Research Paper

An Overview of New Zealand's Economic and Environmental Sustainability in Agriculture: 40 Years Without Subsidies

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Abstract

A range of liberalisation programmes were introduced in New Zealand in 1984 as part of an economy-wide reform. For the agriculture sector, reforms included the removal of price support for sheep and wool, and the removal of input subsidies, resulting in production shifts away from sheep and wool production towards dairying. The changing production patterns generated productivity gains and reduced environmental pressures, as erosion-prone hill country was taken out of sheep grazing and forested instead. Since that time, and unrelated to subsidies, these trends have slowed with relatively more intensive, but still pasture-based, dairying, causing environmental problems such as challenges in relation to the use of fertilisers and greenhouse gas emissions. This is the first paper that examines key economic and environmental indicators of New Zealand's agricultural sector four decades after the reform. I conclude that while the agricultural sector in New Zealand shows resilience in responding to world markets and price volatility, low levels of public investment mean that agricultural productivity growth is constrained. While subsidy removal boosted economic resilience, persistent challenges in the use of soil resources, such as nutrient management practices, necessitate the need for balanced policy. The New Zealand story could help inform a broader discussion about future approaches to agricultural subsidies reform as it advances global discourse about sustainability in agriculture and free trade. The findings from this study will function as a useful reference tool for policymakers, along with researchers and industry stakeholders, who need to find the correct balance between economic growth and environmental stewardship through market-based agricultural sustainability models.

Keywords: Agricultural Subsidies · Agricultural Reform · Agricultural Sustainability · New Zealand

1. INTRODUCTION

The 1984 New Zealand economic reforms were triggered to resolve substantial economic inefficiencies, together with financial instability throughout the nation. The previous economic system of New Zealand reflected intense governmental direction through numerous protectionist measures that encompassed price regulation and substantial subsidy distributions, as well as severe competition limitations (Evans et al., 1996). Through Prime Minister David Lange's Fourth Labour Government with Roger Douglas as Finance Minister, the reforms set out to turn New Zealand towards a market-based economic system which focused on enhanced productivity as well as competition in the international marketplace (Bollard & Buckle, 1987).

The core reason for implementing the 1984 economic reform program arose from New Zealand's support system, which had reached its maximum level. The economic strength of New Zealand suffered because fiscal deficits remained elevated, and inflation kept rising, together with the buildup of public debt throughout the early 1980s. Government subsidies in the agricultural sector generated numerous inefficiencies while producing an excessive amount of food (Lattimore, 2006). The New Zealand government understood that both economic and market access limitations necessitated ending subsidies since Britain entered the European Economic Community in 1973 and the witnessing of reduced trade with Britain at the time (Evans et al., 1996).

The reform initiative aimed to develop an autonomous economy and competitive market through market-driven growth, which required reduced government involvement. The reform agenda termed "Rogernomics" enforced deregulation and privatisation while removing agricultural subsidies (Bollard & Buckle, 1987). Through its governance strategy, the government worked to unite New Zealand with global markets through

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innovation-based reforms, which focused on increased efficiency and improved productivity, specifically in the primary sectors.

However, the reform was not accompanied by effective environmental measures from the government, such as putting in place baseline environmental regulations in 1984 to stop environmental issues from occurring (e.g., from either land use change or intensification). Vitalis (2007) argued that the environmentally harmful aspects of subsidies were not well known by the government when the reform was introduced, and therefore were not a factor driving the reform process. Despite not being the primary factor, the environmental perspective of the 1984 reform has seen itself becoming the ‘unintended beneficiary’ (Vitalis, 2007).

Earlier assessments show that the economy-wide reforms transformed New Zealand agriculture into a sustainable industry with key strengths observed. For example:

1. Farmers became more efficient and productive when subsidies were removed because they needed to streamline operations through sustainable approaches in farm management (Lattimore, 2006).
2. Agricultural businesses removed restricted product limitations because of reduced regulatory support, so they expanded their production which built stronger economic resistance against market challenges (Evans et al., 1996).
3. Market-driven strategies established to promote sustainable land practices resulted in diminished use of chemicals and encouraged adaptation of environmentally safe farming approaches (Saunders & Cagatay, 2003).
4. Global competitiveness in the agricultural sector grew because New Zealand farmers strengthened their market competitiveness by increasing efficiency while targeting high-value exports (Bollard & Buckle, 1987).
5. The subsidy elimination process could be seen as an important first step to achieve sustained environmental benefits in agriculture, provided that agricultural policies work in coordination with policies in other sectors that affect macroeconomic conditions (Vitalis, 2007).

The 1984 agricultural reforms established fundamental transformations that supported sustainable development and market compatibility for New Zealand agriculture. There has been no research that provides a longitudinal view of the performance of New Zealand’s agriculture industry between 1984 and 2024. While prior studies have examined specific aspects of New Zealand’s agricultural reform such as the discussion on the evolution of dairy farming (e.g., Hugonnet, 2025), the impact on sheep and beef farming and land use change (e.g., Kerr & Olssen, 2012), a comprehensive review of the agricultural sector as a whole remains lacking. This is the first paper that investigates the economic and environmental performance of agriculture over the last four decades to attempt to tell this story.

2. RESEARCH METHODOLOGY

The research examines New Zealand’s post-1984 agricultural performance by drawing its data from public information provided by both national statistical agencies and international organisations to track economic and environmental developments. Time-series-based evidence on measuring New Zealand’s agriculture is ‘relatively incomplete in parts and unreliable in others’, as described by Vitalis (2007). This is particularly the case for environmental indicators. This study uses secondary data obtained from Statistics New Zealand together with industry reports, academic research papers, along international organisation studies from the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organisation of the United Nations (FAO). Evidence from a combination of these sources provides a more reliable overview of New Zealand’s agricultural performance.

It is important to note that this research does not assume the effects of the 1984 agricultural reform, with the underlying events in the macroeconomic environment observed four decades later. The primary goal of this research is to provide policymakers and researchers with important insights into the long-term performance of the agriculture sector using selected measurable indicators in economic and environmental sustainability. These indicators were chosen based on the availability and their relevance to key dimensions of agricultural productivity (e.g., total factor productivity), sustainability (e.g., greenhouse gas emissions) and economic contribution (e.g., production and trade). Using secondary data from these reliable sources ensures comparability and methodological transparency. Further evaluation of social sustainability, potentially qualitative, requires careful selection of research participants and data availability, which is beyond the scope of this research.

As an easy reference, an appendix is included to provide detailed definitions and explanations of some key indicators presented in this paper for better understanding.

3. FINDINGS: ECONOMIC PERFORMANCE AND COMPETITIVENESS

3.1 Terms of Trade and Competitiveness

New Zealand heavily relies on trade, particularly on its exports of goods and services. As one of the OECD members whose economy is heavily dependent on agriculture, the agriculture sector in New Zealand contributes more than 6 percent to its GDP, with agro-food products exports accounting for more than two-thirds (68.3 percent) of total exports (OECD, 2023).

The past four decades have seen significantly improved, less volatile, and more favourable export prices relative to import prices. Trade liberalisation stemming from the reforms of the mid-1980s created massive potential for higher export prices (Borkin, 2006). The potential has been reflected in the ongoing trend of terms of trade and the lowered inflation reflected by the consumer price index, with consumer price inflation falling from a peak of 7.36 percent immediately after the 1984 reforms to below 3 percent in recent years, as shown in Table 1. New Zealand's trade has shown signs of economy-wide competitiveness, with institutions and stakeholders now far more adaptive to price shocks.

As shown in Figure 1, which uses the Trade Weighted Index to measure the value of the New Zealand dollar against the currencies of New Zealand's major trading partners, the period following the mid-1980s economic reform is distinguished by durations of strong real exchange rates, indicating strong competitiveness.

