A Nuffield Farming Scholarships Trust Report

Award sponsored by

National Trust

Maximising water's worth in UK agriculture

Lorna Davis

January 2021

NUFFIELD UK

NUFFIELD FARMING SCHOLARSHIPS TRUST (UK)

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"Leading positive change in agriculture"

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Scholarships are open to those who work in farming, food, horticulture, rural and associated industries or are in a position to influence these industries. You must be a resident in the UK. Applicants must be aged between 22 and 45 years (the upper age limit is 45 on 31st July in the year of application). There is no requirement for academic qualifications, but applicants will already be well established in their career and demonstrate a passion for the industry they work in and be three years post tertiary education. Scholarships are not awarded to anyone in full-time education or to further research projects.

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A Nuffield (UK) Farming Scholarships Trust Report

Date of report: January 2021

"Leading positive change in agriculture. Inspiring passion and potential in people."

Title	Maximising water's worth in UK agriculture
Scholar	Lorna Davis
Sponsor	National Trust
Objectives of Study Tour	• Review global water context – explore how we value water as a resource publicly, politically and environmentally • Illustrate the sustainability potential of agriculture in the UK through its access to soil and water • Identify industry tool boxes for resilience • Identify opportunities for agriculture and the environment to thrive together by recognising the value of the co-existence of these landscapes • Driving forces for change – what methods of regulation, engagement and delivery exist to inform UK policy going forward? • How can water management which benefits the environment and wider community be valued and rewarded?
Countries Visited	Brazil, America, Australia, New Zealand, Singapore Sweden, UK
Messages	• Water is a **finite** resource: q**uality** affects the availability of **quantity.** To value both will drive change across society. • Global trade of water resources needs to understand consumer impacts on availability elsewhere to motivate changing behaviours in government, industry and society. • A fragmented approach to water management limits the multiple benefits delivered. The UK risks undervaluing its share of water as a global resource in agricultural trade terms, as its national water policy focuses on the consumer market for water utilities and ignores the UK's global export market of food and manufactured goods and services. • Prioritising agriculture's role in resilience to support society, environment and economy is required within the top-down approach to governance. • Enabling and incentivising industry to measure and manage surface and ground water quantity and quality within the UK would enable farmers to benchmark their performance at a global level.

EXECUTIVE SUMMARY

"You never know the worth of water till the well is dry"
'Thomas Fuller'

Over 97% of our planet's water is held within our oceans and less than 1% is freely available as freshwater. This supplies the demand for food production, drinking water, industry and environment. As water is a finite resource, man's impact on water quality through our behaviours is having a detrimental impact on quantity on a global scale.

The effects of the ever increasing need to produce goods and food is driving countries to increase demand on 'available water', whilst also accessing 'unavailable water' (non-replenishing aquifers and saltwater reserves) to supplement demand on their depleting supplies.

Britain's maritime location and replenishing supplies provides a substantial advantage in the world market for goods and services. However, our ability to capture and manage water on land for flood risk and water scarcity has yet to be developed fully.

The government has set out an aspiration to achieve a productive natural and agricultural environment where land and water work in harmony: this would amend environmental degradation and provide a source for sustainable food alongside a flourishing environment. Looking at the complexities of directing funding to reward this dual result raises some pressing questions as to how we, as a society, understand and value our landscape, water and food. There is a lack of awareness of the negative impact which consumer demands are having on our own environmental infrastructure, and in that of the wider world.

Through my travels, I explored how others manage water in environments where scarcity and excess are daily issues to better understand the value they place on this resource and the methods used to deliver good water management through engagement, enforcement and education.

My report aims to illustrate how the value of water needs to be considered on a global scale and discusses methods which enable the agricultural industry to quantify and evidence its environmental impact. UK agriculture, by developing and demonstrating real water stewardship, could lead the change for government, retail and consumers to value its contribution and recognize and reward the sector as being an environmental leader of this global resource.

At present the UK government documents appear to focus on the provision of water for utility services to meet increasing domestic demands. This could lead to an emphasis only on environmental measures to be taken by the agricultural industry to deal with flood risk and water quality. Recognition of water as a valuable resource to be used effectively in sustainable food production would enable the agricultural industry to develop a resilient approach to the provisioning of food, water, environment and economy, alongside flood resilience to our growing population.

The challenge is to develop a cross sector, robust measurement system which acts as a conduit to enable change, bridging government silos of healthcare, environment, food and farming, and education. Globally this is proving complex because of the different weighting of the value of water and of the environment perceived and applied around the world.

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor, or my employers.

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1. Introduction

Having grown up in Wales where the rainfall is comparatively high, my initial impression of water within the UK was 'we have too much' …… 'when will it stop raining?' This was not an opinion echoed by the major influence in my formative years, my grandmother, Janet Trant. Janet's years in farming have inspired many women in our family to pursue their own dreams in agriculture. Today, she is inspiring mine.

Granny's most pertinent words were '*there will be wars fought over water'*. In our isolated hill top in Wales this seemed extreme. However through my career and Nuffield Farming journey I have come to realise how right she was.

In life and work I have always looked to nature as my default solution to assist in the management of water. A degree in landscape architecture from Edinburgh University, followed by a career in the engineering and the water industry has given me a tool box for assessing landscapes on a catchment scale and identifying green solutions to manage and mitigate flood risk and water scarcity where possible. Working with the water industry illustrated the value of the whole water cycle, exploring the hydraulic links of man and nature within a catchment. This was combined with observing the casualness we have with water use, raising the question of 'What is our relationship with water within the UK'.

My passion however has always been to work with agriculture, identifying methods to maximise its value to the natural environment. Returning to the farm, and those who work within the industry always strengthens my belief that our farmed landscape creates an opportunity to feed both the body and soul. Through farming I believe our closeness to nature enables us, if informed and empowered, to seek out a solution which provides benefits to all.

Figure 1. The author

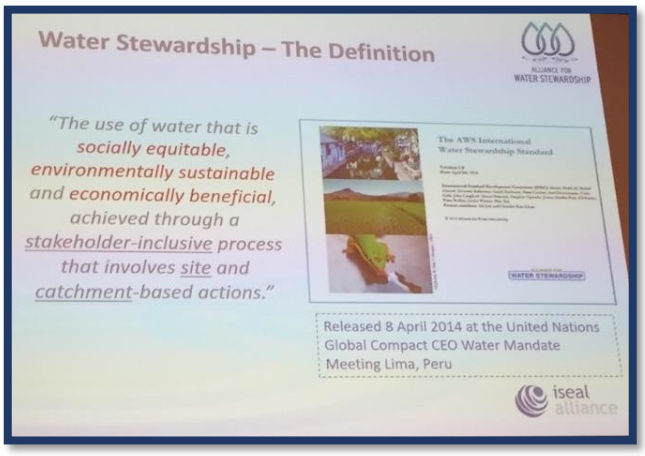
2. Background to my study

I set out on my Nuffield Farming journey to identify a value for agriculture in the UK in its role of managing water quantity in the uplands, so alleviating flood risk downstream. I believed as a landscape architect I could assist those farming in the uplands to evidence the value that their land management provides to both environment and farming through natural flood management (NFM). My hilltop home provides many families with a community to live in, a landscape to cherish and an economy which provides food and water for our nation. My initial question was: *'How can water management which benefits the environment and wider community be valued and rewarded?*

I started my travels with a visit to Sweden for the Global Swedish International Water Institute's World Water Week 2017. Within a week my whole perspective on what my travels aimed to achieve had dramatically changed.

Stockholm taught me that internationally water is seen through a variety of lenses:

- Water resource
- Flood risk
- Water scarcity
- Water security
- Sanitation
- Drinking water availability
- Water in agriculture
- Environmental water
- Regulation
- Resilience
- Climate change



Source: Alliance for Water Stewardship presentation SIWI World Water Week 2017

The contrasts in views of water's value by attendees was huge. For farming in Australia, water is a lifeblood; every drop is precious and financially valued in whatever role it performs. Within Wales, it is embraced, cursed, ignored and in some instances abused due to the perceived abundance. This conference enabled me to better understand the complex relationship we have with water and provided me with a broader view of *'why water matters'*.

Further, the conference enabled me to see how the prioritization of water quality, alongside quantity, was essential in establishing a value for this precious resource. My take home message from this was that: *'Without quality we don't have quantity*' and *'we need to work together collectively to deliver this'.*

The enthusiasm of others to better manage their limited water resource motivated me to back track my focus *to 'what is the worth of water'* before I started to explore within the UK the 'why' and 'how' to make better use of it. The replenishing nature of the UK's water supply provides a wealth of opportunity on the global stage for a sustainable, balanced landscape of food production, environment, economy and health and wellbeing. SIWI's attendees included over 130 countries political leaders and environmental non-governmental organisations: however, the absence of UK government was evident, and disappointing. This sadly confirmed my suspicions that we, as a nation, have lost touch with the value of water and the wealth of opportunity it provides.

3. My study tour – where I went

Following my visit to Sweden my perspective of what my travels aimed to achieve changed from *'How to quantify the value of water management in the uplands'*, to embrace a more global perspective of "What is water's worth". My travel locations therefore focused on where water scarcity provided an interesting context of ***why*** water is a valuable resource.

I aimed to meet the farmer, facilitator and regulator to better understand the impacts governance has and the benefits a top-down approach vs bottom-up approach within these systems.

In all countries I looked to explore methods of engagement with farmers and methods of measuring to manage. I also wanted to understand up and coming technologies which might assist in the delivery of valuing our water resource within the UK.

Country	Places visited
Brazil: Sau Paulo	• Catchment based approach to protect water supply outside of Sau Paulo • Flying rivers project – Impacts of deforestation / agriculture on evaporated water supplies • Embrapa research farm – Investing in regional research to support agricultural productivity
USA: Miami / Florida Keys	• Everglades - Climate change impacts and methods to manage • Florida Keys – Environmental enhancements to manage climate change impacts of increased storms and rising water levels • Delivery agents - US Landcorps: roles and responsibilities, methods to manage risk and its associated impacts on climate change, budgets.
Australia	
Fitzroy Basin	• Catchment mapping to identify risks – how scale affects success of measures at a catchment level • Arable land management techniques to reduce soil erosion • Governance - impacts of a top-down approach to catchment management • Delivery agents - ability to deliver through top-down target approach.
Canberra	• Farmer led approach to monitoring and management • Grassland farming methods in a Sydney water catchment • Delivery agents - Landcorp NSW: funding mechanisms, governance and responsibilities
Murray Darling Basin: Renmark Irrigation Trust	• Governance for water management on a 'whole catchment' approach • Alliance for Water Stewardship - Water management / efficiencies delivered for environmental gain. • What drives rewards? – Philanthropic or economic gain • Circular economy – how measuring water drives efficiencies within a business
Adelaide	• Economic drivers to incentivise water efficiency – impacts of being at the 'end of the line' • Circular economy – taking waste water sources to meet demand

Melbourne	• Water industry – Incentivising customer efforts to manage demand • Alliance for Water Stewardship – How catchment partnerships have evolved and been rewarded.
New Zealand:	• Dairy NZ – Delivery agents engagement methods, funding, and efforts to embrace issues and seeking solutions - is it delivering? Overstocking and suitability of land use for type? Driven by economy. • NZ Landcare Trust – Whole catchment assessments of water quality and who affects it.
Singapore	• Urban design to improve water quantity and quality • Messaging, effective messaging on the whole water cycle, and how to manage it
UK	• Defra – historic and future aspirations for water management within agriculture in the UK • Delivery agents - Water resource management within the Non-Government Organisations (NGO) and Internal Drainage Board (IDB) community across the UK. • Governance – Agriculture's social, environmental and economic values. Current methods of management of water resources and engagement organisations with agriculture. • Support systems for whole catchment facilitation of quantity and quality within the UK

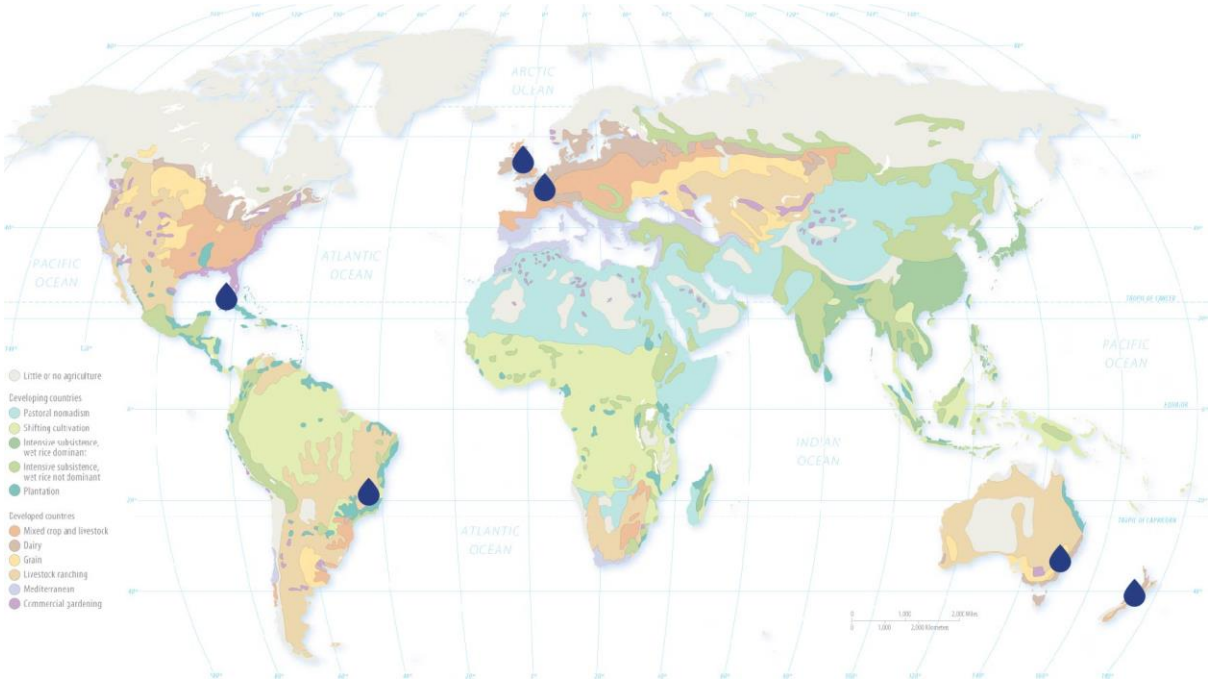


Figure 2 : Where I went, set against types of agriculture

Source of map: https://myfasal.com/agricultural-regions/

4. Water on the world stage

4.1. Global water wealth: why is water important?

When I started exploring water, I hadn't realised literally how little we had 'naturally' available to us. The illustration below outlines how much our 'blue planet' has available.

Of the earth's surface, 70% is made up of water but only 3% of the world's water makes up our fresh water resource, and much of that is locked up in ice sheets.

