NUFFIELD
Farming Scholarships

The integration of new technology to incentivise environmental services

Written by:

Edward Towers NSch

June 2025

A NUFFIELD FARMING SCHOLARSHIPS REPORT

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ISBN: 978-1-916850-53-8

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
Email: office@nuffieldscholar.org
www.nuffieldscholar.org
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Date of report: June 2025

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

Title	The integration of new technology to incentivise environmental services
Scholar	Edward Towers
Sponsor	John Oldacre Foundation
Objectives of Study Tour	• To explore the use of new technologies such as the Internet of Things (IoT) sensors, artificial intelligence, blockchain, and digital assets in promoting sustainability within the agricultural sector. • Identify challenges and opportunities for implementing these technologies to incentivise positive actions such as carbon sequestration and environmental protection, and to provide recommendations for their use in the industry.
Countries Visited	United Kingdom, United States of America, Canada, Brazil, Chile, Japan, Ireland, Qatar, Mexico, India and Australia.
Messages	Incentives decide outcomes: pay for **measured environmental services**, not just compliance. Farmers can deliver **biodiversity and potentially carbon at scale**—when it's profitable. Prioritise carrots over sticks. **Make the invisible measurable**: low-cost (Internet of Things) IoT and remote sensing for robust, auditable measurement (or Monitoring), reporting, and verification. **Tame complexity**: consolidate farm data in enterprise resource programmes; use Artificial Intelligence to surface actions (not just dashboards). **Trust is a prerequisite**: link on-farm data, third-party audits and tamper-evident ledgers; prove claims transparently. **Liquidity matters**: standardised, borderless marketplaces unlock participation, price discovery and fair farmer returns. **Share value fairly** down the chain; avoid capture by intermediaries.

	Insetting and offsetting both have roles—focus on verified outcomes and prevent double counting. **Start small, prove, scale**: pilot on-farm, publish methods and economics, then iterate. **Policy should be outcome-based and tech-neutral**, with open standards, interoperability and data privacy.

EXECUTIVE SUMMARY

Farmers face the critical task of feeding a global population projected to reach 10 billion by 2065, requiring a balanced use of resources to prevent over-exploitation and protect biodiversity. As stewards of the land, farmers play a vital role in maintaining healthy ecosystems and reducing carbon emissions.

Globally, farmers are incentivised to prioritise production at low costs, often favouring short-term gains over long-term sustainability. However, agriculture and forestry are uniquely positioned to deliver environmental services such as carbon sequestration and habitat preservation, though this can create tension between immediate financial needs and environmental objectives.

Shifting agricultural incentives to reward sustainable practices is essential. This requires a fundamental shift in policy, markets, and societal values to recognise the broader role of farmers beyond production alone.

This study explores challenges and technological solutions for incentivising environmentally sustainable practices globally. Key technologies include the Internet of Things (IoT), Artificial Intelligence (AI), blockchain, and digital currencies, which could support farmers in balancing economic and environmental goals.

Since 2018, I have envisioned technology as a means to encourage sustainable farming practices. Through travel to countries including the USA, Canada, Brazil, Japan, India, Qatar, Ireland, Mexico and Australia, this study identified promising applications of these technologies that could enhance transparency, traceability, and market opportunities for sustainable services in agriculture.

The findings suggest that the agricultural sector should adopt these technologies to promote positive environmental action and develop new markets for sustainable services. Policymakers should also consider financial incentives for adopting these tools and sustainable practices.

Farming is more than an industry; it is essential to global stability and health, with the potential to address our most urgent and important environmental challenges. Farmers are both affected by and contributors to climate change and biodiversity loss - and we have the potential to be part of the solution.

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Please note that the content of this report is up to date and believed to be correct as at the date shown on the front cover.

CONTACT DETAILS

Edward Towers

Brades Farm

Farleton

Lancaster

LA2 9LF

eddy_towers18@hotmail.com

07817226782

Nuffield Farming Scholars are available to speak to NFU Branches, agricultural discussion groups and similar organisations.

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
email : *office@nuffieldscholar.org*
www.nuffieldscholar.org

CHAPTER 1: INTRODUCTION

Figure 1: The author, Edward Towers, pictured in an Irish apple orchard on the Global Focus Programme. Photo: Niall Hurson.

After studying Agriculture with Animal Science at Harper Adams University, I returned home to work with my parents (John and April) and a great team. Unknowingly, so began the most challenging period of my life.

Business in the early years was tough; developing the UK's first barista milk (Brades Farm Barista milk) while facing many setbacks, including building and rebuilding sales multiple times and dealing with the farm flooding (that hinted at the looming presence of climate change).

My personal life was tougher; I had a hip condition from a young age and due to wear and tear associated with my lifestyle it suddenly worsened, affecting every aspect of my life from mobility to my mental health. I was constantly battling chronic pain.

Despite the adversity, I emerged with greater humility and empathy. These experiences taught me that hardships are not just obstacles but catalysts for growth. They fuelled my determination to excel, fostering a unique perspective and the embrace of unconventional approaches.

In 2018, with the lead of my brother Joseph, we became the first farm globally to create carbon credits through a reduction in our herd's methane emissions. This was my introduction into mechanisms that might incentivise other farmers to reduce their emissions whilst trying to remain economically competitive.

My journey sparked a deep interest in self-help and the value of understanding complex subjects from their fundamentals. Above all, I've developed a goal to direct my energy towards purposeful outcomes, balancing my suffering with meaningful endeavours. Scientists suggest that, within my lifetime, we'll discover whether our efforts to mitigate climate change have succeeded. It's a sobering thought, but one that motivates me.

As a farmer with a branded product and loyal customers, I still face the ongoing challenge of balancing profitability with sustainability. I'm exploring ways to align profit with purpose in a way that can influence and inspire other farmers globally.

I believe I have developed a concept that combines technology in a new way to create digital assets that represent environmental good – an idea that feels aweinspiring and daunting. If successful, it could reshape how the world's financial system values our environment.

Aims for my Nuffield farming scholarship

1. Is this a good idea?
2. Could it work? Investigate these technologies.
3. Is anybody implementing this idea? Is it novel? If yes - is anybody implementing parts of this idea?
4. What should I do about it?

My Nuffield study centres on using technology to connect public support with farmer incentives. The objective is to empower farmers by enhancing traceability, securing fair compensation, and fostering direct consumer engagement, especially in environmental services. Technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain could be pivotal in achieving this.

I am grateful to Nuffield for broadening my understanding of global systems through its network of scholars, travel opportunities, and hands-on experiences.

"The best way to predict the future is to create it." Abraham Lincoln

CHAPTER 2: MY STUDY TOUR

"The world is a book, and those who do not travel read only one page." Saint Augustine

I visited the countries highlighted in blue. The Nuffield scholarship offers a unique opportunity to expand my understanding of the world, so I looked prioritise those I hadn't yet visited.

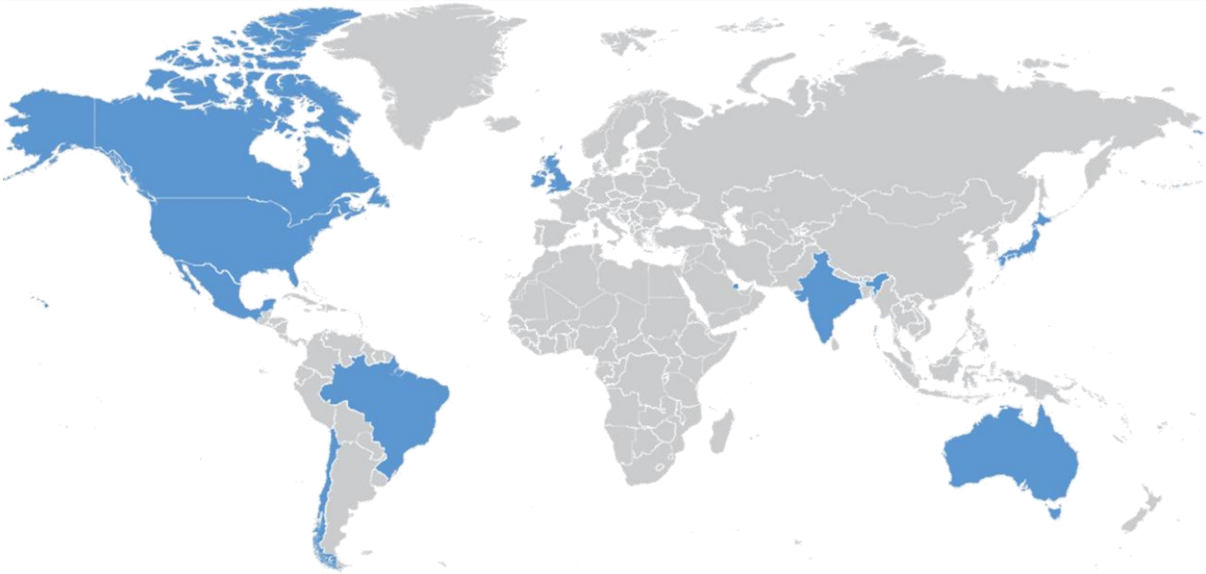

Figure 2: Countries coloured blue were visited on my scholarship. Graphic: Been App

I received my Nuffield scholarship during the COVID-19 pandemic hence my first visits were subject to restrictions as to where was open to visitors. This also gave me the opportunity to complete my Nuffield over an extended three year period.