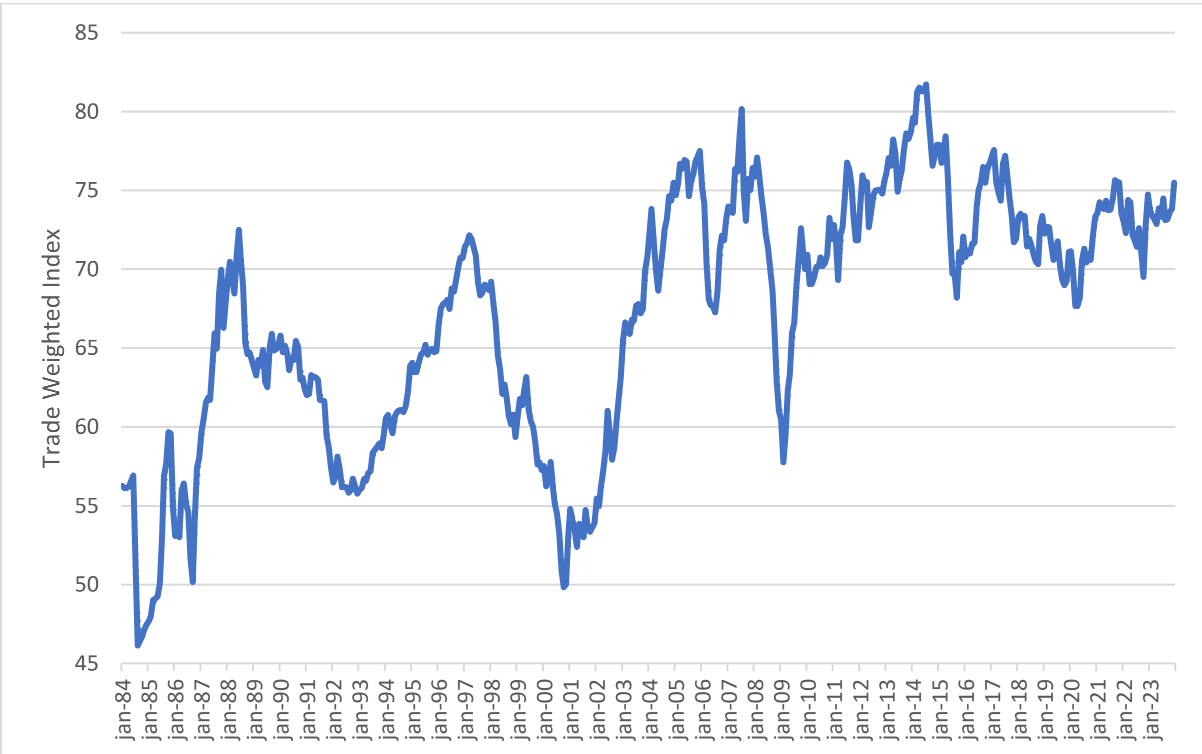

Figure 1. The Trade-Weighted Index (Monthly) for the Period Between 1984 and 2023

Source: Reserve Bank of New Zealand (2024)

In the decade prior to the 1984 economic liberalisation, New Zealand's current account deficit was attributed to the deterioration in terms of trade (Sighvatsson, 2001). With a current account deficit indicating that the country exports fewer goods and services than it imports, the current account is a general reflection of the country's trade balance, offering an indication of its economic performance and global competitiveness.

Looking at New Zealand's terms of trade with its five major trading partners, defined by the measure of New Zealand's export prices relative to its import prices, further sheds light on the overall performance of New Zealand's trade in terms of international competitiveness. As shown in Figure 2, New Zealand's terms of trade have seen a clear upward trajectory. The rise in export prices has had a positive impact on the country's economic growth, and the reduction in export price volatility has contributed to much more stable terms of trade since the 1990s (Borkin, 2006; Mellor, 2015). Reforms which resulted in structural changes in the economy improved conditions to allow institutions and resources to move more efficiently in response to market and price shocks.

This is exemplified by the short-lived impact of the 1997 Asian Financial Crisis and the 1998-99 drought, with the market responding quickly to market price signals (Carroll, 2013). The removal of subsidies has resulted in market conditions that allow farmers to make rational decisions, such as prioritising high-value exports, in the regulatory and market environment they are operating in.

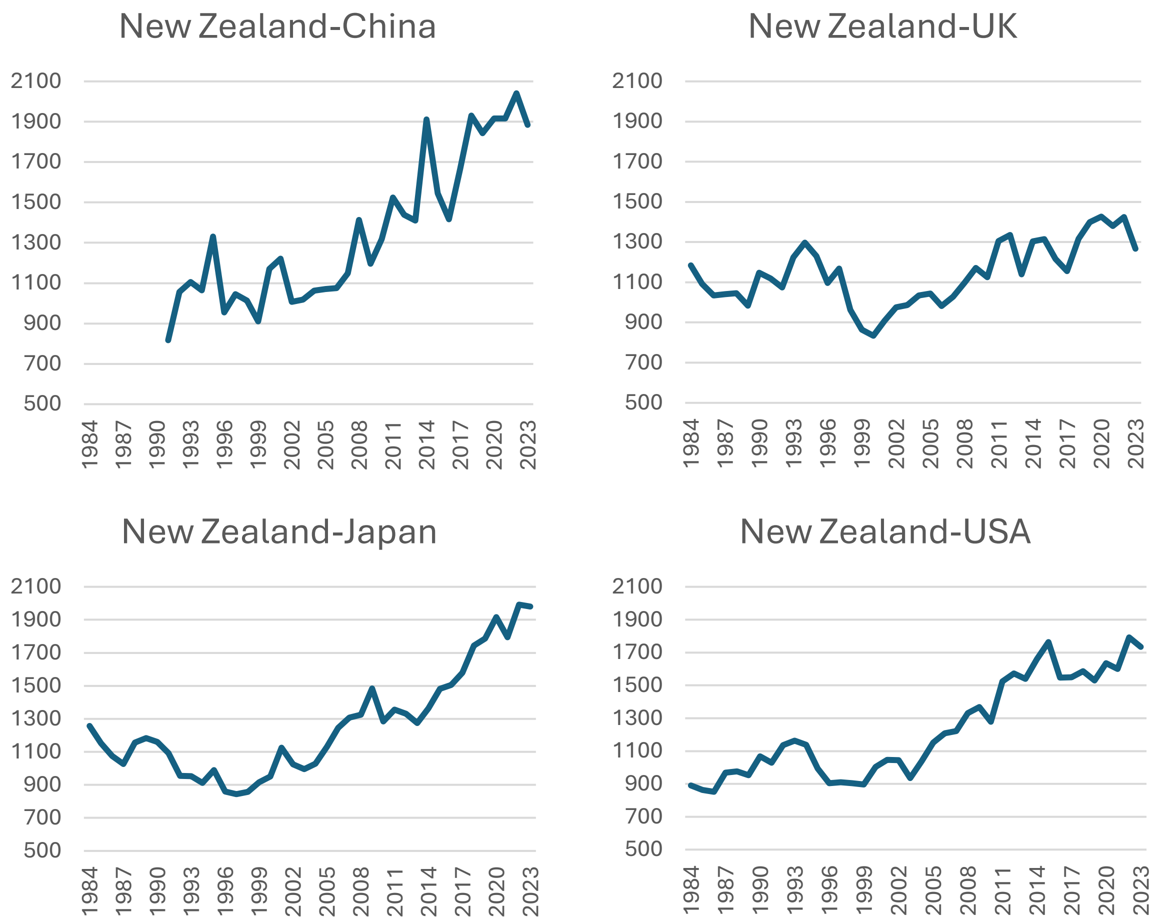

Figure 2. Terms of Trade Index Between New Zealand and Four Major Trading Partners Between 1984 and 2023. 2002 as Base Year (=1000)

Source: Data generated from Statistics New Zealand's data tool Infoshare, for year ending June. Note that no data was available for the Terms of Trade Index between New Zealand and China prior to 1991.

