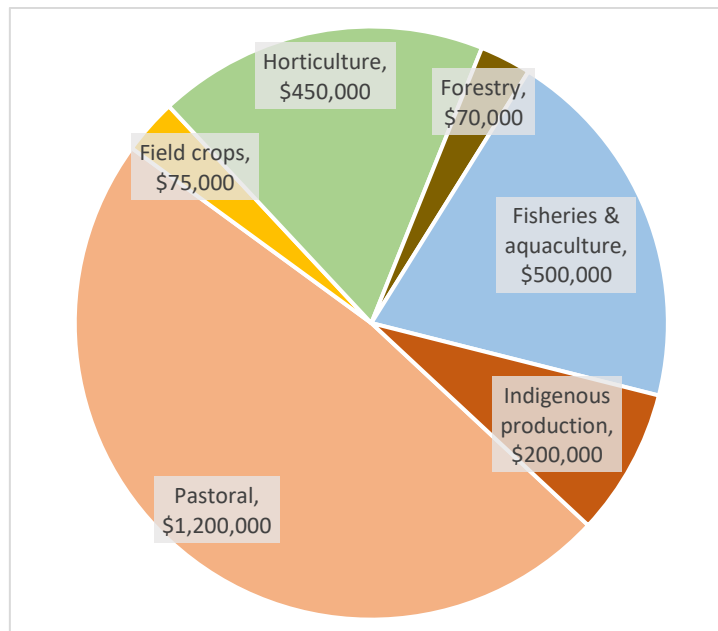


1. Executive summary

The Northern Hub region occupies a third of Australia. The annual production from land and water resources is estimated at \$2.45 bn. In the chart below, pastoral and horticultural enterprises include those under Indigenous management and ownership. Indigenous management of country includes tourism, fire management for the carbon economy, ranger services, and traditional hunting and collecting.



Annual production of Northern Hub sectors

1.1 Key messages

Addressing resilience to climate variation and change is more meaningful than addressing resilience to drought in the Northern Hub region. Average temperatures have increased and will continue to rise. Cyclones, fire, flooding, and heat waves will become more intense. Central Australia will become more arid.

Indigenous management of country

The Hub has a large Indigenous community by population and land custodianship, who are the most susceptible to climate change. Rising temperatures will impact health, may limit tourism, and coastal wild food sources will diminish.

Pastoral

Low input, low output beef production is the dominant industry. Changes to pasture will reduce nutrition and increase fire risk. Heat stress of livestock will reduce growth and reproduction rates. Supply chain disruptions from extreme weather events will increase.

Field crops & Horticulture

Plant water use efficiency will decline, and pathogens may increase. Sowing windows will change. Genetic adaptation to changing regional climates will require sophisticated breeding programs. Extreme weather events will bring losses to yield and soils.

Forestry

Diversified sector with different products and value chains. Climate change impacts are not well understood.

Fisheries & Aquaculture

Fisheries are mostly sustainable, and aquaculture has strong growth potential. Net outcomes from climate change will be variable across species and perhaps subregions.

There are no programs in the Northern Hub region that explicitly address adaptation of primary industries to climate change. Hub nodes are well placed to establish extension, adoption, and commercialization clusters, but should adopt a rigorous co-design process within their subregion.

Markets have failed to fully provide extension and outreach services. Assistance for multidisciplinary peer to peer learning groups is advisable, as is direct funding of extension through Hub partners.

1.2 Summary

Regions & resilience

The Northern Hub region can be broadly divided into seven sub-regions; three in the monsoonal North (the Top end, the Gulf Savanna, and the Kimberley), and four in the Rangelands (the Pilbara, the Gascoyne/Murchison/Goldfields, the Barkly and the Arid Rangelands). Average temperatures have increased over the past century and are predicted to continue to rise, perhaps 1°C by 2030 and 3°C by 2090. Plant-available moisture will decline through reduced rainfall in the Rangelands, and increased evapotranspiration throughout the Northern Hub region. Cyclones, fire, rain events and heat waves will become more intense and volatile. Water resources are available to sustainably

support further development of agricultural industries, particularly in the Ord, the Douglas Daly, and the Fitzroy. There has been recent government investment in water and land resource information, but there is disagreement on whether it is sufficient.