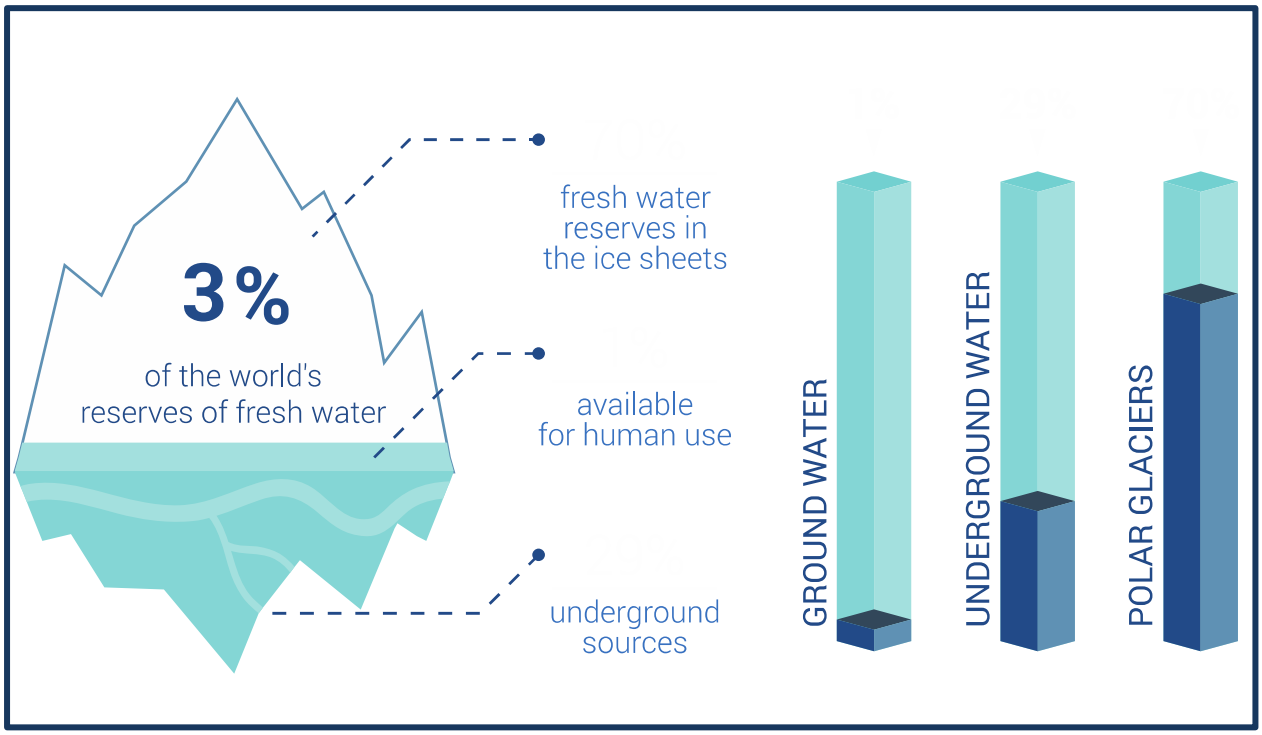


Figure 3. The earth's water availability statistics. *Source: www.worldbank.org*

World's fresh water reserves (3% of the world's water)			
Source	**Resource**	**Volume (% of freshwater)**	**Situation**
Surface waters	lakes, rivers and streams	**1%**	The impacts of rainfall by climate change, over abstraction and the water quality reduce availability for society and environment
Ground water reserves	Aquifers – replenishing / Non-replenishing. Shallow / deep reserves	**29 %**	Abstraction from non-replenishing reserves, climate change affecting replenishing supplies, water quality and industrial processes such as mining affect quantity and quality.
Ice caps and glaciers	Polar ice caps, glaciers, icebergs	**70%**	Melting icecaps due to global warming are depleting these. reserves, decreasing habitats and increasing sea levels.

4.2. Examples of man's impacts upon water

As demand for water grows our changing environments, land use and freshwater abstraction are having a negative impact upon sustainable fresh water supplies. Figure 4 below illustrates how groundwater recharge through surface water supplies is not meeting abstraction demands.

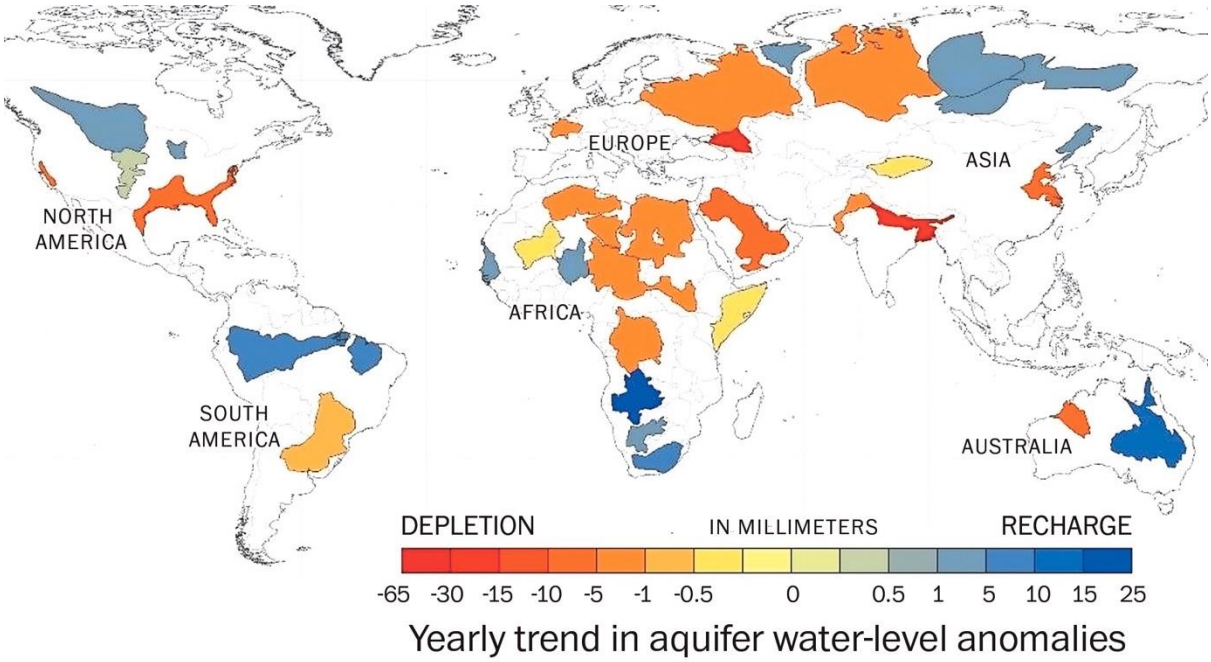


Figure 4. The earths water availability statistics illustrating where water demand is outstripping recharge in aquifers around the globe. *Source: Water Resources Research – The Washington Post*

The following graphic illustrates what the current global water consumption is within each sector.

Figure 5. Global water uses for human purposes as percentage of current global water usage.
Source: http://www.worldwatercouncil.org/fileadmin/wwc/Library/WWVision/Chapter2.pdf

4.3. Risks arising from depletion of water supplies

In many parts of the world, consideration of available water resources and their volumes is key to ensuring the survival of environmental and social systems within a region. Selling off the water resource, directly or indirectly through products requiring water to be produced, without considering these systems could drive the following risks for the future:

- Mass migration to temperate climates increasing demands on food and water supplies
- Depletion of food growing regions affecting supply chains
- Saline ingress causing agricultural and environmental degradation
- Transboundary issues for accessing water resources on shared river systems
- Global warming affecting water resources – drought and flood risk
- Depletion of marine environment to host food supplies and environment

It is against this background in global water supplies that the availability of water within the UK stands in good stead, if managed effectively.

5. Identifying drivers for change

This chapter summarizes what lessons I learnt about the social, environmental and economic values of water in the places I visited.

Healthy and functioning natural ecosystems are vital to the economy. Watersheds, wetlands, floodplains, and river systems create a resilience in our landscape, doing valuable work to protect the demands of an ever-increasing population and stressed environment.

Across the world, the weighting of the drivers of 3 sustainability pillars - social, environmental and economic - behind water management varies, depending on the value which each nation puts on its end product, and the abundance of water it feels it has.

Values differ around water's worth between developed and developing nations. Integrated management systems such as the EU Water Framework Directive (WFD) illustrate measures to secure water's value in both quantity and quality at a regional scale, providing a limited method to measure and manage catchments at a local scale. However, the adoption of these measures is not universal, with tensions arising across catchments and countries due to increasing demands within industries (utilities, industry, agriculture and the environment) exceeding local supplies. The serious consequences of disregarding the value of water may not be felt today but will in decades to come.

5.1 Social value of water – a driver for change

At a local level, provided that it is accessible, water enables people to survive in an environment. The world has witnessed examples of water scarcity, such as the Cape Town emergency water shortage and droughts felt in the UK in 1976 and 2018. These have all highlighted the essential need of a sustainable water supply to meet all our needs.

However water scarcity is not the only driver affecting the social impacts of water management within a catchment: looking at effective use and excess is a very real motivator for changing behaviours towards developing resilience.

5.1.1 Alliance for Water Stewardship (AWS), The Triple Bottom Line and Renmark region

My focus on water scarcity took me to the heart of Australia to see first-hand the work of an organisation called the Alliance for Water Stewardship (AWS).

AWS was first developed in Australia during the Millennium drought. Its aim was to encourage collaboration on water challenges through the recognition and reward of responsible water users. The AWS is a global certification system based on a water using site, sector or catchment complying with the AWS International Water Stewardship Standard. This standard embraces 'whole water stewardship' providing a framework for industry, agriculture and other fresh-water water users to adopt and practice sustainable water management. See Figure 6 for details of how it works.

ALLIANCE FOR
WATER STEWARDSHIP

HOW THE AWS STANDARD WORKS:

The AWS Standard is built around six steps,

in which proponents undertake the following:

(1) commit to water stewardship

(2) gather and understand water-related data

(3) create a water stewardship plan

(4) implement their plan

(5) evaluate performance

(6) communicate progress with stakeholders.

Each step contains (Ref. Image 1) a series of criteria and indicators. Following the steps and criteria will lead to improved performance in four areas (Image 2): water balance, water quality, healthy status of important water-related areas and water governance.

Image 1: The six steps to water stewardship certification

Image 2: The four key outcomes

Figure 6. AWS Standard criteria and indicators *Source: Alliance for Water Stewardship, Australia*

The AWS system has been applied by 'The Renmark Irrigation Trust' (RIT), located in the Upper Murray catchment within the 'Riverland' region. The region predominantly grows high value crops such as wine grapes, stone-fruit, citrus, nuts and greens using irrigation to provide the water supply abstracted from the Murray river. RIT was established to facilitate the operation the water rights to which the ratepayers were entitled under the terms of the Chaffey Bros. Irrigation Works Act of 1887.

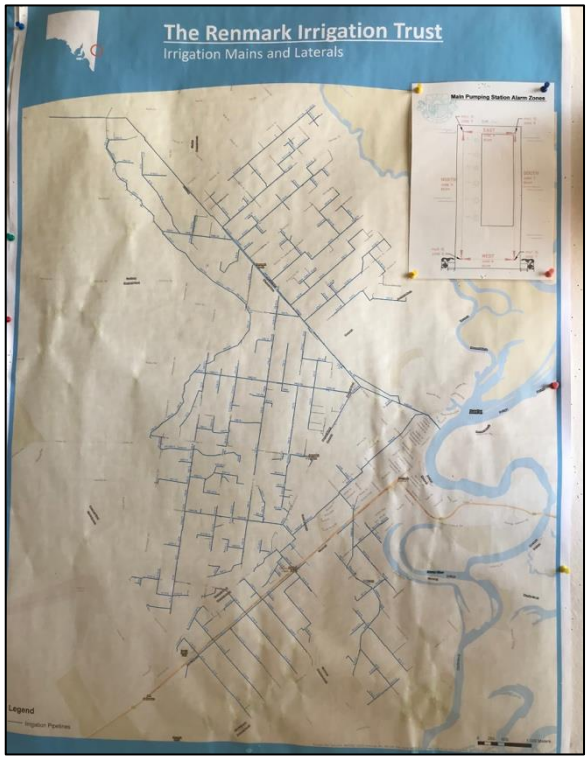
RIT is responsible for :

- 4500 hectares
- 130km of irrigation pipes from 1500mm to 100mm
- Infrastructure to over 600 properties

The water in the area supports multiple industries including agriculture, viticulture and tourism. Over the years, Renmark, along with many other districts, has been under pressure to reduce its abstraction volumes to allow flows in the river to be used elsewhere within environmental and agricultural schemes.

Environmentally, at this location, the Murray river includes a RAMSAR site and a number of national parks and not-for-profit conservation sites. For the local urban community and the farmers providing these environmental areas, it has created an 'Oasis' for industry within a resilient natural environment.

Renmark is set up in such a way that the farmers, not RIT, 'own' the water. All water is metered around the network whether it be for environment, residential or commercial supply. This has enabled farmers to 'own' a surplus of water in an otherwise oversubscribed catchment, running their system under-capacity to provide water security for more challenging drought conditions. RIT set up a 'returning water' scheme whereby irrigators return water to designated environmental areas which would otherwise have been lost through inefficiencies prior to government investment in infrastructure. The volume returned to the environment is about 25% per irrigator, released by the 98% efficiencies in the network, resulting from the investment in the conveyance of water.



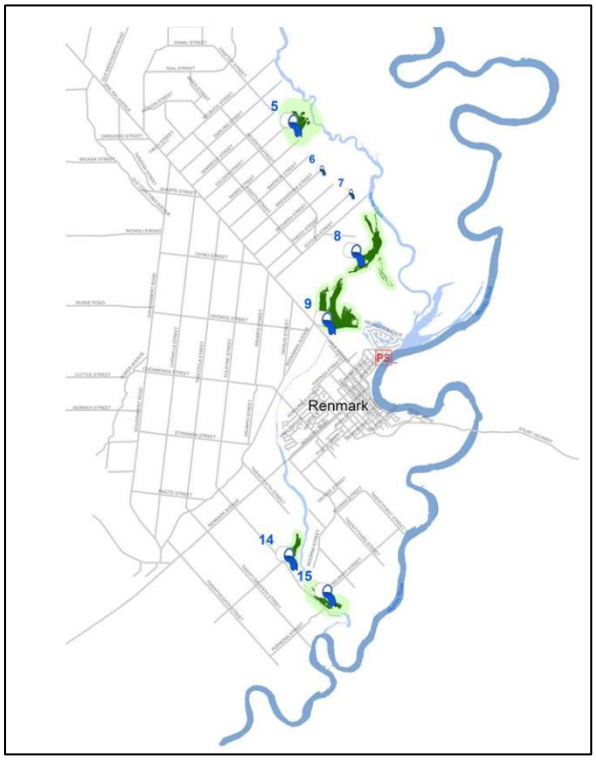


Figure 7a. Left: RIT network illustrating the expanse of piped network supplying the region *Source: RIT office*

Figure 7b. Right: RIT network and environmental watering sites. *Source: https://www.chinawaterrisk.org*

AWS rewards its members by providing awards, such as the 'Environmental water championship award'. This recognition for water stewardship fuels members long-term commitment to investing water in the environment, so conserving these landscapes.

Figure.8. The Murray river meandering through Renmark's environmental areas.

On meeting Rosalie Auricht, the RIT General Manager, and Humphrey Howie, a local farmer and chair of the RIT at the time, I was able to understand what motivated the Trust to invest in identifying a 'Triple bottom line' approach (i.e. economic, social and environment) to valuing water within the catchment and capturing the benefits this delivered. Taking a triple bottom line approach to water drives irrigators to focus on **Win, Win, Win**.