The New Zealand economy faces similar challenges to the rest of the world today, with global energy and food prices surging from the reverberated impact of the global pandemic and ongoing world conflicts. As a result, New Zealand's inflation rate reached 5.6 percent in 2023, below the OECD average of 6.5% (OECD, 2024). However, New Zealand's current account deficit remains notably higher than the OECD average of -0.96% in 2024, and despite a recent decline in the current account deficit, the past four decades have seen a trajectory of it worsening by more than half. Real exchange rates have remained highly appreciated in recent years, disadvantaging export growth and stimulating imports (Chen, 2011). One model exercise concludes that New Zealand's current account deficit could be econometrically unsustainable, meaning the country could run the risk of facing debt problems (Chen, 2011). However, another study concluded New Zealand could service debt despite an ongoing deficit, which is considered common for advanced economies (Kim et al., 2006). While New Zealand's debt levels are atypical for advanced economies, its historical adaptability suggests the capacity to manage deficits.

3.2 Shifts in Production and Exports and Output Productivity

The removal of distorting incentives in the 1984 reform saw a dramatic change in the agriculture sector with a sharp reduction in sheep numbers, fewer beef farms, and a significant increase in dairy herds (Vitalis, 2007). Mellor (2015) observes that the expansion of the share of exports towards dairy was largely at the expense of meat, and therefore, the weighting effects were neutral in terms of the contribution of sectoral change to the terms of trade. Notably, the share of wool exports also shrank significantly compared to its share four decades ago.

The OECD (2011) calls for the competitiveness of agriculture to be assessed using productivity as another key indicator, which offers an improved understanding of sector-specific resource management. As shown in Table 1, over the past four decades, the share of dairy exports more than doubled, while the share of meat exports witnessed a steady reduction. The total land area used for farming decreased from 18.68 million hectares over the period 1984-1993 to 13.63 million hectares over the period 2014-2023. Noticeably, dairy production has seen significant improvement. The average milk solids produced per effective hectare increased by 85 percent, from 653 kilogrammes to 1201 kilogrammes. Data reflects the overall trend of increased farm performance, benefiting from the positive impacts of feed use intensification, increased herd size and dairy productivity are observed (Ma et al., 2018). Similar trends can be observed for beef and sheep meat, which also saw exponentially higher productivity, with 73 percent and 85 percent growth, respectively, between 1984 and 2023.

Table 1. Selected economic indicators of New Zealand for the period 1984 and 2023

Indicators	1984-1993	1994-2003	2004-2013	2014-2023
Overview of key agricultural industries				
Total area of agricultural land (hectares, millions)[1]	18.67	16.15	14.75	13.63
Dairy export value as a share of total export[2]	12.81%	15.93%	20.82%	26.42%
Meat export value as a share of total export[3]	16.80%	13.25%	12.81%	12.91%
Beef and veal export value as a share of total export[4]	7.93%	5.40%	4.82%	5.89%
Lamb and mutton export value as a share of total export[5]	8.11%	6.75%	6.63%	6.13%
Wool export value as a share of total export[6]	10.41%	3.95%	1.76%	1.02%
Dairy production (tonnes, millions)[7]	1.18	1.69	2.22	2.04
Beef production (tonnes, millions)[8]	0.53	0.61	0.64	0.70
Sheep meat production (tonnes, millions)[9]	0.56	0.54	0.51	0.46
Dairy cattle numbers (including bobby calves, millions)[10]	3.35	4.45	5.71	6.32
Beef cattle numbers (millions)[11]	4.69	4.81	4.12	3.73
Sheep numbers (millions)[12]	61.04	45.08	34.99	26.94
Average kg milk solids per effective hectare[13]	653.00	750.20	923.70	1207.11
Economic conditions				
Agriculture as percentage of GDP[14]	5.26%	4.84%	4.27%	4.20%
Consumer price index[15]	7.36	1.98	2.57	2.58
Current account balance as percentage of GDP[16]	-2.60%	-3.39%	-4.80%	-4.02%
Competitiveness				
Producer support estimate as percentage of farm receipts[17]	4.68%	0.76%	0.74%	0.64%
Agricultural labour productivity growth[18]	-1.24%	-0.17%	-1.05%	-0.15%
Agricultural multifactor productivity growth[19]	3.37%	3.98%	2.97%	1.05%
Agriculture total factor productivity index (2015=100)[20]	84.59	95.44	94.71	96.30
Research and development spend on primary industries as a percentage of total expenditure[21]	-	-	17.37%	15.67%

Source:

[1] Statistics New Zealand data tool - Infoshare, calculated by author. Data for years ending June. Note that data for 1997-2001 was not available.

[2,3,4,5,6] Statistics New Zealand, calculated by author. Data for years ending June. Note that figures for year 1984 were not available.

[7,8,9] OECD-FAO Agricultural Outlook database, calculated by author. Note that data before 1990 and for year 2023 was not available.

[10,11,12] Statistics New Zealand, calculated by author. Data for years ending June. Note that data for year 1997, 1998, 2000 and 2001 was not available.

[13] Livestock Improvement Corporation & DairyNZ (2023). The average between 1984 and 1993 was taken by year 1993 value as no data was available. Data for milk seasons ending May.

[14] Statistics New Zealand, calculated by author. Data for years ending March. Note that data for year 2023 was not available.
[15] Statistics New Zealand, calculated by author.
[16] Statistics New Zealand, calculated by author. Data for years ending March. Data was not available for years prior to 1988.
[17] OECD Agricultural Policy Monitoring and Evaluation database, calculated by author. Note that no data available before year 1986 and for year 2023.
[18,19] Statistics New Zealand, calculated by author.
[20] Economic Research Service of the United States Department of Agriculture (September 2023 edition). Note that no data was available for year 2022 and 2023.
[21] Statistics New Zealand, calculated by author. Data was collected through the biennial Research and Development Expenditure Survey. Note that sector specific data was not available before year 2008. The only available data for primary industries, which covered more than the agricultural sector, was for year 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022.

3.3 Agricultural Productivity Growth - Labour and Capital Inputs

Figure 3 illustrates New Zealand's percentage change in agricultural productivity growth in terms of labour and capital. The multifactor productivity in the agricultural sector saw its growth reach 4 percent on average in the two decades immediately following the removal of agricultural support in the 1980s, benefiting from the increasing economies of scale and changes in land use. But the productivity growth rate has since slowed down and is frequently experiencing negative growth, which has been predominantly driven by fluctuations in labour productivity. For all economic activities, New Zealand's labour productivity growth is weaker than the OECD average (OECD, 2024), although, despite continued average negative growth, the labour productivity of agriculture has seen a slight improvement in the most recent ten years. With New Zealand moving towards a service economy, the share of people employed in the production workforce is being negatively impacted (Janssen et al., 2022). Labour shortages in the agriculture sector and the need to recruit workers from overseas could also explain negative productivity growth. Another explanation behind the weak labour productivity performance is New Zealand's low physical, financial, and knowledge-based capital (Janssen, 2018). The ageing rural workforce and migration policies could also be potential influencing factors.

Further, agricultural productivity growth could be constrained by the availability of highly productive land (Clark, 2024). Extreme weather events could also be a disruptive factor, although assessments from satellite data indicate that drought and floods have a minimal impact on agricultural productivity in New Zealand (Blanc & Noy, 2023).