Figure 3: The author in Seattle on my first trip, Covid mask in hand outside the climate pledge arena and about to watch ice hockey. Photo: author's own.

Table 1 in the appendices gives more information about the places, businesses and, most importantly, people I was lucky enough to spend time with including experiences from my global focus programme an intense trip shared with eight other international Nuffield scholars.

CHAPTER 3: THE CHALLENGE

"*You do not rise to the level of your goals, you fall to the level of your systems.*"
James Clear, Atomic Habits

The outcomes we see in agriculture - whether financial, environmental, or social - are not just the result of individual choices, but of the systems that shape those choices. Farmers, businesses, and policymakers respond to the incumbent social expectations, regulations and incentives built into the system they operate within.

Right now, the financial system prioritises immediate returns over long-term sustainability, making it difficult to justify regenerative practices unless they also provide an immediate financial benefit. If we want different outcomes, we need a system including better incentives that align profitability with sustainability, ensuring that doing the right thing is also the most logical and rewarding choice.

The current financial system prioritises short-term gains over long term sustainable outcomes:

	Incentive/Metric for success	**Timespan**
Individual	Wealth, acquisition of assets, status	Annual salary
Business	Turnover, profit, valuation	Annual accounts
Government	Gross Domestic Product (GDP) Short term popularity (votes)	GDP - Annual Elections five years max

The United Nations' goal of limiting global temperature rises to under 2°C will remain out of reach unless the global governance system aligns economic incentives with long-term sustainability. A world driven by constant short-term growth overconsumes resources, leading to depletion and environmental damage. Currently, there is a win-lose relationship between human success and long-term planetary balance.

Farming faces the crucial challenge of feeding a growing global population (projected to reach 10 billion within our lifetime). Most industries' efforts towards sustainability are limited to:

- Resource use efficiency (intelligent utilisation of natural resources and reduced waste).
- Pollution reduction (nutrient and chemical).
- Fossil fuel phase out/clean energy transition.

Farmers - who steward 44% of the world's habitable land - have a unique ability not only to minimise harm but also to actively create environmental benefits by:

- Protection and/or restoration of ecosystems (biodiversity)
- Sequestering of carbon/improving soil health, increase biomass (climate)

These unique abilities make agriculture (and forestry) essential in addressing climate change and environmental protection/regeneration.

Figure 4: Cartoon credit: Eco-Resilience Ontario Einat Danielli

"Only when the last tree is cut down, the last fish eaten, and the last stream poisoned, you will realise that you cannot eat money." Cree Indian Proverb

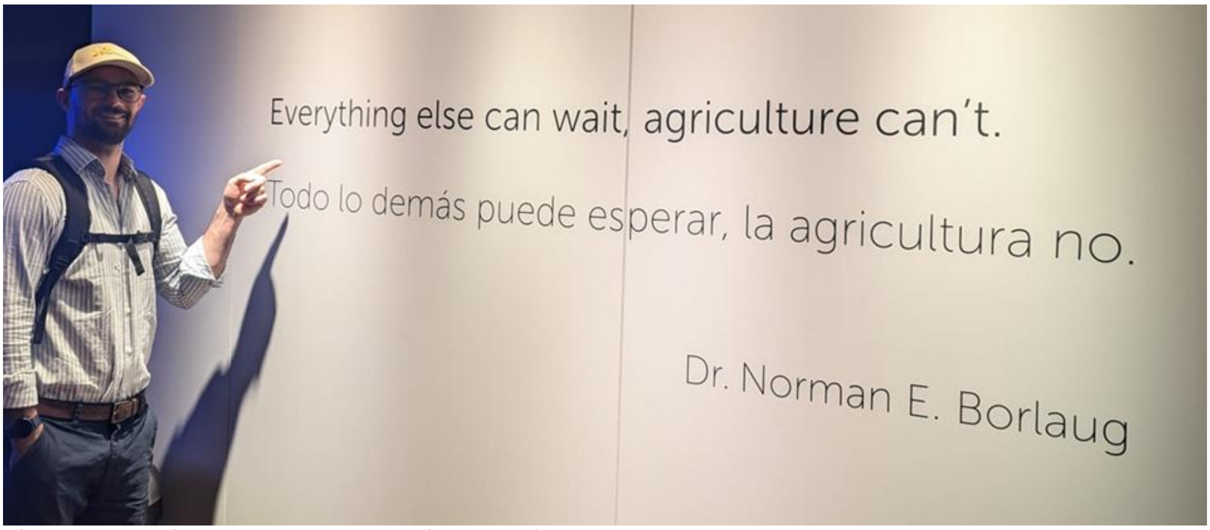

Figure 5: Mexico CIMMYT International Maize and Wheat Improvement Centre. Photo: Author's own.

This immense responsibility underscores farmers' importance on a global scale. Due to their critical role, farmers will inevitably be governed or incentivised to prioritise sustainable practices whether we like it or not. Dr Norman Borlaug understood this and at CIMMYT in Mexico they've printed his quote on the wall of their research facility.

Governance can be split into two basic categories, disincentives (regulations/Sticks) and incentives (Carrots).

Regulatory mandates: (Sticks)

These are compulsory regulations that dictate minimum standards and practices, often with penalties for non-compliance. They aim to discourage undesirable behaviour and prevent negative outcomes associated with farming, such as environmental degradation or public health risks. Examples include:

Environmental regulations	Laws mandating water quality standards, restrictions on pesticide use, or air quality compliance. They are a very blunt tool and hard to enforce.
Food safety and quality standards	Compulsory adherence to safety protocols from farm to fork, including hygiene and traceability requirements.
Land use and zoning Laws	Mandates on how land can be used, aiming to balance agricultural needs with environmental conservation.
Labour laws	Minimum standards for worker safety, wages, and working conditions.

Sticks are top-down, difficult to enforce and can leave farmers feeling restricted, policed and undervalued. Further to that they are the responsibilities of local or national authorities and therefore out of the scope of this report.

Incentives for Compliance: (CARROTS)

These are positive, proactive measures designed to encourage desirable behaviours through rewards or benefits. They are often used to foster voluntary adherence to sustainable practices and enhance the economic viability of adhering to higher standards.

Subsidies and financial incentives	Direct payments, tax breaks, or grants for adopting environmentally friendly practices or for cultivating specific crops.
Sustainable farming incentives	Support programs for sustainable practices, renewable energy integration, organic farming, or carbon sequestration initiatives.
Market Access Enhancements	Preferential market access for certified organic or fair-trade products.
Carbon credits biodiversity net gain credits	Certificates that denote either tonnes of carbon sequestered or not emitted or Biodiversity improvements intended to offset emissions or destruction elsewhere

Government incentives and regulations lack global alignment. The Sustainable Farming Incentive was introduced after I had started my Nuffield Scholarship; seemingly well-intentioned incentives, however national incentive mechanisms can have unintended consequences -limited to national borders, these programmes don't address global issues.

I fear these top down incentives have the risk of reducing a country's food output, leading to increased imports. This shift effectively transfers the responsibility for sustainable food production to the exporting countries, where standards may differ. When we import food, we also export the responsibility for how it's produced.

The way sustainability incentives are structured can impact their effectiveness. Incentives can be split again into two categories: insetting and offsetting. A key question challenge to insetting arises: What if someone values the environmental service but does not need the product?

A more detailed discussion on the challenges and opportunities of insetting vs. offsetting, is provided in Appendix [3].

CHAPTER 4: CHALLENGES IN CREATING INCENTIVES SUSTAINABILITY IN FARMING

"Nothing worth having comes easy." Theodore Roosevelt

There is a pressing need for incentives that not only promote harm reduction but also encourage the adoption of positive agricultural practices on a global scale.

During my Nuffield scholarship, I identified four areas of challenge to incentives:

1. **Invisibility -** Measuring and quantifying positive action and outcomes.
2. **Complexity -** Processing data to produce meaningful recommendations.
3. **Traceability/trust**
4. **Tradability/invest-ability** - Even if a valuable service is defined, who pays?

This report is focused on the potential development of new global incentives and possible application of new Information Technology as solutions to these problems.

CHAPTER 5: INVISIBILITY – THE INTERNET OF THINGS

"Not everything being counted counts and not everything that counts can be counted." Albert Einstein

Many harmful practices and environmental services are largely invisible and difficult to measure; for example, emissions released or sequestered from farmland are difficult to see or measure. This lack of visibility limits credibility, making it challenging to prove that these benefits are real and consistent. Without reliable measurements, investors and stakeholders hesitate to support environmental projects due to doubts about their impact.

The Internet of Things (IoT) is a system of devices that are connected to the internet or a local network. These devices collect data from the environment and communicate with each other, often through cloud-based platforms where data can be stored, processed, and analysed, with or without human intervention.

IoT has revolutionised many industries by providing a continuous stream of information that can be used to monitor and optimise processes and it has a significant role to play in environmental monitoring and sustainability. Technologies like sensors and satellite imaging can make these benefits visible, providing the measurable proof needed to build trust and attract investment.

These devices include sensors embedded in soil, weather stations, microphones, phones and drones to satellites in orbit - all with the capacity to transmit data in real time, sometimes 24/7.

