



IV CONGRESO IBEROAMERICANO DE INGENIERÍA DE LOS ALIMENTOS

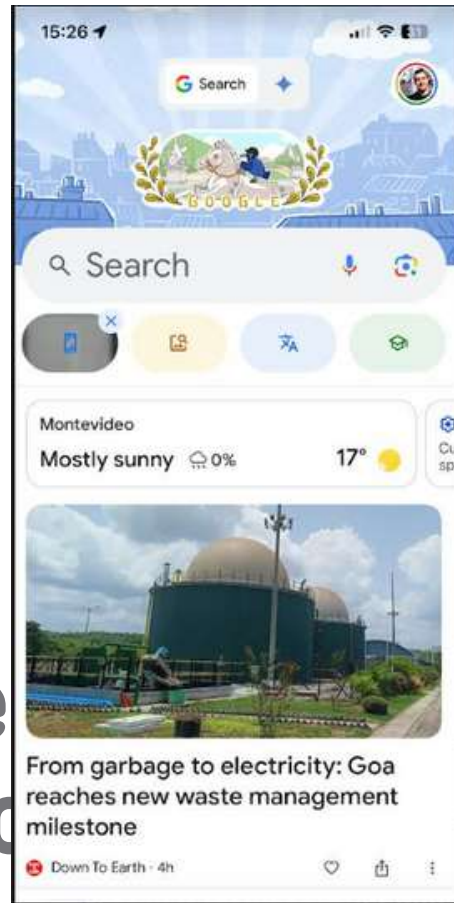
ESTRATEGIAS DE VALOR AGREGADO Y PROCESAMIENTO PARA ALCANZAR SOSTENIBILIDAD Y RESILIENCIA EN SISTEMAS ALIMENTARIOS.

PABLO JULIANO/ CSIRO.

6 de Septiembre, 2024

Organiza:

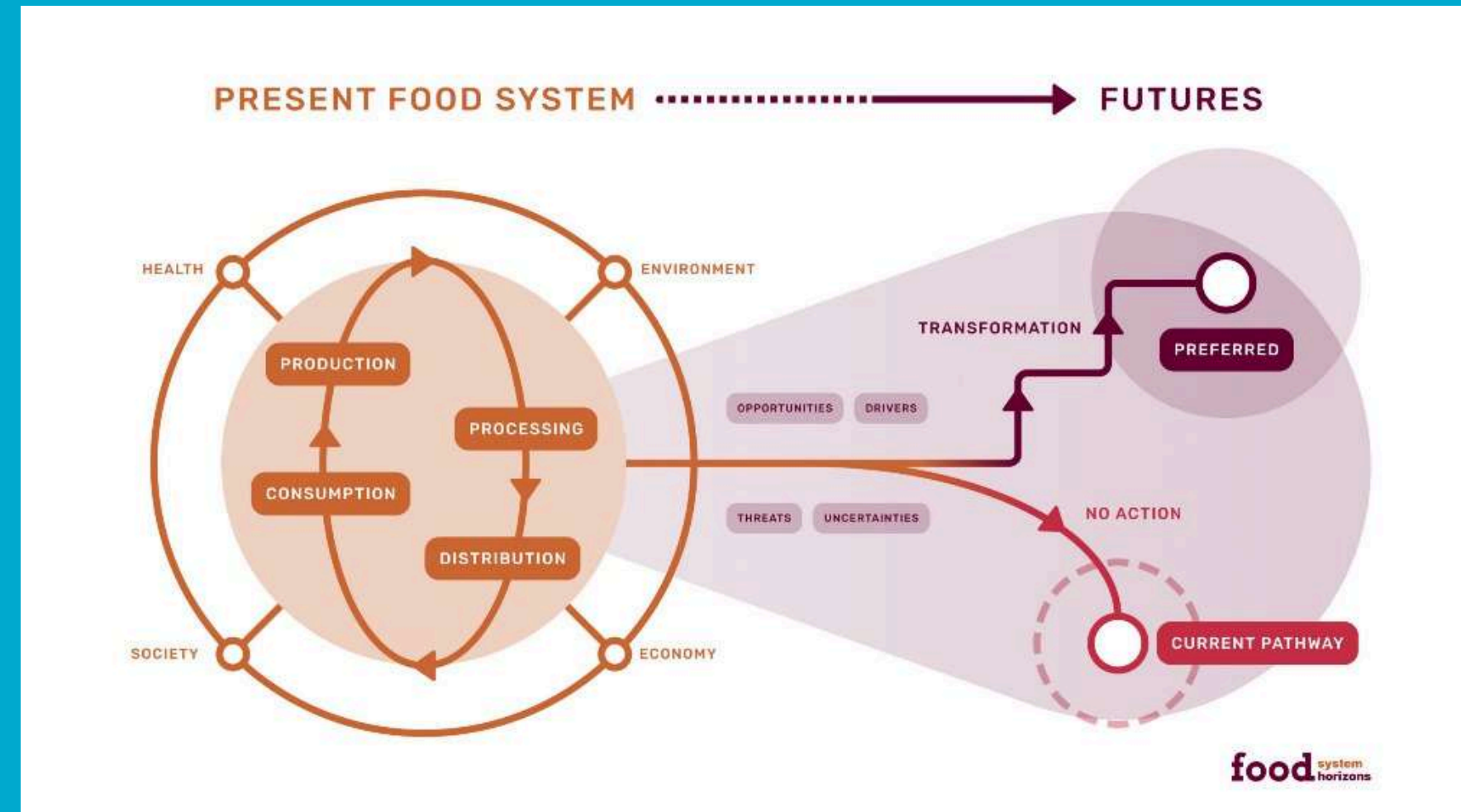




Strategies for greater food sustainability and resiliency

Pablo Juliano, Group Leader
Food Processing and Supply Chains

Australia's National Science Agency

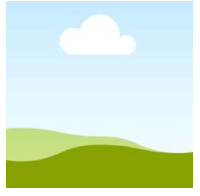




Outline

- State of our food system and challenges
- Minimising waste – Australia's national food waste strategy
 - National food waste strategy
 - Whole of crop and whole of animal opportunities
- Transition towards net zero emissions
 - Sustainable drying techs
 - Shelf stable foods

- Role of value addition



Mega - shock: Population Growth

9.8b



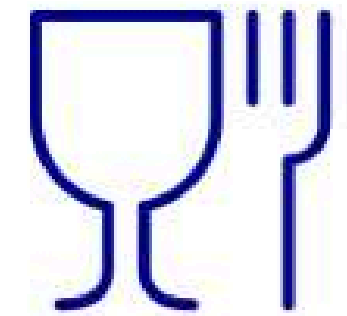
People
by 2050

-55%



Agricultural land
per capita (1961-2016)

