Manaaki Whenua
Landcare Research

Future scenarios for livestock agriculture in New Zealand

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Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

National SCIENCE Challenges
OUR LAND AND WATER
Toitū te Whenua, Toiora te Wai

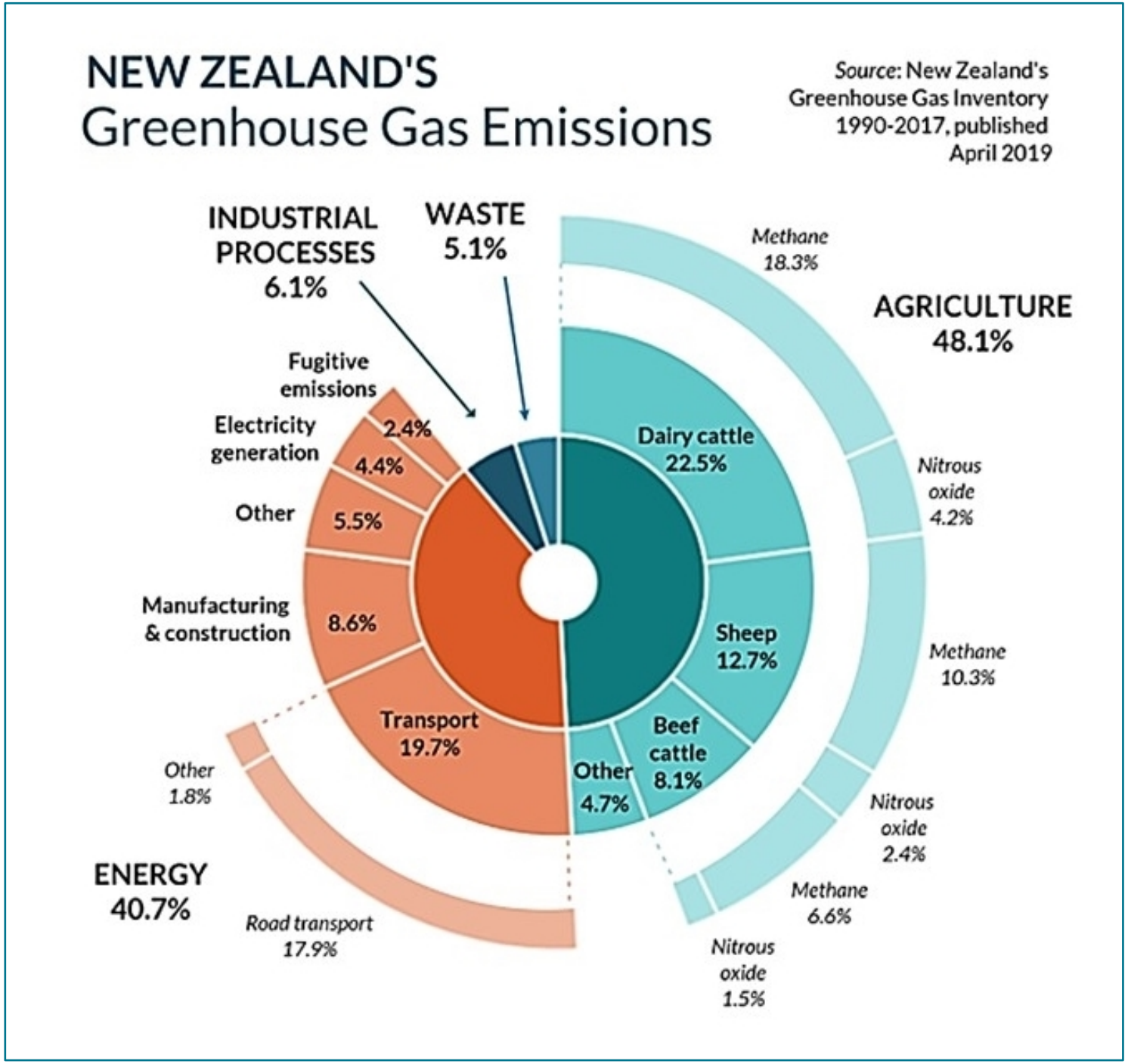
AMBASSADE DE FRANCE EN NOUVELLE-ZÉLANDE, AUX ÎLES COOK ET AUX SAMOA
Liberté Égalité Fraternité

74th Joint International Congress on Animal Science – August 2023 – Lyon, France

1. Introduction

Context

- 48% of GHG emissions come from agriculture:
  - 35% from methane
  - 8% from nitrous oxide
  - 5% from gas/electricity on farm + non-livestock sectors



