.

---

42. Number of casual staff.

Click or tap here to enter text.

43. Number of contractors.

Click or tap here to enter text.

44. Of the above, how many are local people from your nearest town/village?

Click or tap here to enter text.

45. Of the above how many are family members?

Click or tap here to enter text.

46. How many outside volunteers?

Click or tap here to enter text.

47. How many unpaid family members?
These might include family members who take a cut of profits instead of wage.

Click or tap here to enter text.

48. What is the average wage range for your employees on a per hourly basis?
Mark only one box.

☐ Less than $20/hr
☐ $20-25/hr
☐ $25-$30/hr
☐ $30-$35/hr
☐ Above $35/hr
☐ Volunteers

Capital and credit

49. What percentage of your income is sourced off farm?
Mark only one box.

☐ 100%
☐ 75%
☐ 50%
☐ 25%
☐ None

50. What is your farm debt level as a percentage of your equity in the farm? *Mark only one box.*

Low amount of debt High amount of debt
☐ 10% ☐ 20% ☐ 30% ☐ 40% ☐ 50% ☐ 60% ☐ 70% ☐ 80% ☐ 90% ☐ 100%

51. What are your existing sources of capital?
Check all that apply.

☐ Income from farm
☐ Income from outside sources
☐ Family loans
☐ Bank/Building Society/Credit Union loans
☐ Livestock Agent loans
☐ Shareholder loans
☐ Other

Livestock

52. What are the types of livestock being sold?
Check all that apply.

☐ Cows and Calves
☐ Weaners
☐ Yearlings
☐ Trade Steers/Hfrs 250-400kg
☐ Trade Steers/Hfrs 350-450kg
☐ Trade Steers/Hfrs 450 to 500kg
☐ Finished steers/hfrs 500Kg plus

53. What were your livestock numbers as at December last year?
Please include: bulls, cows, calves, weaners, yearling steers, yearling heifers, gown steers, grown heifers in your answer.

Click or tap here to enter text.

---

54. What was the income from each of your various cattle enterprises? The amount you sold each class of stock for before costs of producing them

Click or tap here to enter text.

---

55. How much did you purchase the above stock for?

Click or tap here to enter text.

56. What was the annual cost of carting the above cattle to your property?

Click or tap here to enter text.

---

57. What were your annual livestock and vet costs?
This may include preg testing, 5 in 1 vaccine, drenching, lice treatment and vet visits. Please list the various treatments separately.

Click or tap here to enter text.

---

58. If you grow fodder crops, what was the annual cost of growing this crop?

Click or tap here to enter text.

---

59. Which cattle enterprise was the fodder crop for?

Click or tap here to enter text.

---

60. How much did you spend over the last 12 months on hay, grain, silage or agistment?

Click or tap here to enter text.

---

61. How much would you spend annually on pasture maintenance?
This includes both fertiliser, mineral applications and pasture seed. Please list the various applications and costs separately.

Click or tap here to enter text.

---

62. What was the annual cost of selling your livestock?
This would include freight, MLA levy, ear tags, LLS Rates

Click or tap here to enter text.

Aims and objectives of the farmer

63. How would you rate out of 10, the importance of having a profitable farm?
Mark only one box.

Low importance High importance
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

64. How would you rate out of 10, the importance of improving your property for capital gain purposes?
Mark only one box.

Low importance High importance
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

65. How much is your farm a "way of life" or a "lifestyle choice"? *Mark only one box.*

Not about lifestyle All about lifestyle
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

66. How would you rate your attitude to risk?
This could be in relation to trying something new such as a new enterprise, new ideas or a change in direction.
Mark only one box.

I don't like to take on risk I feel comfortable taking on risk
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

67. How often would you test a new idea?
Mark only one box.

☐ Constantly
☐ Occasionally if it makes sense
☐ Only when scientifically proven to work
☐ Only when I can see the results for myself

68. How comfortable are your with debt?
Mark only one box.

Not very comfortable Doesn't worry me
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

69. What percentage of your family's living expenses are dependent on farm earnings? *Mark only one box.*

☐ 100%
☐ 75%
☐ 50%
☐ 25%
☐ None, we have enough off farm income to cover living expenses

70. What are your objectives/aims for your farm?

Click or tap here to enter text.