+71%



Food needed
by 2050



State of our food system

2B



extra mouths
to feed by 2050

33%



of food
produced is
wasted

800m



people go
hungry

2B



650 m obese

1 in 5 under 18
overweight

9.8%



population
60y+ >> 20%,
median 38 yrs
by 2050

70%



fresh water
used for
agriculture

1 in 4



GHGE from
food
production

1.5 **WRITE TO US**



Paris
agreement
on global
warming

5



animals & 12
plants = 75%
calories

0x



new farm
land
available



Role of food processing



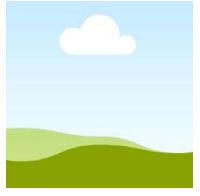
Food Security
Access to sufficient, safe, nutritious food for all people at all times

Threats to food security

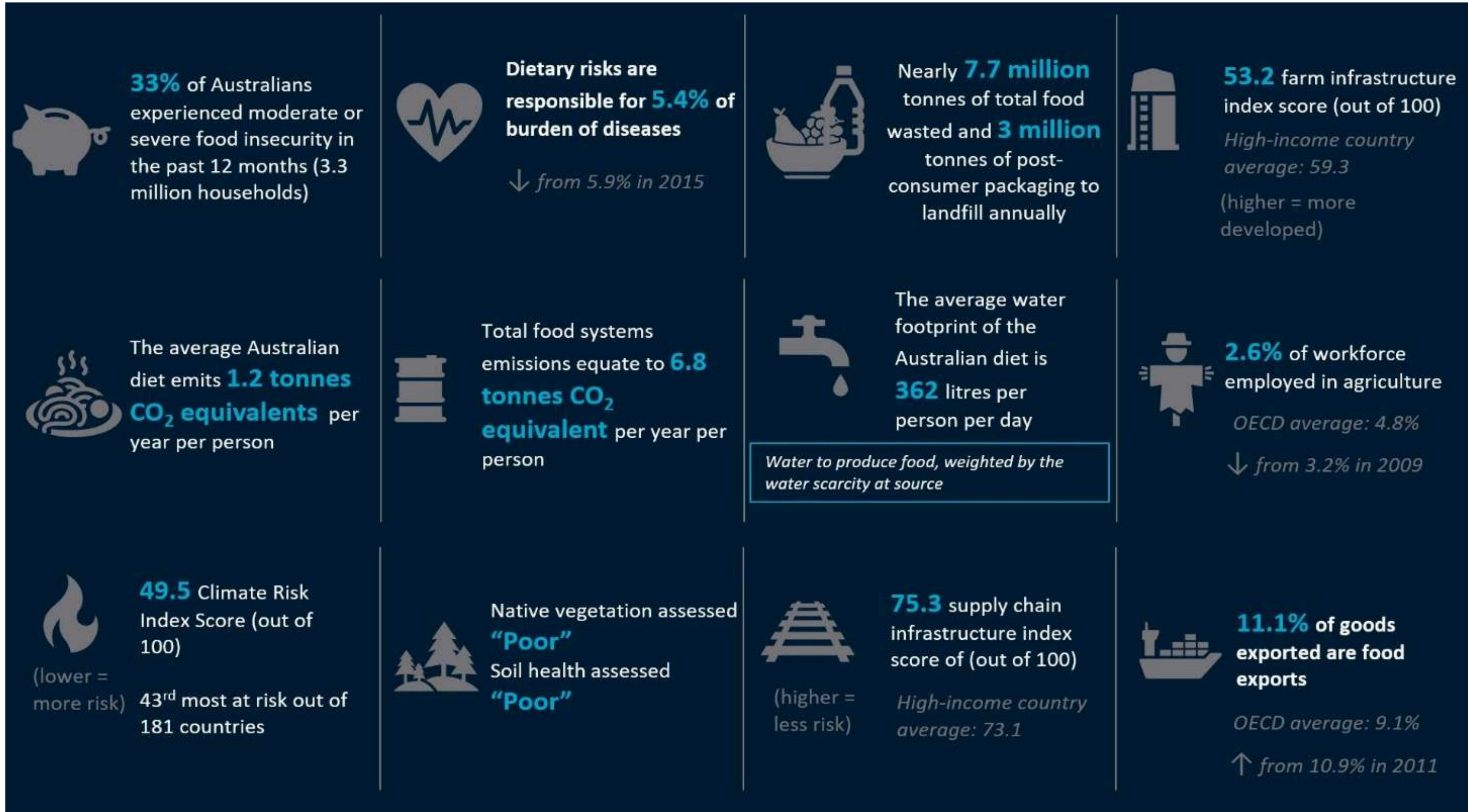
- Food waste
- Poor harvesting/storage
- Lack of effective food preservation
- Wars and conflict
- Environmental degradation
- Climate change
- Soil degradation

SDG 2

- End hunger
- Achieve food security and improved nutrition
- Promote sustainable agriculture