- They need to make money
- Don't want to overwater their crops
- It provides resilience for them to remain farming there and sustain a community

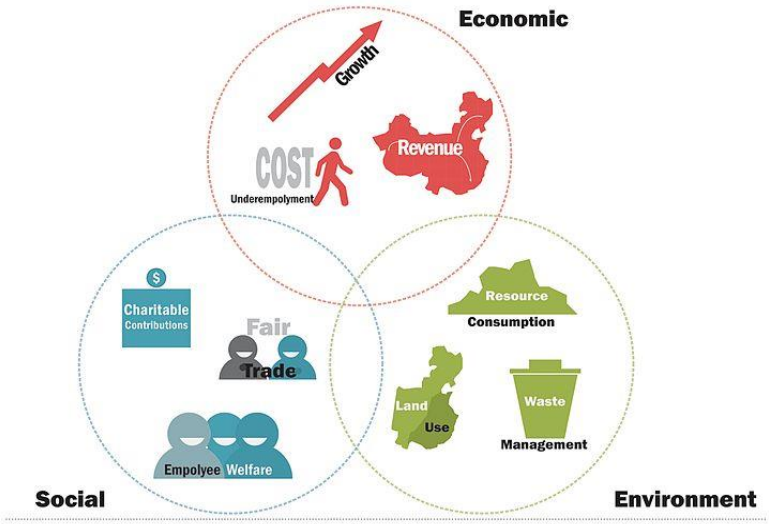


Figure 8: Triple bottom line example

Source: Wikipedia

Through conversations with Humphrey and Rosalie, it was apparent how proud the RIT is of its achievements in developing a measurable system for the outcomes delivered by sustainable water management. The recognition of how environmental water provided a revenue locally, enabled

businesses to think out of the box as to how the environment figured economically within their business model.

RIT's recognition of social benefits showed how water management provides:

- Community stability through access for businesses to a sustainable, managed water supply – through understanding volumes available annually
- Tourism earnings. River waters provide recreation for water sports, environmental water provided habitat within the surrounding bushlands for nature, providing drivers for visitors to require accommodation, dining, and outdoor pursuits
- Education. Water stewardship measures enable people to understand 'Why' managing water within this landscape is so important

The 'whole catchment management' system this region has created around water conservation is driven by environmental stewardship, and a clear understanding of the benefits all industries receive by providing water for nature. Appendix: 1 outlines an example of one of the producers, Humphrey Howie and his company Fat Goose Fruits.

Figure 9. An environmental outcome of RIT's work. This attracts tourism to the local area and conserves habitat for local flora and fauna.

Source: Author's own photo of Renmark environmental area enhancement sign supplied by the Australian government

5.1.2 Landcorp NSW- an example of farming community governance

In Australia, I visited a farmer called John Klem. John has been a 'go to' for me since I first met him on my travels to Australia 15 years ago. John is a 75 year old farmer, whose engagement at a community scale on both agricultural and water boards made him an obvious choice to visit.

During my visit to Goulburn, a wool town sitting within the Sydney Water Catchment, John introduced me to Landcorp NSW, a part government-funded body which provides rural land service advice, guidance and professional engineering support to the region for water supplies, risk identification, soil conservation, catchment management and water quality protection for Water New South Wales. This encompasses the whole state, not subdivided into regions.

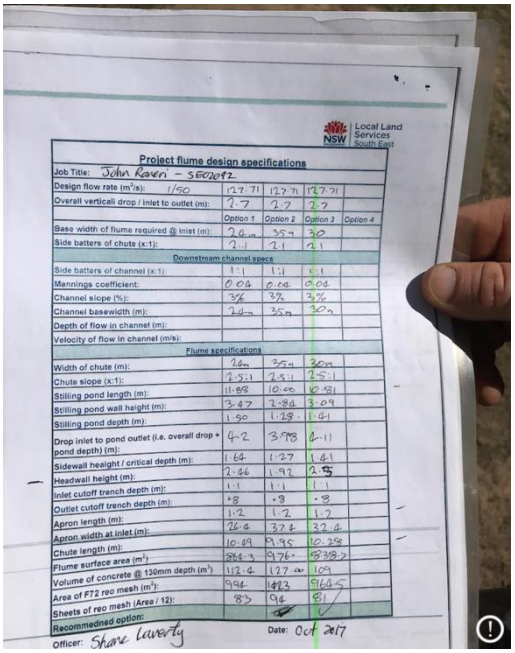
Stuart Little, the delivery lead for the agents of Landcorp NSW and his team were state funded, using local knowledge to engage with the community via community advisory groups (grassland groups etc). The work was overseen by a board made up of 3 elected farmers and 4 appointed members, governed by a community advisory group of volunteers with the chair reporting to the Australian agriculture minister.

Using the Pollution Source Assessment Tool (PSAT,) modelling to identify high risk areas, including maps of overall risk for pathogens, P, N, and suspended sediment (there were 12 modules in PSAT which included grazing and gully erosion risk), the delivery agents outline the methods available to improve infiltration and reduce soil loss. This provides farmers with the confidence and opportunity to apply for funding relevant to their individual situations. The aim is for farmers to map their own farm, identifying risk and value, then put in an expression of interest to Landcorp for support in addressing these.

I saw on John's farm a soil probe identifying moisture content to a metre below ground. This enabled him to map the water availability in the soil to plan his 'standing crop' of fodder and forecast how long his holding could accommodate the stock numbers he had. The monitoring of borehole levels and knowledge of his farm put John in the driving seat of how and when his farm needed to change to react to water availability.

The funding to supply the monitoring along with 'farm dams' to reduce erosion risk and water losses in dry ravines and gullies was all provided through Landcorp. The scheme involved grazing groups measuring and sharing data of their water levels, forecasting yields, and the results their land management methods were delivering. The measurement of benefits delivered by understanding the hydrology and hydrogeology of their farms included the economic returns on the management and sale of stock.

Prior to visiting John, I hadn't appreciated how soil erosion was such a big threat for the region and the water authority. The geology of the region is predominantly basalt, easily eroded by underground rivers, leading to collapse of the farmland above, forming ravines where soil and water is lost. Stuart showed me some of the farm dams made to reduce the speed and velocity of these flows once a gulley had become exposed.(See Figure 10 next page). The costs and scale of this engineering were similar to the flood defence projects I had seen delivered to protect entire towns within the UK's Environment Agency budget. However, in Australia the value of water's every drop, and conserving its quantity and quality in a catchment is so appreciated that they are prepared to do this at a farm level.



Project flume design specifications

Job Title: John Raven – SE02072				
Design flow rate (m^3/s): 1/50	127.71	127.71	127.71	
Overall vertical drop / inlet to outlet (m):	2.7	2.7	2.7	
	Option 1	Option 2	Option 3	Option 4
Base width of flume required @ inlet (m):	26m	35m	30	
Side batters of chute (x:1):	2:1	2:1	2:1	
Downstream channel specs				
Side batters of channel (x:1)	1:1	1:1	1:1	
Mannings coefficient:	0.04	0.04	0.04	
Channel slope (%):	3%	3%	3%	
Channel basewidth (m):	26m	35m	30m	
Depth of flow in channel (m):				
Velocity of flow in channel (m/s):				
Flume specifications				
Width of chute (m):	26m	35m	30m	
Chute slope (x:1):	2.5:1	2.5:1	2.5:1	
Stilling pond length (m):	11.85	10.66	10.58	
Stilling pond wall height (m):	3.47	2.84	3.09	
Stilling pond depth (m):	1.50	1.28	1.41	
Drop inlet to pond outlet (i.e. overall drop + pond depth) (m):	4.2	3.98	4.11	
Sidewall height / critical depth (m):	1.64	1.27	1.61	
Headwall height (m):	2.66	1.97	2.5	
Inlet cutoff trench depth (m):	1.1	1.1	1.1	
Outlet cutoff trench depth (m):	.8	.8	.8	
Apron length (m):	1.2	1.2	1.2	
Apron width at inlet (m):	26.6	37.8	32.4	
Chute length (m):	10.89	9.95	10.28	
Flume surface area (m^2)	384.3	976+	8382	
Volume of concrete @ 130mm depth (m^3)	112.6	127.0	109	
Area of F72 reo mesh (m^2):	994	1473	9665	
Sheets of reo mesh (Area / 12):	83	96	81	
Recommended option:				

Officer: Shane Laverty Date: Oct 2017

Figure 10 Catchment interventions:

Figure 10 a. left above A Landcorp dam structure installed to reduce erosion. The design and installation of the structure is carried out by the resident engineers on behalf of the farmers. These risk spots are identified by Landcorp using modelling and monitoring within the catchment.

Figure 10 b. right above Dam calculations sheet to design the sizing and capacity of the dam structures to ensure the correct flows are managed in a safe and sustainable manner.

Figure 10 c. left above

The top-down approach of the project supports the bottom-up element by encouraging soil monitoring with moisture probes. This information is shared regionally through the grassland groups.

Figure 10 d. right above

One of the many farm dams providing watering for the stock. These are rain fed, and provide the water supply for the farm, and homestead. As their levels drop, John is required to review how many months of water he has available for drinking water supply, alongside his soil moisture for cropping. All dams have to have a licence to ensure the farmer is not over collecting water within the catchment.

My conclusions from my visit were that the farming community benefitted from being engaged in the whole process, especially being engaged at step one.

Figure 11. below illustrates the outcomes hierarchy which Landcorp work to within the NSW region.

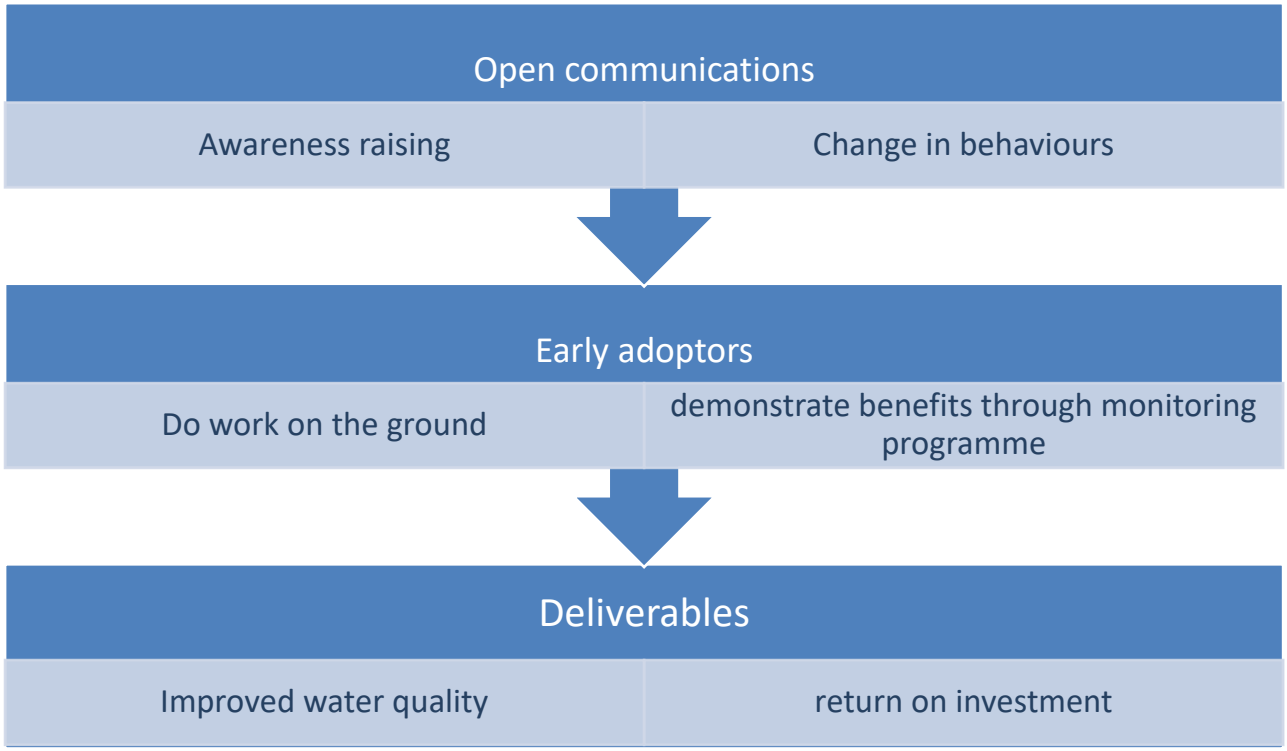


Figure 11: Landcorp NSW's outcome hierarchy

The free flow of decision making between government and the farmers set up by the governance structure gave social stability to this scheme. But it was economically unstable due to the short term funding cycle of 5 years provided through government grants. Stuart and the board stated that: *"Funding isn't ring fenced, it gets ring barked sometimes".* Sometimes initial allocations to deliver outcomes in the catchment could be removed and reallocated elsewhere, so making it difficult for the team to plan long term delivery projects because of not knowing if the funding would be available to complete the work planned.

5.1.3. Conclusion on the social value of water

The two examples, from the various locations I travelled to, of social benefits through land and water stewardship had strong governance and support structures in place to provide a free flow of information from the top and bottom including:

- Multi stakeholder governance structure to recognise how a triple bottom line approach to measure and manage risks and opportunities could reward accordingly.
- Whole catchment management of local environmental and economic water
- Development and delivery of localised solutions, using the Pollution Source Assessment Tool enabled farmers and advisors to identify recognisable issues affecting the local hydrology and hydrogeology.

- Support structure to develop and deliver best practice for industry and environment, embracing technology and taking a long term approach to solutions and the benefits delivered.
- Development of engagement groups, monitoring, and advice through a mass of advice and guidance handbooks
- Value to government through resilience in the water supply to Sydney
- Farmer-led approaches addressed The Australian 'Native Vegetation act' which acted as a catalyst for Integrated Catchment Management

However, a major benefit to communities engaging in a bottom-up approach is that farmers feel empowered, taking ownership of their solutions as they:

- Are being engaged, firstly, with root cause analysis of impacts affecting quantity and quality
- Being assisted with quantifying the economic benefits of solutions delivered alongside the social and environmental
- Have access to education & training,+ PSAT tool – monitors rainfall, intensity, soil type, farm dam handbook (design guide) and farm plan
- Have a voluntary 10 year agreement for the farmers, giving security to their investment, and the returns it is going to deliver

This empowerment gives longevity to the work. However there still remain the challenges of securing federal funding to maintain continuity within the catchment, investing in the 'one face' engagement approach to minimise disruption. The absence of such investment could lead to a very rapid decline in the water resources, through unmanaged demands by industry and consumers on the water supplies.

5.2 Environmental value of water

I have always sought to understand what 'balance' might look like between the human and environmental demands on water, often thinking: "*What sacrifices might we have to make to take care of our planet?"* Travelling to look at the range of environments across the world really helped me understand the relationships between food production and environmental health in other countries, to then compare these with our own.

Visible and invisible pollution:

Sweden taught me that the issue of visible pollution is much more likely to inspire change than the hidden effects of water quality. However, I learnt there and elsewhere that the invisible impacts are as crucial to focus on as the visible.

Within the UK 'influencers' such as David Attenborough raise awareness of the need to care for water and the environmental concerns a globally degraded water resource might have. Images, such as Figure 12 below, remind people how far our physical pollution with plastics can travel if allowed to enter the environment, pushing behavioural change to deliver that.

Figure 12 Visible impacts of plastic pollution affecting the marine environment, invisible pollutants remain un measured. *Source: Adobe Stock.*

Quality and quantity:

My travels taught me that water cannot be solely viewed at a local level (catchment scale), it also needs to consider the global water cycle. Agriculture has a responsibility to improve water quality, but it is also to manage the quantity. Within the UK, 80% of our landscape is maintained / managed by agriculture, and within that an estimated 2 million tonnes of soil is lost per year to the rivers and the sea.

Figure 13. An example of agricultural practices impacting environment : pollutants are mobilised in surface water runoff and groundwater ingress.

Through enabling agriculture to manage both water quantity and quality, resilience could be provided to benefit the agricultural industry, environment and society. This could address justified criticism of current environmental degradation.

5.2.1 Pollutants from farming impacting on nature

When visiting New Zealand I focused on water quality work in two organisations, DairyNZ and NZ Landcare Trust. The different roles of these organisations meant I could get a better understanding of how engagement with agriculture could address achieving good water quality, and its effectiveness by looking at monitoring the results.