---

71. What are your objectives/aims in life?

Click or tap here to enter text.

---

72. What keeps you awake at night?

Click or tap here to enter text.

Social outcomes and personal situation

73. How would you rate out of 10, your family relationships in general?
Mark only one box.

Poor Excellent
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

74. How would you rate out of 10, your community engagement in general?
Mark only one box.

Poor Excellent
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

75. How would you rate out of 10, your social life?
Mark only one box.

Poor Excellent
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

76. How would you rate your commitment and action when it comes to continuing education for yourself? *Mark only one box.*

Poor Excellent
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

77. How would you rate your finances?
Mark only one box.

Poor Excellent
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

78. How would you rate your physical health?
Mark only one box.

Poor Excellent
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

79. How would you rate your mental health?
Mark only one box.

Poor Excellent

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

80. How would you rate the amount of leisure time you have?
Mark only one box.

Very little — Plenty of time out
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

81. How would you rate your ability to cope with problems that arise? *Mark only one box.*

Weak — Strong
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

82. How would you rate your outlook on life?
Choose one or more of the following

☐ Pessimist
☐ Optimist
☐ Somewhere in between
☐ You make your destiny
☐ Believe in fate
☐ My faith will get me through

Appendix D: Thematic Analysis Outline and Approach

Process: Read and re-read data in order to become familiar with what the data entails, paying specific attention to patterns that occur.
Result: Preliminary "start" codes and detailed notes.
Journal: List start codes in journal, along with a description of what each code means and the source of the code.

Comments regarding Lorraine's work Firstly, align my aims with the Resilient Framework)	**Lorraine's initial approach /examples**	**Resilience Factors to be used for coding**
Start codes might be (1) the presence or absence (0/1) of actions that adhere to each of the resilience elements. (2) 2-3 classes (economic, social, and environmental) for 2-3 coded variables for a set of questions that relate to beliefs. Note that the researcher is the one that names and describes those beliefs (3) 2-3 classes for 2-3 codes that address change between the two observations	Economic (Management Approach) 1. Having more than one enterprise Eg: Presence/Absence (0/1) 2. Selecting high yielding enterprise Eg: Breeder/Trader (0/1) 3. Money spent on hay, silage, grain or agistment in the drought Eg: (0-2K =1, 2-5K =2, 5K plus = 3) 4. Money spent on animal health Eg: per head 1,2,3 as above 5. Pay rates for employees Eg: Award/Above Award (1/2) 6. Sell into more profitable markets Eg: saleyard/other (1/2) 7. Presence of other income sources Eg: 100%/less than 100% 8. Level of direct interaction with the consumer Eg: Direct/not direct Environmental (Both Management and Beliefs) 1. Proportion of tree cover 2. Amount of biodiversity of pasture through native pasture mix 3. Use of organic fertiliser application Social (Both Beliefs and Wellbeing) 1. Financial situation 2. Community engagement 3. Social life 4. Continuing education 5. Problem coping 6. Testing new ideas 7. Outlook on life	**Maintain diversity and redundancy** 1. Having more than one enterprise a. Eg: Presence/Absence (0/1) 2. Money spent on hay, silage, grain or agistment in the drought a. Eg: (0-2K =1, 2-5K =2, 5K plus = 3) 3. Presence of other income sources a. Eg: 100%/less than 100% 4. Financial situation 5. Debt to Equity ratio 6. Proportion of tree cover 7. Amount of biodiversity of pasture through native pasture mix 8. Rest and recovery type grazing systems **Manage connectivity** 9. Proportion of tree cover 10. Amount of biodiversity of pasture through native pasture mix 11. Community engagement 12. Social life

		Manage slow variables and feedbacks 13. Financial situation 14. Continuing education 15. Problem coping 16. Testing new ideas **Understanding that social-ecological systems are complex adaptive systems** 17. Use of organic fertiliser application or not 18. Using Holistic Grazing Techniques or not 19. Grazing Management Practices are they Regenerative or not **Encourage learning and experimentation** 20. Continuing education 21. Problem coping 22. Testing new ideas 23. Levels of taking on risk 24. Levels of information sharing ie: member of Hoffman COP or not, member of Ebor Beef or not **Broaden participation** 25. Community engagement 26. Social life **Promote polycentric governance systems** 27. member of Ebor Beef or not 28. Marketing system and provenance 29. Member of Local RFS 30. Level of direct interaction with the consumer Eg: Direct/not direct