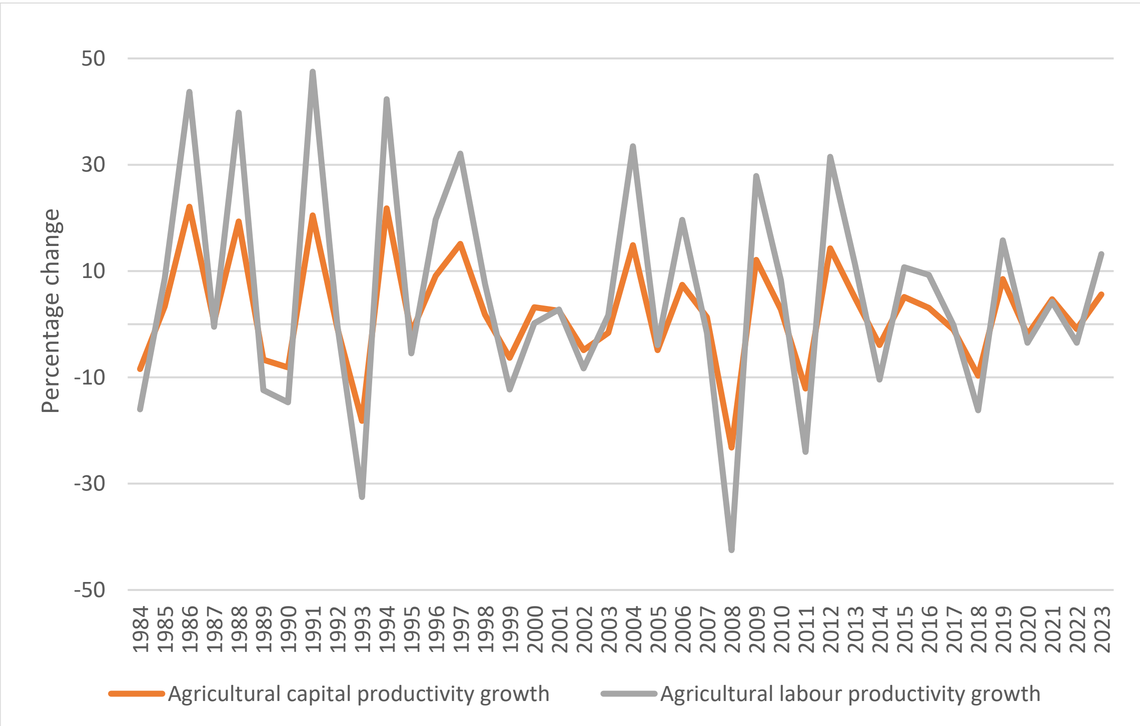

Figure 3. New Zealand's Percentage Change in Agricultural Multifactor Productivity Growth Between 1984 and 2023

Source: Statistics New Zealand's data tool Infoshare. Note that capital and labour productivity indicators constitute multifactor productivity.

3.4 Agricultural Total Factor Productivity

A more informative indicator of productivity is agricultural total factor productivity (TFP), which measures the amount of agricultural output produced from the combined set of land, labour, capital, and material resources employed in farm production (USDA, 2024). TFP reflects the overall technological change in the agricultural sector.

Figure 4 compares New Zealand's agricultural TFP with the OECD average. Following the removal of agricultural subsidies, New Zealand's agricultural TFP growth considerably outpaced the OECD average. But since 2003, the average level of agricultural total factor productivity among OECD countries has grown much faster, and the gap is widening, with New Zealand struggling to catch up.

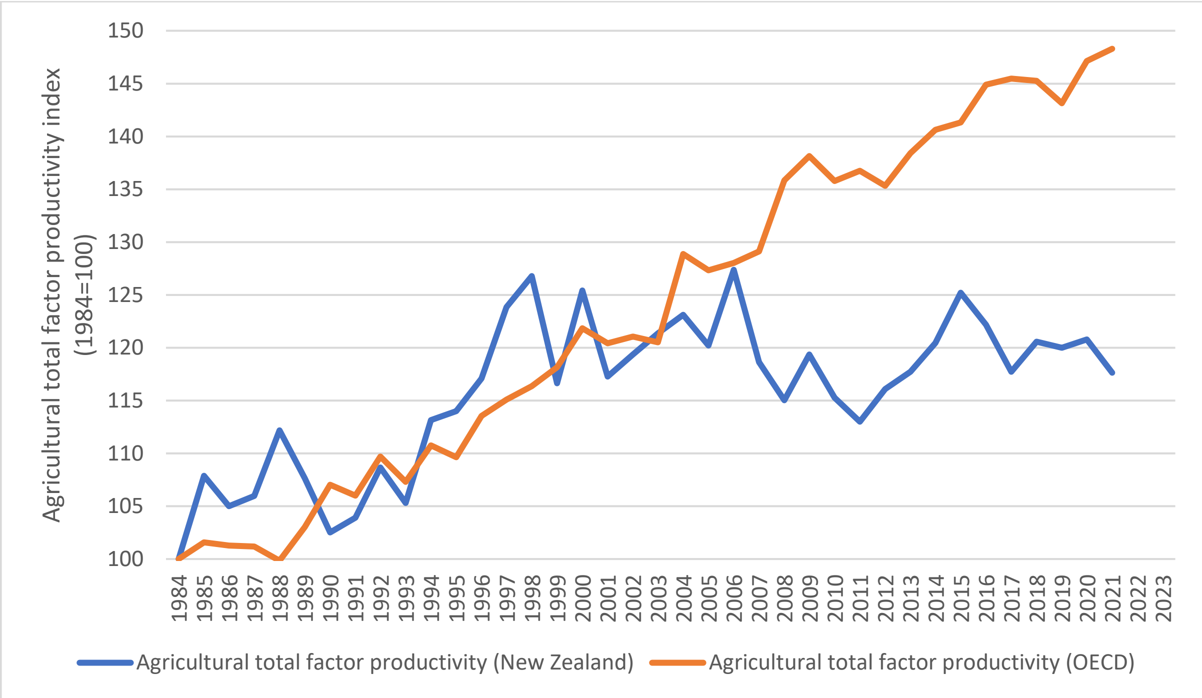

Figure 4. Agricultural Total Factor Productivity Index for New Zealand and the OECD Between 1984 and 2021

Source: Agriculture total factor productivity (TFP) data sourced from the Economic Research Service of the United States Department of Agriculture. TFP indices were taken from the 29 September 2023 release, which used the year 2015 as the baseline (=100). The graph above is rescaled proportionally by adjusting the year 1984 as the baseline (=100). TFP data not available for 2022 and 2023. OECD data includes 38 countries as of 2021. The outputs used to calculate agriculture TFP include the total gross value of agricultural output from crops, livestock, and aquaculture. Inputs were an index of agricultural inputs only, which are land, labour, capital, and materials.

3.5 Investment in Research and Development (R&D)

Innovation is a key influencer of productivity. As shown in Table 2, between 1991 and 1998, only 0.97 percent of New Zealand's GDP was invested in innovation, a trend which has persisted. For example, between 2008 and 2023, New Zealand only spent an average of 1.29 percent of its GDP on R&D in comparison to the OECD average, which sits at over 2 percent. In recent years, investment in R&D as a percentage of GDP has been increasing amongst OECD countries from 2.29 percent in 2019, to 2.56 percent in 2020 and to 2.71 percent in 2021 (OECD, 2023). Private sector expenditure on R&D in New Zealand's agriculture, forestry, and fisheries has increased over the period 2008-2023.

Due to the lagged effect of agricultural R&D, it is difficult to attribute agricultural productivity growth to R&D (OECD, 2011). Furthermore, research examining the level of returns from R&D expenditure, specifically in the New Zealand agricultural sector, is scarce. Hall and Scobie (2006) and Johnson and colleagues (2007) observe that following the economic reforms in the 1980s, there was some level of agricultural productivity growth due to R&D investments. The sector-wide economic reforms led to a period of higher agricultural TFP growth in the 1990s, but in the longer term, agricultural TFP growth has not kept up due to reduced R&D spending and policy approaches which constrain the commercial value benefits which can be reaped from public R&D investments.

Johnson (2000) finds that for every one dollar invested by the private sector in agricultural physical and knowledge capital during the period 1962 to 1998, the return in agriculture is NZD 68.70, with depreciated stock at 5 percent. However, every dollar of public funding sees the New Zealand agricultural output lose NZD 5.70. This could imply that public R&D has experienced overinvestment or underutilization, which could negatively impact agricultural TFP. This finding, however, has not attracted scholarly debate and New Zealand's agricultural investment return remains insufficiently researched.

Non-agricultural sector investments in R&D also play a role in facilitating some of the agricultural TFP (Johnson, 2000). Using a different model, Hall and Scobie (2006) derive a 17 percent rate of return for all R&D investment in agriculture from both private and public sources between 1927 and 2001 using a 30 percent depreciation rate. However, foreign knowledge capital is found to be the major driver of high domestic R&D growth. Industry-level investment, including foreign-sourced funding, creates more returns from investment. This could be explained by the low return on investment to individual companies from government-funded R&D (Johnson et al., 2007) due to the government's sensitivity of not providing subsidies that benefit only a limited number of actors in the agricultural sector and ensuring that public money supports public goods.