How IoT works

Connectivity	IoT devices are connected to a network, allowing them to communicate with each other and with central data systems.
Data Collection	Sensors embedded in IoT devices collect various types of data, such as temperature, humidity, light levels, soil moisture, air quality and more.
Data Processing	The data collected by IoT devices can be processed and analysed to extract valuable insights.
Automation	IoT systems can be designed to automate certain processes based on the data they collect, improving efficiency and reducing human intervention.

In agriculture, IoT can be used to improve sustainability by optimising resource use and reducing environmental impact methods include:

Informed decision-making	IoT provides accurate, real-time data that can be used to make informed decisions about resource management and environmental practices.
Increased efficiency	By automating certain processes and providing data-driven insights, IoT can increase efficiency, reducing waste and energy consumption.
Enhanced traceability	IoT data can be used to create a traceable record of environmental services, ensuring transparency and accountability in sustainability initiatives.
Early warning systems	IoT can detect changes in environmental conditions, providing early warning systems for events like droughts, floods, or pest outbreaks, allowing for proactive responses.
Examples	
In-field sensors	IoT sensors in the field can monitor soil moisture levels, enabling precision irrigation that conserves water. IoT devices can also track the health of crops, allowing farmers to identify and address issues before they become serious problems
Satellite-based monitoring	Satellites equipped with IoT technology can monitor large areas, providing data on the green area index, land use changes, and deforestation rates. This data can help identify areas at risk and track the success of reforestation projects.
Soil and water sensors	IoT sensors placed in soil or water sources can measure moisture levels, nutrient content, and contamination, allowing farmers to optimise irrigation and fertilisation while reducing waste and environmental impact.
Air quality monitoring	IoT devices can monitor air quality in real time, providing data on pollutants and greenhouse gases. This information can be used to assess the environmental impact of agricultural practices and to implement corrective measures.
Biodiversity tracking	IoT devices can be used to monitor wildlife activity and biodiversity, providing insights into the health of ecosystems and the impact of human activities.

On my travels I visited various tech savvy farming businesses using IoT devices to optimise their resource use efficiency.

In Brazil we visited several large arable farms, campo Novo, Groupo Morena, Sape Agro were we learnt it was standard practice to use precision farming and satellite positioning systems to aid drilling accuracy.

Figure 6: John Deere tractor drilling soya utilising satellite technology for yield mapping, variable rate applications and autosteer in Maracaju, Brazil. Photo: author's own.

Soil health has traditionally been difficult to quantify, making it challenging for farmers to track improvements over time. Soilmentor from Vidacycle, Chile, provides a solution by offering a set of soil health indicators that farmers can measure and track using simple field tests and digital tools. It helps monitor aspects such as soil structure, earthworm activity, infiltration rates, and organic matter levels. By transforming raw observational data into structured insights, Soilmentor reduces complexity, allowing farmers to make informed decisions about soil management. This aligns with the broader goal of turning complex environmental processes into measurable and actionable metrics.

For tax and management purposes, we generate annual profit and loss reports and a balance sheet of assets. In land-based businesses, many non-tangible assets hold significant value e.g. hedges and wildlife like dung beetles - not only in terms of production potential, but also for biodiversity, soil quality and other environmental assets. Attempting to measure these non-financial assets is essential for tracking environmental indicators, providing valuable insights for resource management and promoting sustainable practices.

"What gets measured gets managed" Peter Drucker

CHAPTER 6: COMPLEXITY – ENTERPRISE RESOURCE PROGRAMMES (ERP) AND ARTIFICIAL INTELLIGENCE (AI)

"The art of simplicity is a puzzle of complexity." Douglas Horton

From personal experience and where I travelled, it is clear farming is a highly complex occupation requiring a diverse set of skills, involving complex biological systems with multiple, often uncontrollable inputs and outputs, including increasingly unpredictable weather.

Most farmers are small to medium-sized businesses, where a small team or an individual manages a wide range of tasks which can lead to farmers feeling overwhelmed. With numerous moving parts, the human brain's limited capacity to process and hold information (only about seven items at once), makes it difficult to fully grasp both short- and long-term consequences of our decisions.

Figure 7: Mind Map displaying some of the many roles farmers balance. Graphic: author's own.

Further to this, many farmers have a large volume of data produced from their operations but this data tends to be in fragmented data silos and raw; this is not always useful or usable, adding to the complexity of farm management by requiring either time-intensive manual consolidation and analysis, or just abandonment of this data in favour of a 'gut feel' approach, both of which can hinder effective decision making limiting the ability to see the full picture.

Consolidating these data streams into a unified management system would enable farmers to transform raw information into actionable insights, streamline decision-making but also provide opportunities for benchmarking, predictive analytics, and improved sustainability practices. Addressing fragmented data is a critical step toward enhancing management efficiency, improving resource use, and preparing farms for future opportunities.

During my Global Farming Programme (GFP) in India, we encountered a company called Farm ERP (Enterprise Resource Program), which offers whole-farm model software. Another opportunity might be integrated software solutions using Application Programming Interfaces (API) to help gather data from fragmented software, potentially connecting various data sources - such as financials, farm management, and soil analysis - into a unified view of the farm.

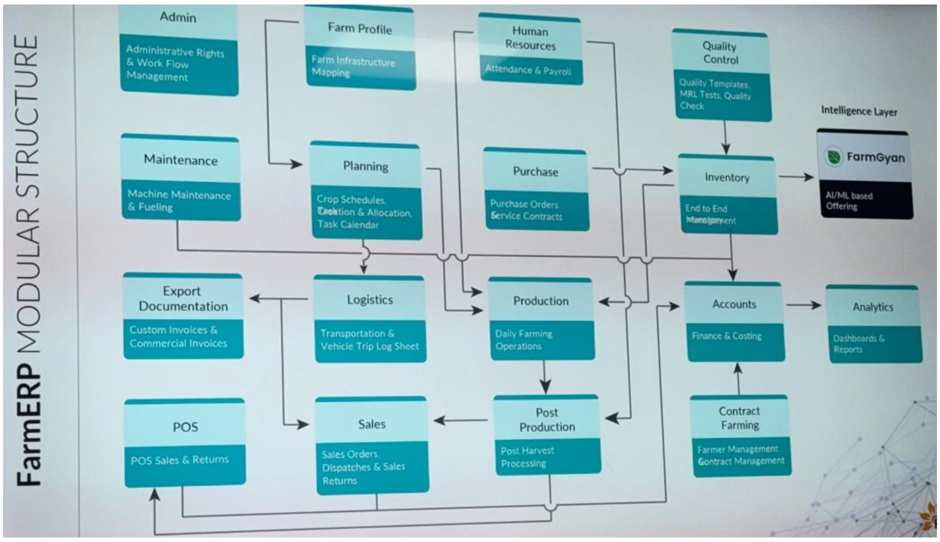

Figure 8: Modular structure of FARM ERP software in presented to us in India on our GFP. Photo: author's own.

By linking IoT data with ERP, farmers can automate decisions, model farm conditions, track relevant market fluctuations and streamline compliance reporting, resulting in more efficient, data-driven operations. This integration enables a holistic approach, transforming isolated data points into actionable insights for sustainable farm management.

Figure 9: The author with and Peter Notman at his Walcha dairy farm ,NSW Australia. Photo: author's own.

In Australia, dairy farmer and owner of a seed merchant Peter Notman had recognised the need for better data utilisation and had used a developer to create an automatic dashboard with all the key financial data for their dairy farm. This allowed them to see trends and performance at a glance; creating these dashboards is technically challenging at the outset but, once set up, they provide useful insights with minimal effort.

The more data collected the greater the challenge in processing it, however Artificial Intelligence (AI) simplifies this complexity by processing data from IoT sensors and software. AI analyses data, recognises patterns, and generates insights that humans may not be able to recognise, model complex systems, and even predict outcomes, transforming raw fragmented data into actionable information. By filtering data, AI allows humans to step in only when necessary. This is especially valuable in managing environmental services, which are influenced by complex variables like soil quality, climate, and ecosystem dynamics. The complexity of these systems often raises the cost and difficulty of measurement and verification, limiting scalability, allowing us to optimise farming practices and protect the environment.

For example, AI has shown an impressive ability to handle complexity, particularly in domains like chess and Go, where it can surpass human intuition by analysing vast possibilities at incredible speeds. Interestingly, the combination of AI and human collaboration often outperforms AI alone, highlighting the unique strengths of each through advanced techniques like deep learning and reinforcement learning.

AI encompasses various technologies, including machine learning, deep learning, natural language processing, and computer vision. Here's a brief overview of how these technologies work:

Machine learning	This involves training algorithms on large datasets to recognise patterns and make predictions. In agriculture, machine learning can be used to analyse data from IoT sensors, satellites, and other sources to identify trends and inform decision-making.
Deep learning	A subset of machine learning, deep learning uses neural networks to process complex data. This is especially useful for tasks like image recognition, which can be applied to analysing satellite images or identifying crop diseases.
Natural language Processing	This technology allows AI systems to understand and process human language. It can be used in agriculture for tasks like analysing customer feedback or automating report generation.
Computer vision	This involves teaching AI systems to interpret visual information, which can be used for tasks like monitoring crop health or identifying pests.