Phase 2. Process and classify the codes

Process: Generate the initial codes by documenting where and how patterns occur. This happens through data reduction where the researcher collapses data into labels in order to create categories for more efficient analysis. Data complication is also completed here. This involves the researcher making inferences about what the codes mean.
Result: Comprehensive codes of how data answers research question
Journal: Provide detailed information as to how and why codes were combined, what questions the researcher is asking of the data, and how codes are related.

Comments regarding Lorraine's work	Lorraine's initial approach /examples
Spell out the research questions being addressed (re-evaluate now I have collated the data) Simple analysis of codes from phase 1 into summaries and then group them together (note the need to explain why the groups are assembled and what the relationship is to the research question) Give a name to the summary codes and detail which classes of the code mean what.	Are Northern NSW regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate? 1. Economic indicators for resilience (to manage diversity and redundancy, slow variables and feedbacks and connectivity) 2. Environmental indicators for resilience (to manager diversity and redundancy, slow variables and feedbacks and foster complex adaptive systems thinking) 3. Social indicators for resilience (to broaden participation, encourage learning, foster complex adaptive systems thinking)

Phase 3.

Process: Combine codes into overarching themes that accurately depict the data. It is important in developing themes that the researcher describes exactly what the themes mean, even if the theme does not seem to "fit". The researcher should also describe what is missing from the analysis.
Result: List of candidate themes for further analysis.
Journal: Reflexivity journals need to note how the codes were interpreted and combined to form themes.

Comments regarding Lorraine's work	Lorraine's initial approach /examples
Assemble some candidate themes by combining the simple themes, for example: a) Beliefs and basis b) Actions and basis c) Congruence of beliefs and action d) Divergence of beliefs and actions e) Constraints and Facilitators for management actions	Themes around: 1. Economic Themes: Diversifying, Inputs and Outputs 2. Environmental Themes: Biodiversity, soil and water quality 3. Social Themes: Community, Education and Outlook Beliefs compared to actions with the above themes Constraints Facilitators for actions NB: Themes are Beliefs, Management Approaches and Wellbeing. Which align with the Resilient Framework and go across three areas.

Phase 4. Relate to research questions and theoretical frameworks

Process: In this stage, the researcher looks at how the themes support the data and the overarching theoretical perspective. If the analysis seems incomplete, the researcher needs to go back and find what is missing.
Result: Coherent recognition of how themes are patterned to tell an accurate story about the data.
Journal: Notes need to include the process of understanding themes and how they fit together with the given codes. Answers to the research questions and data-driven questions need to be abundantly complex and well-supported by the data.

Comments regarding Lorraine's work	**Lorraine's initial approach /examples**
Identify the relationship between the Resilience Framework and a), b), c), and d), e) as emerging from the data Use the Stockholm Resilience Framework but reference others such as Derek's and Climate Works @ Monash.	1. Economics themes affect: manage diversity and redundancy, slow variables and feedbacks, and connectivity in the resilience framework. 2. Environmental themes affect; manager diversity and redundancy, slow variables and feedbacks, and foster complex adaptive systems thinking in the resilience framework 3. Social themes affect: broaden participation, encourage learning, foster complex adaptive systems thinking in the resilience framework

Phase 5.

Process: The researcher needs to define what each theme is, which aspects of data are being captured, and what is interesting about the themes.
Result: A comprehensive analysis of what the themes contribute to understanding the data.
Journal: The researcher should describe each theme within a few sentences.

Comments regarding Lorraine's work	**Lorraine's initial approach /examples**
Relate the dissertation's research questions to the Resilience Framework and the themes emerging.	Are Northern NSW regenerative beef cattle production systems more resilient than conventional beef cattle production systems in a changing climate? Focusing on the Dorrigo/Ebor plateau and parts of the New England Tablelands in Northern NSW: 1. How does the Resilience Framework as presented by the 'Stockholm Group of Scientists' fit into the context of Northern NSW beef cattle production systems? 2. What does a resilience framework for Northern NSW beef cattle production systems look like? a. What are the environmental, social and economic indicators for a resilience framework? 3. What beliefs and practices (ie: management decisions) are made by Northern NSW beef farmers in a changing climate? a. Regenerative beef farmers? b. Conventional beef farmers?