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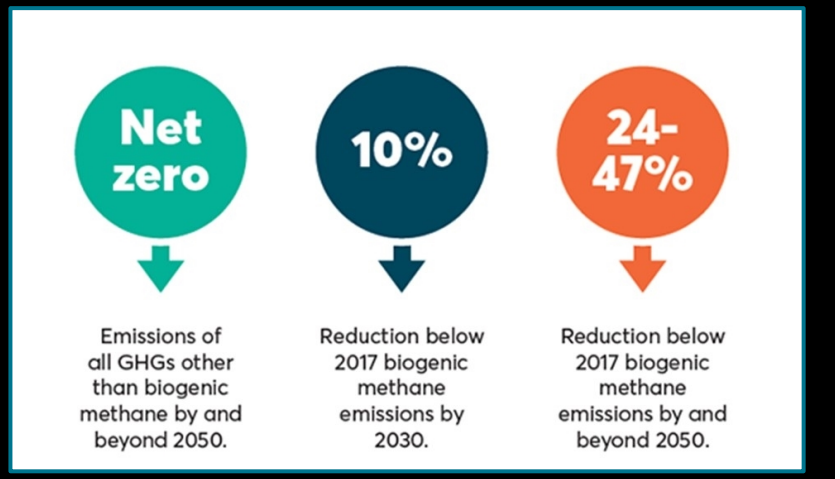
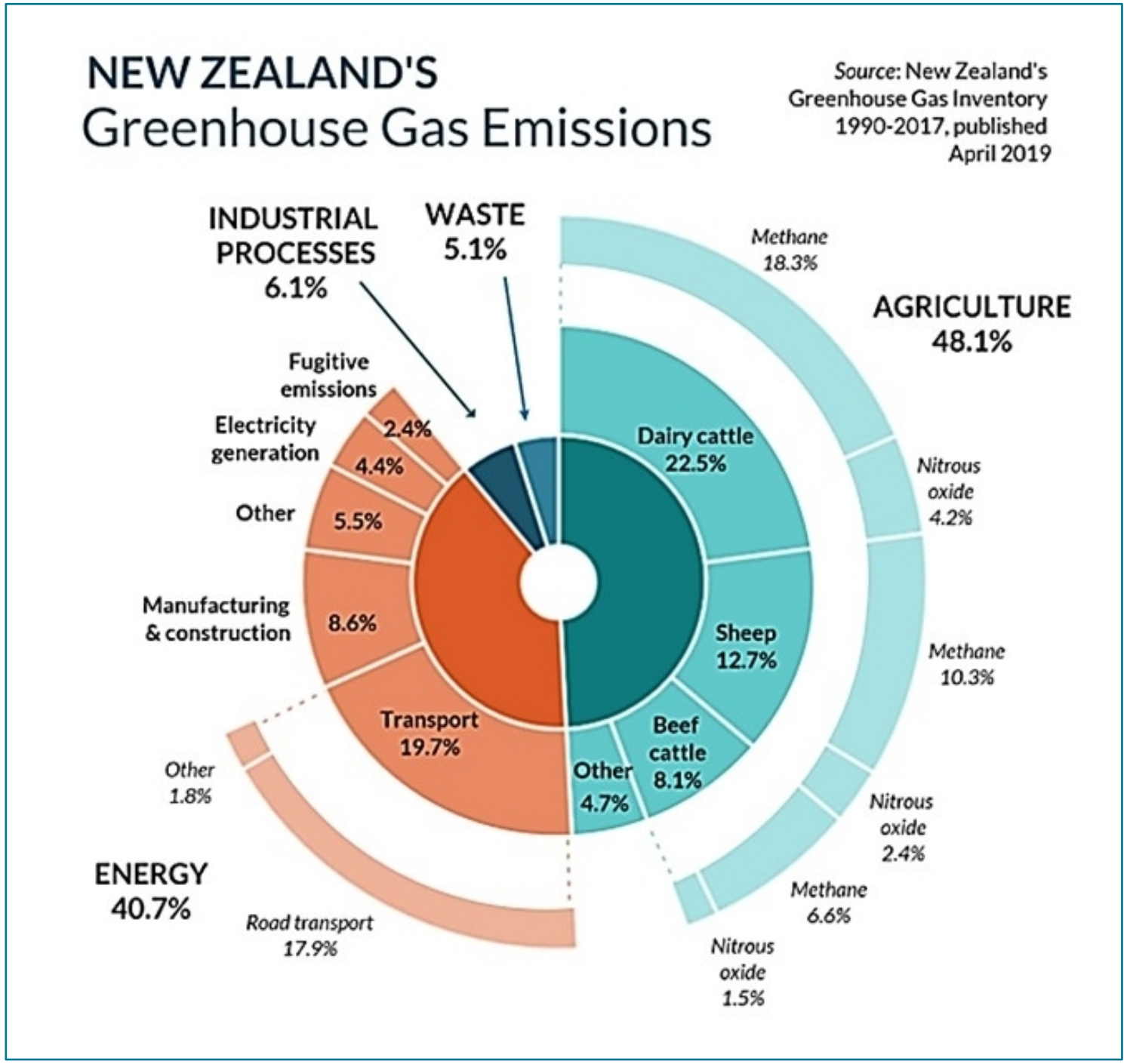
→ Zero Carbon Amendment Act (2019)