5.2.1.1. Dairy NZ

Dairy NZ is a levy board engaged with the dairy industry to develop and deliver water quality, amongst other outcomes, for the dairy sector. It is one of the larger science funding bodies in the water space of New Zealand.

Professor Tom Stephens, one of six water quality scientists within Dairy NZ, manages the $4-5mn/yr. investment into water science for the dairy sector.

Dairy NZ's work includes developing and delivering a tool box for change within the industry, providing mitigation methods to reduce the impact of dairying including loss of contaminants into water, with the methods to measure and manage this within a farm business. The aim is to help both decision makers in policy and farmers on the ground to act on good science, so keeping farming within limits.

I felt the success of this work was very much based on New Zealand government's approach to governance, managing at a catchment scale rather than the top down generic system of one size 'will' fit all. Its 'enabling' ability within local catchments involving all industries develops an approach best suited to the risk within a catchment.

The project benefitted from the cross-party agreement around the environmental outcomes the country is looking to deliver. This helps enabling debate and political balance on the vision, investment, and governance for the people.

Working within the NZ approach, Dairy NZ has used the space to develop and deliver methods for an industry-led solution to its impact on water quality. For agriculture, both water quantity and quality has become a marketable value, one which not only drives behavioural change by farmers (or within the farming sector), but also has led to developing science to evidence the effect of Water Stewardship, and water's worth within this sector. For me, the fact that the dairy sector were arming themselves with science through monitoring and management tools strengthened their ability to inform and guide policy and investment. This could be a real opportunity for the UK to follow.

One question I considered was '*Is this a branding exercise, or a way to develop resilience within the industry? '*Tom's answer was quite quick to follow: the science provided by Dairy NZ could trace the impact individual farms were having through contaminants entering the water courses and affecting natural processes in streams such as algal growth. This evidence could then be used to determine the on-farm contributions and the effects at a catchment scale.

New Zealand government's 'outcomes' approach is through a policy which sets a high-level strategy across the country, which is then developed at a regional / local scale. This enables catchment reserves of nutrient and water quantities to be accessed through a quota system, monitoring of the inputs industry generates, and managing the water volumes required. The approach aims to ensure water quantity and quality impacts are mitigated on a catchment scale.

The tools created for farmers to measure and manage this, as well as the monitoring of industry's performance to evidence change are impressive. Real efforts are made to illustrate how Dairy is looking to mitigate their impacts on water quality, however, it is by no means the silver bullet. Creating tools to engage with science to provide evidence that making efforts was worthwhile and getting all to undertake behavioural change is no mean feat. Other approaches I have researched in Scotland and Australia were looking at a 10 – 15 year timescale to engage and embed behaviours.

Figure 14 on the next page shows NZ Dairy's achievements.

Appendix 3 at the end of this report shows the on-line 'one stop shop' information for members.

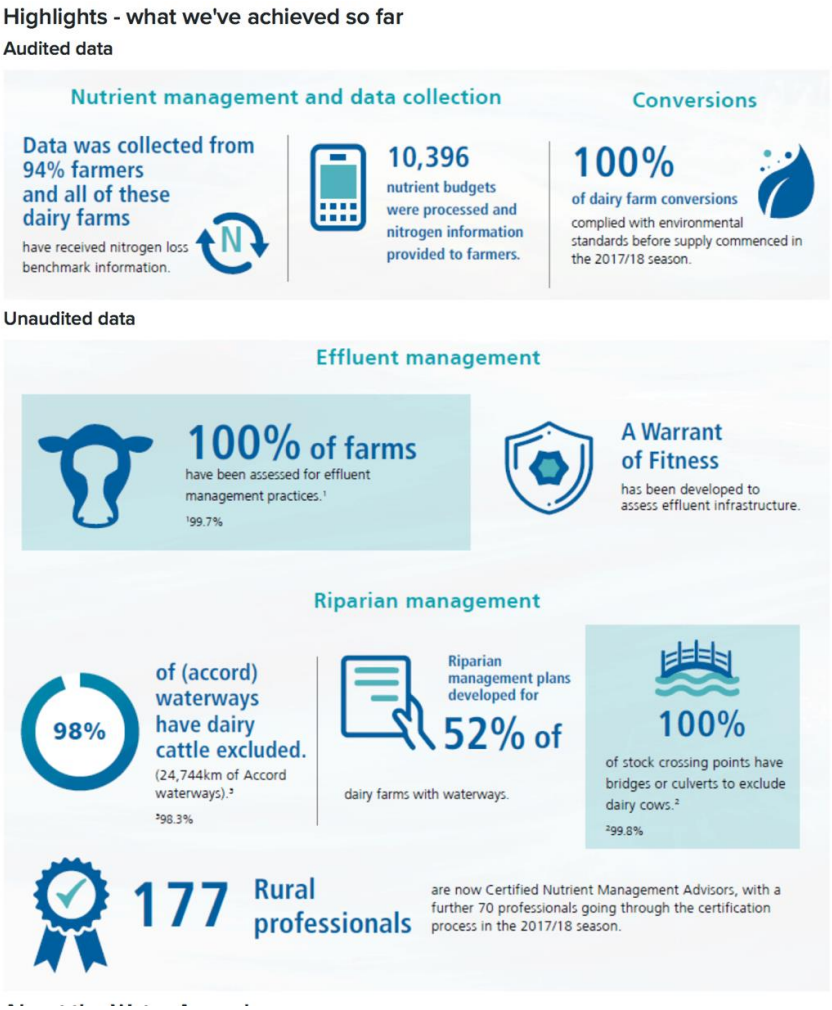


Figure14. Photo of a summary page taken from Dairy NZ's Water Accord, illustrating the uptake so far, and where the journey is yet to go.

Within the toolbox Dairy NZ had focused on the use of buffer strips alongside water courses. It was one of the most obvious features farmers appeared to be implementing, supported by tools such as the Riparian Planner which illustrated how, from a nutrient loss perspective, the filtration benefits for overland flow were high. See Figure 15 on the next page on the features and benefits of buffer strips.

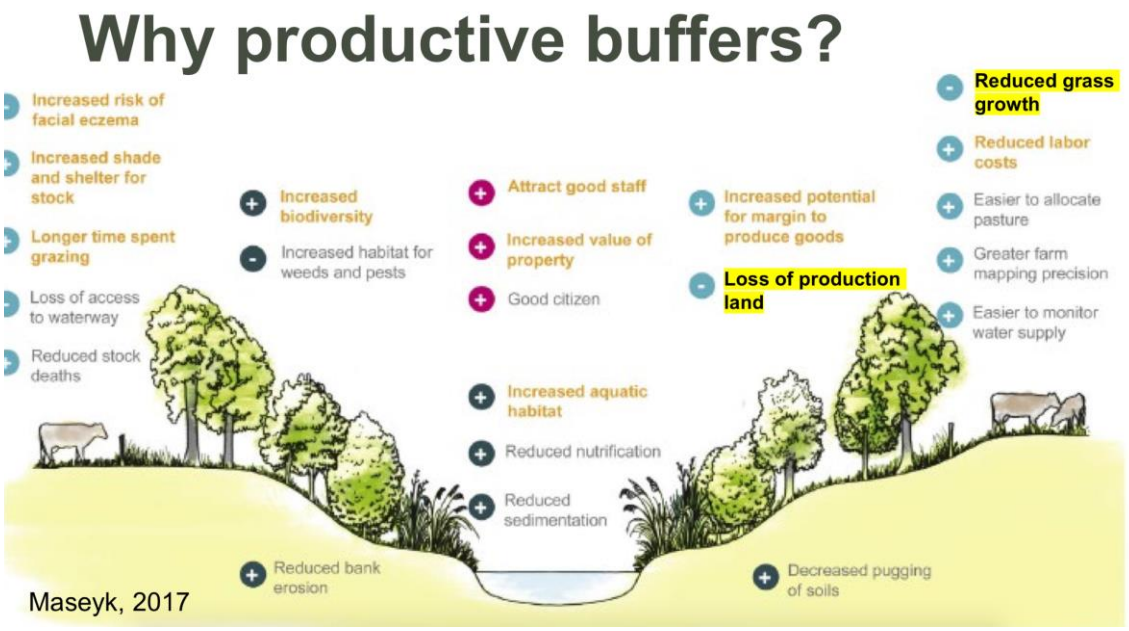


Figure 15. Benefits of implementing a buffer strip as illustrated by Dairy NZ. *The delivery of this information was carried out through on-farm engagement officers and a tool called the 'Riparian Planner'. Source: (https://www.dairynz.co.nz/environment/waterways/productive-riparian-buffers/)*

5.2.1.2 NZ Landcare Trust

NZ Landcare Trust is as a science-based organisation taking an overarching view of catchment waters and the projects being undertaken in New Zealand to retain / improve water quality. Landcare's focus, through looking at water on a catchment scale, was on the effectiveness of land use to deliver improvements to both quantity and quality of water. An understanding of who owns the land and how it is classified in terms of land use illustrated how complex the balance of economy and environment is within the countryside.

New Zealand's aim is to supply the high end consumer market by 'being green' (95% of the gross GDP is from agriculture) meaning agriculture's performance needs to be scrutinised. My understanding from meeting with Landcare was concerns included water quality within a catchment being affected by faecal matter, E coli and Nitrates / Phosphorus. Water quality was monitored to get accurate outcomes of industry effects to surface water flows.

This was complex: monitoring the inputs of intensive paddock grazing and management systems needs to be overlaid onto the outcomes – catchment quality and demands. By measuring the environmental impacts on ground water reserves, steps can be taken to minimise the effects on groundwater supplies and leaching into the surface water systems.

Figure 16. Negative dairying campaign signs when entering Christchurch

Whilst travelling around New Zealand I saw a lot of negative press towards dairy. Signs, such as Figure 16 above, gave the impression that the industry was doing very little to combat pollution. However this was not the impression I got from speaking to those developing the science and delivering advice on the ground. They felt there were other threats to the national water reserve which were rising at a concerning rate. The growth of tourists accessing remote parts of the country increased the risk of nutrient run-off from human sources. With a rainfall range from 3 - 8+m, New Zealand definitely has one of the fastest water cycles I could imagine, but the new sources of pollution needed measuring.

I related this to a UK example: Cemaes Bay catchment, Ynys Mon, Wales. Through DNA sampling the pollution causing the failing bathing waters was identified as 50% agriculture (dairy farming in the headwaters), 25% canine (through dog walkers taking the scenic route along the river banks upstream of the bay) and 25% human from failing septic tanks and combined sewer overflows (CSO's). This level of detail when identifying the root cause of failure enables catchment managers to quantify risks within their industries and invest accordingly to mitigate this.

It is apparent that understanding the impacts of all industries on a catchment ensures that no one sector takes the brunt of negative press, or that the problem of water quality becomes too great to resolve amicably across sectors and economies. (Tourism directly benefits both the urban and rural NZ population directly).

5.3 Economic value of water

One way to measure the economic value of water was illustrated at SIWI, For the majority of nations their focus was on their ability to meet the UN's Sustainable Development Goals targets of 2030, evidencing ecosystem services within their own government, and industries.

International speakers gave an insight into some of the challenges they faced with their water resource, and how that potentially drove governments desire to access others water resources, due to the quantity and quality of their own. An example of this from China is cited alongside in the 'Factoid' text box.

SIWI 'FACTOID'

Water quality impacts of industrialization in China

'Drinking water is the same as taking medicine'

- 80 percent of the mainland's shallow groundwater is unfit for human contact or consumption due to surface water discharged by industrial plants and farming units
- 68 types of antibiotics found in surface water, with in some rivers an antibiotic residue ten times higher than the permitted limit
- 75% of watercourses are unfit for fish to survive in
- 280 million people only have access to contaminated water

This water is used for irrigation of cropping of veg and cereals and has the potential to impact over 2/3rds of China's urban population.

5.3.1 Sustainable Development Goals: SDGs

Sustainable Development Goals form a blueprint aimed to achieve a more sustainable future for all. and address poverty, inequality, climate, environmental degradation, prosperity peace and justice. The goals include an end to poverty and hunger everywhere, ensuring the lasting protection of the planet and its natural resources by 2030. See Figure 17 below.

Water forms a basis of goals 6, 13,14 and 15. However the affordability of fresh water naturally available within a region influences achieving many of the other goals and can cause tensions due to water resources bridging country boundaries. See also **Appendix 2** illustrating how water and sanitation is central to sustainable development and the post-2015 development agenda, with strong linkages to many of the other proposed Sustainable Development Goals.

Figure 17. The 17 interlinked global goals designed to be a "blueprint to achieve a better and more sustainable future for all". *Source: United Nations*

As a developed nation, the UK has achieved many of the 17 development goals, so does not see water as the conduit for change that some others might do. My perception, prior to attending SIWI, was that the delivery of water, sanitation and health were problems for third world nations, not an issue for the UK *per se*. But I was mistaken.

Within the UK, our climate provides quantity of water, quality comes through the utilities and security through it being a "human right to water" or (for convenience) "the right to water" as stated by the government. I think that these factors, alongside the water industry regulator 'OFWAT' requiring water companies to reduce their bills by 5% in the next 5 years, has led us as a country to be profligate with our water resource, to think its abundance as a reason not to be resourceful with availability. A limited storage capacity, and disjointed regional management of water resources for flood risk and water scarcity led the Environment Agency lead Sir James Bevan to state at the 2019 Waterwise Conference

> "*The impact of climate change, combined with population growth, means the country is facing an "existential threat, we all need to use less water and use it more efficiently, in around 20 to 25 years, England would reach the "jaws of death - the point at which, unless we take action to change things, we will not have enough water to supply our needs".*

[1]Add to this the news commentary that the increasing demand regionally for water from agriculture and from consumers creates a conflict which our current regulatory approach, planning policies and catchment management resources do not address.