A clear definition of ‘drought’ is elusive, but government policy recognizes the link between increased drought frequency and climate change. The Future Drought Fund aims to improve resilience through adaptation, reorganization, and transformation. Adaptation to climate variation can be incremental (genetic and agronomic changes in response to changed conditions), systemic (genetic, agronomic, and management changes in anticipation of changed conditions), or transformational (changed land use, new products). The Northern Hub region has seen transformational adaptation particularly with fire management for carbon offsets, but production systems are mainly reliant on incremental rather than systemic change. Current drought resilience activities focus far more on production efficiency and natural resource sustainability than on human capacity and social sustainability. Impacts to production of reduced plant-water availability is well understood but impacts of extreme events such as heat waves are less understood.

Indigenous production

The Northern Hub region contains traditional lands of over 100 aboriginal cultural groups who comprise a third of the population and own or manage a third of the land area. The region contains spatially 74% of the Australia’s Indigenous Protected Areas. Non-monetary value of natural resources to Indigenous populations is important, with ‘connection to country’ improving health and wellbeing metrics. Value is realized through (a) commercial tourism, pastoral and horticultural enterprises, (b) providing environmental management services (fire, biosecurity, pest, weed), of which savannah fire management for earning Australian Carbon Credit Units is increasingly important, and (c) management of country to sustain wild harvests for sale and consumption. Total monetary value is estimated at \$204m, excluding pastoral and horticultural enterprises. Half this monetary value is derived from tourism and a further quarter from land management services. Indigenous communities have the lowest carbon footprints but are the most susceptible to climate change. Indigenous production channels income directly to this most vulnerable group. Rising temperatures will further impact health and may limit tourism. Wild food production may be impacted by seawater incursions and more extreme dry periods. Aboriginal owned pastoral stations normally employ or lease out to non-Aboriginal managers.

Livestock

Beef production dominates agriculture in the Northern Hub region, with buffalo and crocodile also produced. Pastoralism is mostly a low input, low output enterprise reliant on native perennial pastures and thus subject to seasonal variation and long-term trends in pasture base. Properties have invested in animal genetics and infrastructure (water points, fences) but investment in nutrition, good management practices, technologies and techniques is variable. Difficulties in attracting staff of all levels is a limitation to production. Extension efforts are poorly coordinated in

northern WA and there are too few consultants providing objective methods for utilizing rainwater and forage. Changing climate affects beef production in multiple ways, such as through potential changes to pasture composition and growth rates reducing nutrition and/or increasing fire risk. Increased heat stress will reduce weight gain and reproduction. Enhanced plant growth from higher atmospheric CO₂ will be countered by plant heat stress and increased evapotranspiration. Supply chain disruptions from extreme weather events are expected to increase.

Field crops

Broadacre cropping includes irrigated and dryland systems, with the main crops being sorghum, maize, and hay/fodder. There is a strong growth potential, but most current crops are a component of a cattle production business. Fodder produced for sale is marginal while integrated systems produce the greatest value. Disease resistant cultivars have been essential for the emergence of cotton and Leucaena, and yields of cotton, sorghum, rice, corn, Rhode's grass and chickpea are approaching that required for profitability. Niche crops offer potential for small-scale production but are subject to market flooding. The region has a tendency for large-scale investment based on insufficient testing. Yield potential and phenological timing must be assessed in each region since extrapolation is unreliable. Simulation modelling will become more important than field trials in predicting yield impacts of a changing climate.

Cropping is a resilience strategy when it is used by pastoralists to diversify income. Climate change is expected to reduce plant water use efficiency, increase pathology, disrupt some sowing windows, and increase yield and soil losses from extreme weather events. Declining government support for extension and adoption has been replaced in part by industry-led organizations.

Horticulture

The region contains irrigated horticultural centres in Carnarvon, Kununurra, and northern NT, collectively producing around \$400m annually. The tropical north is dominated by mango and melon production sent to the East Coast markets while subtropical Carnarvon is dominated by vegetables sent to Perth markets, but a wide variety of products are grown in both regions and a small volume is exported. To be successful, industries must capitalize on a seasonal market window to overcome transport costs.