1. Introduction

NZ agricultural system

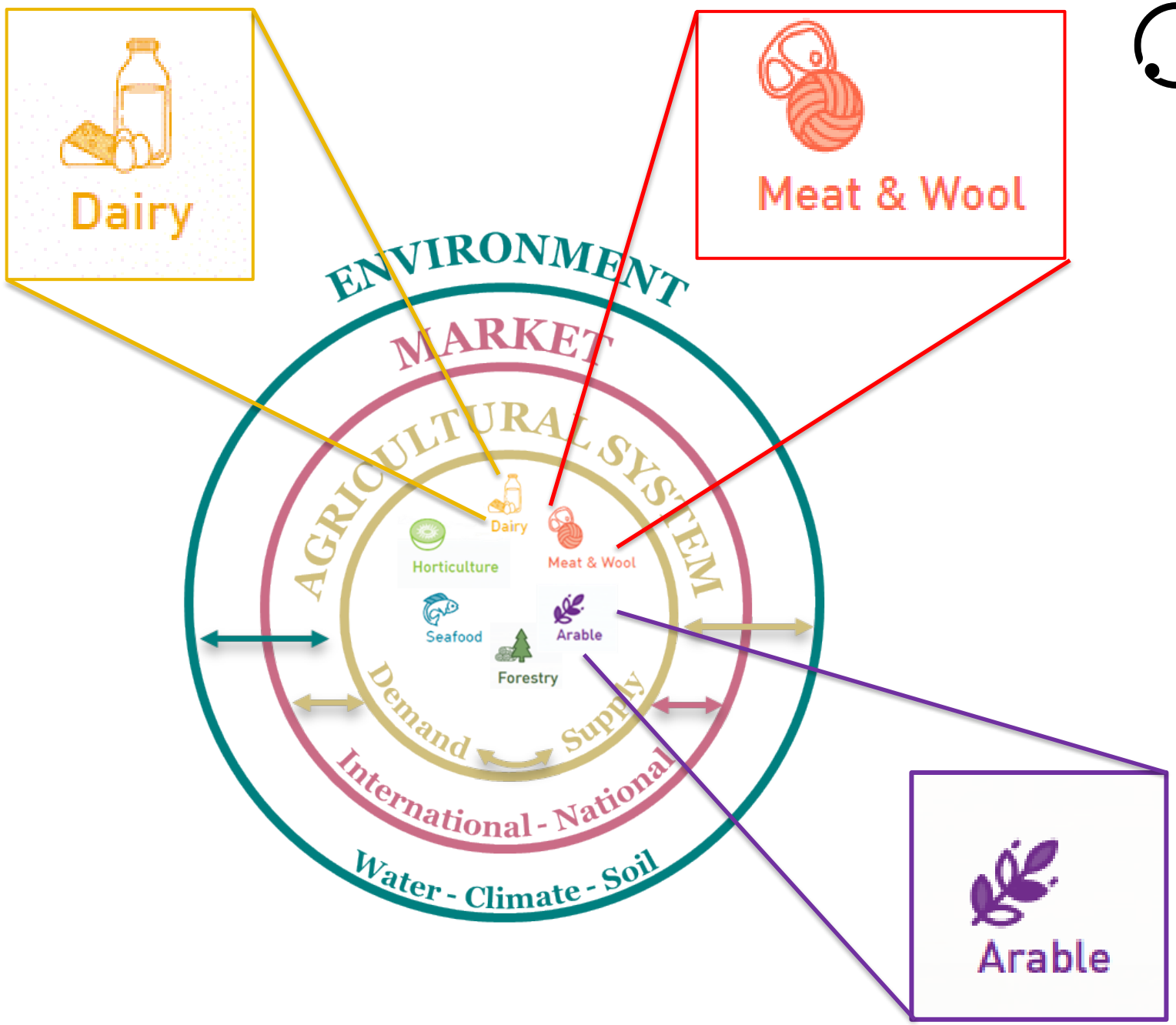
- New Zealand agricultural system framework is based on six main sectors.
- 82% of the production is exported, generating NZ$56.2 billion in export revenue *(11% of GDP, 14% of employment)*.
- Government profitability goal of +2% to +4% each year