Phase 6. Writing (interpretation)

Process: When the researchers write the report, they must decide which themes make meaningful contributions to understanding what is going on within the data. Researchers should also conduct member checking. This is where the researchers go back to the sample at hand to see if their description is an accurate representation.
Result: A thick description of the results.
Journal: Note why particular themes are more useful at making contributions and understanding what is going on within the data set. Describe the process of choosing the way in which the results would be reported.

Comments regarding Lorraine's work	Lorraine's initial approach /examples
Outline a set of potential actions that producers are taking or might take, in relation to the Resilience Framework and thematic explanations for beliefs or divergence between belief and action. Then identify steps which might to be taken (by government, farmer, adviser or other) to enhance resilience. Use these steps and the evidence from the Thematic Analysis to answer the research questions.	Bring in the Principles and Practices for Regenerative Agriculture here as a recommendation for enhancing resilience. Cover why some are reluctant to take them up even though they are aware of challenges around climate change. 1. What regenerative grazing practices assist farmers to be more financially resilient in a changing climate? Economics resilience: manage diversity and redundancy, slow variables and feedbacks, and connectivity in the resilience framework. Economic Themes: Diversifying, Inputs and Outputs 2. What regenerative grazing practices deliver long term environmental resilience in a changing climate? Environmental resilience; manager diversity and redundancy, slow variables and feedbacks, and foster complex adaptive systems thinking in the resilience framework Environmental Themes: Biodiversity, soil and water quality 3. What regenerative practices assist farmers to be more mentally and physically resilient in a changing climate? Social resilience: broaden participation, encourage learning, foster complex adaptive systems thinking in the resilience framework Social Themes: Community, Education and Outlook

Appendix E: Principles of Regenerative Agriculture Survey

Principles of Regenerative Agriculture

The aim of this survey

This short online survey for regenerative agriculture farmers, graziers and consultants across Australia is to test the "Principles of Regenerative Agriculture" that can provide resilience in a changing climate, increase biodiversity and sequester carbon into the future. The survey will take approximately 6 minutes.

No personal information is collected in this online survey, your contribution as a Regenerative Agriculture practitioner is anonymous. For further information please read the "Information Sheet for Participants".

Consent of Participant

- I have read the information contained in the Information Sheet for Participants and any questions I have asked have been answered to my satisfaction.
- I agree to participate in this study, with the understanding that:

My participation is voluntary,
My contribution is anonymous
Information concerning my identity will not be collected, and
I may withdraw at any time without consequences & without follow-up.

- I agree that the anonymous research data collected for the study will form part of a thesis and may be published, or presented at conferences as a later date.
- I agree that I may be quoted using a
- pseudonym I am 18 years of age or older.
- In preservation of anonymity, I understand that no name or signature is required of me to give consent.
- By activating the proceed button below I am agreeing to the above and also to participate in this study.

Principles of Regenerative Agriculture

* 1. Are you a farmer?

☐ Yes

☐ No (specify your occupation)

Principles of Regenerative Agriculture

Do you agree with these principles?

* 2. Do you agree or disagree with the following principle on a scale of 1-10 (1 being strongly disagree and 10 being highly agree)

Be ecologically literate, think holistically and understand complex adaptive systems: Appreciate how ecosystems behave in complex, adaptive and often unpredictable ways. Consider how the landscape is nested within, and interconnected with, smaller and larger ecological, social and economic systems.

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

* 3. Do you agree or disagree with the following principle on a scale of 1-10 (1 being strongly disagree and 10 being highly agree)

See your landscape as a community that you belong to and work with: Your ecosystem is a community of species that you are part of. Do not try and control the members of this community but work alongside them.

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

* 4. Do you agree or disagree for each principle on a scale of 1-10 (1 being strongly disagree and 10 being highly agree)

Acknowledge and consider diverse ways of working with landscapes: There are many approaches to managing landscapes and be open to integrating them with your practice.