The main impacts of climate change will arise from increasing temperature. Heat stress, cool-chain costs, evapotranspiration, and extreme weather damage are expected to increase, and climatic zones are expected to shift southward. Tree crop industries will be slower to adapt due to longevity of perennial plants. The largest crop in the Hub region is mangoes, which will require cultivar development and management changes to adapt. Energy market reform may be needed to support the cool chain. As with broadacre crops, much of the extension work is now done by industry groups and some market failure is evident.

Forestry

Approximately a third of Australia's forests lie within the Hub region, of which >80% is under Indigenous management and 0.22% has been converted to the emerging forestry industry. Forestry is a diversified sector with different products and value chains, including Acacia hardwood, African mahogany, Indian sandalwood, and wild harvesting of native eucalypts and sandalwood. Sandalwood is parasitic, requiring a host tree, and is normally irrigated through the dry season. Forestry has a high proportion of Indigenous employees. Plantation forestry is well represented by industry bodies and plantations tend to be well designed to prevent losses from wildfire. Native forests provide environmental and social benefits in addition to economic and are frequently integrated with pastoralism (silvopasture). If current area is maintained the industry will reach \$70m annually when plantations mature.

The impact of climate change to forestry in the north is not well understood. Changed fire patterns could have a large impact. Irrigation costs for sandalwood may increase and irrigation may become necessary for mahogany establishment, while reduced rainfall in the Arid Rangelands may impact survival. Trees grow within a complex community of species that may respond unpredictably, such as by further favouring weeds such as Gamba grass. Nevertheless, native forests are more biodiverse and thus expected to be more resilient than plantations.

Fisheries & Aquaculture

The third of Australia's coastline within the Hub is some of the most pristine and biodiverse, supporting many small, established fisheries. A wild catch of around 20 000 t is obtained from 400 registered fishing vessels, supplemented by Indigenous traditional hunting and recreational fishing. Most fisheries are classified as sustainable though some species face localized threats. Aquaculture is an emerging sector that has overtaken wild harvests for barramundi and pearls. It is a highly efficient form of protein production in which environmental concerns and product quality can be controlled. Thus, it has potential for strong export market growth, and the possibility of the Northern Hub region being positioned as a global leader. The current value of fisheries and aquaculture in the Northern Hub is approximately \$500m.

Rising sea levels, changed volume and frequency of freshwater flows, and increased seawater heatwaves can impact fish nurseries and trigger mass deaths of adult populations. Water chemistry changes may have unforeseen impacts in addition to the pH impacts on shell and exoskeleton production. Net outcomes will be variable across species and perhaps subregions, with winners and losers. Pelagic species will be more resilient than benthic species.

Resilience and outreach

There are no programs in the Northern Hub region that explicitly address adaptation of primary industries to climate change. Tools and services are available to interpret weather forecasts, and

adaptation to a changing and fluctuating climate is implicitly addressed through many programs. A first step for a drought / climate resilience program is for producers to acknowledge a need to better understand their circumstances. Engagement of the broader community, including financial and other service providers is beneficial. Many in the service sector underestimate the complexity of producers' decision-making processes and thus advise simplistic solutions. Hub nodes are well placed to establish extension, adoption, and commercialization clusters, but should adopt a rigorous co-design process within their subregion.

The case for intervention

Market failure is evident in the Hub region for provision of extension and outreach services. Assistance for multidisciplinary peer to peer learning groups is advisable, as is direct funding and support of positions through Hub partners. Investment in facilitation skills, and producer decision-making skills, is economically beneficial. However, the beef industry is dominated by large corporate and private operators with the capacity to fund their own training and R&D. Large corporations are also present in broadacre and horticulture sectors, but smaller businesses remain common. Increasing the variety of viable primary businesses in the Hub region provides resilience for communities and improves both food security and biosecurity for the country. Increased production within an industry results in increased efficiencies, making service industries more viable.