Data on the type of agricultural R&D undertaken is not consistently collected in New Zealand. Available data from Statistics New Zealand shows expenditure predominantly targeting applied research and experimental development rather than basic research, which tends to see much longer research lags. The rationale for adopting technologies should not be based on a predicted rate of return, which risks losing the potential for future productivity growth. On the other hand, it is important to recognise the possible diminishing marginal return on agricultural R&D investments from the public sector. While the agricultural sector has now become more capable of reacting to international market conditions, the ability of the sector to protect itself from domestic stagnation of capital and knowledge input remains to be examined.

Table 2. Research and Development of New Zealand Between 2008 and 2023

	Expenditure in primary industries (millions)	Total expenditure (millions)	Primary industries R&D as share of total expenditure	Total expenditure as share of GDP	Share of total business sector contribution to primary industries R&D	Share of total government sector contribution to primary industries R&D	Share of total higher education sector contribution to primary industries R&D
1991	-	724.60	-	0.95%	-	-	-
1992	-	714.50	-	0.94%	-	-	-
1993	190	755.30	25.16%	0.96%	-	-	-
1994	-	824.80	-	0.98%	-	-	-
1995	-	-	-	-	-	-	-
1996	240	889.30	27.00%	0.92%	-	-	-
1997	-	-	-	-	-	-	-
1998	230	1107.40	20.77%	1.06%	-	-	-
No available data between this period							
2008	398	2,161	18.42%	1.16%	33.67%	53.52%	13.07%
2009	-	-	-	-	-	-	-
2010	389	2,388	16.29%	1.23%	34.45%	52.70%	12.85%
2011	-	-	-	-	-	-	-
2012	457	2,625	17.41%	1.23%	42.45%	46.61%	10.94%
2013	-	-	-	-	-	-	-
2014	444	2,685	16.54%	1.15%	43.92%	43.24%	13.06%
2015	-	-	-	-	-	-	-
2016	535	3,136	17.06%	1.23%	49.72%	40.00%	10.28%
2017	-	-	-	-	-	-	-
2018	693	3,922	17.67%	1.35%	47.33%	41.99%	10.68%
2019	-	-	-	-	-	-	-
2020	655	4,734	13.84%	1.47%	55.73%	34.50%	9.92%
2021	-	-	-	-	-	-	-
2022	700	5,286	13.24%	1.47%	51.71%	38.86%	9.43%
2023	-	-	-	-	-	-	-

Source: For the period between 1991-1998, data from the New Zealand Parliament (2001) – a background note of statistics on research and development funding. GDP data sourced from Statistics New Zealand's Infoshare online data tool. For the period between 2008-2023, all data sourced from Statistics New Zealand's Infoshare online data tool. Research and development data were collected through its Research and Development Survey for the years ending June. Note that the data is sorted by primary industries only, which consist of agriculture, forestry and fisheries. Statistics New Zealand noted that in 2019, 2021 and 2023, specific iterations of the Research and Development Survey were conducted for the business sector only, which is why total expenditure was not available. The full Survey is usually conducted every two years, covering business, government and higher education sectors. All percentage calculations are done by the author.

4. FINDINGS: ENVIRONMENTAL PERFORMANCE AND SUSTAINABILITY

4.1 Agricultural Land Use

The area of land used for agriculture in New Zealand has decreased over the last four decades, from more than 50 percent of the total land area in 1984-1993 to less than 40 percent in 2014-2022, as shown in Table 3. Pastoral farming continues to dominate land use, accounting for nearly 95 percent of total agricultural land. However, it has seen small reductions in land coverage in the past forty years due to a decrease in sheep farms and beef cattle farm size, partially offset by a relatively small increase in dairy cattle farm size (Ministry for the Environment, 2021). The share of arable land and cropland increased moderately, covering more than 5 percent and close to 1 percent of total agricultural land in the 2014-2022 period, respectively. Land use for horticulture has seen a 46 percent increase from 1984 to 2022, from 86,960 hectares to 133,549 hectares. However, the rate of increase has slowed down since the early 1990s, from 9 percent to less than 1 percent on average in the recent decade. Changes in the production mix, farm size and diversification into horticulture and forestry reflect producers making production decisions in response to market signals following the removal of agricultural subsidies. These changes have had flow-on effects on the environment and the sustainability of the sector.

4.1 Soil Erosion

An immediate impact of the reforms was the conversion from pastoral agriculture to forestry in the early 1980s, particularly in soft-rock hill country vulnerable to soil erosion. Prior to 1984, farmers were subsidised to convert unproductive, steep erosion-prone hill country to pastoral farming with the Land Development Encouragement Loans despite knowing the erosion problems (Basher, 2013).

New Zealand's monitoring of soil erosion is ad hoc and has been criticised by Basher (2013) as lacking a systematic tracking mechanism. From available data, the rate of soil erosion across New Zealand has improved by 15 percent between 1996 and 2018. This aligns with the overall trend of OECD countries, where there has been a continuing improvement since 1990 (OECD, 2013). Increasing rates of afforestation could help explain the improving status of soil erosion across New Zealand. Between 1996 and 2018, the area of exotic forest in New Zealand increased by 12 percent (Ministry for the Environment, 2024). The total change in land use for forestry has seen a 28.9 percent increase over a similar period (1990-2015) (Journeaux et al., 2017).

The positive impact on soil erosion from native bush and plantation forestry conversion observed after 1994 has been incentivised by more recent government initiatives such as the Afforestation Grant Scheme (2015-2020) and the One Billion Trees programme (since 2018) that provide financial support for tree planting.

4.2 Irrigation and Agricultural Water Use

As shown in Table 3, irrigated agricultural land in New Zealand has more than doubled over the past three decades, with a 64 percent increase from an average of 445,895 hectares in 1994-2003 to 733,270 hectares in 2014-2022. In 2022, the irrigated area represented 7.5 percent of total agricultural land (9,747,000 hectares), with an estimated 58 percent of irrigated land used for dairy farming (Ministry for the Environment, 2021). For water use in the agricultural sector, the profit generated per cubic meter of water fluctuates between USD 2 and USD 4. The average return on water usage in 1994-2003 is USD 3.17 per cubic meter, which fell to USD 2.99 in the next decade and then improved to USD 3.88 in 2014-2022. On-farm irrigation practices have driven improved water use efficiency, where there has been a move away from border-dyke flood and spray systems to more efficient sprinkler systems now used by 90 percent of farms (Dench & Morgan, 2021; Irrigation New Zealand, 2017).

4.3 Nutrient Balances and Nitrogen and Phosphorus Use

Over the past four decades nitrogen fertiliser use intensity increased by more than 700 percent primarily driven by the intensification of dairy farming and the increase in dairy cow numbers (Gray, 2023). Nitrogen use has seen a sharp increase from on average of 7.26 kg per hectare in 1994-2003 to 58.36 kg per hectare in 2014-2022 with the largest increase in the use observed between 1990 and 2005 (Parfitt et al., 2012).

To examine the environmental and sustainability risks associated with excess fertiliser use, it is important to assess the nutrient balance in conjunction with its use efficiency and agricultural productivity (Brentrup & Lammel, 2016). New Zealand's nutrient balance is driven by changes in nitrogen inputs and outputs. As shown in Figure 5, New Zealand had a nitrogen deficit prior to the year 2000, meaning that nitrogen input into a farming system exceeded its output. A nutrient deficit also indicates that the soil fertility is declining (OECD, 2024). However, since 2000, a nitrogen surplus has been observed, indicating that a higher level of nutrients is being lost to the soil, water and air, therefore posing a higher risk to the environment.