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

* 5. Do you agree or disagree with the following principle on a scale of 1-10 (1 being strongly disagree and 10 being highly agree)

Understand that human cultures are co-evolving with their environment: People and landscapes are relational. We are co-evolving with our environments on a biological and cultural level.

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

* 6. Do you agree or disagree with the following principle on a scale of 1-10 (1 being strongly disagree and 10 being highly agree)

Engage with First Nations people: Be active in reconciling the trauma of landscapes and displaced communities.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

* 7. Do you agree or disagree with the following principle on a scale of 1-10 (1 being strongly disagree and 10 being highly agree)

Remain curious; seek transformative experiences and continuous learning: Be comfortable in the ambiguity that comes with not having all the answers, be open to paradigm shifts and expanding your thinking.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

* 8. Do you agree or disagree with the following principle on a scale of 1-10 (1 being strongly disagree and 10 being highly agree)

Engage in ecological renewal and make place-based decisions through monitoring: Focus on and monitor landscape functions such as biodiversity, soil health, carbon sequestration, ground cover, water cycles, mineral cycles and energy flow.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Principles of Regenerative Agriculture

Ranking

* 9. Rank these principals in order of importance

Be ecologically literate, think holistically and understand complex adaptive systems

See your landscape as a community that you belong to and work with

Acknowledge and consider diverse ways of working with landscapes

Understand that human cultures are co-evolving with their environments

Engage with First Nations people

Remain curious; seek transformative experiences and continuous learning

Engage in ecological renewal and make place-based decisions through monitoring

Appendix F: Information Sheet and Consent Form 2016

School of Environmental and Rural Science
University of New England
Armidale NSW 2351

Phone: 0427 200 365
Email: Ismith26@une.edu.au

Information Sheet for Participants

My name is Lorraine Gordon, and I am conducting this research as part of my PhD, through the Business School at the University of New England, New South Wales, Australia. My supervisors are Prof. Oscar Cacho, Dr Paul Kristiansen, Prof. Stephen Walkden-Brown, Assoc. Prof. Lewis Kahn and Prof. Derek Baker. I wish to invite you to participate in my research project, described below.

Research Project	The sustainability of conventional and alternative beef cattle grazing systems in the high rainfall areas of Northern NSW.
Research aims	The overall aim of the study is to examine four different grazing systems (conventional, organic, biodynamic and holistic) under similar climatic conditions to determine which systems or hybrids of systems and practices deliver superior performance in sustainability outcomes defined in terms of economic, social and environmental performance (the triple bottom line). The study also aims to assess whether alternative solutions to the use of chemical fertilisers and pesticides in beef production are profitable under the conditions typical of the study region and to determine how supply chain issues may affect overall profitability.
Interview	I would like to conduct a face-to-face interview with you at your home or office or farm. The interview will take approximately 1-2 hours. With your permission, I will make an audio recording of the interview to ensure that I accurately recall the information you provide. Following the interview, a transcript will be provided to you if you wish to see one. In addition, I would also like to take some soil samples and photographs of the property (for the purpose of measuring environmental outcomes and natural resource management indicators).
Length of Research	It is anticipated that the research will be carried out over a two-year period with up to four visits to each farm in both winter and summer periods. Each visit may take up to a couple of hours of the producer's time.
Confidentiality	Any information or personal details gathered in the course of the study will remain confidential. No individual or farm will be identified by name in any publication of the results. Although you may be quoted, all names will be re laced by pseudonyms; this will ensure that you are not identifiable.