1. Introduction

NZ agricultural system

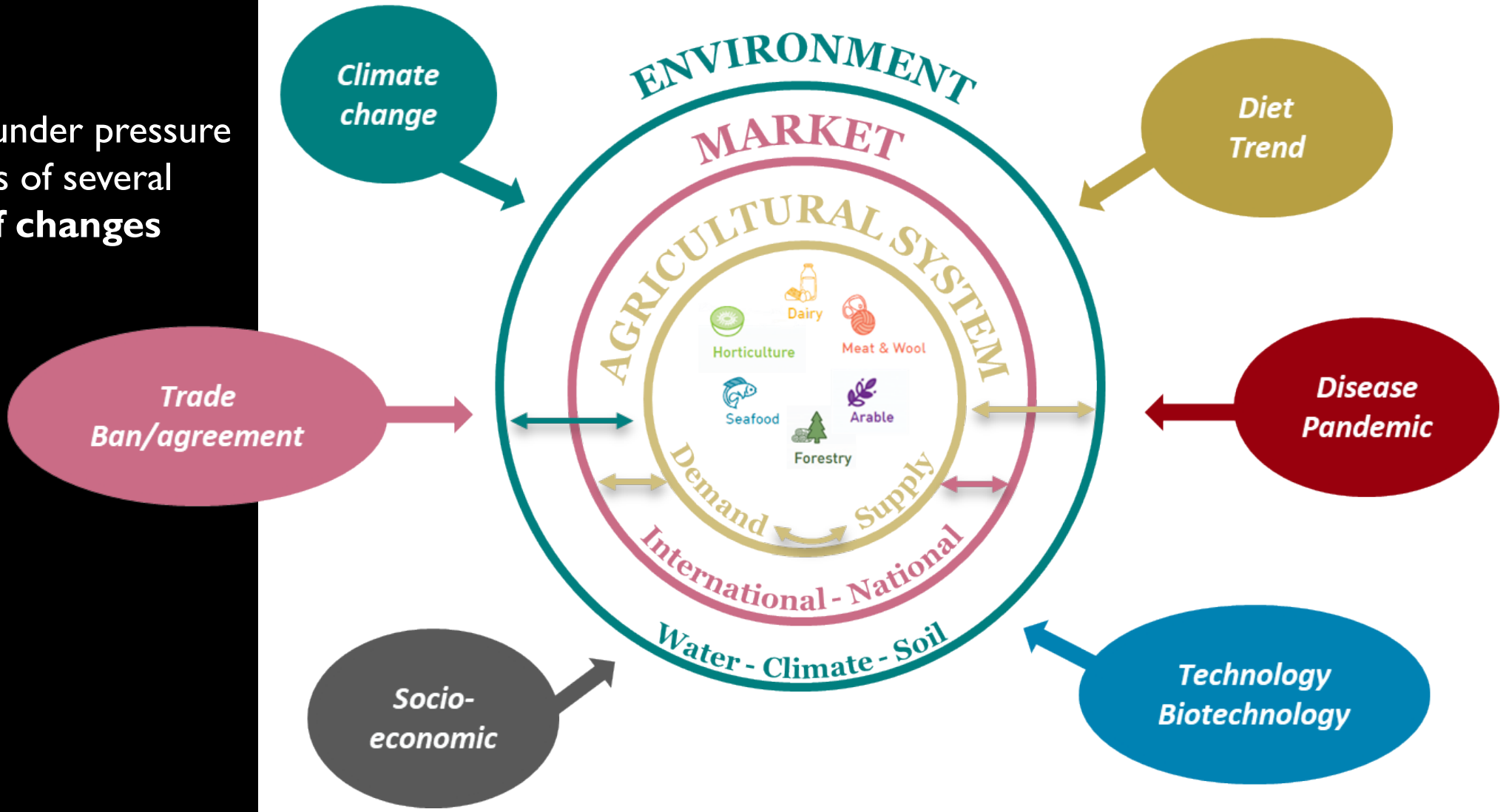
- *Dairy sector is worth NZ$22billion*
- *→ pillar sector for NZ economy*
- *Meat and wool sector is NZ$12billion → stable*
- *Arable sector is worth NZ$1billion*
- *NZ$260 million exported (seeds)*
- *Pillar sector: produce all the grains for human and animal consumptions*

- ***→ the arable sector has the opportunity to grow by increasing co-benefits with livestock sectors and help NZ to adapt to climate change***