While New Zealand's total nutrient balance is among the lowest in OECD countries, when comparing annual changes in nutrient balance with changes in agricultural production, it is clear that nutrient use is not environmentally sustainable. As shown in Figure 6, from 1994-2003 to 2004-2013, agricultural output growth slowed despite a reduced phosphorus surplus. Growth in agricultural production further decreased from 2004-2013 to 2014-2022, with a much faster growth rate of nitrogen and phosphorus surpluses. This long-term trend indicates a higher risk of environmental damage and the unsustainable use of soil resources.

The nutrient use efficiency indicator reflects the different performance of nitrogen and phosphorus use practices. As shown in Table 3, phosphorus use efficiency has continuously improved over the last three decades, with 75.19 percent use efficiency recorded in the decade post-1984. Nitrogen use efficiency, on the other hand, has declined from 186.77 percent use efficiency in 1984-1993 to 63.44 percent in 2014-2022. Intensive use of nitrogen fertiliser negatively impacts clover content in grass pasture and contributes to N_2O emissions.

Emissions from nitrogen fertiliser use account for 4 percent of total agricultural emissions in New Zealand (Gray, 2023).

Noticeably, the rate of increase in nitrogen fertiliser use in New Zealand has been slowing in the past decade. Economic returns for farmers have a strong influence on the use of fertiliser inputs. For instance, low farm profitability between 2006 and 2008, combined with high fertiliser prices and a drought in 2008 and 2009 (Parfitt et al., 2012), resulted in lower nitrogen use.

Phosphate use in New Zealand has declined from a peak reported in 2005 of 45.59 kg per hectare to 19.35 kg per hectare in 2021. This decrease is attributed to the significant price increase in 2008 and lower economic returns for sheep and beef farmers (Fertiliser Association of New Zealand, 2024). The overall trend for the phosphorus balance indicates a more effective use of nutrient input, with the balance coming closer to zero than the nitrogen balance. Sustainable use of phosphorus facilitates soil fertility and nutrient cycling.

4.4 GHG Emissions From Agriculture

The New Zealand Government reports that net GHG emissions is on track to meet the 2050 net zero target (Department of Prime Minister and Cabinet, 2024). However, OECD's calculations (2024) predict that the current trajectory is not going to meet the medium-term 2030 emissions target. The OECD (2024) blames the 'unusual structure' of New Zealand's economic production as the main challenge reducing GHG emissions.

The uniqueness of New Zealand's primary production base means that 71 percent of the country's total agricultural emissions come from enteric methane, which makes up approximately 43 percent of total GHG emissions (New Zealand Agricultural Greenhouse Gas Research Centre, 2024). Agricultural emissions have been increasing at a decreasing rate. Between 1984-1993 and 1994-2003, emissions from agriculture increased by 9.14 percent, but increased by as little as 1.28 percent between 2004-2013 and 2014-2022 with a lower emission intensity level (Table 3). Although New Zealand's agricultural sector has seen a significant increase in dairy herds and nitrogen fertiliser use since the 1990s, emissions are offset by the decrease in sheep, deer, and beef cattle, as well as afforestation. Dairy remains a major contributor of approximately half of the agricultural livestock emissions. New Zealand's commitment to reducing GHG emissions is expected to continue to impact flock size as the OECD and FAO (2024) predict that more productive sheep land is likely to be converted to plantation forest for carbon credits.

Table 3. New Zealand's Selected Agri-Environmental Indicators, 1984-2022

	1984-1993	1994-2003	2004-2013	2014-2022
Land[1]				
Agricultural land (percentage of land area)	53.37%	47.76%	43.46%	39.67%
Share of arable land in agricultural land area	2.92%	3.19%	4.05%	5.16%
Share of permanent cropland in agricultural land area	0.32%	0.40%	0.60%	0.68%
Share of permanent pasture in agricultural land area	96.77%	96.41%	95.45%	94.17%
Share of organic farming in agricultural land area	-	0.30%	0.80%	0.80%
Change in land use for horticulture	0.01%	9.54%	0.95%	0.56%
Water[2]				
Total agricultural freshwater abstraction (cubic metres, millions)	-	-	3013.35	-
Share of agricultural freshwater abstraction in total freshwater abstraction	-	-	59.56%	-
Irrigation area (hectares)	-	445,894.50	463,901.00	733,269.75
Water use efficiency in agriculture (USD/m^3)	-	3.17	2.99	3.88
Fertiliser and pesticide use[3]				
Nutrient nitrogen uses on permanent crop area (kg/ha)	7.26	30.55	51.35	58.36
Nutrient phosphate uses on permanent crop area (kg/ha)	25.75	37.60	31.34	24.30
Total pesticide uses on permanent crop area (kg/ha)	8.69	7.87	9.58	8.73
Percentage change in nitrogen balance per hectare	-6.90%	2.87%	6.40%	4.74%
Percentage change in phosphorus balance per hectare	120.07%	1.68%	-5.08%	3.71%
Nitrogen use efficiency	186.77%	105.69%	73.93%	63.44%
Phosphorus use efficiency	75.19%	54.08%	65.53%	72.52%
Emissions[4]				

Agricultural greenhouse gas emissions (tonnes of CO2-equivalent, thousands)	37,177.98	40,576.08	42,015.56	42,554.53
Agricultural emissions as share of total national emissions	52.92%	51.97%	50.08%	51.57%
Agricultural emissions intensity (kilo tonnes per $1 million value added)	-	-	5.25	4.80
Percentage change in enteric fermentation from all livestock	-0.27%	0.98%	-0.19%	-0.26%
Percentage change in enteric fermentation from dairy cattle	3.19%	4.59%	2.63%	0.39%
Emission of energy use in agriculture, forestry, and fishing as share of total national emission	1.72%	1.98%	1.96%	1.80%
Energy[5]				
Percentage change in bioenergy production	2.10%	1.99%	0.40%	-1.20%
Percentage change in bioenergy consumption	5.66%	6.99%	-0.87%	-0.69%

Source:

[1] FAOSTAT database. Data for 2023 is not available. The share of organic farming for 1994-2003 takes 2000-2003 average, 2014-2022 takes 2014-2021 average. Land use for horticulture sourced from Statistics New Zealand's Infoshare database.

[2] OECD Data Explorer. For freshwater data: data not available for 1984-2005. The 2004-2013 value takes the average of the years 2006 and 2010. Data not available for 2014-2022. For irrigation data: 1994-2003 takes the average of the years 2002 and 2003. 2004-2013 takes the 2004 value. 2014-2022 takes the average of 2014-2020. For irrigation data: 1984-1993 takes the 1990 value. 1994-2003 takes the 1990 value. 1994-2003 takes the average of the years 1995, 2002, and 2003. 2004-2013 takes the average of the years 2004, 2007 and 2012. Data for water use efficiency sourced from the FAOSTAT database. No data available before 2002 and after 2021.

[3] FAOSTAT database: For fertiliser use, data for 2022 is not available. For pesticide use, no data available before 1990 and for 2022. For nitrogen and phosphorus balance, data for 2022 is not available. Percentage calculated by author. Data for nutrient use efficiency in 2022 only is not available.

[4] Ministry for the Environment (2024). Data is not available before 1990. Agricultural emissions intensity data from Statistics New Zealand (2024). Data prior to 2007 is not available.

[5] FAOSTAT database. Data is not available before 1990.