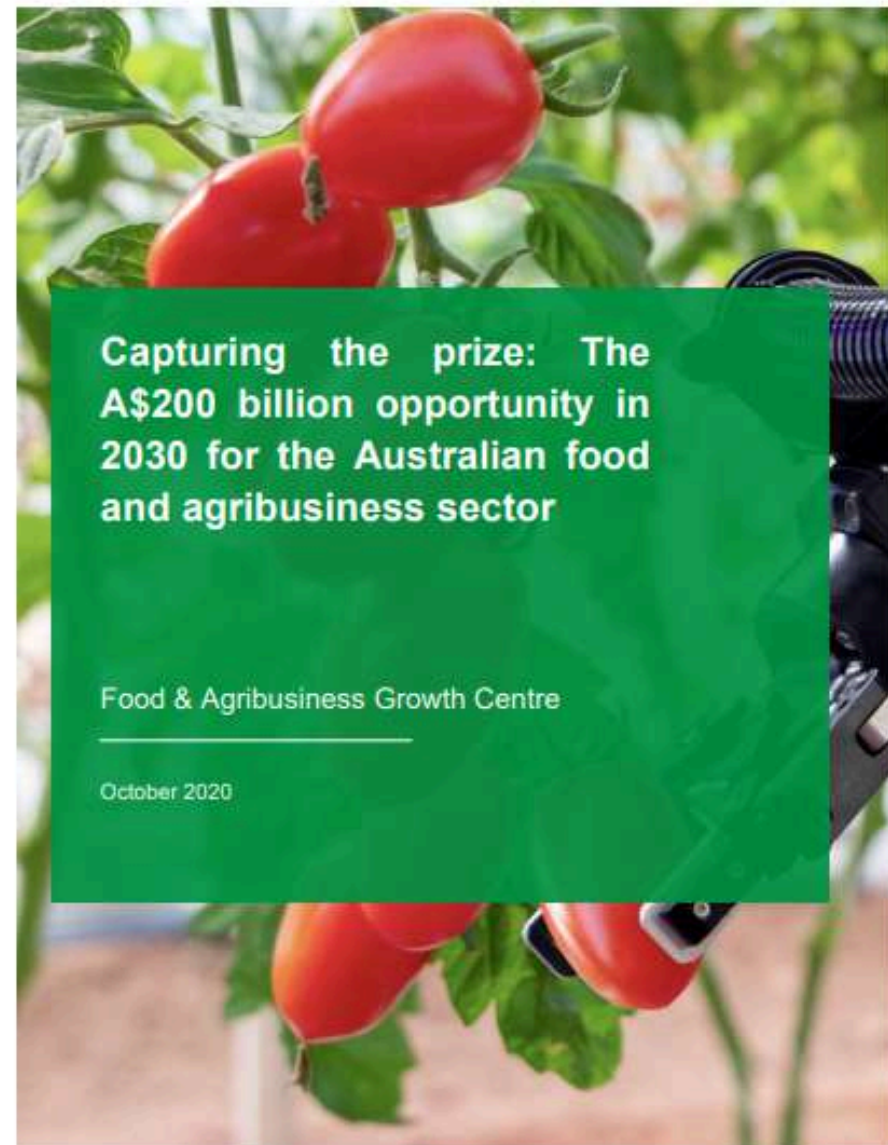
Australian food systems challenges





National challenge:

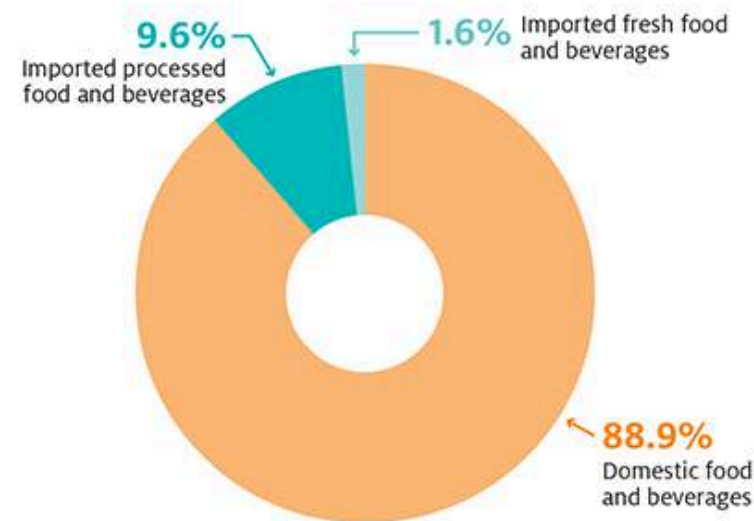
Value adding in the agrifood industry to drive Australia's agri-food economy and food security



www.fial.com.au/sharing-knowledge/capturing-the-prize

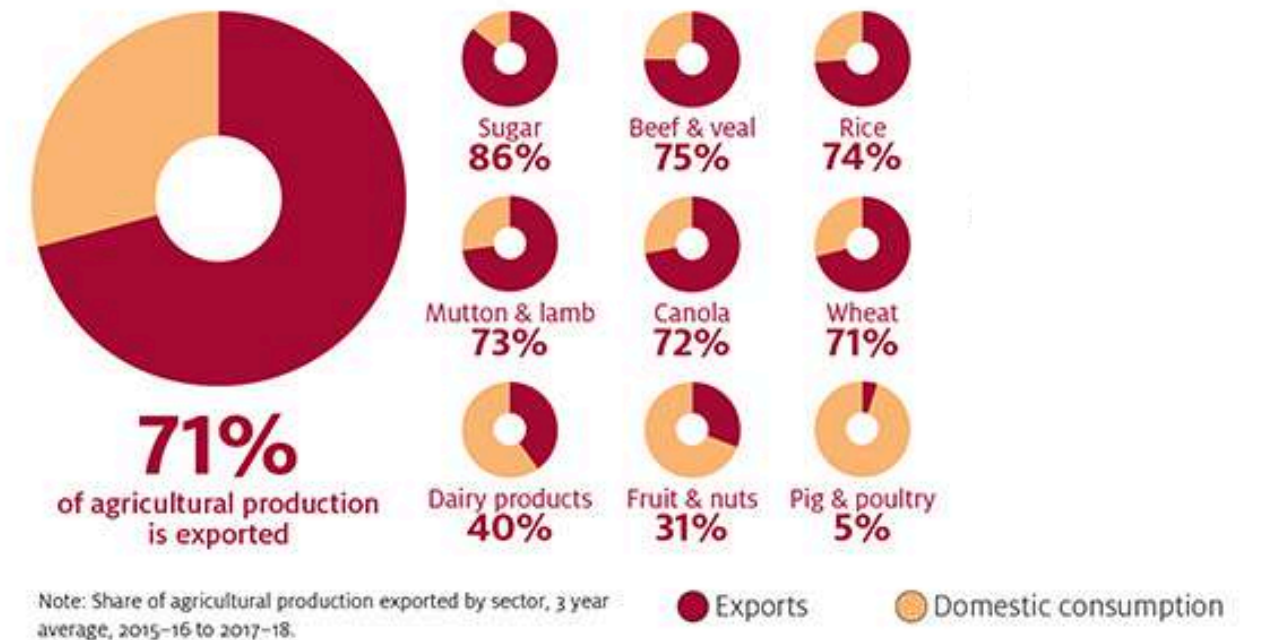


Today's agrifood sector: 538,000 jobs/ \$61B (18/19)
Potential by 2030: 842,000 jobs /\$200B



Source: ABARES

Australia produces substantially more food than it consumes

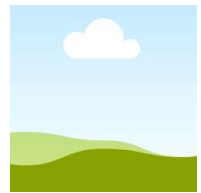


Australia manufactures 89% of its food and beverage mostly with imported ingredients and little value add to agricultural materials



Only aspirational

www.agriculture.gov.au/abares/products/insights/australian-food-security-and-COVID-19



What's happening in Australia?

