Australian cotton industry experimental, partial natural and social capital assessment

The Australian cotton industry and the Queensland Department of Primary Industries (QDPI) have collaborated to use data collected in the revamped Australian cotton sustainability data framework to produce an experimental industry-scale natural and social capital assessment. This is one of the world's first whole-of-industry partial natural and social capital assessments. It follows guidance provided by the Capitals Coalition, a multi-stakeholder organisation recognised as leading the global effort to have the value of all capitals included in decision-making.

Natural capital accounting measures and values change in extent (area or volume – for example the area of soil used to grow cotton) and condition (quality of the natural capital asset – for example the condition of the soil on cotton farms). Natural and social capital assessments measure and value change in dependencies (functions or ecosystem services of an asset – for example, the ability of soil to grow cotton or hold water) and impacts (the external drivers that impact the extent, condition, or dependencies of an asset – for example, soil health practices used by cotton growers, or extreme weather events). Our revamped sustainability data framework is organised into extent, condition, dependency and impact indicators, allowing us to measure all of these.

We are focusing on an "assessment" instead of an "account" initially for several reasons. One of the most important reasons is other organisations are spending a lot of time experimenting with farm-scale natural capital accounting already. Rather than duplicate that work, we are focusing on assessments and talking to those organisations to ensure our extent and condition indicators are consistent with theirs.

Our hope is if we can eliminate duplication and contribute to a nationally consistent approach to natural and social capital assessment methodologies, the accuracy and usefulness of these assessments will quickly increase. This work is being widely shared with other agriculture industries and value chains to support this aim.

We are deliberately calling this an experimental assessment to mirror the language used in Australia's first *National Ecosystem Accounts, experimental estimates*, released in 2025 by the Australian Bureau of Statistics. The industry scale data we have is the best available, and often assumptions have had to be made. Rather than be relied upon for an accurate valuation, this assessment should be used to form a baseline to see observable trends over time and demonstrate what is possible as data quality improves.

This is a partial natural and social capital assessment. We have conducted a materiality assessment to prioritise the most important impacts and dependencies for valuation, but we recognise there are other impacts and dependencies stakeholders would like to see valued. We haven't tried to value everything, or even most things, in this first assessment. Our intention is to broaden the scope of the assessment in future, as our capability and data availability increases.

This pioneering work has uncovered technological limitations and barriers, but also generated actionable insights to enhance reporting accuracy and decision-making.

The Australian cotton industry and QDPI aim to improve the rigour and breadth of this industry-scale annual natural and social capital assessment in future. They will also aim to extend this work to natural and social capital assessments at farm-scale, in other agriculture industries, and with other governments. Collaborations with other stakeholders to support a consistent and coordinated uptake of natural and social capital assessments in Australian agriculture are welcomed.

Background

Context. Cotton is a renewable food and fibre that is recyclable and biodegradable. Grown around the world for thousands of years, the cotton plant is a leafy green shrub in the same family as the hibiscus.

Cotton is grown mainly on family farms in inland eastern Australia. In recent years, cotton has also been grown in northern Australia.

In the 1990s, the Australian cotton industry gained a reputation for excessive water and pesticide use. Sustained and coordinated investment in the industry since then, including becoming the first Australian agricultural industry to independently assess its environmental impacts in 1991, has seen long trends of improvement in many sustainability areas. This natural and social capital assessment is one tool to help the industry continue its work to build customer and community trust, and provide cotton growers with evidence to help them assess if they can make changes to improve their sustainability.

Objective. Quantify selected aspects of natural and human capital to show how the cotton industry creates, preserves or erodes value over time to improve industry and external stakeholder decision-making to grow the industry's resource efficiency, reputation and market access.

Intended application and audience. The purpose of this work is to provide more insightful data to support decision-making and communication inside and outside the industry:

1. The cotton industry can use this data to enhance its ability to monitor progress and allocate resources appropriately
2. Cotton growers can get new insights into the impact of practices on their natural, human and financial capital
3. Customers and other stakeholders can see more detailed and contextual information to inform their decisions on Australian cotton
4. Policy makers and standards developers can use an industry-scale assessment using a single source of industry sustainability data provides as a farmer-centric solution to natural and social capital reporting, instead of the current approach of developing natural capital reporting and measurement approaches with minimal farming input.

Benefits expected. Industry benefit of more informed:

- grower decision-making (increased productivity, resilience, and adoption of more sustainable practices)
- stakeholder decision-making (increased trust, reduced reputation risk)
- industry decision-making (better allocation of resources where they are most needed).