In Tasmania, Halter collars were utilising IoT and AI to enhance farm management. These smart collars use GPS, AI, and automated cues (sound and vibration) to remotely guide cattle, replacing manual herding and physical fences. AI analyses cow movements, optimising grazing for better pasture management, soil health, and reduced methane emissions. This improves efficiency, animal welfare, and sustainability, while also reducing labour costs. One manager could now manage more farms remotely - showcasing how technology can drive both economic and environmental benefits in farming.

Figure 10: Halter collars are an example of the Internet of Things and AI in action. Photo: author's own.

AI in sustainable agriculture

AI can play a significant role in promoting sustainability in agriculture by enabling more precise and efficient practices. Here are some key applications:

Precision Agriculture	AI can analyse data from IoT sensors to optimise resource use. For example, AI algorithms can determine the optimal amount of water and fertiliser for crops based on soil moisture levels and nutrient content, reducing waste and environmental impact.
Predictive Analytics	AI can use historical data and real-time information to predict weather patterns, crop yields, and disease outbreaks. This helps farmers make proactive decisions to minimise risks and optimise production.
Monitoring and Management	AI-powered drones and robots can monitor crops and livestock, detecting issues like disease or pest infestations. This automation reduces the need for chemical interventions and supports more sustainable practices.
Supply Chain Optimisation	AI can analyse data across the agricultural supply chain to identify inefficiencies and suggest improvements. This can lead to reduced waste and a more sustainable distribution system.
Sustainability Assessment	AI can process large datasets to assess the environmental impact of agricultural practices, helping farmers and stakeholders make informed decisions about sustainability
Enhanced Efficiency	AI can help optimise agricultural information processes, reducing physical paper-based waste, increasing productivity

	and offering more time for efficient data driven information exchange and access.
Improved Decision-Making	AI's predictive capabilities enable farmers to make data-driven decisions that support sustainable information, creating more mental space for progressive decision making outside AI capabilities.
Reduced Environmental Impact	By optimising resource use and reducing the need for chemical interventions, AI can contribute to a smaller environmental footprint.
Predict Environmental Trends	AI can analyse historical and real-time data to predict environmental trends, providing insights that can inform sustainability strategies.

Another example is the Merlin Bird ID app, developed by the Cornell Lab of Ornithology, which showcases how IoT technology can enhance environmental monitoring. By using a smartphone's microphone and AI-powered sound recognition, the app identifies bird species in real-time, providing valuable data on biodiversity and ecosystem health. This demonstrates how IoT can make invisible environmental indicators measurable, supporting conservation efforts and potentially playing a role in verifying biodiversity-based environmental incentives. Birds are an incredibly useful biodiversity proxy as they have the opportunity to relocate and fly elsewhere if the conditions aren't suitable.

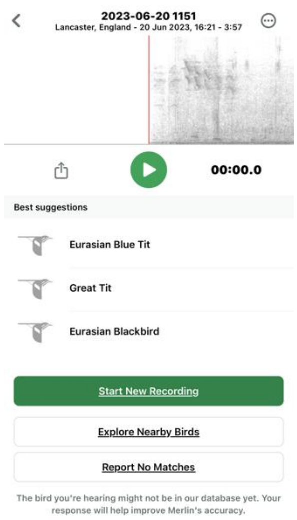

Figure 11: Screen print from a phone using Merlin Bird ID app. Image: author's own.

CHAPTER 7: TRACEABILITY AND TRUST

Environmental services are intangible and easy to misrepresent. Without end-to-end traceability—who measured what, when, where, and who ultimately owns the claim—markets under-price or refuse to buy them.

"Trust, but verify." Ronald Reagan

When creating previously intangible environmental incentives it is essential to minimise corruption. To gain market value and trust by third parties, they must be reliably verifiable from their origin to their final use/retirement.

Blockchain technology addresses this challenge by providing a secure, tamper-proof record of these services throughout their lifecycle, ensuring transparency and enhancing credibility.

Figure 12: London blockchain conference introduction. Photo: author's own.

Blockchain is a distributed ledger technology that securely, transparently, and immutably records data. It functions as a decentralised database, where information is stored in linked blocks, creating an unalterable chain. This makes blockchain ideal for ensuring traceability, especially for complex, intangible services like environmental outcomes. From a legal perspective, its encryption safeguards information, reducing the need for intermediaries and minimising the potential for disputes.

Without robust traceability, there's a risk that services could be misrepresented, leading to duplicate payments or claims. There have been cases where environmental protection credits were issued, only to find that more credits were marketed than produced.

Blockchain technology offers a solution by creating transparent, immutable supply chains. Each step of a product's journey - from farm to consumer - can be recorded on a blockchain, providing verifiable proof of sustainable practices and enhancing trust in environmental services.

Often the balance of power in supply chains skews towards the area with fewest active parties (bottle necks); in agricultural supply chains this is nearly always processors and retailers. While farmers and consumers collectively hold significant power, individually, they have less influence compared to these concentrated market players.

In Brazil, I observed that the price premium paid to arable farmers for organic soybeans was significantly lower than the markup charged to farmers in the UK. Despite the product being the same and certified through mass balance systems, much of the value seemed to be absorbed by intermediaries rather than benefiting the producers. This highlights how middlemen can distort market incentives for environmental services, reducing their effectiveness and limiting the financial rewards for those implementing sustainable practices. Could Blockchain be part of the solution for bypassing these economic gatekeepers or bottle necks?

Figure 13: Soya planted in perfectly straight rows guided by global positioning systems. Photo: author's own.

- **The challenge:** risk of double counting, vague provenance, weak chain-of-custody and asymmetric power in supply chains.
- **Why it matters**: buyers (and the public) won't pay for outcomes they cannot verify; legitimate projects are crowded out by low-credibility claims.
- **What "good" looks like:** a tamper-evident audit trail from measurement → verification → issuance → transfer → retirement, with time/place stamps, identity of parties, and public or permissioned registries to prevent re-use.
- **Tools:** digital Measurement/monitoring Reporting and Verification (sensors/remote sensing), third-party verification, cryptographic signatures and—where helpful—blockchain/immutable ledgers for auditability; legal contracts that bind claims to ownership until retirement.
- **Outcome:** higher trust, lower fraud risk, better price discovery and a larger pool of buyers willing to fund genuine on-farm outcomes.

CHAPTER 8: TRADABILITY/LIQUIDITY

"Demand creates its own supply." Jean-Baptiste Say

"Supply creates its own supply." Say's Law

Sustainability is a global challenge that requires interconnected global solutions. Enhancements in one region should not come at the expense of others. True progress demands a global approach where environmental improvements benefit the entire planet and can be incentivised from anywhere.

For incentives tied to environmental services to have a meaningful market impact, they must be easily tradable on accessible platforms. Currently, the lack of standardised platforms and liquidity limits market access, discouraging participation from both land managers and potential investors.

Digitising and Tokenising Environmental Services

Blockchain-based digital marketplaces and tokenisation might address these challenges by providing liquidity and enabling fractional ownership, opening up opportunities for a wider range of participants to invest in and benefit from these environmental incentives.

Key Advantages of Blockchain for Environmental Markets:

- **Creating Measurable Units**: Blockchain allows for the quantification and tokenisation of environmental services—such as carbon credits—that can be easily tracked and traded.

- **Facilitating Transactions and Marketplaces**: Blockchain supports digital marketplaces where environmental assets can be traded efficiently and transparently, enhancing transaction ease and market confidence.

- **Reducing Fraud and Corruption**: Blockchain's immutability prevents fraud, ensuring environmental services are not double-counted or misrepresented.

- **Supporting Smart Contracts**: Blockchain enables smart contracts, which can automate payments or verify outcomes when specific conditions are met, enhancing traceability and lowering administrative costs.

- **Ensuring Trust and Accountability**: The transparency and immutability of blockchain assure stakeholders that their investments in environmental services are genuine.

- **Global Incentive System/Borderless participation:** capital from anywhere can fund verified outcomes anywhere, enabling a global incentive system while preventing double counting.

I visited Washington to meet with Nori; they were the one business I had come across in my preliminary research that were the closest to implementing the idea. They were taking carbon credits and putting them on the block chain, to help with the marketing and traceability of these certificates.

They have since partnered with Bayer:


Bayer // United States

Home

Crop Science

Nori Adds Unprecedented Number of Soil Carbon Removal Credits to Marketplace from Bayer Carbon Program in the U.S.

More than 125,000 soil carbon credits added to Nori's marketplace, more than 240,000 credits in the pipeline for later this year.

Figure 14: Screenshot of the title of an article on Bayer's website (link in the appendix 1)

Figure 15: Three developers at Nori taking a break for a photo. Photo: author's own.

In June 2024 Nori reported more than 125,000 credits issued from Bayer's programme. In September 2024 Nori subsequently shut down, citing weak demand in the voluntary carbon market and funding conditions. This sequence underscores that even high-profile partnerships and technical progress do not remove risk in this still-emerging market.

CHAPTER 9: MARKETING AND TRADE

The term *Web 3* encompasses all the technologies outlined previously, with the potential to create powerful synergies. Each technology plays a distinct role but reinforces the others, allowing for a comprehensive system where the synergy is greater than the sum of its parts.