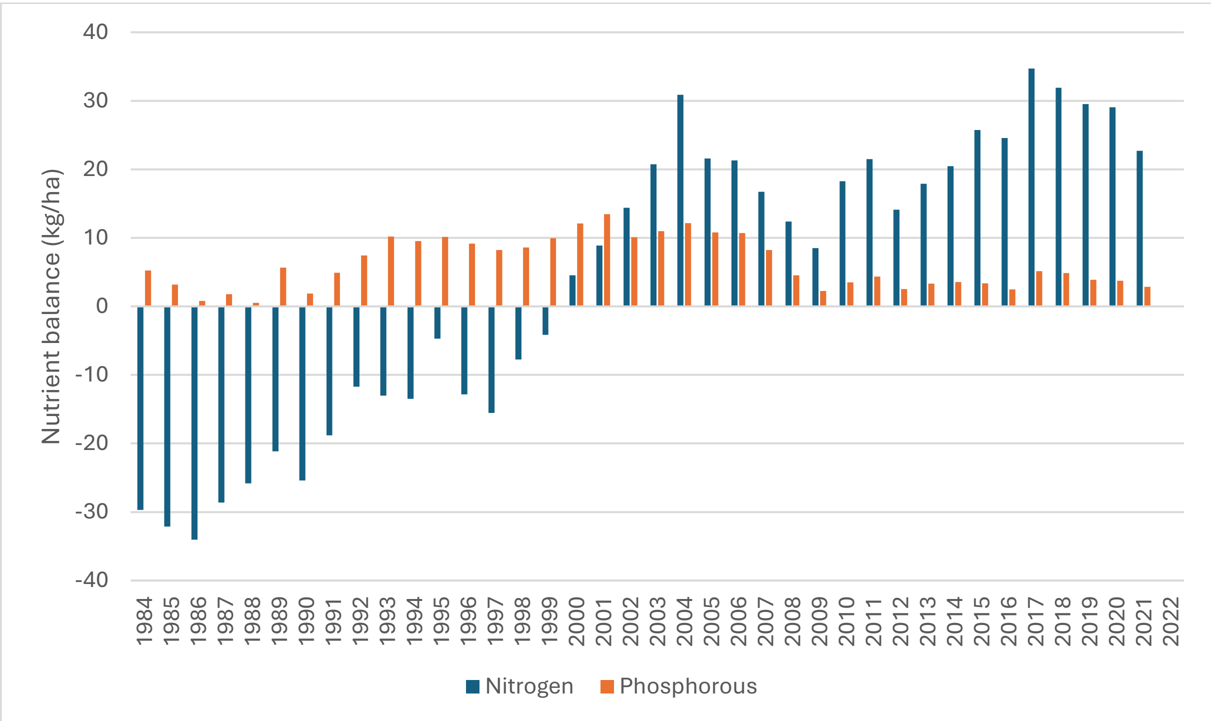

Figure 5. Nutrient Balances Between 1984 and 2022

Source: FAOSTAT database. Nutrient balance for 2022 is not available.

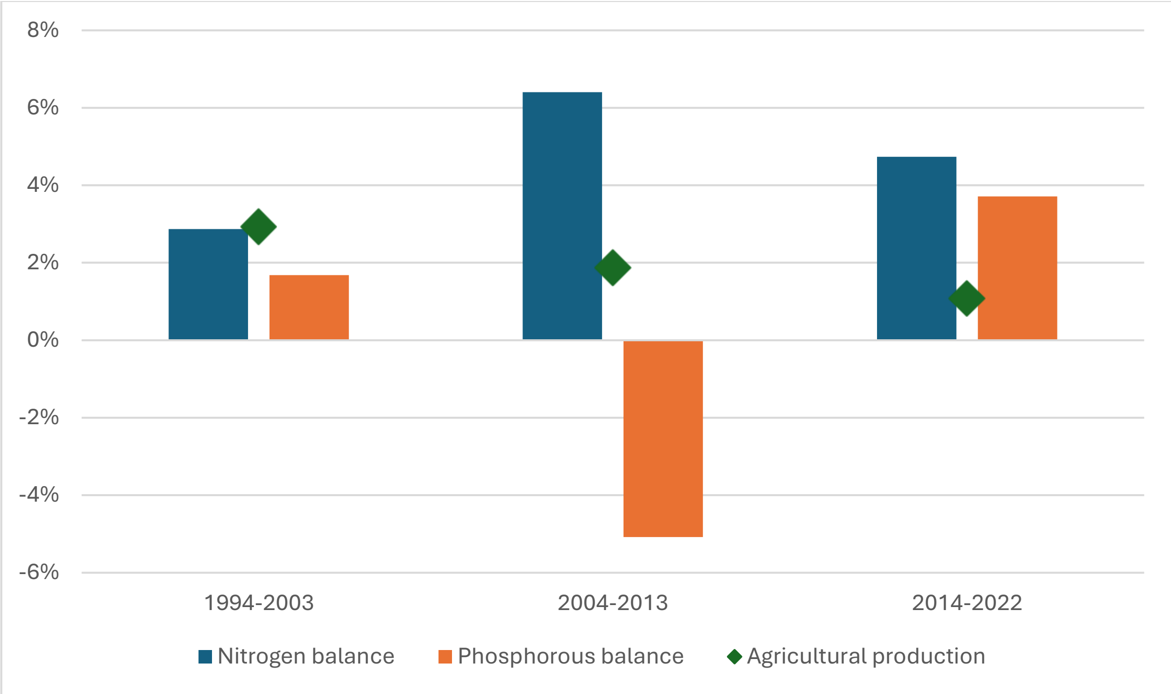

Figure 6. Average Annual Changes in Nutrient Balances and Production Growth Between 1994 and 2022

Source: FAOSTAT database. Note that 1984-1993 value was excluded from the graph because of the strong outlier of phosphorus use growth rate during the period (120.07%).

5. DISCUSSION

The economic and environmental sustainability of New Zealand's agricultural sector post-1984 reforms can be evaluated and measured using various essential indicators. **Terms of trade and competitiveness** showed notable enhancement, and industry competitiveness grew better when market forces compelled farmers to optimise their operations, which lowered expenses and strengthened their position in global markets (Evans et al., 1996). After implementing market-driven reforms, farmers began using advanced technologies and precision farming techniques to maximise their resource utilisation, which resulted in a substantial **growth of agricultural productivity,** particularly for **labour and capital investments** (Lattimore, 2006). The prolonged development of **total factor productivity** underwent improvements because of innovation together with efficiency gains, but New Zealand has found it hard to catch up with other OECD countries in terms of the speed of growth. Investment in **research and development** emerged as a vital catalyst because private-sector involvement, together with governmental backing of science-based farming strategies, promoted extended sustainability within the agricultural sector (Bollard & Buckle, 1987).

Multiple indicators prove that these reforms achieved economic success and established procedures which promoted sustainable agricultural practices. While reforms boosted economic resilience (Figure 2), environmental pressures from intensive dairying reveal tensions between market efficiency and ecological sustainability (Table 3). The modern agricultural land use shows a move toward developing efficient farming businesses with diverse agricultural operations (Smith et al., 2019). **Soil erosion** continues to present difficulties in erosion-prone hill country areas, thus prompting conservation activities (Dymond et al., 2017). New expansion of **irrigation systems** in dairy farming operations alongside **increased water use in agriculture** has stressed freshwater availability, so better efficiency becomes essential (Parliamentary Commissioner for the Environment, 2013). Although the changing production patterns saw reduced environmental pressures in the immediate aftermath of the reform, as erosion-prone hill country was taken out of sheep grazing and forested instead, results show later degradation (e.g., nitrogen surplus). The assessment of **nutrient balances, particularly focusing on nitrogen and phosphorus use,** demonstrates rising agricultural intensification, requiring improved nutrient management practices. The rise in **agricultural GHG emissions** indicates the significance of implementing mitigation strategies because methane and nitrous oxide form the bulk of these emissions (Ministry for the Environment, 2020).

The study contributes its main effects through a thorough examination of New Zealand agricultural performance by using key economic and environmental sustainability indicators. This research provides vital knowledge about how agricultural exports formed New Zealand's economic strength after the 1984 economy-wide reform. This research shows how agricultural productivity stands as a crucial factor while presenting the workforce constraints alongside environmental threats, which remain behind TFP measurements when compared to other OECD countries.

6. CONCLUSION

Farm diversification happened because of the 1984 economic reforms, although these developments saw difficulties in both productivity growth and environmental sustainability. New Zealand agriculture depends strongly on free markets due to the fact that agricultural producers receive limited support for subsidising production, and trade limitations are minimal (OECD, 2023). Evidence has shown that removing agricultural subsidies has enabled producers and exporters in New Zealand to adapt to changing market conditions with long-term resilience. It is important that future fiscal and monetary policies do not harm the ability of agricultural producers and institutions to remain adaptive and efficient in resource mobilisation and market self-determination.