Participation is Voluntary	Please understand that your involvement in this study is voluntary and I respect your right to withdraw from the study at any time. You may discontinue the interview at any time without consequence and you do not need to provide any explanation if you decide not to participate or withdraw. All producers who have lived in the selected areas for at least 3 years, and are 18 years or older, may be invited to participate in this project.
Questions	The interview questions are about your production practices, costs, benefits, constraints and marketing strategies. There will be questions around Gross Margins, Profitability and Wellbeing.
Use of information	I will use information from the interview as pan of my PhD thesis, which I expect to complete in the end of October 2018. Information from the interview may also be used in journal articles and conference presentations. At all times, I will safeguard your identity by presenting the information in way that will not allow you to be identified.
Upsetting issues	It is unlikely that this research will raise any personal or upsetting issues but if it does you may wish to contact your local Falm Financial Counsellor. The name and contact details are as follows: The Salvation Amy Money Care North NSW (02) 6775 4750 The Salvation Amy Money Care Armidale NSW (02) 6771 4186 Lifeline Armidale NSW (02) 6771 3372 Lifeline Coffs Harbour NSW (02) 6651 4093 Lifeline North Coast NSW 13 11 14
Storage of information	I will keep hardcopy recordings and notes of the interview in a locked cabinet at my office on the Mid North Coast. Any electronic data will be kept on a password-protected computer in the same location. Only the research team will have access to the data.
Disposal of information	All the data collected in this research will be kept for a minimum of five years after successful submission of my thesis, after which it will be disposed of by deleting relevant computer files and destroying or shredding hardcopy materials.
Approval	This project has been approved by the Human Research Ethics Committee of the University of New England (Approval No. HE15-007 Valid to 24/4/16.).
Contact details	Feel free to contact me with any questions about this research by email at Igordon@myune.edu.au or by phone on 02 6655 6223. You may also contact my supervisors. Principal Supervisor: Prof. Oscar Cacho, ocacho@une.edu.au or 02 6773 3215 Co-supervisors: Dr. Paul Kristiansen, paul.kristiansen@une.edu.au, 02 6773 2025 Prof. Derek Baker, derek.baker@une.edu.au, 02 6773 2627 Prof. Steve Walkden-Brown, swalkden@une.edu.au or 02 6773 5152 Assoc. Prof. Lewis Kahn, Ikahn3@une.edu.au or 02 6773 2997
Complaints	The Research Ethics Officer at: Research Services University of New England Armidale, NSW 2351 Tel: (02) 6773 3449 Fax: (02) 6773 3543

	Email: ethics@une.edu.au

Thank you for considering this request and I look forward to further contact with you.

Sincerely,

[redacted]

Lorraine Gordon

University of
New England

UNE Business School
University of New England
Armidale NSW 2351

Phone: 0427 200 365
Email: Ismith26@myune.edu.au

CONSENT FORM for PARTICIPANTS

Research Project:

The sustainability of conventional and alternative beef cattle grazing systems in the high rainfall areas of Northern NSW.

I ………………………………………………………………….. have read the information contained in the Information Sheet for Participants and any questions I have asked have been answered to my satisfaction.	Yes/No
I agree to participate in this research activity, realising that I may withdraw at any time.	Yes/No
I agree that research data gathered for the study may be published using a pseudonym.	Yes/No
I agree that I may be quoted using a pseudonym.	
I agree to the interviewer having my audio recorded and transcribed.	
I agree to the Student researcher taking soil samples on the property.	Yes/No
I agree to the Student researcher taking photographs of the property.	Yes/No
I would like to receive a copy of the transcription of the interview.	Yes/No
I would like to receive a copy of the completed research.	
I am 18 years of age or older.	Yes/No
I am a farmer with over 12 months experience	Yes/No
I am the owner/manager of the property	Yes/No

…………………………………….. ……………………………………..

Participant Date

[redacted]

Researcher Date

[redacted]

HE 15-007

Appendix G: Information Sheet and Consent Form 2020

School of Environmental and Rural Science
University of New England
Armidale NSW
2351

Phone: 0427 200 365
Email: lsmith26@une.edu.au

Information Sheet for Participants

My name is Lorraine Gordon and I am conducting this research as part of my PhD, through the Business School at the University of New England, New South Wales, Australia. My supervisors are Prof. Oscar Cacho, Dr Paul Kristiansen, Prof. Stephen Walkden-Brown, Assoc. Prof. Lewis

Kahn and Prof. Derek Baker. I wish to invite you to participate in my research project, described below.