"Recombinant innovation occurs when ideas from different areas come together to create something new." Matthew Syed

Technologies like IoT, AI/Machine Learning, and Blockchain offer tremendous potential in two key areas: they can serve as powerful management tools to enhance resource use efficiency for both farming and non-farming businesses. They can support the creation of new digital assets for environmental good,

1. Resource Management Tools
2. Creating Digital Assets for Environmental Good

In both cases, these technologies drive improvements in sustainability. This dual capability offers businesses flexibility, allowing them to integrate these technologies in a way that supports both immediate operational goals and long-term sustainability.

"Markets can remain irrational longer than you can remain solvent." John Maynard Keynes

When you quantify and verify value, it becomes possible to create tradable assets, such as digital tokens or certificates representing environmental services. These assets can be marketed and traded, opening new opportunities for monetisation.

Quantified and verified value can be tied to incentives, driving behaviour towards specific outcomes. For example, if reducing carbon emissions generates a digital token, it provides a tangible incentive for environmentally friendly practices.

Enhancing Transparency

Consumer Awareness: Technologies like IoT and blockchain can increase transparency, allowing consumers to trace the origin and impact of products or services. This added transparency can be a significant marketing tool, especially for sustainability-focused businesses.

Regulatory Compliance: Quantification and verification help ensure compliance with environmental regulations and standards. This can be crucial when marketing a service or product that claims to offer environmental or social value.

"The only thing that is constant is change." Heraclitus

Enabling Innovation

Data-Driven Decision-Making: IoT and blockchain can provide a wealth of data for analysis, enabling more informed decision-making and fostering innovation. This can lead to the development of new products or services that offer quantifiable environmental or social benefits.

Interoperability: These technologies can be designed to work with various systems and platforms, promoting interoperability and collaboration across different industries.

The table below lists features of normal financial tools and the last column demonstrates the concept of how environmental digital assets might work.

Feature	Fiat Currencies	Carbon Credits	Cryptocurrencies	Environmental Digital Assets (conceptual)
Purpose	Serve as legal tender, medium of exchange, and store of value	Offset emissions and compensate for environmental impact	Serve as a decentralised digital currency or investment asset	Represent measurable environmental services (e.g., carbon sequestration, biodiversity) for investment and impact
Creation	Issued by central banks and regulated by governments	Generated through verified environmental projects (e.g., reforestation)	Created via blockchain protocols, typically through mining or staking	Created through verified, measurable environmental actions; issued as digital tokens on blockchain
Underlying Value	Based on government backing and monetary policy; typically stable	Represents one ton of CO_2 or equivalent removed or avoided	Based on supply, demand, scarcity, and utility	Represents various or combined, measurable environmental
Market Type	National and international currency exchanges;	Part of compliance or voluntary carbon markets	Traded on open cryptocurrency exchanges	Traded on dedicated environmental marketplaces

	widely accepted			, allowing access to investors and stakeholders
Regulation	Regulated by central banks and governments; high compliance standards	Highly regulated with verification standards (e.g., Verra, Gold Standard)	Largely unregulated, though increasingly overseen by financial authorities	Likely regulated with certification and verification standards similar to carbon credits, but with blockchain transparency
Retirement/Use	Continuously circulated as legal tender, without retirement	Used once for offsetting; retired to prevent double-counting	Can be held, spent, traded, or burned	Can be retired or traded; transparent tracking prevents double-counting while allowing liquidity
Traceability	Limited traceability; bank transactions and cash flow monitored within financial systems but less public	Tracked to ensure emission reductions are real and permanent	Transactions recorded on blockchain but not environmentally verified	Fully transparent lifecycle tracking on blockchain to verify environmental impact and build trust
Tradability	Very high liquidity; universally traded and accepted	Limited liquidity and market access; mostly in specialised carbon markets	High liquidity; can be traded across global digital exchanges	High liquidity on digital environmental marketplaces; allows fractional ownership and broad market access

Environmental Impact	Generally neutral, but issuance and management require resources	Directly linked to specific environmental projects aiming at climate impact	Indirect, with some high energy consumption for mining	Directly tied to verified environmental improvements with digital proof, fostering measurable impact
Price (approximately GBP)	Generally Stable; values fluctuate based on exchange rates and economic policy	Typically between £5 - £50 per ton of CO_2, depending on project type and demand	Highly volatile; ranges from pence to tens of thousands of GBP per unit	Expected to vary by environmental service type but designed for transparency and stability

CHAPTER 10: POTENTIAL ECONOMIC IMPACT

A financial system where wealth can be invested into digital assets that represent environmental good might help to balance some of the world's largest problems creating a win-win relationship between short term personal, business and governmental success and long-term planetary success.

Figure 16: Image created by the author using DALL-E and artificial intelligent image generator to visually display the use of incentives and blockchain to balance planet health.

If the financial system mimicked nature's feedback loops, it would focus on balance, self-regulation, and resilience. In nature, feedback loops play a crucial role in maintaining balance and sustainability within ecosystems. Positive feedback loops amplify changes, leading to exponential growth or rapid changes. In nature, they can be beneficial in some contexts (like population growth during resource abundance) but can also lead to instability if unchecked. Negative feedback loops help maintain stability by dampening changes. They are crucial for self-regulation, allowing systems to adjust to varying conditions and maintain equilibrium.

Using currencies and financial incentives that represent efforts to solve the world's problems mean that currency values ought to reflect the size of the problem, and the quality of the solution and as a problem is solved the value ought to move to the next largest.

A system that allows for periods of decline and renewal could foster innovation and adaptability. This could include encouraging business cycles, where failing currencies are allowed to die and new ones to emerge. Emphasising long-term sustainability over short-term growth would lead to a more resilient economy. This could include promoting circular economy principles, where resources are reused and recycled, reducing waste.

	Credits	Assets
Asset vs. Liability Perspective	Functions as a liability in offsetting; goal is to own as few as needed to cover emissions at the lowest cost Primarily used for compliance, often purchased only to meet requirements	Functions as an asset rather than a liability; desirable for long-term ownership as they represent ongoing environmental benefits and can appreciate in value. Are re-saleable and can change in value.

CHAPTER 11: CHALLENGES TO IMPLEMENTATION

"The biggest risk is not taking any risk... In a world that is changing really quickly, the only strategy that is guaranteed to fail is not taking risks." Mark Zuckerberg

While these technologies offer significant benefits, they also come with challenges such as data privacy, security, scalability, and the need for significant technical expertise. Properly addressing these challenges is crucial to ensure the successful implementation and marketing of services or value derived from these technologies.

	Challenge	Risk
Data Privacy and Security	Using IoT, AI, and blockchain in agriculture involves collecting large amounts of data, from soil health to crop yields. Protecting this data is critical, especially as it may contain sensitive business or environmental information.	Poor data security could lead to breaches, exposing proprietary information or even impacting local ecosystems if management practices are disrupted.
Technical Complexity and Cost of Implementation	Integrating new technologies such as blockchain or AI can be resource-intensive and requires technical expertise that may be beyond the reach of smaller farms.	The high cost and complexity might limit accessibility, creating gaps between large and small producers. It may also lead to partial implementation, where the full benefits of the technology are not realised.
Scalability and Integration Issues	Environmental service frameworks and technology solutions need to be scalable across diverse farming practices and ecosystems. Integrating different technologies, such as IoT with blockchain, can also be challenging.	Without scalability, only a limited number of farmers may benefit. Integration difficulties can result in fragmented data and missed opportunities for efficiency gains.
Market Volatility and Economic Viability	The market for environmental assets can be volatile, impacting the consistency and predictability of returns for farmers.	Price fluctuations may deter long-term investments in sustainable practices, as farmers rely on predictable income to justify resource-heavy changes. This volatility can also discourage investors who

		might otherwise support environmental services.
Regulatory Uncertainty	The regulatory landscape for environmental assets and digital tokens is still evolving. Compliance requirements may vary significantly across regions, especially in the realm of carbon markets and digital asset trading.	Farmers and businesses face the risk of policy changes that could affect the profitability or legality of environmental service transactions, leading to compliance costs or even restrictions on certain practices.
Verification and Trust	Ensuring the credibility of environmental claims, such as carbon sequestration or biodiversity enhancement, is essential. Trust hinges on robust verification systems and transparency.	If verification processes are too complex, time-consuming, or inconsistent, it could weaken market trust and discourage participation. Blockchain can improve traceability, but it may still require third-party verification for credibility.
Environmental Trade-offs and Unintended Consequences	Sustainable practices sometimes involve trade-offs. For instance, certain technologies could inadvertently increase energy use or displace biodiversity while aiming for other environmental benefits.	Without careful management, the implementation of sustainability practices may lead to unintended negative impacts, undermining overall environmental goals and public trust.
Stakeholder Buy-In and Change Management	For sustainable practices and digital systems to succeed, they must be accepted by farmers, consumers, investors, and local communities. Managing change and gaining buy-in from diverse stakeholders can be complex.	Resistance to change can delay or prevent the adoption of new practices, limiting the positive impact of these initiatives.
Data Bias and Misinterpretation	AI systems are only as accurate as the data they're trained on. In agriculture, where local variables like soil type and weather can vary widely, relying on generalised data can lead to biased or incorrect recommendations.	Misinterpreted data can lead to poor decisions, such as over-fertilising or under-irrigating, potentially harming crop health, soil quality, and the environment. Ensuring data diversity and local customisation is essential to minimise these risks.