QDPI benefit of:

- internal capacity-building and applying knowledge gained across other industries.

Scope

Boundary. The Assessment boundary is Australian cotton farms.

Value perspective. Value to the cotton industry and growers (private good / cost) and to society (public good / cost) have been considered.

Types of value. Monetary valuation is used wherever possible. Quantitative or qualitative valuations are used when appropriate data for monetary valuations is not available.

Materiality process. Capitals Coalition guidance is clear that organisations should not attempt to value all impacts and dependencies, especially initially. A double materiality approach was applied using Accountability AA1000 guidance to set clear criteria for assessing the effect of an impact or dependency on the cotton industry, and how the cotton industry effects nature, society and stakeholders. This materiality assessment resulted in the following summary that guided this initial partial Assessment:

- Soil quality and degradation are some of the cotton industry's most material impacts or dependencies. Prioritising these for valuation will by necessity also address other impacts and dependencies identified as being material: fertiliser use/pollution, pesticide use/pollution, GHG emissions (via N), C sequestration
    - Due to a lack of reliable industry-scale soil data, valuations of soil quality and degradation was ultimately not conducted. Soil's complexity and regional differences make it difficult to measure properties (condition) and functions (dependencies) at scale. A National Soil Strategy was released in 2021 and will deliver nationally consistent key performance indicators and methods to measure soil health. We support this strategy and will aim to value soil when nationally consistent measures and methods are in place.
- Water use is one of the three most material impacts or dependencies. Water availability has less importance to stakeholders, but is so critical to the industry it is included for valuation. Prioritising these for valuation will be necessity also address other impacts and dependencies identified as being material: fertiliser use/pollution, pesticide use/pollution.
- Land use change / extent of regulated woody vegetation is included because of its importance to stakeholders, and its links to soil and water: water regulation, pesticide use, C sequestration.
- Human capital (people's competencies, capabilities and experience, their motivations to innovate, their health & wellbeing) rates as the most important dependency.
    - Environmental responsibility and responsiveness are equally important, but we know from regular research this is also the main driver of community trust and acceptance (social capital), as is perceived value to Australia
        - Demonstrating environmental responsibility will be achieved by delivering on natural capital improvements; quantifying the value and cost of this through this Assessment will support the communication of environmental responsibility and responsiveness to the community
        - A separate estimate of economic value distributed to the economy by cotton growers (through wages, purchase of goods and services, taxes and payments to providers of capital) has been commissioned, and included in the 2024 Australian Cotton Integrated Sustainability Report
    - As a result, the focus of this initial partial Assessment is on human capital, and in particular physical and mental health and safety.

Materiality assessment matrixes are provided as an Attachment.

AUSTRALIAN COTTON INDUSTRY EXPERIMENTAL, PARTIAL, NATURAL AND SOCIAL CAPITAL ASSESSMENT.

Industry inputs and outputs: summary

	Irrigated area (ha)	Irrigated Bales	Irrigated Bales/ha	Dryland area (ha) (paddock)	Dryland Bales	Dryland Bales/ha	Total area	Total bales	Number farms	Number growers + permanent employees
2019/20	57,983	586,305	10.1	1,750	3,351	1.9	58,858	589,656	na	na
2021/22	425,437	4,669,328	11.0	209,851	960,904	4.6	550,541	5,630,232	1,200	7,222

Natural and social capital assessment: summary

WATER	Indicator	Metric	Year	Value $m	Value / ha
Blue water availability	Total ML annual allocations to farms that grow cotton	Qualitative	2019/20	na	na
	Annual allocations as % of licence		**2021/22**	**na**	**na**
Green water availability	ML/ha effective rainfall	2.77	2019/20	$88.5m	$1,504/ha
		4.29	**2021/22**	**$158.2m**	**$287/ha**
	% change on long-term average (1986-2020)	-12%	2019/20	-$11.7m	-$198.5/ha
		+43%	**2021/22**	**$490.4m**	**$87/ha**
Water use	Total ML irrigation water applied to cotton	6.72ML/ha	2019/20	$211.6m	$3,648/ha
		5.66ML/ha	**2021/22**	**$161.3m**	**$379/ha**
Water use efficiency	Sustainable water use index ML/bale (irrigation + effective rainfall + soil moisture – losses)	na	2019/20	na	na
		1.05	**2021/22**	**$328.5m**	**$70/bale**
	Dryland cotton: effective rain per bale ML/bale	1.35	2019/20	$2.5m	$733/bale
		0.93	**2021/22**	**$59.9m**	**$62/bale**
BIODIVERSITY (forests)	INDICATOR	Metric	Year	Value $m	Value / ha
Threatened species habitat	Area (ha) of significant riparian patches of natural forest	49,299 ha	**2020**	**$81.3m**	**$1650/ha**
Beneficial species habitat	Area of regulated woody vegetation on farms that grow cotton	704,264 ha	**2020**	**$66.5b**	**$95/ha**
Carbon storage	Total tonnes of carbon (C) stored in mature forest	152.66t C/ha	**2020**	**$4.2b**	**$5,964/ha**
WORKPLACE	INDICATOR	Metric	Year	Value / year	Value / farm
Keep everyone safe	Work-related fatalities per five years	<5	**2021/22**	**33 years of healthy life lost**	**0.03 years of healthy life lost**
	Serious injuries per year	47	**2021/22**	**1.8 years of healthy life lost**	**0.0015 years of healthy life lost**
	Mean 6-30 Kessler 6 psychological distress scale	13	**2021/22**	**85 years of healthy life lost**	**0.07 years of healthy life lost**