1. Introduction
NZ agricultural system

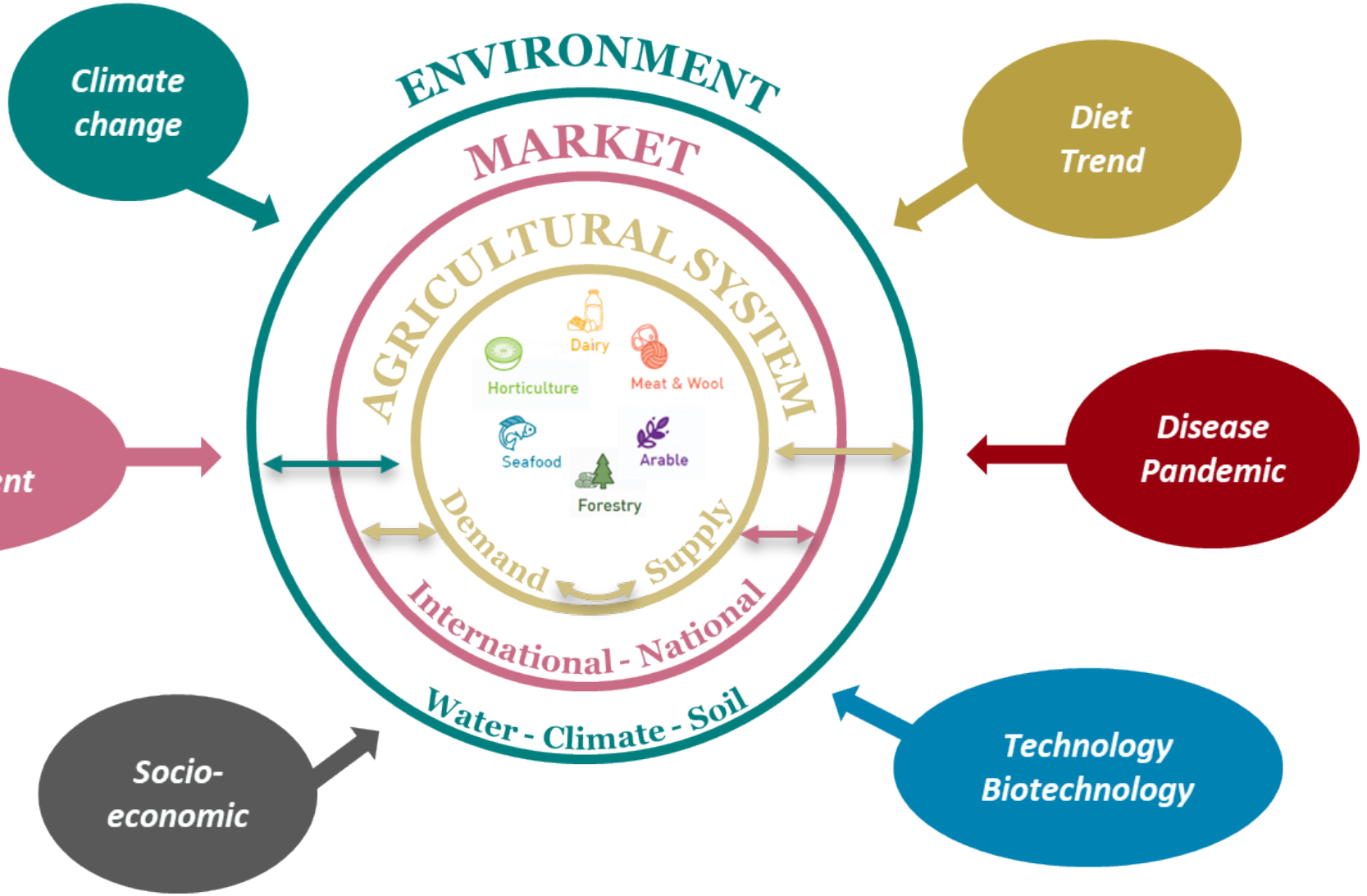
- System currently under pressure due to the impacts of several **global drivers of changes**



1. Introduction
NZ agricultural system

- System currently under pressure due to the impacts of several **global drivers of changes**

- **What are the pathways to sustainability, resilience AND profitability?**



1. Introduction

Aim

- To inform on the impacts and opportunities arising from a range of changes and disruptors

- To develop scenarios at the national scale

→ *for assessing pathways and interventions to underpin strategy initiatives related to livestock and arable agriculture.*

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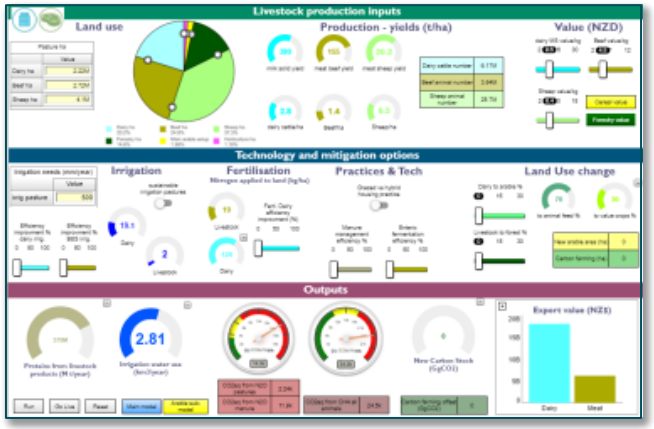

Objectives

1. Engage with sectoral stakeholders to define priorities, challenges, scenarios

2. Develop a Decision Support Tool to simulate scenarios

3. Assess the impacts and opportunities arising from each scenario

2.Methods

Scenarios

Scenario 1

Land use change:
Co-benefits from arable and forestry into livestock systems

- *Irrigated pastures released to arable production (forages and high value crops)*
- *Beef&Sheep land transformed for Carbon farming.*