Agricultural total factor productivity remains lower than OECD averages mainly because New Zealand devotes insufficient resources to agricultural research and development. The study indicates that modern agricultural innovation depends on R&D funding, which directs policymakers to essential investment areas beyond the category of basic research that support New Zealand's agricultural productivity. The study proposes that New Zealand must sustain its focus on investing in the diverse portfolio of research, development and innovation in agriculture. Evaluating the rate of return on this type of investment is not always feasible and timely, but given New Zealand's long-standing political discourse on zero tolerance of domestic agricultural subsidies, projects from a public sector funding source could fall short of achieving maximum commercial returns. Future studies to develop methodology for measuring agricultural R&D investment return, in terms of funding from both public and private sectors, are useful. Policymakers should mandate tracking of the rate of investment for public agricultural R&D, and consider ways to incentivise more advanced and targeted public- and private-sector innovation.

Environmental benefits were observed in the immediate aftermath of the reform, but some say that the 1984 reform unintentionally caused environmental benefits as well as challenges, critics Vitalis (2007) argues, as the economy has since seen the dairy industry booming. Irrigation and fertiliser applications have become vital tools for intensive farming since 1984, even though soil erosion has decreased, and water efficiency has increased. Nutrient overabundance continues to exist in agricultural systems, thus creating elevated environmental danger factors. However, the decline of market-driven livestock stocks builds progress toward future GHG emission targets for New Zealand. Policymakers could remain cautiously hopeful with meeting emission targets as the productivity and efficiency of land use for dairy production have seen improvements over the past four decades. But the production mix may need to change, i.e., further reduction in sheep and dairy cattle numbers. Policymakers must balance productivity gains with environmental safeguards, leveraging New Zealand's subsidy-free model as a blueprint for sustainable agriculture, but only if R&D and emission mitigation become immediate priorities.

One aspect that has not been addressed in the existing literature, and this paper is a thorough examination of social sustainability after the reform. The exposure to the world market has been posing invisible and intense pressure on farmers to produce and compete (Vibart et al., 2017). Despite the common practice of assessing New Zealand's agriculture in terms of good or bad farming expressed at profitability and productivity levels (Brooking & Pawson, 2010; Rosin, 2013), the trajectory of New Zealand's agricultural sector demands further understanding of social impacts and sustainability. Campbell (2009) argued that the history of Western subsidising agriculture, including New Zealand, has long privileged agricultural science as a 'hegemonic political project', creating a false narrative that 'all knowledge production around agriculture' is considered. Recognising that the institutional form that predominantly constitutes New Zealand agriculture is medium-sized family-owned farms, social considerations are important for future research to examine. A qualitative approach to social sustainability in agriculture would be a useful addition to further understand the nuanced interactions between economic and environmental sustainability, and to understand what it means for farmers and policymakers.

APPENDIX: EXPLANATION OF POSSIBLY UNCLEAR KEY INDICATORS.

The table below provides detailed explanations of some indicators presented in this paper. They are listed in alphabetic order.

Indicator	Description	Implication
Agricultural emissions intensity	The amount of greenhouse gas emissions produced per unit of agricultural output. This metric is commonly expressed as emissions per unit of economic activity, such as kilograms of CO_2-equivalent emissions per dollar of agricultural output.	Emissions intensity highlights how efficiently emissions are being converted into agricultural output. This is especially relevant for New Zealand, where total emissions are high due to the size of the agricultural sector.
Agricultural greenhouse gas emissions	The release of gases from farming activities. These emissions are primarily methane and nitrous oxide, with smaller amounts of carbon dioxide.	Assessing absolute emissions as an indicator provides a clear signal for policy.
Agricultural multifactor productivity	Statistics New Zealand defines multifactor productivity in the agricultural sector as a measure of how efficiently capital and labour inputs are used to produce outputs.	Rising multifactor productivity suggests that farmers are producing more with less, without necessarily increasing input use or environmental pressure.
Agricultural total factor productivity	The United States Department of Agriculture maintains the database of International Agricultural Productivity with a key data product of the Total Factor Productivity (TFP). TFP measures the amount of agricultural output produced from the combined set of land, labour, capital, and material resources employed in farm production	TFP encompasses the average productivity of all of these inputs employed in the production of all agricultural commodities. Growth in TFP reflects that overall rate of technical and efficiency change in the sector.
Applied and experiential research	This type of research is directed towards solving practical problems in agriculture. It involves the application of existing knowledge to develop new or improved products, processes, or services.	A high level of investment in this type of research suggests that the agricultural sector is actively improving its methods and technologies.
Basic research	This type of research includes work undertaken primarily to acquire new knowledge of the underlying foundations of agriculture.	Rather than focusing on giving immediate solutions, basic research underpins the foundational breakthroughs in agricultural systems that drive productivity and sustainability over time.
Current account balance	The current account balance records the country's transactions with the rest of the world over a specific period. It provides insights into the country's economic interactions concerning trade, income, and transfers. It is calculated by subtracting total imports from total exports.	A positive current account balance indicates a surplus, while a negative balance signifies a deficit. New Zealand has historically experienced a current account deficit, meaning it imports more goods, services, and capital than it exports.
Enteric fermentation	Enteric fermentation refers to the digestive process in ruminant animals such as cattle, sheep, and deer, where microbes in the rumen break down feed, producing methane as a by-product. The methane is then released into the atmosphere primarily through belching.	Enteric fermentation is the largest source of methane emissions in New Zealand, accounting for 80 percent of the country's total methane emissions and approximately 31 percent of New Zealand's total greenhouse gas emissions.
Nitrogen use efficiency	It refers to the effectiveness (e.g, ratio) with which nitrogen inputs such as fertiliser are converted into agricultural products.	Higher nitrogen use efficiency indicates that more of the applied nitrogen is utilised productively, leading to increased farm profitability and reduced environmental impacts,

		particularly nitrogen leaching into waterways.
Nutrient balance	It refers to the difference between nutrients entering and leaving a farming system. It is calculated by comparing all nutrient inputs, such as fertiliser and feed, with outputs like farm products, nutrient transfers to non-productive areas and losses through leaching, runoff, or gaseous emissions.	A positive nutrient balance (surplus) suggests excess nutrients, which can lead to environmental pollution, while a negative balance (deficit) may indicate declining soil fertility.
Phosphorus use efficiency	It refers to the effectiveness with which phosphorus inputs are converted into agricultural outputs.	Higher phosphorus use efficiency indicates that more of the applied phosphorus is utilised productively, leading to increased farm profitability and reduced environmental impacts, particularly phosphorus loss to waterways.
Producer support estimates	The Organisation for Economic Co-operation and Development (OECD) created the Producer Support Estimates (PSE) to help governments better understand how much support is provided to agricultural producers. PSE estimates the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that support agriculture, regardless of their nature, objective, or impact on farm production or income.	The OECD's PSE provides New Zealand valuable insights into the level and structure of government support for agriculture, which is a reliable source for international comparison.
Soil erosion	It is defined as the process by which soil is worn away from the land surface due to natural forces such as wind, water, and gravity, or through human activities that disturb the soil. Soil erosion can lead to the loss of fertile topsoil, reduced agricultural productivity, and environmental degradation.	Understanding and addressing soil erosion is crucial for maintaining New Zealand's agricultural productivity and environmental health.
Terms of trade	It is defined as the ratio of the prices of a country's export goods to the prices of its import goods. It measures how much imported goods a country can purchase per unit of export goods, serving as an indicator of a country's economic health and its ability to trade on favourable terms.	Terms of trade are a crucial economic measure for New Zealand as a small open economy that is heavily reliant on trade. An increase in the terms of trade indicates that export prices are rising relative to import prices, improving the purchasing power of export revenues.
Water use efficiency	It is defined as the productive return per unit of water applied, reflecting how effectively water resources are utilised in agricultural systems.	New Zealand has been facing increasing pressure on freshwater resources due to reasons such as irrigation. Better water use means less runoff and leaching of nutrients like nitrogen and phosphorus into waterways.

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Hanyang Ge: Sole author.

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