Natural and social capital assessment: detail

WATER	Indicator	Metric	Value $m	Value / ha	SO WHAT	Data source, notes and comments.
Dependency **Blue water availability**	Total ML annual licences of farms that grow cotton	na	na	na	In Australia's regulated water system, water users own licenses to withdraw up to a certain volume of water each year. The actual volume of water they can access each year (their licence) varies each year and is determined by state governments' sustainable water regulations that prioritise water for the environment and basic human needs over industry.	Assessment type: qualitative Currently there is no readily available data on water allocations and licences that can be disaggregated to specific commodities (eg cotton production). Accurate data on water allocations directly related to cotton production would: • Track the portion of allocations as a percentage of licences over time to give insights into the reliability of water resources that irrigated cotton growers depend on. This will better quantify current and future risks and opportunities for production • Allow us to put a value on the monetary impact of the water farmers "missed out on" in their annual allocation. Less than 100% allocation translates to less economic capital generated (ie revenues) and distributed (ie taxes paid, goods and services procured, etc). Allocations are dependent on seasons; we can't control what volume of water is available for irrigation, but there may be ways for industry and government to minimise the economic impact of lower water availability.
	Annual allocations as % of licences		na	na		
Dependency **Green water availability**	ML/ha effective rainfall	2019/20 2.77 2021/22 4.29	$88.5m $158.2m	$1,504/ha $287/ha	By putting a price on rainfall, we can more clearly see its direct value. This will further support messages to farmers about the importance of soil health practices that impact the utilisation of rainfall. For example, if a farmer's soil health practices result in 25% of rainfall that should be soaking into their soil running off, that farmer is losing 25% of the direct value of that water: $374/ha in 2019/20 and	Assessment type: monetary • Monetary valuation technique: Market Price • Formula: volume (ML) x price ($/ML) Data source: • Rainfall is calculated by summing the average rainfall for the most recent year across major cotton growing river regions for the months November-March: Australian Water Outlook • ABARES estimates the $/ML to be ~ $543 in 2019/20 (NB this was a drought year) and $67/ML in 2021/22 (NB this was a wet year).

					$72/ha in 2021/22. With further calculations in future, we can also translate that lost resource into estimated lost production.	Using this method: • 2019/20 average growing season rainfall was 277mm • 2021/22 average growing season rainfall was 429mm • 2022/23 average growing season rainfall was 273mm • Long-term average (FY1986-FY2023) was 299mm
	% change on long-term average (1986-2020)	2019/20 -7% 2021/22 +43%	-$7.0m $490.4m	$119.5/ha $87/ha	This valuation shows the impact of wetter and drier seasons. In future, we aim to calculate the impact of these changes on other sources of capital: for example, changes in biomass production that impacts soil organic carbon, and that impacts economic value generated and distributed.	Assessment type: monetary • Monetary valuation technique: Market Price • Formula: change on long-term average (ML) x price ($/ML) Data source: • As for ML/ha effective rainfall (above)
Impact **Water use**	Total ML irrigation water applied to cotton	2019/20 6.72ML/ha 2021/22 5.66ML/ha	2019/20 $211.6m 2021/22 $161.3m	2019/20 $3,648/ha 2021/22 $379/ha	Growers convert water resources into financial capital that supports local jobs and farm business investment. In 2019/20 growers produced approximately $673 of value of irrigated production per ML used Murray-Darling Basin water market catchment dataset 2021 - DAFF Alternative indicator may be $ / ML applied irrigation (SDG water use efficiency indicator)	Assessment type: monetary • Monetary valuation technique: Market Price • Formula: volume applied (ML) x price ($/ML) Data source: • Water applied: Water Use on Australian Farms, 2020-21 financial year | Australian Bureau of Statistics (discontinued data; new water application data source is needed, either from industry sources or as part of the Modernising ABS agricultural statistics project) • Water value: ABARES estimates the $/ML to be ~ $543 in 2019/20 (NB this was a drought year) and $67/ML in 2021/22 (NB this was a wet year). Using this method: • 2019/20: 0.66 x 586,305 = 386,646ML • 2021/22: 0.58 x 4,669,328 = 2,407,973ML
Impact **Water use efficiency**	Sustainable water use index ML/bale (irrigation + effective rainfall + soil moisture – losses)	2021/22 1.05	2021/22 $328.5m	2021/22 $70/bale	In this example, growers are using $70 of natural capital resource (irrigated water) to create $558 of economic output in 2021/22. Water resources are more efficiently turned into economic	Assessment type: monetary • Monetary valuation technique: Market Price • Formula: ML/bale x bales x price ($/ML)