Scenario 2

Mitigating climate change:
Changing animal diets

- *Alternative forages and grain diet introduced significantly in the system*
- *reduce CH_4 and N_2O emissions from livestock*

Scenario 3

Food security:
Increasing wheat production to gain self sufficiency

- *In 2021, 250,000 tonnes shortfall for consumption in NZ.*
- *Objective to reach 700,000 tonnes produced to gain self-sufficiency.*

2.Methods

Decision Support Tool

- Designed to test scenarios
- Help reaching government goal as well as profitable production
- Systems dynamic model
- Implemented in Stella Architect
- Display a national quantitative picture
- A multisectoral main model linked with arable and livestock sub-models
- Model is setup with 2021 values *(national dataset, FAOSTAT)*
- Validated with 2010 and 2019 dataset

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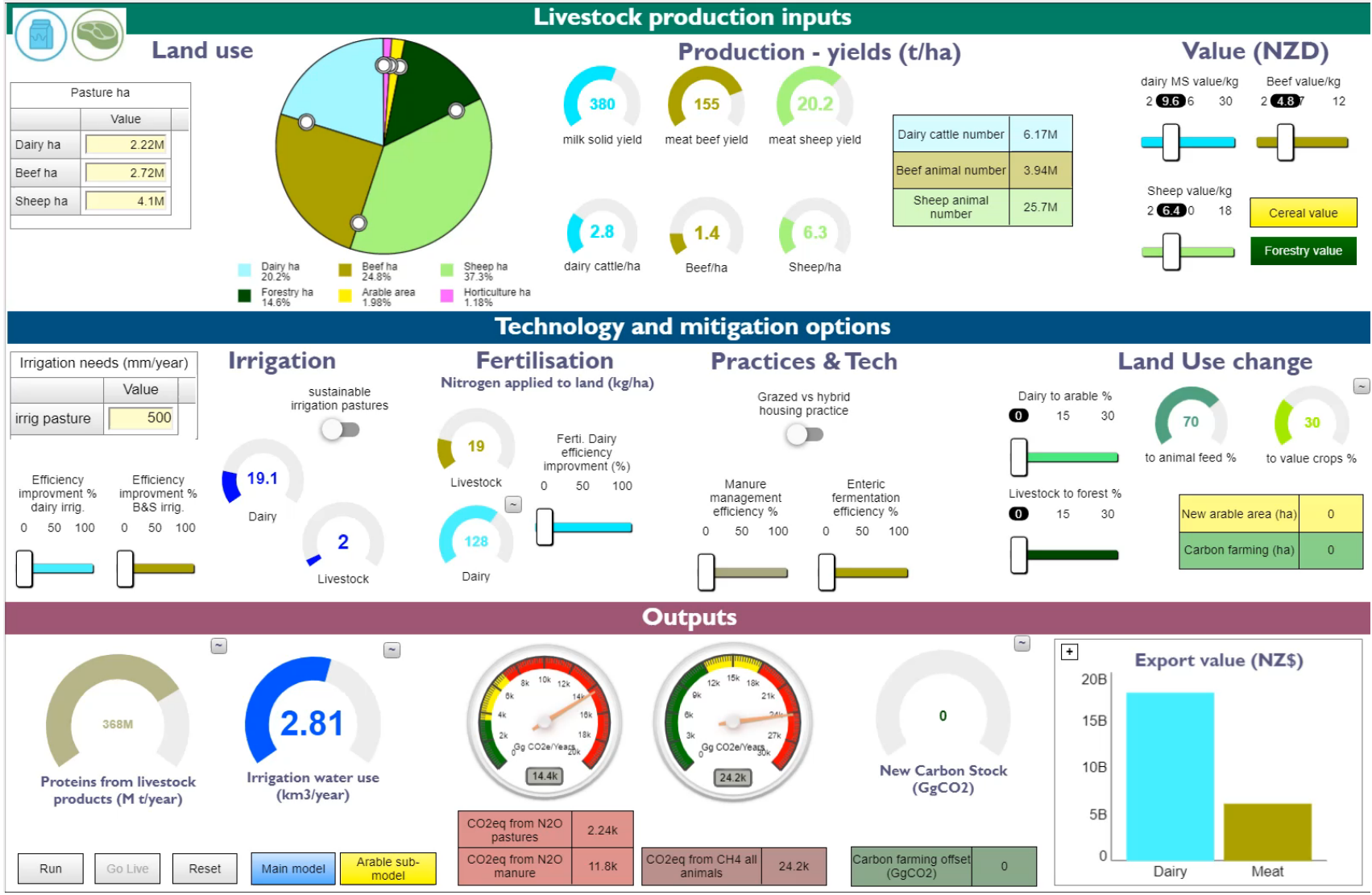


https://exchange.iseesystems.com/public/clemence/future-ag

3.Results

Scenario projections

3.Results
Scenario projections

→ Two main levers tested to reduce and offset emissions:

- Irrigated pastures released to arable production (forages and high value crops)
- Beef&Sheep land transformed for Carbon farming.