Australian Food Story: Report Released

The Committee has made 35 recommendations to address food security in Australia, including:

- creating a comprehensive **National Food Plan**;
- appointing a **Minister for Food**;
- establishing a **National Food Council**;
- developing a **National Food Supply Chain Map**;
- measures to **facilitate innovation in the production of food**; and
- measures to **eliminate food waste**.

Committee Chair, [Meryl Swanson MP](#)



Australian Food Story: Feeding the Nation and Beyond

Inquiry into food security in Australia

House of Representatives

Standing Committee on Agriculture

November 2023

CANBERRA



Australian food systems roadmap

Focal areas



3.1 Enabling equitable access to healthy and sustainable diets



3.2 Minimising waste and improving circularity



3.3 Facilitating Australia's transition to net zero emissions



3.4 Aligning resilience with socioeconomic and environmental sustainability



3.5 Increasing value and productivity

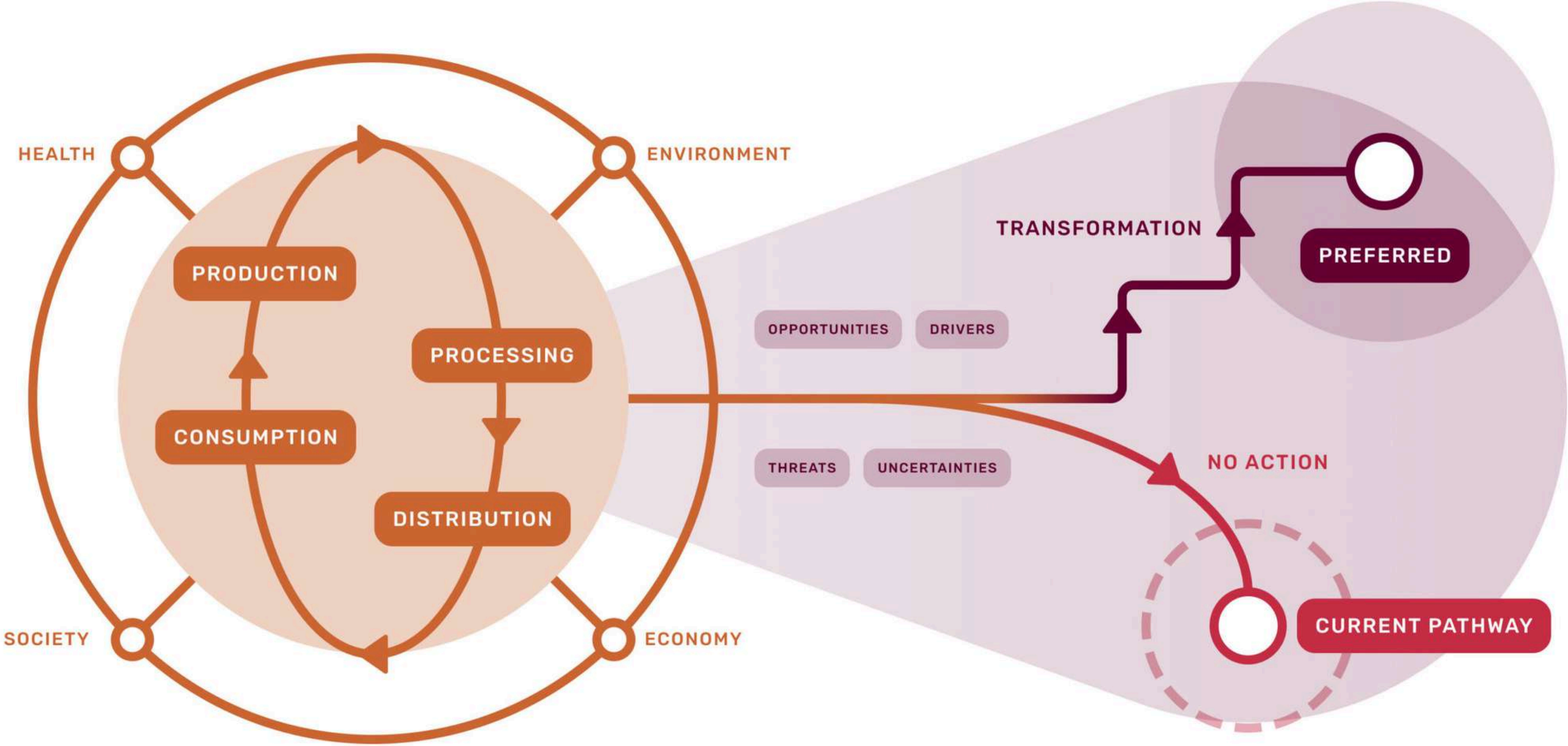
SUSTAINABLE DEVELOPMENT GOALS



PRESENT FOOD SYSTEM

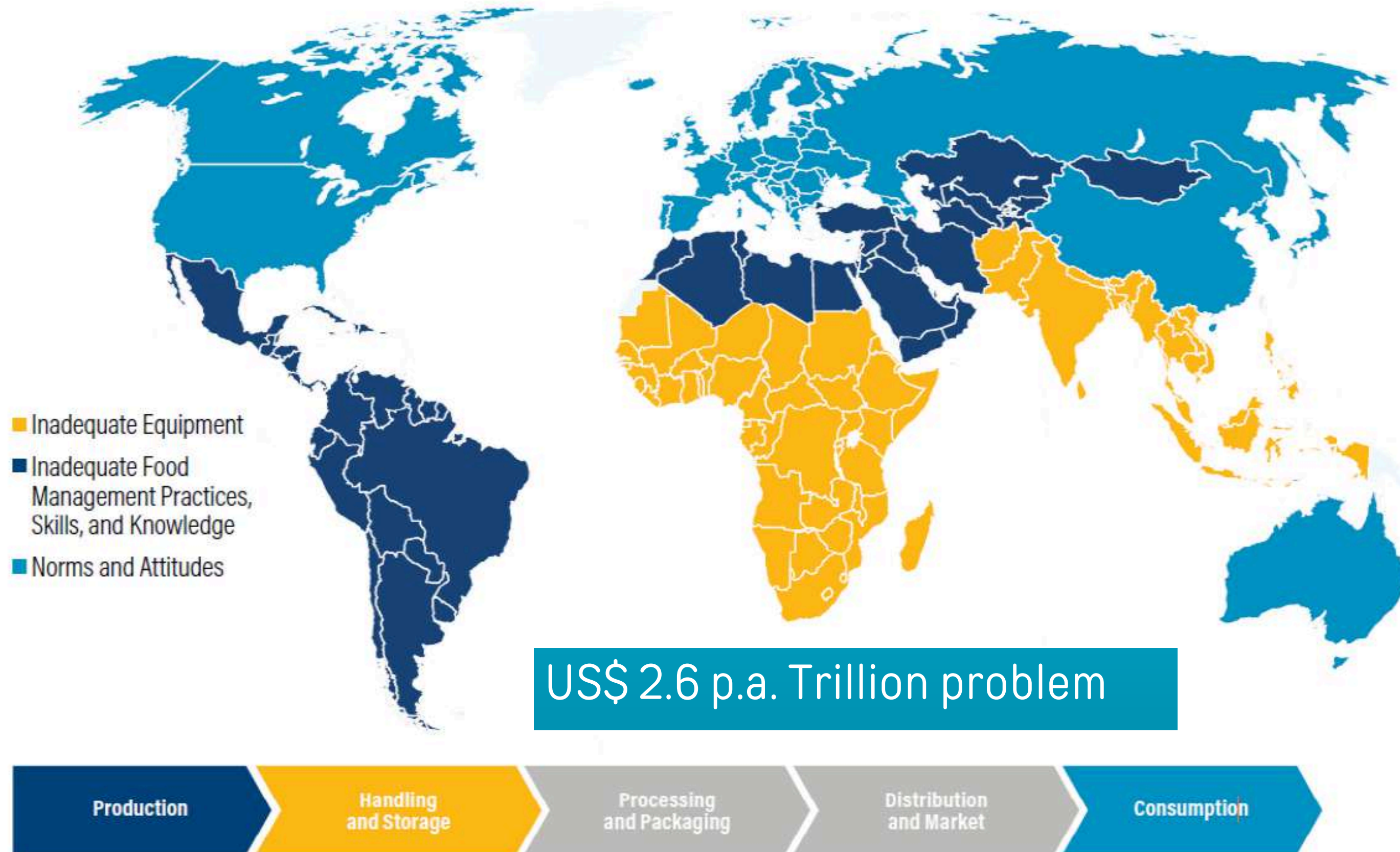


FUTURES



Food loss and waste causes differ by region

739 Mt loss + 378 Mt waste = 1.1 Bt underutilised food (out of 13 Bt)

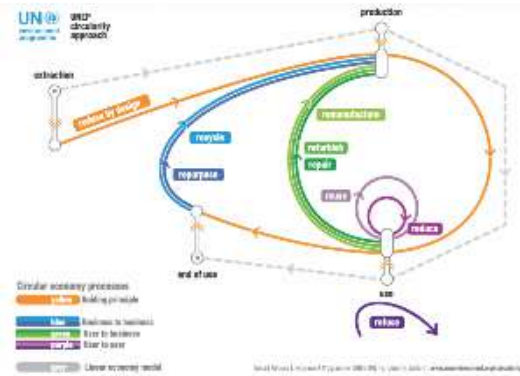




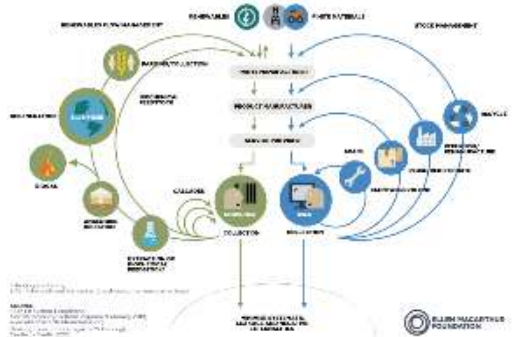
keys to transition

principles

hierarchies; standards



UN Circularity Diagram



Ellen MacArthur Foundation Butterfly Diagram



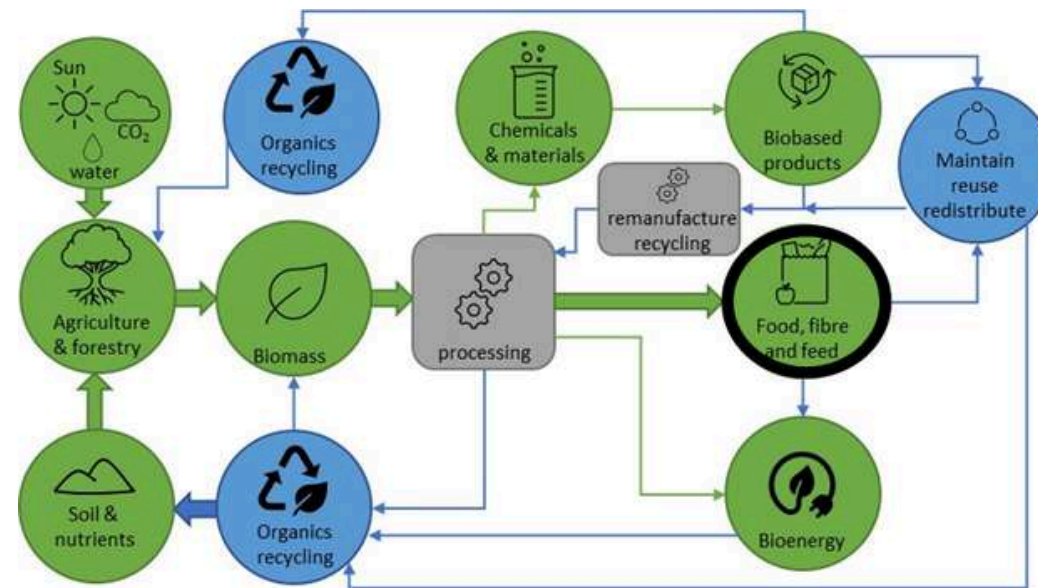
J. Cramer (2017) - 10RS

11 Cramer, J., The Raw Materials Transition in the Amsterdam Metropolitan Area: Added Value for the Economy, Well-Being and the Environment, Environment, 2017, 59, 3, 14-21, https://doi.org/10.1080/00139157.2017.1301167.