	Dryland cotton: effective rain per bale ML/bale	2019/20 1.35 2021/22 0.93	2019/20 $2.5m 2021/22 $59.9m	2019/20 $733/bale 2021/22 $62/bale	capital in normal seasonal conditions, but their value in keeping jobs in local communities in drier seasons is an important factor.	• Assessment type: monetary • Monetary valuation technique: Market Price • Formula: effective rain (ML) (dryland) x price ($/ML) Data source: • Rainfall is calculated by summing the average rainfall for the most recent year across major cotton growing river regions for the months November-March: Australian Water Outlook • ABARES estimates the $/ML to be ~ $543 in 2019/20 (NB this was a drought year) and $67/ML in 2021/22 (NB this was a wet year). Using this method: • 2019/20: 2.58*1,750/3,351=1.35 • 2021/22:4.29*208,892/960,904=0.93

BIODIVERSITY	INDICATOR	Metric	Value $m	Value / ha	SO WHAT	Data source, notes and comments.
Dependency **Beneficial species habitat**	Area of regulated woody vegetation on farms that grow cotton	2020 704,264 ha	$66.5m	$95/ha	Providing habitat for beneficial species that prey on pests in cotton, provides a private good for cotton growers by reducing reliance on insecticides. The data shows 704,264ha of regulated woody vegetation on farms that grow cotton, but only some of this provides meaningful habitat for beneficial species. This is because proximity to the crop is important – beneficial species living in forest adjacent to a crop will have much greater impact than beneficials living in a forest 10km away on the same property. More work is needed to quantify this benefit	• Assessment type: Qualitative • NB: Quantitative provided as example only. Based on beneficial species reducing average annual insecticide cost ($189/ha in 2023/24) by 50% Data source: • Area of natural forest: Estimated data only of the area of regulated woody vegetation on cotton properties • Insecticide cost: CottonInfo 23/24 gross margin budget Caveat: This approach assumes all natural forest on farms that grow cotton provide habitat for beneficials, which is not correct. No allowance has yet been made for proximity of habitat to a crop, so this method will over-estimate the value.