→ How much need to be change for how much benefits or trade-offs?

Co-benefits of arable and forestry growth:

- *Half or less irrigation water used*
- *Offset large amount of CO2 but ecosystem services should be assessed (biodiversity, soil erosions)*
- *Release land create new arable opportunities (peas and fava beans?)*
- *Increase forage production, reduce CH4 emissions*

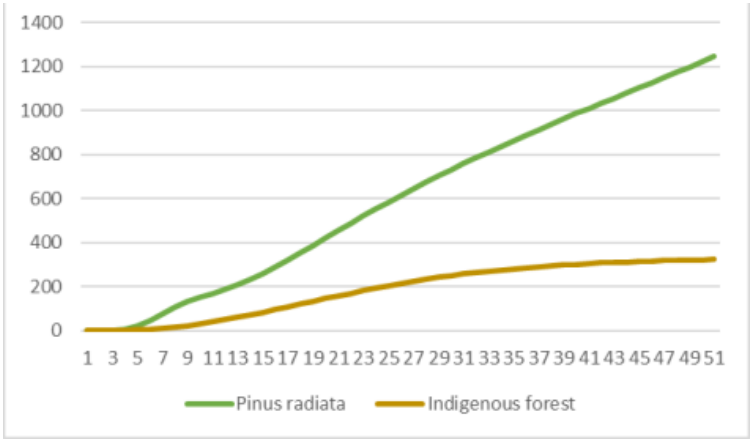
LAND USE CHANGE

→ Dairy pasture change to arable crops

	Baseline	1% Dairy land	5% Dairy land	10% Dairy land
Dairy area	*2,200,000*	22,000	110,000	220,000
New area	*2,200,000*	2,178,000	2,100,000	1,980,000
Animal pressure	*2.8*	2.8	2.9	3
10% herd reduction – new pressure	*2.5*	2.65	2.65	2.8

- Increase food security, wheat self-sufficiency
- Animal alternative feed (forages, small grains)

→ Beef&Sheep land change to Carbon farming



Baseline: 6,820,000	1% B&S land	5% B&S land	10% B&S land
Area	68,200	341,000	682,000
Pinus radiata MtCO2 30years	51.7	258.5	517
Indigenous forest MtCO2 30years	*17.5*	*87.6*	*175*

3.Results
Scenario projections

→ Two main levers tested to reduce emissions:

- a decrease of herd numbers by 5, 10 and 15% and a significant introduction of alternative animal diet by 10, 20 and 30%.
- In best combinations, reduction by 21% to 23% of emissions from N_2O and by 30% from CH_4.

Co-benefits of alternative forages:

- *high quality feed over the time of the year where ryegrass productivity is limited;*
- *relative low cost option compared to purchasing supplementary feed;*
- *can be used in pasture based rotation providing soil fertility and re-establishing high yielding grass.*

Alternative feed (% of overall feed) / Herd (head)	0%	10%	20%	30%
Current *6.2m dairy cattle 3.9m beefs*	**24.2k Gg CO2 eq from methane** *14.4 Gg CO2eq from nitrogen*	**22.5k** *13.3k*	**20.8k** *12.2k*	**19.2k** *12.2k*
-5% *5.89m dairy cattle 3.7m beefs*	**23.7k** *14k*	**22k** *12.9k*	**20.3k** *11.8k*	**18.7k** *11.9k*
-10% *5.58m dairy cattle 3.51m beefs*	**23.4k** *13.2k*	**20.7k** *12.2k*	**19.2k** *11.2k*	**17.7k** *11.3k*
-15% *5.27m dairy cattle 3.31m beefs*	**21.2k** *12.7k*	**19.9k** *11.8k*	**18.4k** *10.9k*	**17k** *11k*

In red, unmet goal (CH_4), in orange, 2030 met goal, in green, 2050 goal met.