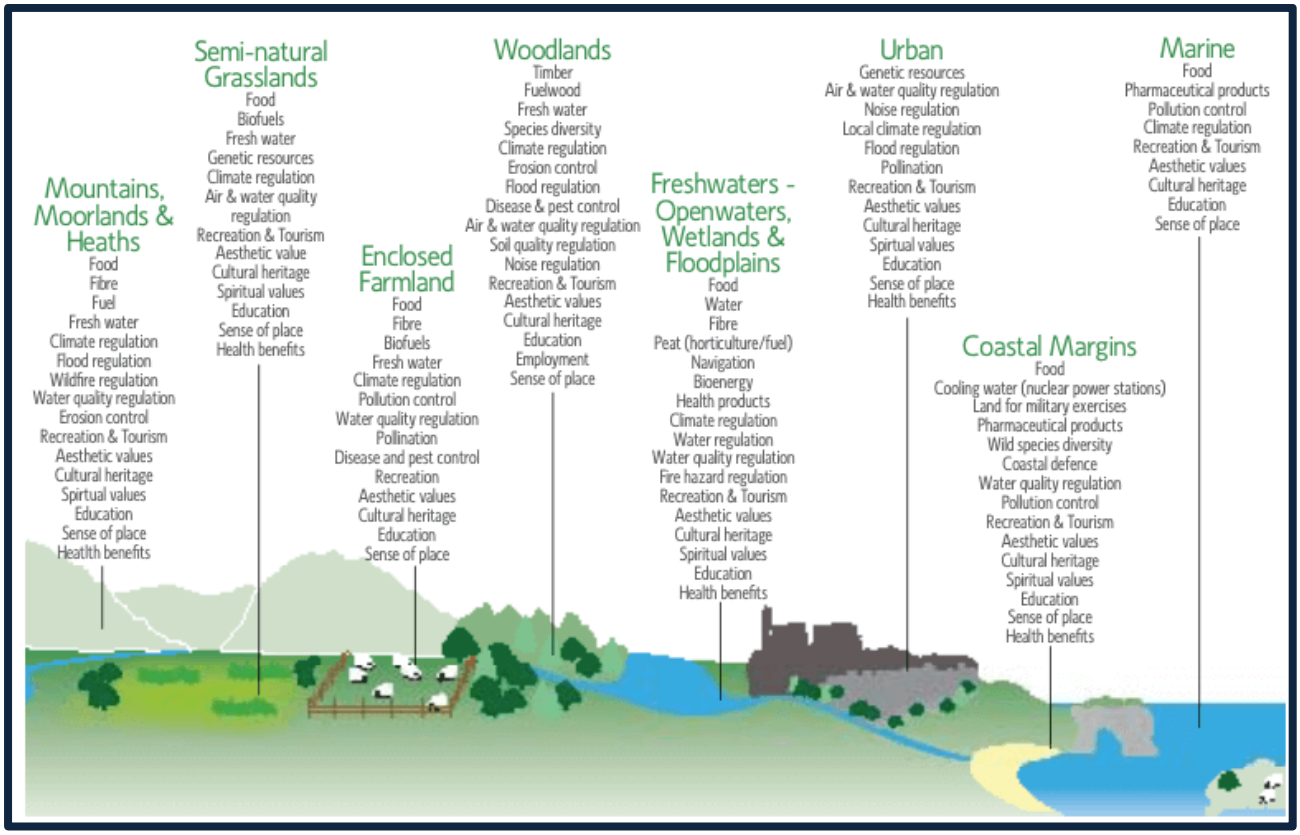
But I suggest the issue is more far reaching. Alongside the mistaken perception in the UK that many see water supply as a bottomless well not a finite resource, I feel it is our obligation to ensure consumer demands for water-based products do not undermine other countries' ability to achieve their own sustainability goals for which they need water.

5.3.2 Paid Ecosystem Services : PES

Another possible tool to drive effective and careful management of water is Paid Ecosystem Services (PES): these are the benefits derived from the natural environment. They include the supply of food, water and timber (provisioning services), the regulation of air quality, climate and flood risk (regulating services and opportunities for recreation, tourism and education (cultural services).

Figure 18 on next page illustrates the diversity of services provided by the broad categories of habitat and land uses to the public, and how farming can impact both positively and negatively on that. Currently the payment for these services is derived through the Common Agricultural Policy payment, however this is due to change within England and Wales in 2021.

[1] https://www.bbc.co.uk/news/uk-47620228



[2] **Figure.18. The eight Broad Habitats assessed in the UK National Ecosystem Assessment and examples of the services derived from each.**
Source: DEFRA Payments for Ecosystem Services: A Best Practice Guide

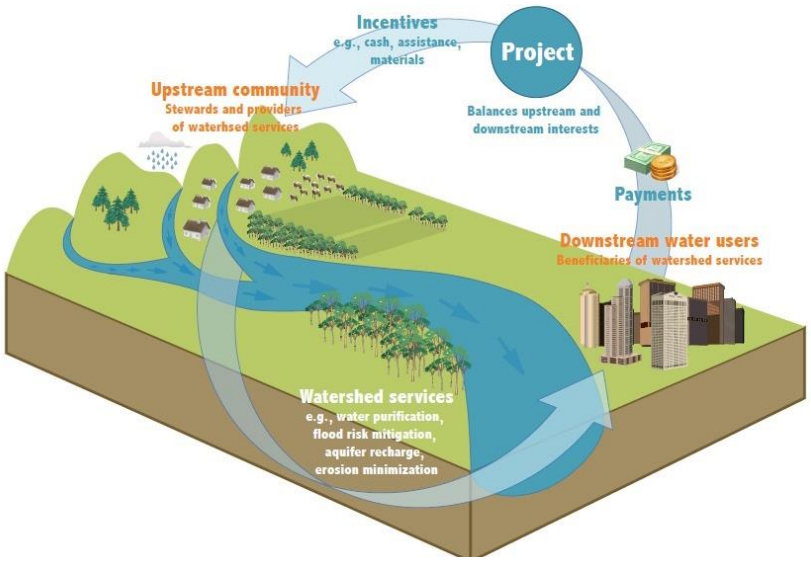


Figure.19*[1] Illustration of the PES concept in relation to payments for watershed services. *Source: DEFRA Payments for Ecosystem Services: A Best Practice Guide*

[2]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/200920/pb13932-pes-bestpractice-20130522.pdf

I saw PES at work during my travels in Brazil where I met with Professor Nilo de Oliveira Nascimento, Department of Hydraulic and Water Resources Engineering, from the University Federal de Minas Gerais. At a town called Extrema we looked at the work being undertaken by the local authority to protect water supplies to Sau Paulo. The work was about changing agricultural practices to protect water resources using such tools as participatory processes, capacity building and payment for ecosystem services. The project resembled the UK's system of payments to farmers to deliver environmental services alongside farming, however the project focus was to inform and encourage farmers to embrace water quality, whilst fitting solutions into their farming practices through the identification of risk, with water quality payments as the reward. The regional council put the successful delivery of the scheme down to the payment for ecosystem services approach being embedded into a 20 year business plan. This was provided through the continuity of the political party in place.

Locally, farmers were supported to fence off and plant trees around all springs on their land. Where soil erosion was a risk, farmers were encouraged to install sediment traps, this improved water quality by reducing soil losses, alongside creating stream protection called 'blue corridors' in the countryside. See photograph in Figure 20 on next page. I saw many examples in Brazil of catchment work being supported by research bodies capturing the benefits of the work, and methods to develop solutions which are fitted to the social, economic and environmental challenges of the time.

Brazil for me proved a fascinating country as the whole water cycle is a strong geographical feature, alongside its economic and cultural value. **Appendix 4 at the end of this report** gives a greater flavour of this.

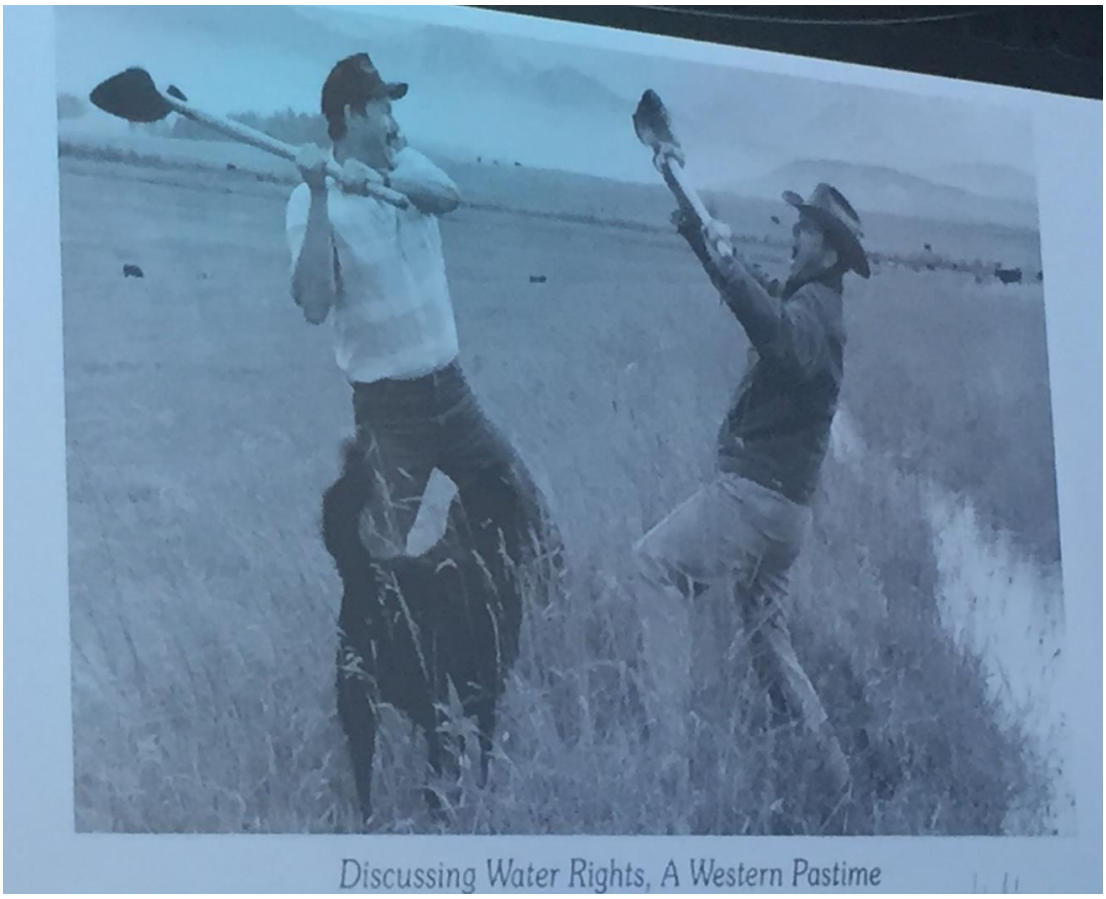
Figure.20 Brazil: One of the sediment traps installed within the catchment to reduce soil loss into the surrounding rivers. *Source Author's own*

5.4 Chapter Summary

By using the Sustainable Development Goals to identify how the water resource is utilised and affected by a local community, comparison can be created across developing and developed nations. For instance, food production in the UK might have a positive weighting on the delivery of social SDGs outside of the UK, however it could have a negative weighting on the environmental SDGs if not appropriately managed because of the negative impacts on water quantity and quality arising from food production. The use of SDGs as a baseline, building PES into the detail enables these outcomes to be delivered, including their worth. This could create a model for quantifying the worth of water resources in either a water-scarce or water-excess environment.

However using the PES system on its own would provide a very useful framework for establishing effective water catchment management.

6. Tool box for change: resilience, food security, environmental stability, and water resource management.



An illustration of "discussing water" provided at SIWI World Water week 2017.

Throughout my travels I aimed to focus on the question of what might threaten us if we don't protect and conserve both water quantity and quality. From the case studies I had seen so far I wanted to consider - 'What methods of regulation, engagement and delivery exist to inform UK policy going forward'.

6.1 From the top down

6.1.1 Fitzroy basin - the Chirrup farm engagement organization.

An Australian example where the management of governance had had a negative impact on water quantity and quality was the Fitzroy basin - the Fitzroy basin feeds into Keppel Bay onto the Coral Sea of the Great Barrier Reef. This catchment scale project aimed to: "Connect people and resources for thriving communities".

Work within the catchment has been ongoing to assist the negative impacts a landscape of arable, grassland, scrub and mining has on sediment loads received by Keppel bay and the reef beyond. The

required compliance measures identified for this work were developed by government using a modelling tool, with the scales of interrogation set regionally. This scale affects the results as scrutiny of land use needs to be at a close enough scale to identify different industries such as agriculture and mining within a catchment.

On interviewing those running the Chirrup farm engagement organization and those who farm within the catchment, I discovered that the predominant land use affecting water quality risks was actually mining. However, the heavy regulation of overland flows off this landscape were enforced on agriculture, so impacting on farmers' ability to function. Due to the scale of mapping set at a 5km + resolution, the Fitzroy basin industries such as mining were going unnoticed, meaning regulation, and investment to manage their impacts was not addressed.

Given the differing nature of Australia's soils and geology to our own, the lesson I drew from here was less about land management, and more **about mapping and the scale at which we identify the root cause of risk, manage its impacts through engagement and reward, alongside proportionate governance where required**. In contrast, in New Zealand the ability to quantify risk at a farm scale (as seen with DairyNZ) enables the success of investment to be much more readily quantified.

6.2 From the bottom up

An alternative approach when seeking to secure changes in landowner/farmer practices is by working with individuals within each region. This avoids imposing blanket rules which are unable to flex to unique regional elements.

My visit to Goulburn and Landcorp Australia Ltd provided an example of this. In Chapter 5 Landcorp was cited as an example of governance but it also shows how bottom-up water management can work. Landcorp had a regional network of catchment protection advisors providing farmers with guidance, advice and engineering services for the catchment. This was supported by an entirely voluntary system, with economic and engagement stability enabling behavioural change to occur. The measures delivered fit the local physical, social and economic constraints, delivering benefits to both the immediate farming unit, and neighbouring industries and activities, alongside the wider environment, community and water catchment area.

My belief is, in the words of Albert Einstein: *"We can't solve problems by using the same kind of thinking we used when we created them."*

Australia captured both the success and failures of a top-down/bottom-up approach. However, the separation of water from land for resale seemed to cause environmental chaos as the groundwater to surface water relationship is intrinsically linked. Where communities were given the opportunity to develop the methods to deliver benefits to water quality, agriculture and environment with a bottom up approach, it could only function if the top down is also engaged.

Figure 21. Alliance for Water Stewardship 3 pillars of water management and the benefits it delivers. Factors to be taken into account in both top-down and bottom-up approaches

Source Alliance for Water Stewardship, Australia

6.3. Chapter Summary

In the countries I visited governments recognized the value of water, and the need to support effective use of it locally, and at a wider scale. They sought a range of management approaches to secure this, with varying degrees of success.

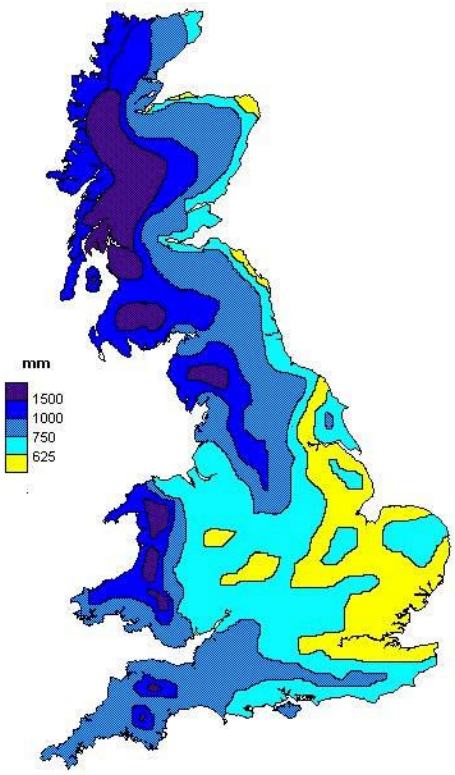
Evidence that governance structures affect the ability to make a difference could be seen in examples such as the Fitzroy basin. A top-down approach with the focus on scale to enable 'quick wins' rather than the root causes didn't deliver water quantity / quality. The scale of root cause analysis affects the analysis of the factors affecting water quality and the accuracy of outputs to identify natural resource management opportunities.

On the other hand a bottom-up approach, facilitated by government's attitude towards engagement, evidencing and incentivisation delivers the most resilient solutions to economic variables by:

- embedding protection of the environment including water as a valuable tool in the success of agricultural economic resilience, even in times of stress due to farmers' respect for its worth
- providing stability and continuity in the programmes with delivery agents providing catchment 'relationships' to deliver change. Where the regulator is an effective delivery agent this enables them to be regarded as an ally in the delivery of environmental goods and services, not a policeman looking to penalize.

Although I saw a number of examples where good practices were being delivered through 'incentivisation' such as grants and catchment facilitation work, no government had a stable economic system to reward for 'environmental offsetting' as none of them had the regulation to deliver it.

7. Water, a conduit for change: the UK perspective



UK Annual precipitation description

Climatically the western seaboard of the country is very wet, with the eastern seaboard seeing considerably less rainfall dryer.