Dependency **Threatened species habitat**	Area (ha) of significant riparian patches of natural forest	2020 49,299 ha	$81.3m	$1,650/ha	Providing habitat for native species, especially those threatened or endangered, is a public good that all of society benefits from. This public good provided by farms that grow cotton was valued at $81.3m in 2020: if farmers are expected by society to maintain native vegetation, there is an argument that all of society should contribute to the benefit we all receive.	Assessment type: monetary • Monetary valuation technique: Replacement cost • Formula: Area (ha) x cost of revegetation Data source: • Area of significant riparian patches: Estimated data only of the area of significant patches of connected riparian regulated woody vegetation on cotton properties • Value of natural forest: (cottoninfo, page 14) estimates the cost of establishing each hectare of new habitat at $1,650. Caveat: This approach counts only high value patches of riparian vegetation as providing habitat for threatened species. In reality, there will be native and threatened species in all classes of vegetation. There are also other data sources that would support different valuation techniques, such as the NSW Biodiversity Conservation Trust (or similar) pricing for current market value factors for threatened species, which are higher than the $1,650 per ha cost to plant riparian areas. As a result, the value of biodiversity on cotton farms to society is likely to be undervalued.
Dependency **Carbon storage**	Total tonnes of GHG stored in mature forest	704,264ha (assuming an average of 152.66 tC/ha)	$4.2b	$5,964/ha	Land holders can only receive carbon payments for new plantings. Farmers who have kept trees in the landscape are storing an estimated $3.8 billion dollars of carbon, but not being recognised for it. **Note**: The estimated value of carbon stored in trees is derived by multiplying total tonnes of CO_2 equivalent (tCO_2e) by the current Australian Carbon Credit Unit (ACCU) spot price. This estimate is intended for illustrative and exploratory purposes only. The carbon sequestration represented here does not meet the eligibility, permanence, or additionality	Assessment type: monetary • Monetary valuation technique: market price • Formula: Ha of mature forest x Carbon Stored (T Co2e/ha) x tree carbon conversion factor x price ($/ACCU). 704,264ha x 45.98 x 3.67 x $35 = $4,159,475,443 Data source and assumptions: • Carbon storage by mature forest: One hectare of forest (using the PICCC average for mixed species environmental plantings in NSW Northern wheat/sheep and Qld Darling Downs on clay soil) has a total average tree carbon production of 45.98t over a 100-year life time) (PICCC). If gum is used instead of mixed species, the total storage – and value – is about four times greater. To be conservative, we have used the lower figure for this experimental estimate. • Conversion factor: 1 tonne tree carbon = 3.67 tonnes CO_2 (PICCC)

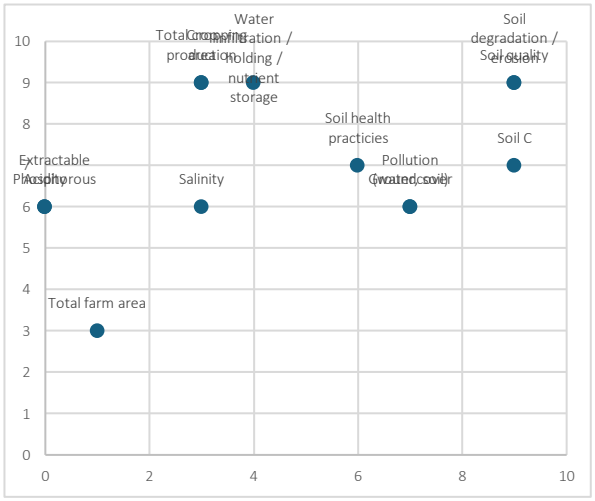
					requirements of the ACCU scheme or other formal carbon markets, and is not currently tradeable or financially receivable by landholders. As such, these estimates should not be interpreted as financial assets or as representing a realised or realisable income stream.	• Price of carbon: ACCU price is $35 per tonne Co2e

WORKPLACE	INDICATOR	Metric	Value / year	Value / farm	SO WHAT	Data source, notes and comments.
Dependency **Keep everyone safe**	Work-related fatalities per five years	2019/20 na 2021/22 <5	33 years of healthy life lost	0.03 years of healthy life lost	These quantitative valuations aim to show the impact of physical and mental health in a new light. In particular, while fatalities and injuries have a real and tangible impact on farm workplaces, the impact of stress and mental health may be far greater. The need to improve farm physical safety is rightly recognised as an imperative. Attempting to value the impact in different ways may add new insights or provide new motivation for individuals to make changes that lead to safer workplaces. This analysis suggests the same urgency needs to be given to managing stress and mental health in farm workplaces.	Assessment type: Quantitative • Monetary valuation technique: DALY/QALY <u>Data source:</u> • SafeWork Australia. Report compiled by AgHealth Australia Safety, The University of Sydney. Assuming 5 deaths, a median age of 50 (33.2 years of remaining life expectancy) implies that over the 5-year period that 166 years of life lost (YLL) due to premature death. To further improve this estimation, the age and equivalent life expectancy at the time of premature death would be used. Further accounting for the significant social, emotional and community loss associated with on farm fatalities could be included in future revisions.