Research Project	The sustainability of conventional and alternative beef cattle grazing systems in the high rainfall areas of Northern NSW.
Research aims	The overall aim of the study is to examine four different grazing systems (conventional, organic, biodynamic and holistic) under similar climatic conditions to determine which systems or hybrids of systems and practices deliver superior performance in sustainability outcomes defined in terms of economic, social and environmental performance (the triple bottom line). The study also aims to assess whether alternative solutions to the use of chemical fertilisers and pesticides in beef production are profitable under the conditions typical of the study region and to determine how supply chain issues may affect overall profitability.
Interview	I would like to conduct a face-to-face interview with you at your home or office or farm. The interview will take approximately 1-2 hours. With your permission, I will make an audio recording of the interview to ensure that I accurately recall the information you provide. Following the interview, a transcript will be provided to you if you wish to see one. In addition, I would also like to take some soil samples and photographs of the property (for the purpose of measuring environmental outcomes and natural resource management indicators).
Length of Research	It is anticipated that the research will be carried out over a two-year period with up to four visits to each farm in both winter and summer periods. Each visit may take up to a couple of hours of the producer's time.

Confidentiality	Any information or personal details gathered in the course of the study will remain confidential. No individual or farm will be identified by name in any publication of the results. Although you may be quoted, all names will be re laced by pseudonyms; this will ensure that you are not identifiable.
Participation is Voluntary	Please understand that your involvement in this study is voluntary and I respect your right to withdraw from the study at any time. You may discontinue the interview at any time without consequence and you do not need to provide any explanation if you decide not to participate or withdraw. All producers who have lived in the selected areas for at least 3 years, and are 18 years or older, may be invited to participate in this project.
Questions	The interview questions are about your production practices, costs, benefits, constraints and marketing strategies. There will be questions around Gross Margins, Profitability and Wellbeing.
Use of information	I will use information from the interview as part of my PID thesis, which I expect to complete in the end of October 2018. Information from the interview may also be used in journal articles and conference presentations. At all times, I will safeguard your identity by presenting the information in way that will not allow you to be identified.
Upsetting issues	It is unlikely that this research will raise any personal or upsetting issues but if it does you may wish to contact your local Farm Financial Counsellor. The name and contact details are as follows: The Salvation Amy Money Care North NSW (02) 6775 4750 The Salvation Amy Money Care Armidale NSW (02) 6771 4186 Lifeline Armidale NSW (02) 6771 3372 Lifeline Coffs Harbour NSW (02) 6651 4093 Lifeline North Coast NSW 13 11 14
Storage of information	I will keep hardcopy recordings and notes of the interview in a locked cabinet at my office on the Mid North Coast. Any electronic data will be kept on a password-protected computer in the same location. Only the research team will have access to the data.
Disposal of information	All the data collected in this research will be kept for a minimum of five years after successful submission of my thesis, after which it will be disposed of by deleting relevant computer files and destroying or shredding hardcopy materials.
Approval	This project has been approved by the Human Research Ethics Committee of the University of New England (A roval No HE20-161 Valid to 13/10/21.).
Contact details	Feel free to contact me with any questions about this research by email at Igordon@myune.edu.au or by phone on 02 6655 6223. You may also contact my supervisors. Principal Supervisor: Prof. Oscar Cacho, ocacho@une.edu.au or 02 6773 3215 Co-supervisors: Dr. Paul Kristiansen, paul.kristiansen@une.edu.au, 02 6773 2025 Prof. Derek Baker, derek.baker@une.edu.au, 02 6773 2627 Prof. Steve Walkden-Brown, swalkden une.edu.au or 02 6773 5152 Assoc. Prof. Lewis Kahn, Ikahn3 une.edu.au or 02 6773 2997

Complaints	The Research Ethics Officer at: Research Services University of New England Armidale, NSW 2351 Tel: (02) 6773 3449 Fax: (02) 6773 3543 Email: ethics@une.edu.au

Thank you for considering this request and I look forward to further contact with you.

Sincerely,

[redacted]

Lorraine Gordon

University of New England

UNE Business School University of New England une Armidale NSW 2351
Phone: 0427 200 365
Email: lsmith26@myune.edu.au

CONSENT FORM for PARTICIPANTS

Research Project:

The sustainability of conventional and alternative beef cattle grazing systems in the high rainfall areas of Northern NSW.