Over-Reliance on AI for Decision-Making	As AI systems become more embedded in agricultural processes, there's a risk of over-relying on automated recommendations, sidelining farmers' traditional knowledge and experience.	Excessive reliance on AI could reduce farmers' active involvement in decision-making and leave them vulnerable if the technology fails or provides inaccurate predictions. Balancing AI insights with human judgment is key to maintaining resilience.
Job Displacement and Skills Gaps	As AI automates various farming tasks, there may be a reduction in demand for certain roles, particularly those involving manual labour and traditional farm management.	Job displacement can lead to economic disruption in rural communities. Additionally, a skills gap may emerge if farmers and workers lack the necessary training to manage and interpret AI technologies, creating reliance on external experts and limiting local autonomy.
Environmental Impacts of AI Technologies	Running AI algorithms, especially for large-scale applications, requires significant computational power, which can increase energy consumption and indirectly contribute to emissions.	If not managed sustainably, the increased use of AI could contribute to environmental harm, potentially offsetting the benefits of the agricultural efficiencies it aims to create.
Security and Privacy Risks	AI systems gather and process large amounts of data, raising concerns over data security and privacy. In agriculture, this data can include sensitive information about farm operations and personal data of workers.	Breaches of AI systems could expose sensitive data or lead to operational disruptions, making farms vulnerable to cyber-attacks. Privacy risks also affect compliance with data protection regulations, which may impact business reputation and finances.
Ethical Concerns in AI Decision-Making	AI may prioritise efficiency and yield over other values, like environmental protection or animal welfare, if not explicitly programmed to balance these aspects.	The application of AI in agriculture may unintentionally prioritise productivity over sustainability, leading to practices that favour short-term gains but compromise long-term environmental health.
Energy cost of processing data	Currently AI and blockchain are very energy hungry processes.	The cost of running may outweigh any benefit incentivised.

CHAPTER 12: CONCLUSION

"Show me the incentive, and I'll show you the outcome." Charlie Munger

Globally farmers are at the heart of sustainability efforts. Managing much of the world's habitable land, they have an opportunity to play a unique role in enhancing biodiversity, sequestering carbon, and improving water quality, alongside efficiently nourishing the population. Emerging technologies like blockchain, IoT, and AI hold significant potential to improve farming and support environmental goals, yet these tools can either empower farmers or risk diminishing their autonomy depending on how they're applied.

Carrot: Technology as a Tool to Incentivise Sustainable Practices

When used as an incentive, technology can empower farmers by creating measurable, marketable environmental assets. IoT sensors can monitor soil health or carbon sequestration, AI can optimise inputs, and blockchain can verify sustainable actions, creating new revenue streams through assets like carbon credits or biodiversity tokens. By turning environmental stewardship into an economic asset, these technologies reward farmers for sustainable practices and reinforce their role as active agents in the fight against climate change.

Stick: Technology as a Means for Regulation and Compliance

Conversely, if these technologies are applied primarily for regulatory enforcement, they risk becoming tools of external control, reducing farmers' autonomy. IoT devices could be mandated to monitor farm emissions or water use, and blockchain could track every input, potentially turning farmers into "land-owning caretakers" bound by mandates without real agency in their practices.

As these technologies continue to develop, it's essential to ensure they empower farmers and contribute to fair, economically viable pathways toward sustainability. Rather than enforcing top-down control, technology should enable farmers to leverage their expertise and connection to the land, recognising them as indispensable partners in achieving environmental goals.

While technology presents promising solutions, challenges remain in scaling these innovations and ensuring adoption among both farmers and investors.

The real challenge is ensuring that the entire system - policies, markets, financial structures, and cultural norms - supports sustainable, long-term success rather than rewarding short-term extraction.

CHAPTER 13: RECOMMENDATIONS

For Nuffield Scholars

- Foster a community of shared learning by connecting with other scholars, researchers, and practitioners in sustainable agriculture. Collaborative knowledge exchange can drive innovative approaches and amplify impact across the sector.

For Policymakers

- **Use Incentives over Enforcement**: Encourage sustainable practices through incentives ("carrots") rather than punitive measures ("sticks"), empowering farmers to adopt environmentally friendly practices by offering rewards rather than imposing mandates.
- **Recognise the Environmental Costs of Imports**: Importing food often shifts the responsibility for sustainable production to the exporting country. Consider policies that support local, sustainable farming and discourage reliance on imported goods with unclear environmental standards.

For Farmers

- **Engage with Emerging Technologies and Incentive Systems**: Explore the opportunities provided by technologies such as IoT, blockchain, and AI, as well as incentive programs. These tools can enhance productivity, generate new revenue streams, and strengthen your role in sustainable agriculture.
- Many people use the term 'wild west' amongst others as derogatory descriptions of the incentive markets. I feel this discourages farmers from engaging in the development of solutions. The market is similar to the wild west in that it holds significant potential for innovation and development but lacks established regulations, but without engagement from good and well-meaning farmers it won't develop into an established and positive mechanism. The demand and want for environmental services is present; we need the mechanisms to develop and create an opportunity to drive positive change.

For the Public

- **Support Regenerative Agriculture**: Show support for regenerative farming practices by choosing products that emphasise sustainability. Take an interest in where and how your food is produced, as consumer demand can drive positive changes within the industry. Choosing farm-owned brands with reputable and accountable owners.

For Businesses

- **Focus on Reducing Environmental Footprints**: Commit to lowering your environmental impact by investing in sustainable practices within your operations. By setting an example, businesses can inspire others along the supply chain to prioritise sustainability.

For Farming Businesses

- **Adopt Comprehensive Sustainable Practices**: Embrace practices that balance productivity with environmental stewardship. Leverage technology to track and report on sustainability metrics, positioning your business as a leader in regenerative agriculture.
- **Engage** with developing incentives where possible.

CHAPTER 14: MY NEXT STEPS?

To me, success means being proud of the life I'm living - a life marked by courage, risk-taking, and the pursuit of projects that might leave the world a better place because of my efforts.

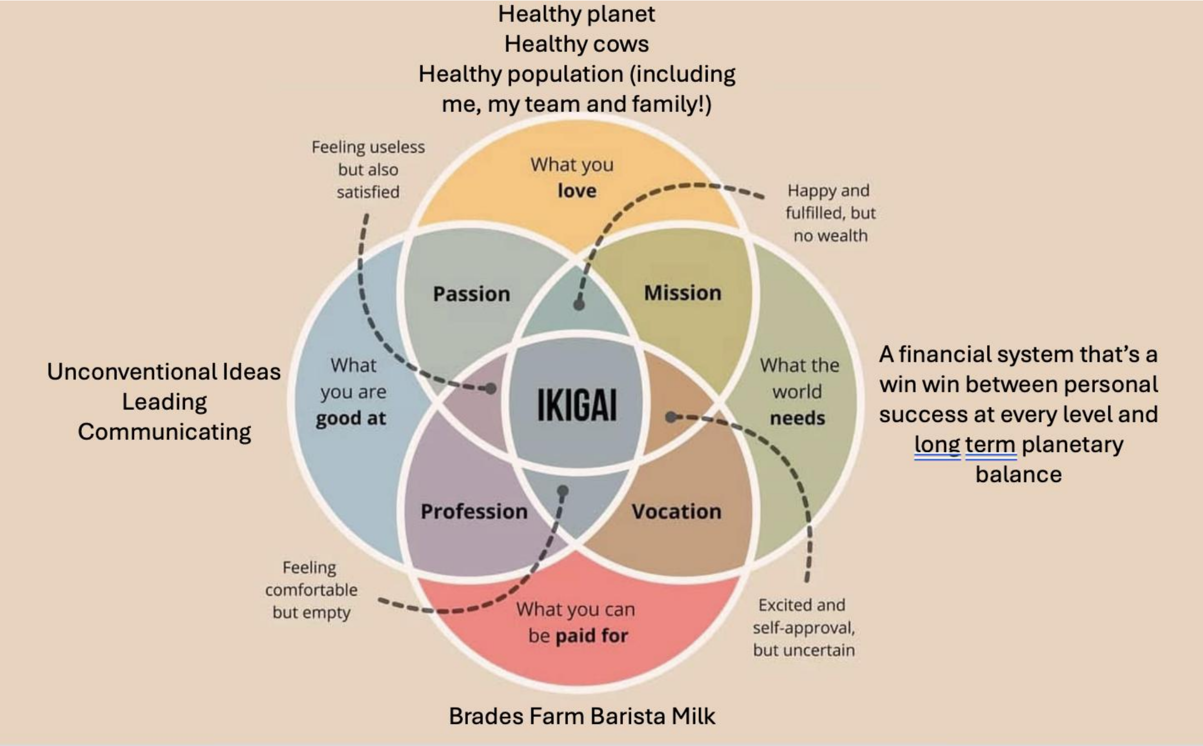

Figure 17: Venn diagram edited to show my purpose/thoughts.

A Nuffield scholarship was the ideal challenge to explore this vision, offering the opportunity for travel, adventure, learning, and the chance to connect with remarkable individuals.

My goal is to apply these technologies within my own farming business, initially to enhance resource use efficiency while gaining firsthand insights into their capabilities and challenges. Beyond this, I aim to:

- Showcase these technologies to other farmers, demonstrating their potential for sustainable impact.
- Implement and measure environmental projects in collaboration with partners to explore real-world applications.
- Create and market digital assets that represent the environmental services we provide, such as carbon credits or biodiversity tokens.
- Share these efforts with customers, farmers, and investors, and reinvest in similar sustainability-focused projects.