! @ micro- meso- macro- scales

resource flow

within- lateral- sector;
+ data

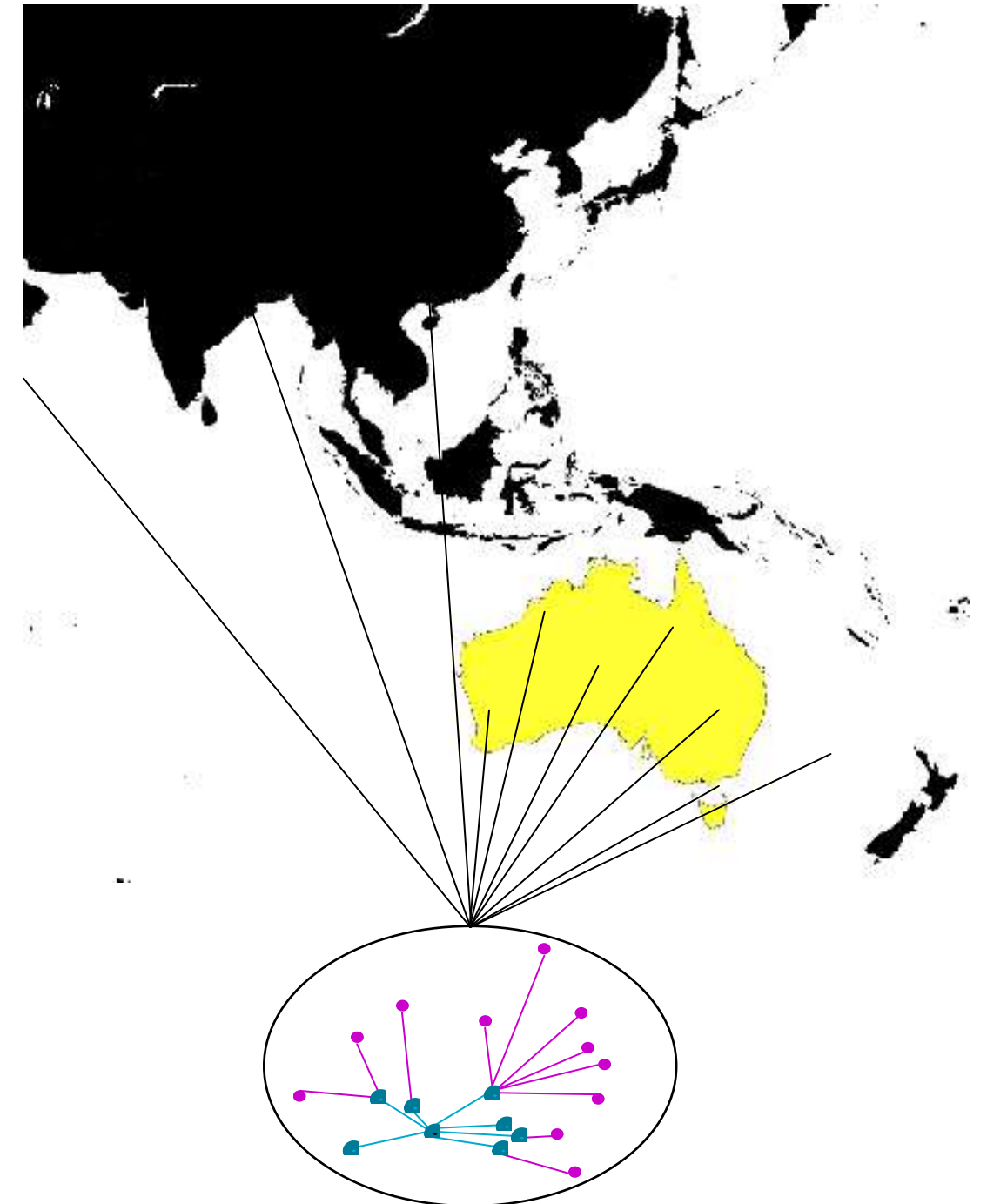


Arsic et al (2022) Australian Farm Policy Journal

Hetherington et al (2022) Australian Farm Policy Journal

transition partnerships

place-based solutions





National Food Waste Strategy

Resources for Implementing the National Food Waste Strategy