3.Results
Scenario projections

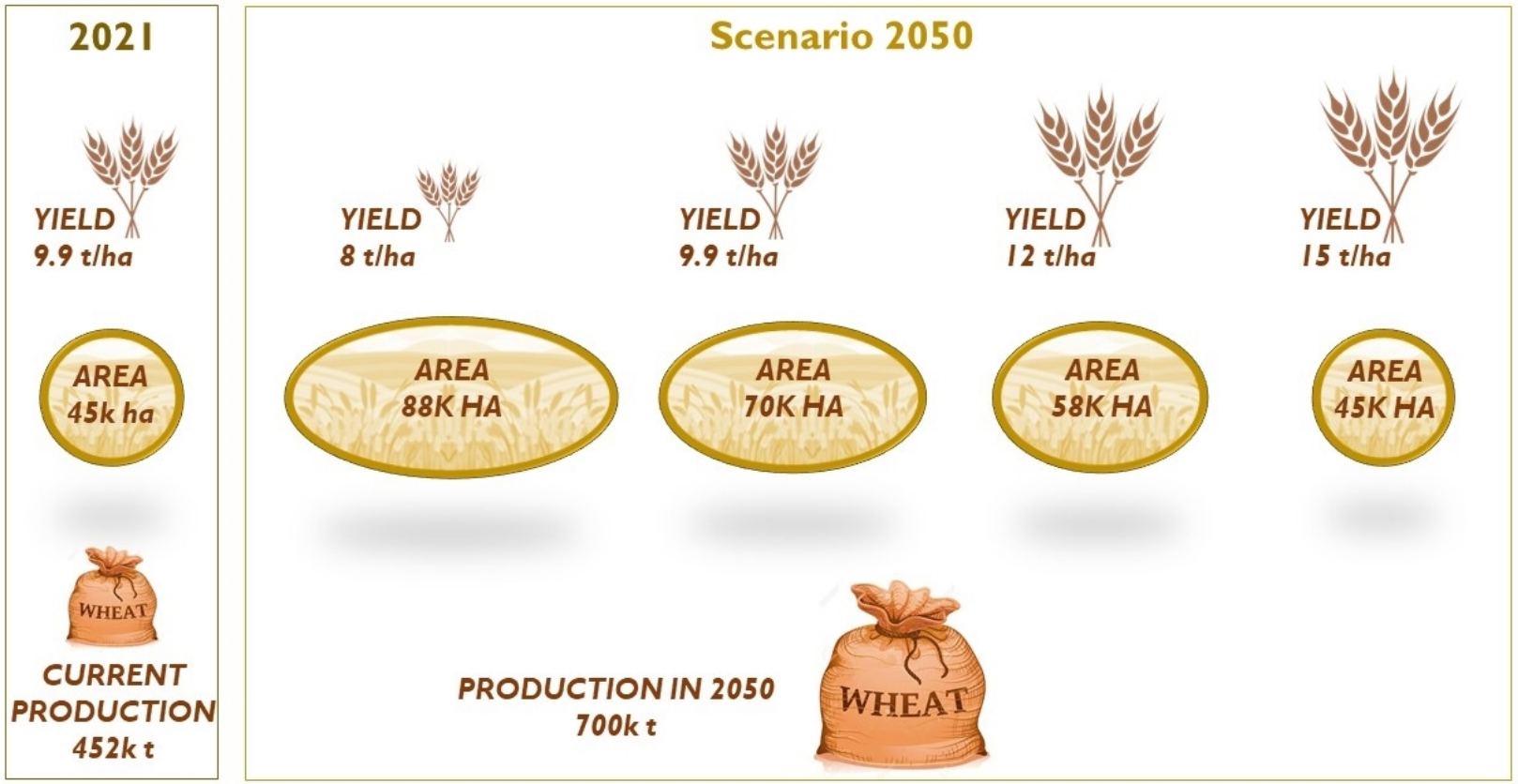
→ Two main levers, surface of production and potential yields.

- Keeping the same yield, i.e. 9.9 t/ha, or improving it to 12 t/ha
- require to grow an extra 13k to 25k hectares of wheat.

→ *Irrigation water used, if current standards are applied (i.e. a mean of 295 mm/year for wheat production) could halve pasture irrigation in the Canterbury region.*

→ *CO_2 equivalent emissions from Nitrogen is a third of Dairy pasture application.*

FOOD SECURITY



5.Conclusions and next steps

- DST + participatory approach has improved stakeholder's engagement
- DST has a great potential for land planning and policy formulation

Future developments:

→ *more sectors and industry stakeholders on board*

→ *downscaling (regional) options*

→ *robust spatial approach for adaptation strategy development*

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- DST + participatory approach has improved stakeholder's engagement
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Dissemination

Story maps

The future of New Zealand agriculture:
Modelling pathways to sustainability, resilience, and profitability in 2025.

Future scenarios for arable agriculture

Scientific publications

- Vannier C., Cochrane T.A., Zawar Reza P., Bellamy L., 2022:"An Analysis of Agricultural Systems Modelling Approaches and Examples to Support Future Policy Development under Disruptive Changes in New Zealand". *Applied Sciences*, 12, 2746. https://doi.org/10.3390/app12052746

- Vannier, C.; Cochrane, T.A.; Zawar-Reza, P.; Bellamy, L. 2022: "Development of a Systems Model for Assessing Pathways to Resilient, Sustainable, and Profitable Agriculture in New Zealand". *Land* 2022, 11, 2334. https://doi.org/10.3390/land11122334

- Vannier C., Lawrie I., Bellamy L., Cochrane T.A.:" Future scenarios for arable agriculture: Exploring pathways and interventions for increasing the profitability, resilience, and sustainability of arable agriculture in Aotearoa 2050", *New Zealand Journal of Agricultural Research, in prep.*

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Thank you

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