Once established, the system could scale rapidly and bring widespread environmental impact. A successful proof of concept could inspire other farms or industries to adopt similar assets, building a network effect.

Develop partnerships **-** We would like to invite partnerships with businesses that are developing solutions using these technologies that we could showcase and build into a model to help improve sustainability.

CHAPTER 15: ACKNOWLEDGEMENTS AND THANKS

Thank you to my family and team for excelling in my absence and teaching me how non-essential I am. Thank you to my generous sponsors for allowing me to travel and to Nuffield for having such a great scholarship and network of alumni.

"Feeling gratitude and not expressing it is like wrapping a present and not giving it"
William Arthur Ward

It's difficult to mention all the people who have helped - those who organised, planned, transported, taught, and shared their time with me on my travels. This journey has left me deeply grateful for the kindness, generosity, and insights I've received along the way.

To my family, thank you for your unwavering support, and to my brother, Joe, for introducing me to incentive mechanisms and for pioneering a branded market for our produce. To our fantastic customers, whose belief in our product and vision has been instrumental in our journey.

Finally, to my incredible team – thank you for your dedication and hard work keep everything running whilst I was absent .

John Oldacre Foundation

Brades Farm Est 1960 Jersey Holstein The Original Barista Milk

APPENDICES

Appendix 1: Table listing countries and businesses visited

Country/State /Dates visited	Brief overview of key insights gained from each country
USA Seattle 14th/15th Feb 2022	Nori - mentioned in the report. https://www.bayer.com/en/us/news-stories/unprecedented-number-of-soil-carbon-removal-credits
Oregon Gordon and Julie Larson 17th/18th Feb 2022 Branch of Natural Resources John Day Basin Office	Fire regeneration, rebuilding soil Berry Creek. Gordon Larson had worked as a policeman; he had attempted to develop water credits to incentivise farmers to use water efficiently and reward farmers for the opportunity cost of allowing water to pass through their properties in a protected manor. The property had been burnt by an unusually hot fire which had left the top soil sterile. He was using cows to reinoculated life back into the soil.    
Canada 24th Feb 2022 & Vancouver 2023	Lac Brome Lake Vancouver was shortly after the CSC which I couldn't attend due to attending the UK CSC the year prior but I met with many other scholars afterwards in Whistler.
Brazil October 2022	I chose Brazil because it is the largest country in South America and often receives negative press due to deforestation. While

	many countries, like the UK, experienced significant deforestation centuries ago, preserving the Amazon is now critically important. The Amazon plays a crucial role in pumping water vapour into the atmosphere, helping to irrigate areas as far as North America. A huge thanks to Sally Tompson for organising the visits and all the hosts! 30th September Bayer Sao Paulo In 2024 Bayer and Nori signed a supply partnership where Bayer will create verified CO_2 removal offsets to be marketed on Nori's market place. 2nd October Delacari and Letissimo, Craig Bell, Simon Wallace, Sally Thompson, Sao Paulo. A dairy business focussed on high end products, sold into many major cities around Brazil. The farming and processing operations are based in 3rd October Embrapa 3rd October Campo Grande Faramsul - Senar 4th – 6th October Sape Agro, Artur Maracaju - Behavioural Economics 7th – 10th October Pantanal 11th - 12th October Groupo Morena 13th October Famato Agri Hub, Bom Futuro, 15th October – 19th October Letissimo Sally Thompson and Simon Wallace, Craig Bell. 19th October Brasilia Breno – Solar Business 20th October Rio development bank of Brazil. BDNES. 26th October YAMI
Chile	Eliza Blanco, Water Nuffield scholar
Japan 23rd Aug – 7th Sep	Sheigo Maeda popcorn Hokkaido Agri food expo Tokyo, Sumitomo corporation, Alltech Kei Nakayama, Kosuke Kubo, Dairy, strawberries, visitor centre Shinya Okazaki, Beef wholesale, butchers and restaurant.
The United Kingdom	Groundswell Low carbon agriculture conference London Blockchain conference 21/5/24 – 23/5/24 Newcastle University Philip Hughes Joshua Riddett Crypto hunter – Easy Compute BX Ben Bardsley Chatham house sustainability
Australia (Tasmania)	Jane Bennett Ashgrove Dairy Halter Collars Rob Bradley

Appendix 2: Table listing the itinerary for the global focus group 3

AUSTRALIA	
Narrabri, NSW Thursday 6 June	Hosts: Stuart Tait & Andrew Watson. Stuart Tait is a 2017 scholar and chair of Nuffield NSW, Andrew Watson is 2006 scholar and vice chair of Nuffield NSW
	Australian Cotton Research Centre Daniel Kahl (2017 Nuffield Scholar) Merced Farming, Wee Waa Cotton/Cropping
Friday 7 June: Australia	The Narrabri Plant Breeding Guy Roth University of Sydney in Narrabri specialises in the genetic improvement of crops like cotton and grains to boost yield and disease resistance. It utilises advanced breeding techniques to develop new varieties, contributing significantly to agricultural sustainability and food security.
	Narrabri Fish Farm is the state's largest aquaculture farm, known for producing and supplying a wide range of freshwater fish such as silver perch and Murray cod. It also doubles as a tourist attraction, Rich Cunningham
	Boggabri Cotton Gin
	Andrew Watson Farm, a 2006 scholar. Kilmarnock Farming Grows Corn, Cotton and wheat
Saturday 8 June: Australia	George and Richard Avendarno, Tropical Grasses
	"Kuranda" Dryland, cover cropping and bug juice Scotty McCaluman Grain Valley Way
	"Pinecliff" Large grain operation Kate Gunn & James Davidson
	Wilmont Cattle Company "Morocco"
Sunday 9 June: Australia	Oilseed crushing facility Dust suppression, Canola Oil Wayne Foster
	Angus Duddy Spring Ridge
	"Colorado" Derek & Kirrily Bloomfield www.theconsciousfarmer.com.au
	"Breeza Station" Andrew Pursehouse and James Pursehouse "Swarmbot"
Monday 10 June: Australia	Turf Farm Rob Sizer
	Rob Sizer Christmas Trees Agripath
	Michael Taylor (2024 scholar) Grazing Silviculture, Sawmill, Wool marketing
Tuesday 11 June: Australia	Martin Oppenheimer Petali, Merino/white Suffolk, technograze
	Walcha Dairy Paul (manager), Peter Notman
	Glasshouse Medical Cannabis
	Red Jewel Strawberry Nursery Jim Cameron
	Welders Dog Brewery
Wednesday 12 June: Australia	University of New England SMART Region Incubator (SRI) Dr Justin Bailey Dr Lou Conway (SRI Director), Andrew Lawson

	School & Manager Armidale Node of the SQNNSW Innovation Hub
	UNE SMART Farm Innovation Centre UNE Centre from Animal Research and Teaching (CART)
	Guyra Glasshouse tomatoes
	Rob Kelly Bald Blair Angus, Guyra
Thursday 13 June: Australia	Fisherman Tom Kerr boats/packing factory – sardines
	Costa Group Blueberry Farm By Daniel Grono
	NSW State selection Dinner
Friday 14 June: Australia	Travel Arrive Delhi (16 hour flight)

INDIA	
Saturday 15 June	Hosts: Parmindar Singh (NZ 2022 Nuffield Scholar)
	Suri Agro Fresh - a prominent importer and distributor of fruits, which has expanded into manufacturing cold press juices.
	Binsar Farms Pvt Ltd - Dr Sankil Kumar, private dairy farms with herd size of up to 500 animals - a relatively new farming model that emerged across major cities of India in the last 10 years, offering consumers milk at a premium price, with a marketing pitch of pure cow milk (as opposed to multi-breed milk offerings from dairy cooperatives).
Sunday 16 June: India	AMUL Dairy Plant - AMUL is one of the world's most successful examples of cooperative dairy farming and milk marketing.
	Dudhmansagar Dairy
	Le Marche retail store - Visit to modern food retail chain Le Marche Mr Karan Ahuja
	A bespoke Indian traditional dinner
Monday 17 June: India	Introduction to Indian Agtech: Introduction to Indian Consumer Market: Partner with Mr Rajat Mathur Interaction with Mr Hemendra Wahi, Former Partner, Deloitee India overview of the Indian consumer market in the context of F&B retail: current trends and future opportunities Mr Aleen Mukherjee, Former VP - National Commodities & Derivatives Exchange (NCDEX)\ an overview of India's agriculture sector (production, policies, tech & FPO disruptions) and commodity trading (NCDEX) Dr Jay Cummins from Australia An overview of Australia-India relationships in conversation agriculture - Perspective on the major challenges facing Indian agriculture sector in terms of productivity, climate change and sustainability
Tuesday 18 June: India	Australian High Commission meeting with Dr Kiran Karamil, Agriculture Counsellor, Department of Agriculture, Forestry & Fisheries, Government of Australia Overview of Australia-India agri-food trade