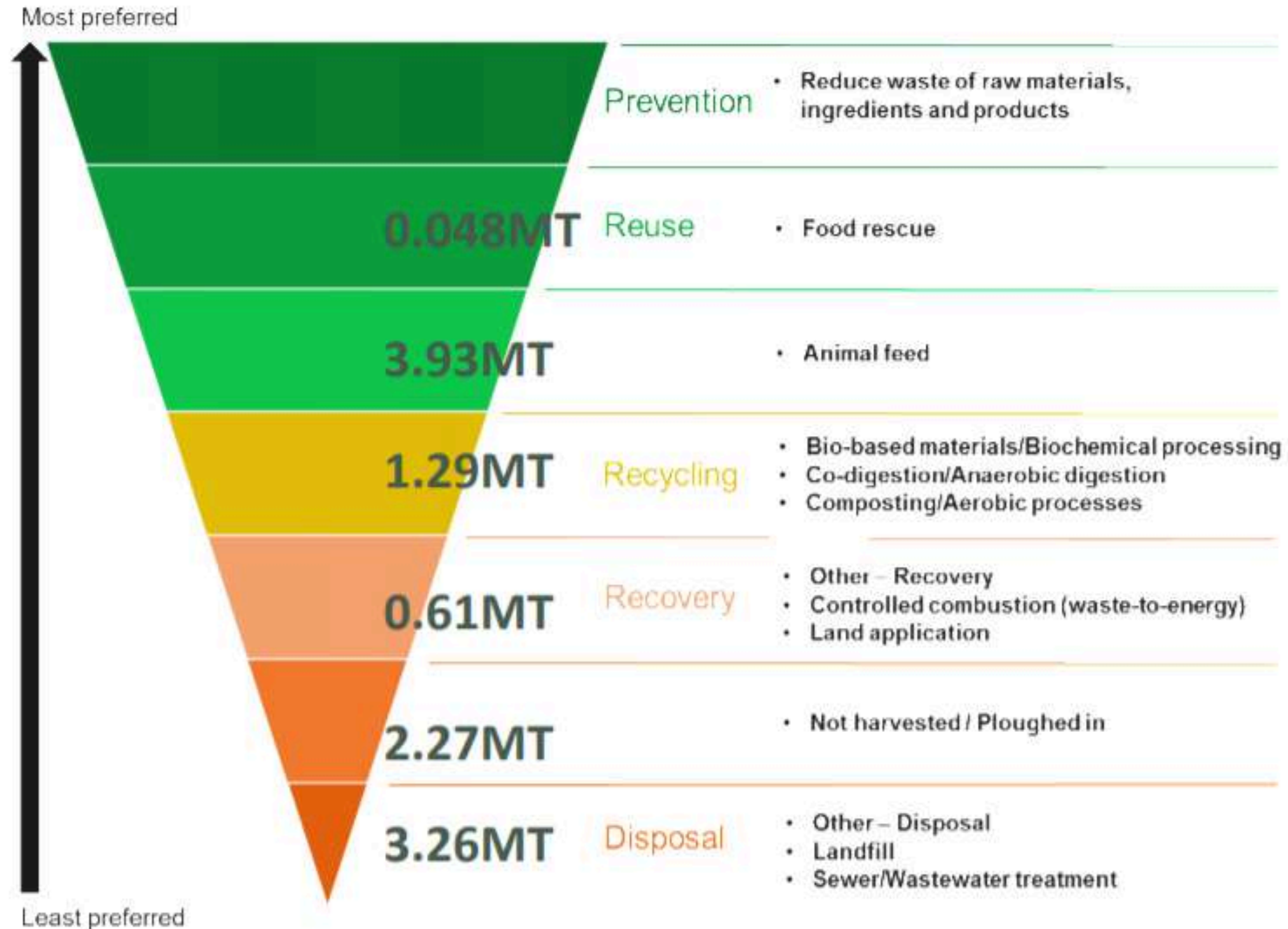
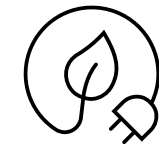
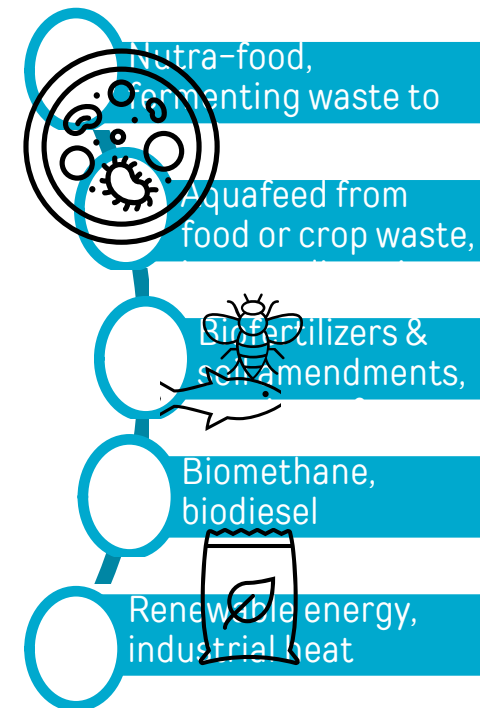
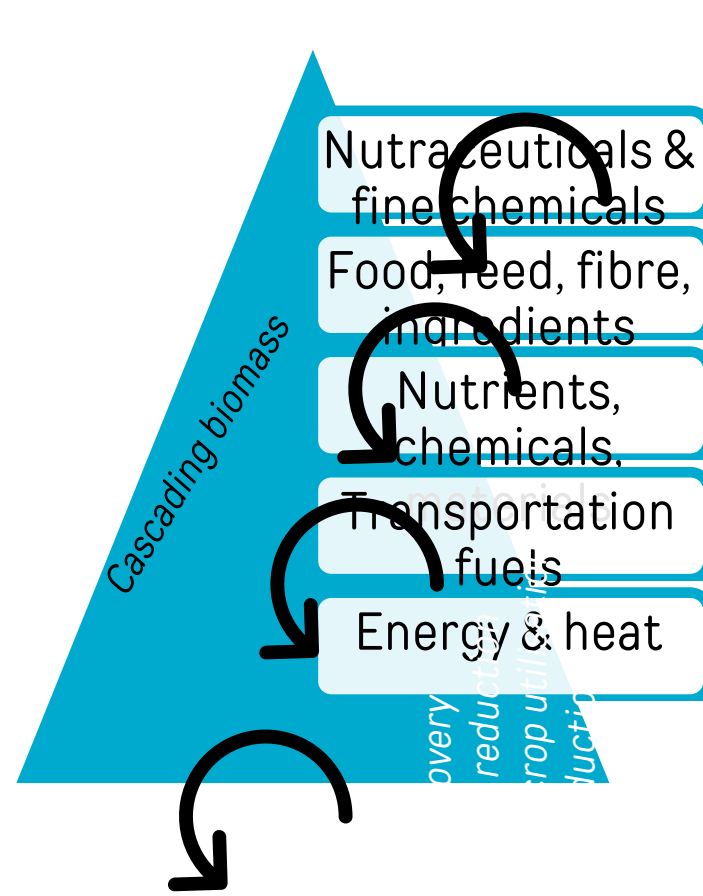
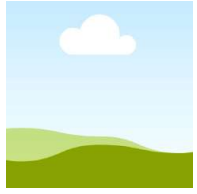
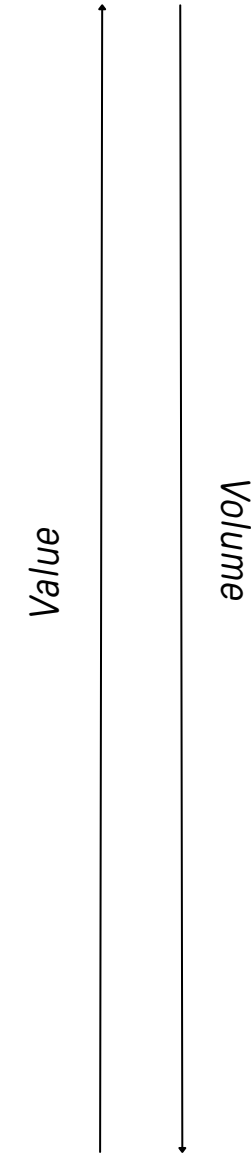


Figure 6: Interpretation from National Baseline Report (Arcadis, 2019)