I ……………………………………………………………………….. have read the information contained in the Inf01mation Sheet for Participants and any questions I have asked have been answered to my satisfaction.	
I agree to participate in this research activity, realising that I may withdraw at any time.	
I agree that research data gathered for the study may be published using a pseudonym.	Yes/No
I agree that I may be quoted using a pseudonym.	Yes/No
I agree to the interviewer having my audio recorded and transcribed.	Yes/No
I agree to the Student researcher taking soil samples on the property.	Yes/No
I agree to the Student researcher taking photographs of the property.	
I would like to receive a copy of the transcription of the interview.	YesTN0
I would like to receive a copy of the completed research.	
I am 18 years of age or older.	Yes/No
I am a farmer with over 12 months experience	Yes/No
I am the owner/manager of the property	Yes/No

…………………………………….. ……………………………………..

Participant Date

[redacted]

Researcher Date

[redacted]

HE20-161

Appendix H: Information Sheet for Online Survey

Lorraine Gordon
UNE Business School
University of New England
Armidale NSW 2351

Phone: 0417 317 390
Email: lsmith26@myune.edu.au

Information Sheet for Participants

My name is Lorraine Gordon, and I am conducting an online survey to evaluate the "Principles of Regenerative Agriculture". This research is part of my PhD, through the Business School at the University of New England, New South Wales, Australia. My supervisors are Assoc. Prof. Paul Kristiansen, Prof. Oscar Cacho, Prof. Derek Baker and Dr Jacqueline Williams. I wish to invite you to participate in my research project, described below.

Research Project	**Evaluation of the Principles of Regenerative Agriculture**
Aim of the Research	This research aims to survey regenerative agriculture farmers, graziers and consultants across Australia to test the "Principles of Regenerative Agriculture" that can provide resilience in a changing climate, increase biodiversity and sequester carbon into the future.
Survey	I would like to conduct a short online survey for you to complete. The survey will take approximately 6 minutes.
Confidentiality	No personal information is collected in this online survey, your contribution as a Regenerative Agriculture practitioner is anonymous.
Participation is Voluntary	Please understand that your involvement in this study is voluntary and we respect your right to stop participating in the study at any time without consequence and without needing to provide an explanation, however, once you begin the survey your anonymous data which you have already provided cannot be withdrawn.

Questions	The survey questions will not be of a sensitive nature, rather they are general and focused on ranking of the "Principles of Regenerative Agriculture".
Use of information	I will use information from the survey as a chapter of my PhD thesis. Information from the survey results may also be used in journal articles and conference presentations.
Upsetting issues	It is unlikely that this research will raise any personal or upsetting issues but if it does you may wish to contact Lifeline Australia on 131114.
Storage of information	Any electronic data will be kept on cloud.une.edu.au, UNE's centrally managed cloud server managed by the research team. It will also be kept on a password protected computer. Hard copy data and information will be stored in a locked filing cabinet within my office. The online survey platform (SurveyMonkey) will be used in the data collection phase, however SurveyMonkey does not have permission to view or access the data.
Disposal of information	All the data collected in this research will be kept for a minimum of five years after the successful submission of my thesis, after which it will be disposed of by deleting relevant computer files and destroying or shredding hardcopy materials.
Approval	This project has been approved by the Human Research Ethics Committee of the University of New England (Approval No **HE21-220**, Valid to 30/11/2021).
Researcher contact details	Feel free to contact me with any questions about this research by email at lsmith26@myune.edu.au or 0417317390. You may also contact my supervisors. Principal Supervisor: Dr. Paul Kristiansen, paul.kristiansen@une.edu.au, 02 6773 2025 Co-supervisors: Prof. Oscar Cacho, ocacho@une.edu.au or 02 6773 3215 Prof. Derek Baker, Derek.baker@une.edu.au 02 6773 2627 Dr Jacqueline Williams, jackydorrigo2@bigpond.com or 0428542214

Complaints	Should you have any complaints concerning the manner in which this research is conducted, please contact: Human Research Ethics Officer Research Services, University of New England Armidale, NSW 2351 Tel: (02) 6773 3715, Email: humanethics@une.edu.au

Thank you for considering this request and I look forward to further contact with you.

Sincerely,

[redacted]

Lorraine Gordon