The UK's watershed of rivers flowing westward tend to be smaller and shorter in length in comparison to those running eastwards, the massive River Severn being a notable exception.

Figure 22. UK Annual precipitation *Source: Map courtesy of ARIC's Atmosphere, Climate & Environment Information Programme https://www.british-towns.net/weather/uk-annual-rainfall*

When travelling, my experiences gave me time and information to reflect on how we in the UK are fortunate enough to have an abundance of water at our disposal but actions to use and take advantage of this are needed.

7.1 Overview.

Today's political climate within the UK is changing the future for farming in a way which hasn't been seen since the second world war.

For more than forty years, the EU's Common Agricultural Policy (CAP) set the framework of how we farm our land, the food we grow and rear and the state of the natural environment. In the future, government are looking to provide payments to land owners / farmers for the delivery of public goods and services. Public perception of farming suggests that over that period, the environment has deteriorated, productivity has been held back and public health has been compromised.

With the rise in global population, future demands for food production are predicted to double by 2050. This increases the stresses on agriculture to deliver food (at a low price), and water for public consumption and public goods and services alongside this. Figure 23 shows the current assessment of water stress across the world.

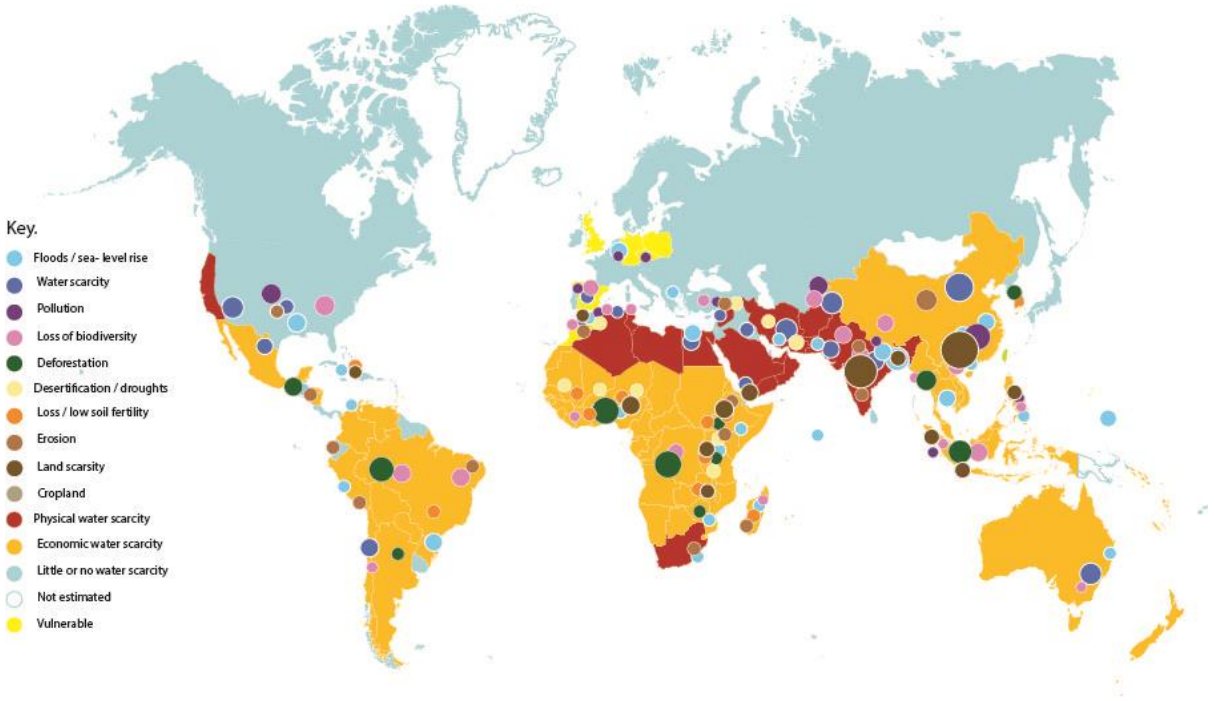


Figure 23. Current global water stress illustrated regionally. This map illustrates regions of water stress, with an overlay of coloured dots to illustrate the types and impacts agriculture is having on these environments. *Source: World Resources Institute*

7.2 Government – the political perspective

In 2018 the UK government made clear that the days of the EU Common Agriculture policy which had had the effect of deterioration on the environment were over. The Government's future vision for an agriculture policy was one that promotes the environment, supports profitable food production and contributes to a healthier society.

In 2018 the UK government separately undertook a review of how water management was delivered within Defra's 'Improving our management of water in the environment' consultation[3]. Agriculture was not mentioned in the water consultation document as a stakeholder group: The consultation suggests the utilities water industry is the main party in turning water into a valuable resource. I see this as a serious omission of government in recognising the value of the benefits which agriculture might contribute to build up the country's health and wellbeing through water management for the environment and the supply of food to the UK and global produce market. This lack of recognition is reflected across a number of other consultation documents relating to Government strategies to protect and improve the environment. Admittedly with household water supply accounting for 55% of freshwater abstracted, and just 1% being used for agriculture, the utilities sector is very important but the management and uses of water go wider than this.

[3] https://consult.defra.gov.uk/water/improving-management-of-water-in-the-environment/supporting_documents/floodwaterconsultation190114.pdfhttps://consult.defra.gov.uk/water/improving-management-of-water-in-the-environment/supporting_documents/floodwaterconsultation190114.pdf

At present the UK agricultural products supply chain is only 38% self-sufficient in water (the ratio of internal to total Water Footprint), according to WWF (formerly known as the World Wildlife Fund, the leading conservation organisation promoting of conservation of the natural environment and the sustainable use of natural resources and ecological processes). This makes the UK the 6th largest net agricultural virtual water importer in the world. Although these figures include non-food products, the production of crops to service our consumer demands are having a detrimental impact on the regions they are grown in. Looking at the sourcing, and alternatives available to supply more sustainable products to reduce our water footprint should be considered going forward.

Our global water footprint means that the water used by the UK is interwoven with that of communities and economies across the world. Not only are we over-abstracting water from some of the UKs aquifers, but through our globalised consumption patterns we are driving over abstraction (or pollution or water conflict or ecosystem degradation) in countries across the world[4]. I suggest that the Government should recognise food production within the UK is a key part in addressing our global social and environmental footprint.

Agriculture in the UK has the capacity to deliver so much more. The UK government's 25 year Environment Plan seeks to ensure that food is produced sustainably and profitably, taking all possible action to mitigate climate change, while adapting to reduce its impact. These aims should include doing so by maximising the value of water. The PES methodology, described in Chapter 6, provides a way to identify the additional benefits can have a value, as also the following Figure 24 shows.

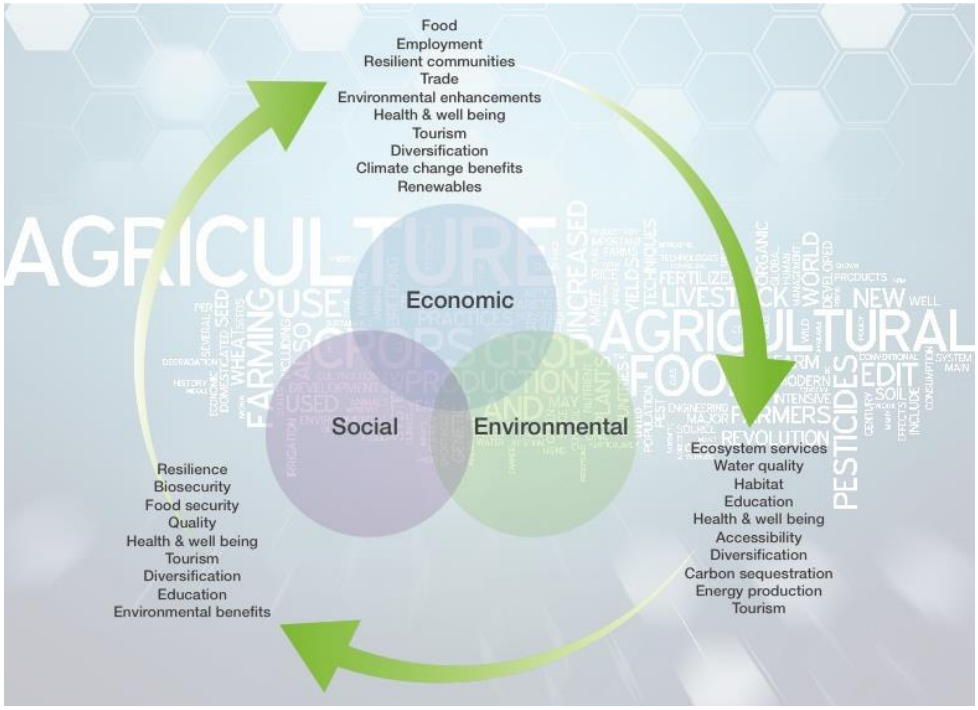


Figure 24. Graphic illustrating the benefits delivered by agriculture to the 3 pillars of sustainability. *Source: A Background map - Sparovek et al (2012) Env Science & Policy with info overlaid / sourced from http://revistapesquisa.fapesp.br/en/2015/12/02/rain-dance-2/ with author's own additions*

[4] Text from Statement by Dorcas Pratt, deputy director of Water Witness International, the sustainable development and water charity

7.3 Industry – the practical approach

I suggest that the Government should recognise food production within the UK is a key part in addressing our global environmental footprint including maximizing on our water resource.

As an industry agriculture needs to be able at a farm level, to turn awareness into practical action that protects both food and water security. Being a predominantly rain fed 'Green water' industry, I feel that although the stresses UK agriculture feels towards water availability are regional, the solution needs to be nationwide. Currently, unlike in the countries I visited, methods to measure and manage agriculture's impacts on water and efforts to mitigate these are not readily available to UK farmers.

Within the UK, the lack of detailed, consistent water quality monitoring of potential pollution sources, pathways and receptors within our waters makes the job of root cause identification challenging. This lack of investment in water quality monitoring by the government, the regulator and industry, leaves the UK behind others in evidencing farming's impact on both water quantity and quality at a farm level. It is also not yet possible to provide the information required to acknowledge and reward UK products' water footprint against our global competitors.

Action needed, as I saw on my travels, includes enabling agriculture to plug the evidence gaps within catchments and throughout the supply chain. Such data, if collected and well used, would aid water management on the farm and ensure, at a catchment scale, farming can deliver on Defra's targets of improving water quality and increasing flood and drought resilience.

The changed approach would need:

- Research – increase the understanding of the link between farming practices and run-off at both high and low flows in order to develop appropriate mitigation actions for water management: this builds on research undertaken in projects such as Pont Bren, North Wyke (Rothamsted) and Allerton (GWCT).
- Water efficiency - identify opportunities for saving water on the farm and new innovations to make them viable
- Supply chain – evidence food production's water footprint both in the UK and globally for the UK's food imports to improve water use efficiency and reduce environmental and social issues
- Collaboration across sectors – improve forecasting of short and medium term water availability to improve water management and consumer allocations across industries
- Global impacts – create a better understanding of the wider impacts of climate change on future water availability, including changing catchment hydrology. This will enable better long term planning
- Governance – create a framework for flexible water allocation, with mechanisms to allow the reallocation of water between different uses, to the wider benefit of society

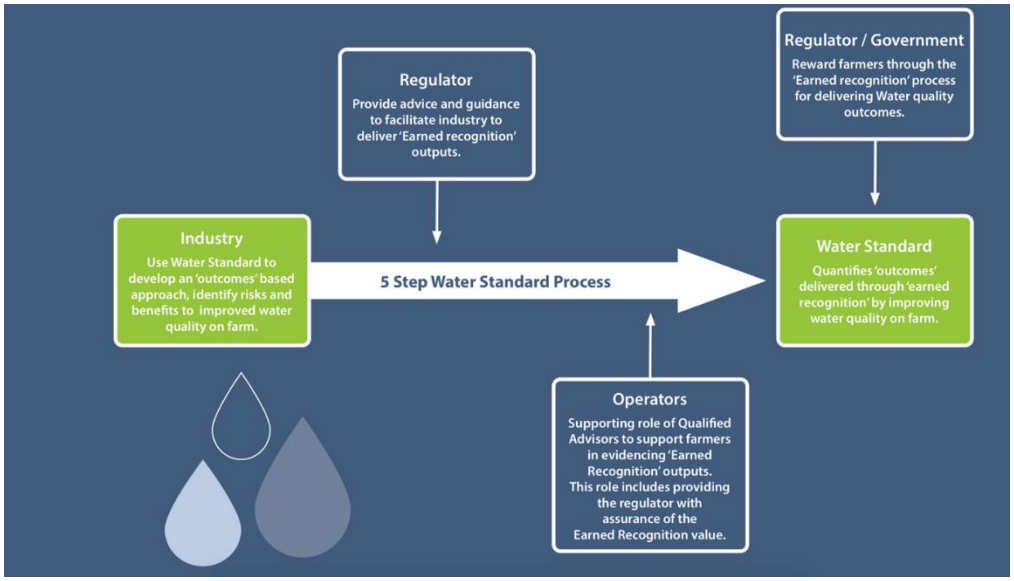


Figure 25. Graphic illustrating NFU Cymru's Water Standard pathway, intended to provide a method of evidencing behavioural change and good practice, so promoting continual improvement of water quality. *Source: Author's own designed on the basis of my Nuffield Farming travels for NFU Cymru Farmer led approach to nutrient management programme project*

7.4 Local governance structures

We also need to take a look at the engagement and regulatory methods we have at a local level. The local governance structures of New Zealand, and standardisation of stewardship of water across industries and environment illustrated how to empower industries to measure and manage their performance so benefitting all.

On my visits around England I travelled to East Anglia, a complex region, facing water stress for the urban populous alongside the demands of a productive farmed landscape. Here I found one possible model structure which has been established relatively recently, Water Resources East (WRE). Alongside this I also visited the Internal Drainage Board (IDB) Welland and Deeping who managed the water infrastructure for the region.

Water Resources East was formed in 2017 during a step change in government policy. This culminated in the development of a National Framework of regional planning groups led by the Environment Agency. Unlike other regional planning groups WRE became an independent legal entity in 2018. Its multi-sector board enables all the stakeholders to input into creating a regional plan which identifies and addresses the needs and potential trade-offs of all, so providing for balance between the considerations of customers, agriculture, the economy and environment.

On talking to the Chairman, Henry Cator, and Technical Director, Steve Muncaster, my impression was that the independence this organisation had from the regulator (The EA), and the water industry enabled it to take a more balanced approach to all the catchment partners and environments needs, enabling trade amongst the partners for the supply and demand of the regional water resource. Complimenting this, with its skills and resources, the IDB works with landowners in both the urban and rural landscape, providing the management and maintenance of water resources at a local level. Within England, an IDB's board is made up of 51% elected farmer members and 49% local council members. With farmers working in partnership with the authorities, agriculture has a voice on the

challenges of water supply and storage for flood risk and water scarcity. The English IDB structure typically involves farmers working in partnership with the authorities, and like Renmark this appears to work well.

This combination of an overarching view such as WRE provides, and the IDB's services could, going forward, support agriculture to access public good and services positively. Such a framework could encourage agriculture to invest in research etc, and deliver PES benefits by measuring and managing:

- Soil health
- Nutrient management
- Resilience to flooding and drought
- Animal health / welfare
- Environment and biodiversity
- Education
- Catchment scale benefits to industry, environment and society

7.5 Chapter Summary

Looking ahead, the biggest challenge industry and government face when making better use of the UK's valuable water resources is establishing a true, representational price for water, incorporating a value for the environment our water footprint sustains, both locally and abroad.