	Meeting with Dr Pratibha Singh, Director, ACIAR Australian Centre for International Agriculture Research Overview of ACIAR's programmes in India
	India | Research Program for Cropping Systems & Groundwater Management ACIAR Opportunity for a group photo in the Australian High Commission with Dr Kiran Karamil and Dr Pratibha Singh.
	Australian Wool Innovation A, Shivalik Colony, Malviya Nagar, Delhi Meeting with Mr Kaushik Overview of AWI/Woolmark's market development programs in India
	National Association of Farmer Producer Organisation (NAFPO) Introduction to Farmer Producer Organisation agribusiness model. Ms Aneesha Bali, Mr Anish Kumar
	Flight to Pune
Wednesday 19 June: India	Bhagyalakshmi Dairy Farms Dr Amol D Hande, Farm Manager, Bhagyalakshmi Dairy Farms Pvt Ltd It is one of India's largest private sector dairy farm operations with 1500 animal herd size and rotary milk parlour. website https://prideofcows.com/poc/
	Aussan Laboratories India Mr Sandeep Jayaswal, CEO, Aussan Laboratories India Pvt Ltd The company is marketing two products in India: - CropBiolife: Organic crop improvement input - Miracle: Organic, alcohol-free sanitiser for the food industry
Thursday 20 June: India	Jain Irrigation Systems Ltd Meeting with Dr Dilip N Kulkarni, President - Agri Food A billion dollar company, Jain Irrigation has a unique business model
	Shivrai Technologies Pvt. Ltd Mr Sanjay Borkar, CEO & Co-Founder, FarmERP - Introduction to FarmERP and applications in the agri-value chain - Perspective of how the agriculture industry in India is growing with agtech innovation
	Weikfield Foods Pvt Ltd - From its humble beginning in 1942, the A$50 million company, with more than 50 products, is today an Indian household name for its Weikfield brand of Custard Powder, Cornflour, Baking Powder, Vegetarian Jelly, Crystals in India. Mr Mukesh Malhotra, Chairman
	Depart Pune to Bengaluru
Friday 21 June: India	Mr Sridhar Easwaran, Founding Member, Samunnati Agenda: - an overview of Samunnati - financial inclusion of the Indian agriculture producers - how technology is driving this important development, and the opportunities it is potentially creating in the sector India's largest food grocery e-commerce business. Investors include TATA Group and World Bank's International Finance Corporation. Interaction with one of India's prominent agtech entrepreneurs Mr Kumal Prasad, who is a founding member of India's first Unicorn, CropIn.
	Bambrew: the role of sustainable packaging solutions in agriculture production and supply chain management

	Mr Ranjith Mukundan, CEO & Founder, Stellapps - one-stop dairy supply chain digitisation via IoT services two million farmers, one milion animals, - enabling 11 million litres of milk to flow through Stellapps solutions per day, creating $3.4 million payment per day to farmers.
	Fox in the Field. Interact with Mr Abhay Kewadkar, India's first wine maker turned microbrewery entrepreneur. Toit microbrewery
Saturday 22 June: India	Grover Zampa Vineyards Contact: Ms Sonali Debnath. Ms Namrata Sudhakar India's oldest winemaker
Sunday 23 June: India	Bengaluru-Doha

QATAR	Hosts: Mattnew Ipsen - a 2013 Australian scholar
Sunday 23 June: Qatar	Widam Food Qatar Slaughterhouse, Central Market, AL Wakrah CTC: Manager Dr Ahmed Visit Widam Food Qatar. Tour sheep/cattle feedlot and abattoir with Slaughterhouse
	Embassy of Australia Meet with Australian Ambassador to Qatar
	Meat and Livestock Australia Amanda Hodge (Access & Trade Project Manager, Meat and Livestock Aust.)
Monday 24 June: Qatar	Heenat Salma
	Zad Holding Company (Q.P.S.C) ZAD Holding - Flour Mill and Bake House
	Soup Wagif Tour (Managed by Matt)
Tuesday 25 June: Qatar	Fish Market - AL Mina District
	Baladna Food Industries'
	Desert tour (Managed by Matt) Islamic Museum and Fanar (Managed by Matt)
Wednesday 26 June: Qatar	Lulu Hypermarket Mr. Simon Alexander
	Agriculture Research Center Qatar University
	Agrico Organic Farms - Ajay Chopra
Thursday 27 June: Qatar	Flight

IRELAND Thursday 27 JUNE	Catherine Lascurettes & Joe Leonard Catherine is the Nuffield Ireland exec & Joe Leonard is Nuffield Ireland Chair Niall Hurson 2024 Nuffield Scholar
Friday 28 JUNE: IRELAND	DAFM: John Clarke Department of Agriculture, Food and the Marine.
	Bord Bia: Mike Neary Bord Bia, the Irish Food Marketing Board
	UCD Lyons Farm 250ha University
	Stafford Vigors Lecturer/Assistant Professor School of Agriculture and Food Science
Saturday 29 JUNE: IRELAND	Donoughmore Workshouse Museum, Co. Laois: a history of the Irish Famine Dunacleggan,
	Francie Gorman, president, IFA
Sunday 30 JUNE: IRELAND	Kilkenny Castle
	Bryan Daniels Dairy Farmer
Monday 1 JULY: IRELAND	William Hutchinson Kells (Sheep +Tillage)
	Ballykilcavan Brewery (tillage & rewing)
Tuesday 2 JULY: IRELAND	Pearson Milking Technology Woodstock Tirlan Processing Bellview Processing, IDA Science and Technology
Wednesday 3 JULY: IRELAND	Castlemartyr (Mixed grassland & tillage) - Pat Collins, a 2022 Nuffield Scholar
Thursday 4 JULY: IRELAND	Brain McCarthy - McCarthy rooftop farm and English market
	John Keane & Elaine Houlihan, Laois | John Keane
	(Young Farmer Assoc) Jim o the mills dinner Music and Dinner
Friday 5 JULY: IRELAND	MSD Animal Health Red Oak

MEXICO Saturday 6 July:	Arrive in Mexico City (12.75 hour flight)
	CIMMYT Museum, Isabel Peña, Institutional Relations
	Mexico City and the Pyramids of Teotihuacan
Monday 8 July: MEXICO	Cristian Zavala, Germplasm Safeguarding maize and wheat biodiversity for the world, visit the Wellhausen-
	Anderson Plant Genetic Resources Center Kai Sonder, Geographic Information System Laboratory Manager
	Kai Sonder, Geographic Information Climate Change, spatial data and analysis

	Systems Laboratory Manager targeting and foresight work and agro meteorology to development- oriented agricultural research on maize, wheat and sustainable agriculture
	Julio Huerta, Wheat Breeder Wheat Wide Crosses research
	Aldo Rosales, Maize Quality and Nutrition Specialist Improved nutritional and processing end use quality analysis of maize
	Cesar Petroli, High-throughput CIMMYT'S SAGA team unlocks the genetic
	Genotyping codes of crops, revealing their astonishing diversity and hidden potential
	Thanda Dhliwayo, Maize Breeder He Xinyao and Nerida Lozano, Wheat Phytopathologists Wheat Phytopathology research
	Wheat Phytopathology and Rust Disease Research Naeela Qureshi, Wheat Scientist
Tuesday 9 July: MEXICO	Toluca Experimental Station "Sanjaya Rajaram"
Wednesday 10 July: MEXICO	World Food Prize Foundation: Dialogue NEXT Mexico

Appendix 3: Insetting vs. Offsetting: A Comparative Analysis

Insetting and offsetting represent two distinct strategies within carbon management, each with unique approaches and potential drawbacks in incentivising sustainable practices in the agricultural supply chain. Below is a comparative analysis, highlighting key challenges and benefits of each method.

Comparing Insetting and Offsetting

Current insetting models do not fully account for this, potentially limiting financial rewards for farmers or land managers providing valuable environmental benefits.

- **Insetting**: Focuses on reducing carbon emissions within the supply chain, integrating sustainability into core business operations. While it promotes localised impact, it faces challenges in power dynamics and transparency.

- **Offsetting**: Involves compensating for emissions through investments in external projects, often with clearer traceability and consumer understanding, though it risks being perceived as "outsourcing" sustainability responsibility.

Challenges in Insetting

1. **Power Dynamics**: Large players, such as traders and supermarkets, dominate the supply chain and often leverage their bargaining power to negotiate lower premiums for sustainability initiatives. This can dilute the impact of insetting, reducing the financial incentives for farmers to adopt sustainable practices.

2. **Decreased Traceability**: Insetting can sometimes obscure the traceability of sustainability efforts, which may deter consumers from paying a premium for sustainable products. This lack of transparency can undermine insetting's effectiveness as a sustainability tool.

3. **Affordability and Accessibility**: Paying for the environmental externalities of food production may be a luxury that not all consumers can afford, particularly in developing countries or during economic hardships. Some consumers may value the environmental service itself but not require the specific product associated with it.

Evaluation

- **Benefits of Insetting**: Localised impact, potential for direct improvements within the supply chain, integration with core business practices.

- **Limitations of Insetting**: Power imbalances, reduced transparency, and potentially lower consumer premiums.

- **Benefits of Offsetting**: Clearer traceability, external validation, and broader environmental impact.
- **Limitations of Offsetting**: Risk of disconnect from core operations and potential perception of responsibility outsourcing.

978-1-916850-53-8

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ISBN: 978-1-916850-53-8

Published by The Nuffield Farming Scholarships Trust
Bullbrook, West Charlton, Charlton Mackrell, Somerset, TA11 7AL
Email: office@nuffieldscholar.org
www.nuffieldscholar.org
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