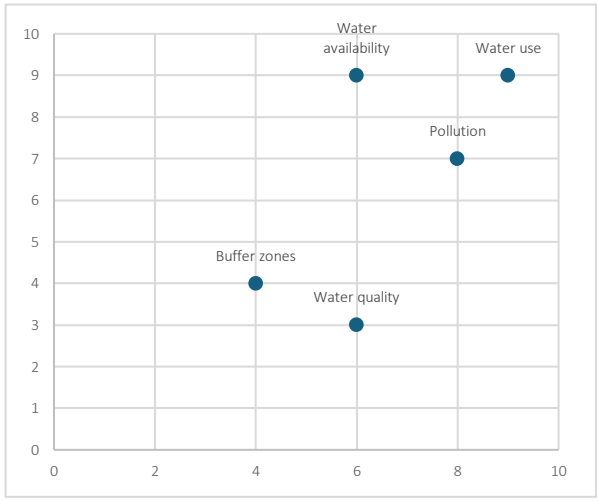
	Serious injuries per year	2019/20 na 2021/22 47	1.8 years of healthy life lost	0.0015 years of healthy life lost		Assessment type: Quantitative • Monetary valuation technique: DALY/QALY Data source: • SafeWork Australia. Report compiled by AgHealth Australia Safety, The University of Sydney. Assuming an average of 47 serious injuries per year and an average duration of 12 weeks per injury implies that 564 weeks are lost per year at a disability weighting of 0.196 days lost per day experiencing injury. Disability weights are between 0.518 and 0.112 for relevant injuries.
	Mean 6-30 Kessler 6 psychological distress scale	2019/20 na 2021/22 13	85 years of healthy life lost	0.07 years of healthy life lost		Assessment type: Quantitative • Monetary valuation technique: DALY/QALY Data source: • Regional Wellbeing Survey, University of Canberra. A disability weighting of 0.076 is applied to this metric. It is assumed that this score is experienced across the total number of employees for 365 days a year. This means that the estimate is significantly higher compared to Serious injuries per year. *if the industry scored <11 the years lost would be 0

Appendix: summary materiality assessment

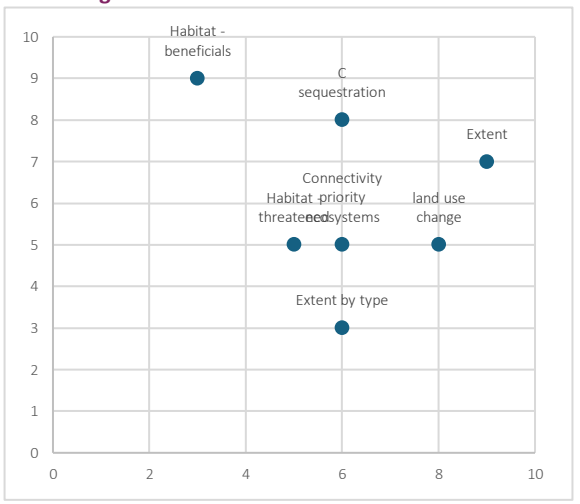
Soil



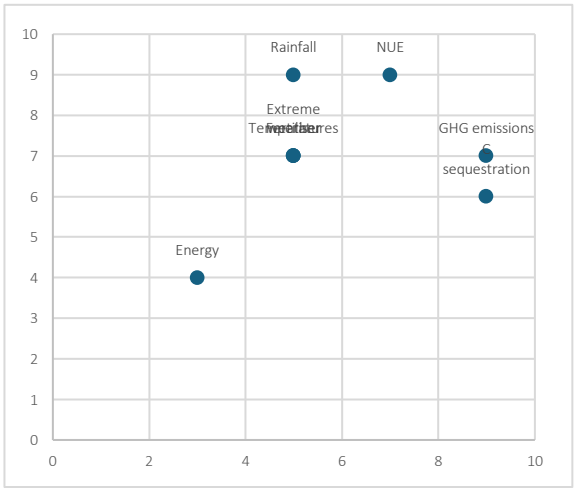
Water



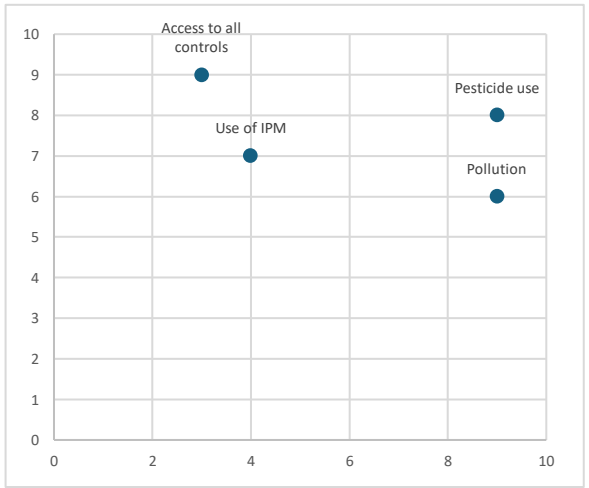
Native vegetation



Air



Pesticides



People