I feel to deliver this we need to understand 'why' our flood risk and water scarcity exists, and then to identify what a sustainable solution to water management and apportionment between industry and environment looks like.

My belief is that agriculture's role in water management within the UK could provide local and global benefits to society, environment, and industry. The adoption of rewards for 'public goods and services', including a weighting towards the value of water use for food production on a global scale would enable agriculture to be part of the UK's solution to better water management, producing a sound investment for benefits in aspects of:

- Social – health and education
- Environmental – habitat, biodiversity, resilience
- Economic - stable income to provide for all

Referring to a quote by Thomas Fuller – '*You never know the worth of water until the well is dry*' - maximising on a successful rain fed agriculture means we would have the capacity to manage internal and external risks to food security, environmental value and societies health and wellbeing before it is too late.

8. Discussion

All through my travels I sought to find the perfect answer to catchment management for water: however, there are too many variables in society, governance, markets and environment to see one size which fits all. Climate change will affect how we manage our landscape going forward, but the use of whatever access a country has to water should be maximised, and risk mitigation built in, to the benefit of all users including the environment.

On reflection the separation of agricultural water issues from those of other water users is not straightforward. I drew four conclusions from World Water week which continue to resonate. These are as follows:

- We have a need to consider water in a circular cycle and economy within its value at a local level and on a global scale.
- Innovation: ensure no water is seen as 'waste' water, it should be managed to ensure it is available for 'when' it may be required.
- The collection, availability and monitoring of data provides evidence to enable change and influence the direction of travel.
- Leadership: enabling change through good governance and the recognition of waters value socially, environmentally and economically at a global level.

8.1 Global considerations

My travels illustrated how the UK's global access to water through the importing of goods and services, so contributing to the water stress which some countries face, means the UK risks exporting its environmental footprint to others. The global issues of food security, water scarcity and environmental degradation have been exacerbated by the increasing disconnection with the value of our natural resources and all that they deliver socially, environmentally and in turn economically.

Both SIWI and the global Sustainable Development Goals illustrated to me the importance of a country's water resource. But to deliver better use of water, in terms of production, imports, and exports, it is necessary to know what water the UK has and how it is being managed.

The disparities between the availability of water and its value to those who have access to it makes achieving a global unified value challenging: however, can the recognition of one's own water footprint drive change in others' ability to value and conserve their own?

8.2 The worth of water

My travels raised so many questions around what is water's worth.

Leadership from government, and society's attitude to what is the worth of food, farming and environment in a UK context is important. Within the UK, a focus on its own environmental targets for rewilding etc. has the potential to ignore the impact on others, simply by accepting that the degradation could be reduced if more products were imported. The majority of food production in the UK is serviced by 'Green water'(that is rainwater), a sustainable water supply, but the biggest threat to it might lie in actual availability due to water quality.

Given the UK's advantageous access to a sustainable water supply, how can it be maximised upon, marketing the UK's soil and water resource to the global market in the form of a sustainable supply of an essential good – food?

8.3 Considerations for action by and within the UK

As the United Kingdom moves into the next era of our political landscape, within both agriculture and politics, it has an opportunity to develop a fresh approach to using water where 'health' and 'wellbeing' form the core of industry, environment, and society. Existing plans and the political environment require changes to deliver this. This could include:

- Identify impacts on water quantity and quality at a local level of all industries engaging with the water cycle – ground, surface and evaporated water sources
- Quantify and monetise the worth of public goods and services to bridge silos within government of approaches which embrace environment to deliver health, education, climate change mitigation alongside food production
- Measuring localised social and environmental change to enable true economic values to be allocated
- Use the sustainable development goals to identify how the water resource is utilised and affected at a local level
- Bench mark UK's agricultural, environmental, food security and water resource performance on a global scale

The value of UK agriculture to provide goods and services with our water resource needs recognition. Payment for such goods and services must either be provided through the 'true value of food production' and/or a secure public goods and services scheme rewarding sustainable farming practices measured on their water stewardship. Investment in technologies to refine agriculture's work and impacts on the environment alongside improving productivity and sustainability will assist in the delivery of valuing our water resource within the UK, so achieving targets such as Net Zero 2040 to name but a few.

8.3.1 Achieving better water management

A changed approach to deliver the 25 year environment plan, including sustainable food production and action to mitigate climate change through better water management/use to benefit all sectors needs to come from the top. This could include breaking down silos between the several strands of government strategies to access social and environmental deliverables within agriculture from the healthcare, environment and education budgets. Methods to deliver this include green health, amenity, water storage and flood protection, e.g. rewarding agriculture for the management and maintenance of localised Sustainable Drainage Systems (SuDs) to protect infrastructure, housing and industry.

By looking at the lessons we can learn from others, the bringing together of a UK-wide top- down and bottom-up approach to water management through appropriate governance, and a supported agriculture industry would deliver the 3 sustainability pillars more evenly.

The methods to achieve better water use and management could include:

At catchment level

1) Policies with the flexibility to develop bespoke approaches dependent on catchment needs, so reducing the risk of unexpected impacts in other places.

2) Catchment allocation of water for farming, domestic and industrial supply and environment to deliver public goods and services

3) Focus on water use efficiency, especially in times of scarcity, by better management in times of excess supply

4) Measuring water quality within a catchment establishes the means to enable all industries to be aware of their impacts on water quality, so developing well designed methods to mitigate adverse effects. Such a multi-faceted approach would deliver multiple benefits within a catchment

5) Another possibility could be to develop a Rural SuDs tool box to support the development of ELMS (Environmental Land Management Schemes - agricultural policies which enable multiple benefits to be delivered and rewarded for (See Scottish Environment Protection Agency example: https://www.crew.ac.uk/publication/rural-sustainable-drainage-systems-practical-design-and-build-guide-scotlands-farmers)

At farm level

1) Introduce ways to help farmers develop best management practices for their water resource, including data on availability and quality

2) Encourage the use of new technologies and methods to get farmers into the 'driving seat' of their agricultural and environmental resources, to support agriculture's economic resilience, such as Australia's Landcorp's engagement and funding scheme.

8.3.2. Delivery timescales

Policy needs to take account of the fact that results do not happen overnight. It can take many years for agricultural change to show evidence of the benefits it is delivering to environment. My travels showed that a lack of longevity in funding and single government cycle timescales do not align with environmental and behavioural change or the scientific research to evidence it.

8.3.3 Governance

From my travels I saw the value of examples where social benefits achieved through land and water stewardship had strong governance and support structures in place to provide a free flow of information from the top and bottom. Particularly striking were the multi stakeholder governance structures of whole water catchments, and recognition of how a triple bottom line approach to

measure and manage risks and opportunities could reward accordingly: below that a support structure was in place to develop and deliver best practice for industry and environment, embracing technology and taking a long term approach to solutions and the benefits delivered. Examples were Renmark and-Landcorp NSW's success.

Within the UK, the delivery of this a number of top-down and bottom-up elements would need to be laid in place locally both to engage and facilitate change.

8.4 Last thoughts

Many of my Nuffield Farming peers have established the need for a drive towards sustainable agricultural systems and lobby for change within production methods and value of the commodities produced. Added to this is my conclusion is that ***'Without water quality we don't have quantity'.*** An agricultural industry which can evidence its impacts, so benchmarking its performance with water against others, stands itself in good stead. This would stabilise the industry's ability to 'make space' for environment and society to benefit from our farmed environment and be rewarded accordingly.

Further, the focus on water delivers a more holistic approach to our soil and water management, which is definitely for public and global good, as Fat Goose Fruits demonstrated. Looking 25 years ahead, even with climate change, the UK's location provides us with a supply of quantity. Is this not an opportunity, and an obligation to manage both quantity and quality for ourselves as well as others?

9. Conclusions

Throughout my travels I observed a feeling of pride in the agricultural industry where it, government, and other engagers with water discussed on a level platform the value of water management at a catchment scale and the responsibilities of those impacting upon it.

1. Within the UK I found agriculture and water undervalued, where social pressures are skewing government to take a partial approach to water resource management. In that context my conclusions from all I have seen are:

2. Water quantity and water quality is every person's responsibility. Decisions everyone makes on consumer goods and lifestyle choices should take account of that.

3. Nationally, there is a very urgent need for government and the public / private sector to-recognize the value of UK agriculture in providing goods and services with our water resource.

4. By viewing quantity as a finite global volume shared by all, we in the UK can start to understand the import and export of our water footprint as a tradable commodity, recognised in the value of goods and services..

5. The UK soil and water, quantity and quality, provides the ingredients to create a balanced landscape where water availability, food production and environment can work in harmony.

6. Globally we need to recognise in production of goods and services, the impacts on sustainable water supply and demand regionally to justify the sustainability of that product produced in that environment. Constructing a silver bullet solution for water relies on a unified value for this finite resource becoming globally recognised.

7. Agriculture needs to 'measure to manage' its water footprint and be able to sit alongside other industries, participating in schemes to achieve collectively beneficial environmental impacts on water quantity and quality.

8. Measurement, knowing what water we have and its quality and knowing agriculture's needs for productivity, drives innovation on water capture and reuse, and the social and environmental benefits farming delivers. Addressing water quality and quantity management by all users within our catchments can provide resilience for the future.

I have left my travels feeling empowered by the potential of water's worth within the UK, and methods to develop an industry which is resilient to the climatic changes in our environment, however my words to government stand as before 'you never know the worth of water until the well is dry'. By undervaluing our agricultural industry we run the risk of offsetting our water footprint on others, destroying the resilience farming provides to us and others through food and environment across the globe.

10. Recommendations

In my view it cannot be one man's mission to preserve, conserve, and improve our water resource: it is the responsibility of all those who engage with it.

UK government has a responsibility to our own landscape, and to that of other countries to value and protect the natural resources we look to capitalise on for our economy. To ensure this is delivered fairly I believe government need to do the following:

1. Place an economic value which includes an amount for the value of water in UK agricultural produce e.g. wool, timber, food, environment. This empowers consumers, retailers and producers to not offset our environmental footprint, but embrace sustainably produces local goods and services.

2. Break down the urban / rural barrier through education – by raising the consumer awareness of our environmental footprint, and the value of managing our natural resources, and how we impact them.

3. Provide a UK wide support service for farmers to manage water effectively– this should assist with identifying and delivering environmental goods and services, alongside good business practice.

4. Break down silos, and facilitate joined up thinking – investment on environment, health and education shouldn't be seen in isolation.

5. Facilitate water management to deliver public goods and services – the provision of UK wide catchment advisors to assist in the delivery of good land management.

6. Engage with other industries to discuss cross cutting themes, such as health and wellbeing, high quality food production and environmental enhancements.

11. After my study tour

This report summarises my own personal journey to date: it is most definitely not complete.

As a self-confessed 'water bore' I am seeking a path which demonstrates the value of water quantity and quality on a catchment scale. My relationship with all things that affect water has been supercharged through undertaking this journey. I find I finish frustrated by the value we put on our water resource and lack of understanding of the complexity of this resource. Because of that, my desire is to make my knowledge on water more digestible to others, assisting our understanding that water's wealth lies in its health, and it's our job is to preserve that.

Following my travels I have been fortunate enough to become heavily involved in progressing the recognition of agriculture's responsibility for water quality and the way our farming and environmental practices engage with this.

I have worked to develop a 'farmer-led approach to nutrient management' through the creation of an industry-wide Water Standard with NFU Cymru and Natural Resources Wales. *https://www.nfu-cymru.org.uk/nfu-cymru/documents/the-water-standard/*

Alongside this I continue to develop and deliver on my obligations as director of SuDSPLanter Ltd, a company providing sustainable drainage solutions to improve water quality within our towns and cities.

My next steps, in collaboration with academia and industry, are to develop the tool box for farmers to evidence the benefits of water quantity and quality within their businesses. This would help build resilience for climate change, consumer demands on water resources and benchmarks the benefits that land and water management delivers to the UK and global markets.

Assisting farmers to understand the water cycle within their farms, and how they interact with it, allows industry to measure the cumulative effects nutrient management and changing behaviours have on soil and water health. Measuring this means industry can demonstrate the value water quality has to our sector. Measurement also allows agriculture to bench mark its performance against other potential polluters and capture the multiple benefits good farming practices deliver, on farm, and within our water courses.

Through my work within industry and agriculture I continue to lobby government on the value of water and how as a resource we should be developing the tools to link land management, water use and Industry resilience within the catchment for both water quantity and quality.

My Nuffield Farming Scholarship has fueled my desire to continue learning and developing my skills within the subject, alongside when time allows to travel and further explore the subject of water in a changing climate. I hope the enlightenment and learning I have undertaken provides inspiration to others for their own journey, whether as a reader or potential scholar working to improve our environmental footprint on earth.

12. Acknowledgement and thanks

There are many people who have chivvied me to get to this point, prior to applying, and along the journey, a special thanks must go to my family and friends for all their help and support and to my grandmother,Janet Trant, whose perceptive words on water set me on this path.

*Janet Trant (formerly Owen) my grandmother (1st person on the left) undertaking a tractor ploughing test for Women's Land Army girls on the long mountain, Welshpool*5.*

I'd like to thank the Nuffield Farming Scholarship Trust and my sponsors the National Trust for providing me with this opportunity to travel and learn.

My eternal thanks go to my Nuffield Farming mentor Walter Simon and Editor Alison Blackburn for their help and support in writing my report.

Finally I'd like to give a special thanks to my fellow Nuffield Farming Scholars and friends both old and new I visited on my travels, they provided a welcome face at every door, time and generosity of knowledge I couldn't have completed my report without.

A special thanks must go to John and Waff Klem, old friends with young minds who've twice provided hospitality and knowledge on my travels around the globe.

Lorna Davis

5 http://search.digido.org.uk/?id=llgc-id%3A1462457&query=*&query_type=full_text&page=1&qf=subject_name_lcsh%3AWomen%27s+Land+Army+(Great+Britain)+

Appendix 1

AWS: Fat Goose Fruits – Renmark
Case study of one participating farm

Humphrey and Michelle Howie, are citrus fruit growers who formed part of the Renmark Irrigation Trust's AWS project. Humphrey Howie is also chair of the RIT.

As part of the ways to maximise water use within the improved irrigation system Humphrey and Michelle had looked at ways of creating a 'sustainable land management system to reduce costs elsewhere. To this end, Humphrey had the whole farm electric fenced from all native browsing species and predators such as wild cats and dingoes, and native browsers: kangaroos. By introduced his own browsing livestock to keep down weeds below the fruit trees, such as hares, geese, dauper sheep and wallabies, Humphrey set up a rotational grazing system which reduced fuel consumption and labour by reducing his mowing regime. The livestock provided a small income through meat sales of geese and sheep.

To offset additional electricity demands they set aside a small portion of land purchased for its water rights to become a solar farm. Ironically to date there has been very few incentives to invest in this technology from the Australian government, preferring to invest in coal instead.

Native woodland planting provides increased habitat value for the farm and assists with the risk of saline intrusion. This also provides a food source for bees housed in hives on the site for pollenating the fruit trees.

The circular approach to managing the fruit crop has increased productivity of the farm as well as additional incomes from the solar farm and reduced over heads of fuel and labour. Although the meat sales don't generate much of an income, they do assist Humphrey with delivering environmental benefits to the locality and his own farm as well as provide nutrients to the soil through the grazing regimes.

Humphrey and Michelle in the fruit packing house.

Appendix 2

Water's role within the delivery of the Sustainable Development Goals.

Source: https://www.unwater.org/publications/sdg-6-infographics/

Water and sanitation are central to sustainable development and the post-2015 development agenda. Strong linkages exist to many of the other proposed SDGs illustrating how agriculture as the largest user / land manager has a role to play in managing it's impacts on both quantity and quality locally and globally.


ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL
A STRONG, INTEGRATED WATER AND SANITATION GOAL SHOULD HAVE INTERCONNECTING, MUTUALLY REINFORCING TARGETS - WHICH LINK TO ALL OTHER AREAS OF SUSTAINABLE DEVELOPMENT.
SUCCESSFUL REALISATION OF GOAL 6 WILL UNDERPIN PROGRESS ACROSS MANY OF THE OTHER GOALS AND TARGETS.
GOAL 6
WATER & SANITATION
THE KEY TO A SUSTAINABLE FUTURE
6.1 SAFE DRINKING WATER
1 in 10 of the population has no access to clean water. This means a child dies from a water borne disease every 15 seconds. The burden for gathering drinking water falls largely on women and girls, who spend a back-breaking 200 million hours every day collecting it. This is time that could be spent in school or gainful employment.
LINKED GOALS: END POVERTY (1.4) END HUNGER (2.2) HEALTHY LIVES (3.2, 3.3, 3.9) QUALITY EDUCATION (4.1, 4.5) GENDER EQUALITY (5.4) REDUCE INEQUALITY (10.3) SUSTAINABLE CITIES (11.1)
6.2 SANITATION AND HYGIENE
Over 1/3 of the global population are still without access to an improved sanitation facility. More than 1 billion defecate in the open. Millions lack vital handwashing with soap or menstrual hygiene facilities. Diarrhoeal disease, largely caused by poor water, sanitation and hygiene, is a leading cause of malnutrition, stunting and child mortality. Inadequate facilities also affect education and economic productivity and impact the dignity and personal safety of women and girls.
LINKED GOALS: END POVERTY (1.4) END HUNGER (2.2) HEALTHY LIVES (3.2, 3.3, 3.9) QUALITY EDUCATION (4A, 4.1, 4.5) GENDER EQUALITY (5.2) SUSTAINABLE CITIES (11.1) REDUCE INEQUALITY (10.3) SUSTAINABLE GROWTH (8.9)
6.3 WATER QUALITY
Research suggests only 20% of global wastewater is currently being treated. The rest gets dumped untreated into water supplies – rivers, lakes and oceans. If wastewater is drunk – as happens in many water-stressed cities – or used directly in agriculture, the impacts for human health, ecosystems, biodiversity and agriculture can be considerable.
LINKED GOALS: HEALTHY LIVES (3.3, 3.9) RESILIENT INFRASTRUCTURE (9.4) SUSTAINABLE CITIES (11.6) SUSTAINABLE CONSUMPTION (12.4) SUSTAINABLE ECOSYSTEMS (15.1) SUSTAINABLE OCEANS (14.1)
6.4 WATER EFFICIENCY
Successfully balancing interrelated global demands for water, energy and food will be central to realising sustainable development. Agriculture currently uses 70% of freshwater supplies – and the need for water will only grow as demand for food and energy is expected to rise by 50% and 35% respectively by 2030. Water efficient innovations and practices must be rolled out across all sectors to help meet growing need without degrading ecosystems.
LINKED GOALS: END POVERTY (1.4, 1.5) END HUNGER (2.4) QUALITY EDUCATION (4.7) ACCESS TO ENERGY (7.1, 7.2) RESILIENT INFRASTRUCTURE (9.4, 9A) SUSTAINABLE CONSUMPTION (12.2) SUSTAINABLE ECOSYSTEMS (15.1)
6.5 WATER RESOURCES MANAGEMENT
2/3rds of the world's population could face water stress by 2025 – with the potential to fuel social, economic and environmental tensions within and between countries. The impact of climate change – droughts, floods and ecosystem degradation – will only serve to exacerbate resource-related unrest.
LINKED GOALS: RESILIENT INFRASTRUCTURE (9.1, 9.4) SUSTAINABLE CITIES (11A, 11B, 11.5) SUSTAINABLE CONSUMPTION (12.2) INCLUSIVE SOCIETIES (16.1, 16B) GLOBAL PARTNERSHIP (17.6, 17.7, 17.8)
6.6 WATER-RELATED ECOSYSTEMS
Water-related ecosystems – such as wetlands and mountains – underpin most of the Earth's natural processes. But water stress is depleting aquifers, reducing river flows and degrading wildlife habitats. Unless urgently addressed, this will have devastating economic, ecological and human consequences.
LINKED GOALS: RESILIENT INFRASTRUCTURE (9.4) SUSTAINABLE CITIES (11.5) SUSTAINABLE CONSUMPTION (12.2, 12.4, 12.8) CLIMATE CHANGE (13.3) SUSTAINABLE OCEANS (14.1) SUSTAINABLE ECOSYSTEMS (15.1, 15.3, 15.8, 15.9)
KEY:
LINKED GOALS
Unilever

Appendix 3

Support systems for the New Zealand Dairy Sector as provided by the Levy Board (https://www.dairynz.co.nz)

Dairy NZ provide a comprehensive 'one stop shop' for the industry to better understand what water quality means, their impacts on it and how to measure and manage these impacts through land management and natural vegetation. This one stop shop was provided, as follows, on a website with member access to certain tools, and a number of officers on the group to support the design and delivery of the projects objectives.

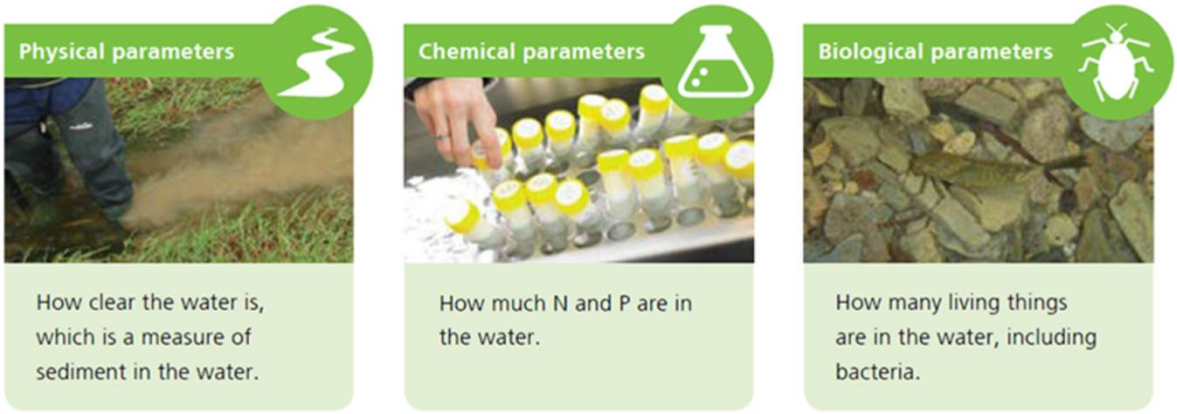
Text taken from: https://www.dairynz.co.nz/environment/water-quality/water-quality-and-limits/

''Water quality is a description of the condition of the water. It includes measurements, using proven scientific methods, of physical, chemical and biological parameters.

There is no single definition for what is "good" or "bad" in terms of water quality. To determine what is good or bad we need to consider:

- *What are the parameters of water quality?*
- *What is the water used or valued for?*
- *When setting water quality limits both parameters and values are considered.*

Parameters of water



Values and uses of water

In New Zealand water values typically include:

1. *Ecosystem health and biodiversity*
2. *Cultural values including Mahinga kai (food gathering)*
3. *Recreational values including primary contact (swimming, water-skiing, kayaking) and secondary contact (fishing, tramping)*
4. *Amenity values such as landscape and scenic values*
5. *Health values including stock and human drinking water*
6. *Economic values such as irrigation water and hydro power generation*

7. *Not every water body has the same values. A farm drain which we value for its ability to remove water, does not have the same value as Lake Tekapo, which we value for its ability to create hydro-electricity and scenic views.*

However, even farm drains have values and characteristics around drainage, biodiversity and mahinga kai that can be threatened by inappropriate land management.

Water quality limits

Water quality limits take into account both the values or use of the water and the parameters required for the values to occur.

A water quality limit is then set at a "point" (or number) that balances agreed community values with the significance of the impact on the values.

The cultural aspects of New Zealand's mauri people is captured within the following section, illustrating how the industry not only embraces the farmers social wellbeing, but the people's cultural well being as well.

Te Mana o te Wai

The concept of Te Mana o te Wai reflects the recognition of freshwater as a natural resource whose health is integral to social cultural economic and environmental wellbeing. This will inform future policy development and regional freshwater planning.

Te Mana o te Wai is about a hierarchy of obligations:

1. *the first obligation is to protect the health and mauri of the water;*
2. *the second obligation is to provide for essential human health needs, such as drinking water;*
3. *the third obligation is to enable other consumptive use, provided that such use does not adversely impact the mauri of freshwater.*
4. *Te Mana o te Wai prioritises these principles:*
5. *the dual roles of iwi/hapū and the Crown to develop and maintain decision-making processes for water, including mana whakahaere;*
6. *kaitiakitanga and stewardship practices to sustain water; and*
7. *manaakitanga and care and respect in providing for the health of our nation.*

Action for Healthy Waterways

Action for Healthy Waterways introduces new rules and regulations to:

- *stop further degradation of New Zealand's freshwater resources and improved water quality within five years*
- *reverse past damage and bring New Zealand's freshwater resources, waterways and ecosystems to a healthy state within a generation.*

The National Policy Statement for Freshwater Management (NPS-FM) requires regional councils to have new plans in place no later than 2025.

How will the water quality limits be set?

Central government has made clear that they want to actively engage local communities, to determine which values to protect, what level of protection is needed and what timeframes.
Engagement and consultation mean that you and your community can play a pivotal role in protecting your waterways and farm systems.
Everyone in your community, including stakeholders with competing needs, will be able to sit down together and work out what is best for the catchment while satisfying the particular circumstances of local users.''

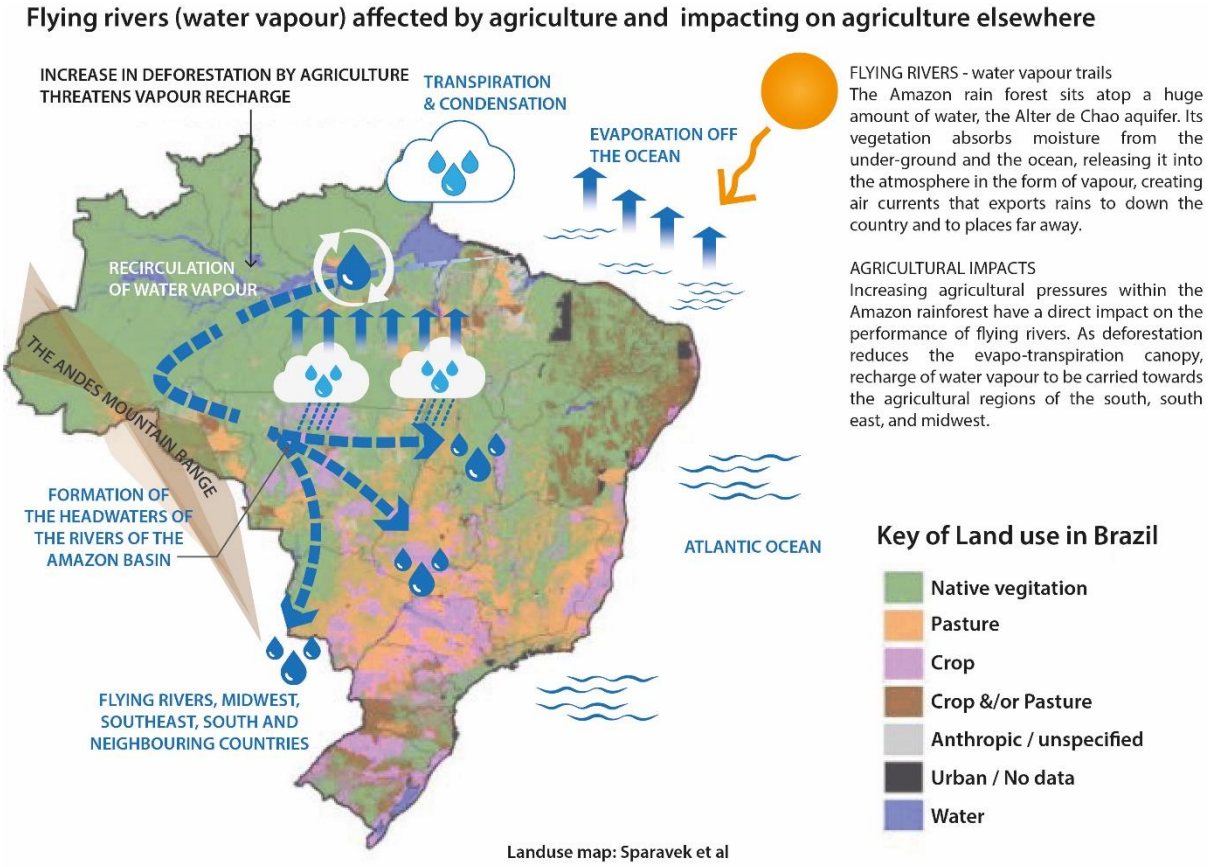
End of quotation of 'one stop shop' for NZ Dairy members

Appendix 4

Brazil's water cycle and its relationship with agriculture

Brazil's whole water cycle is a strong geographical feature, alongside its economic and cultural value. The moisture-laden trade winds initially bring humidity off the Atlantic to the mouth of the giant river, and then carry it inland across the continent in an on-going process of rainfall/evapotranspiration/rainfall until coming up against the wall of the Andes. As the Cordillera forces the winds to swerve southwards, they continue carrying the moisture generated by the forest to other regions of the continent.

The Figure below shows the water cycle and how different states within water's physical form are affected by land management.



Environmentally the country is rich with 'water features' such as flying rivers, the amazon rainforest, cerranos (savannahs), and the Amazon river basin: this forms a very fragile system as agriculture is intrinsically linked to the wealth of waters success due to farms locations and farming practices.

The big question with deforestation in the north is, what might happen to the south if the rainforest is destroyed to make way for yet more pasture, soya and sugarcane causing the hydrological cycle to stop pumping out such huge volumes of humidity?

Through my travels in Brazil it was evident that efforts to develop regional science alongside technology was a responsibility government recognised and supported. Organisations such as Embrapa, The Brazilian Agricultural Research Corporation affiliated to the Brazilian Ministry of Agriculture, were supporting agriculture through research, development and innovation corporation. Embrapa's agenda is to generate new knowledge, translating this into products, processes and services for the agricultural sector. Teamed with work undertaken by universities such as Federal de Minas Gerais the development of science based information contributed to the formulation and improvement of public policies.

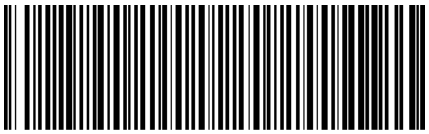
Brazil's landscapes are categorized by their natural vegetative state and 'protected' through the 'Forest Code' and registered with the 'Rural Environment Agency' (CAR). The figure below shows the Brazilian 'Rural Environment Agency' (CAR) landscape categorization and the legal limits of vegetation removal allowed by land owners.

Land Use	Legal Amazon			Rest of Brazil
	Forest	Cerrado	Grasslands	
Legal Reserve	80%	35%	20%	20%
Productive Use	20%	65%	80%	80%

Source: Embrapa

This sets out parameters as to the volume of natural habitat to be retained within the different biomes featured within the Brazilian landscape. This prescriptive approach to land management aims to protect existing and restore natural habitats where deforestation and agricultural intensification doesn't have a legal right to remove vegetation within the Amazon basin.

End of appendices



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