Arsic et al 2022

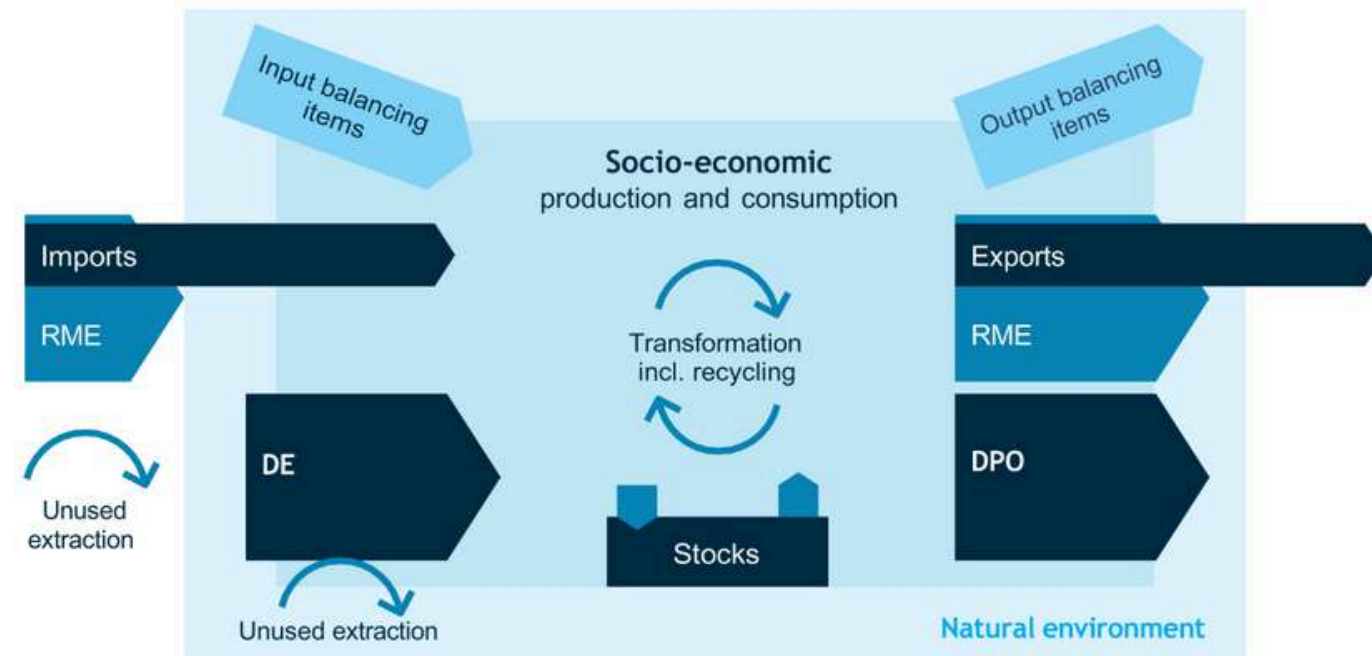




Material Flow Analysis

- a well-established tool to track the use of resources in a national economy
- complementary to economic accounts, SEEA framework
- used to measure circularity in the EU, Japan, China, the UNEP and OECD

Figure 1.2 Schematic representation of EW-MFA.



Legend

DE = domestic extraction; DPO = domestic processed outputs, i.e. wastes, emissions, dissipative uses and losses;

RME = raw material equivalents

Source: (Matthews et al. 2000, modified).

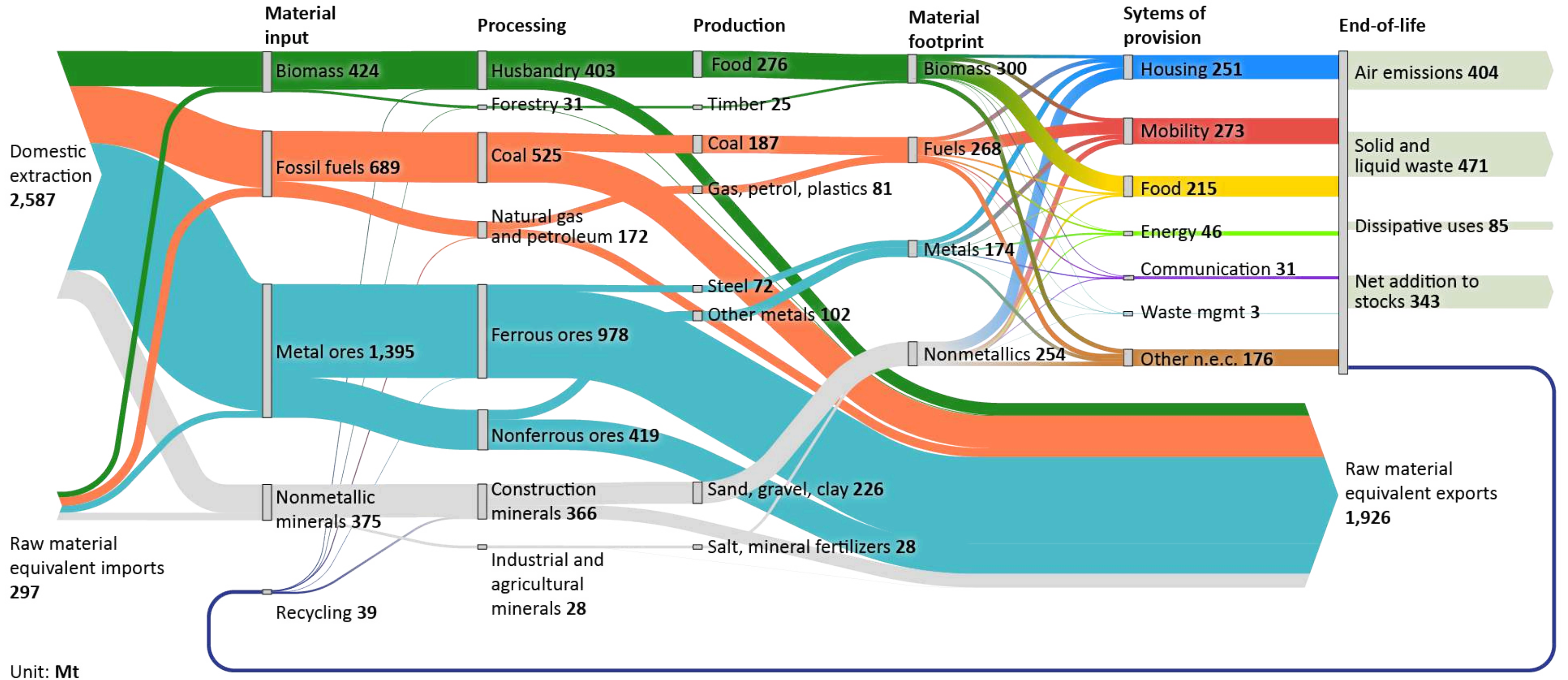


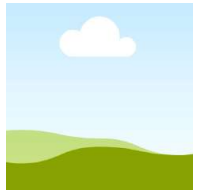
[A Global Manual on Economy Wide Material Flow Accounting | Resource Panel](#)



Australia's biomass footprint 2019

Australia, 2019, material footprint.



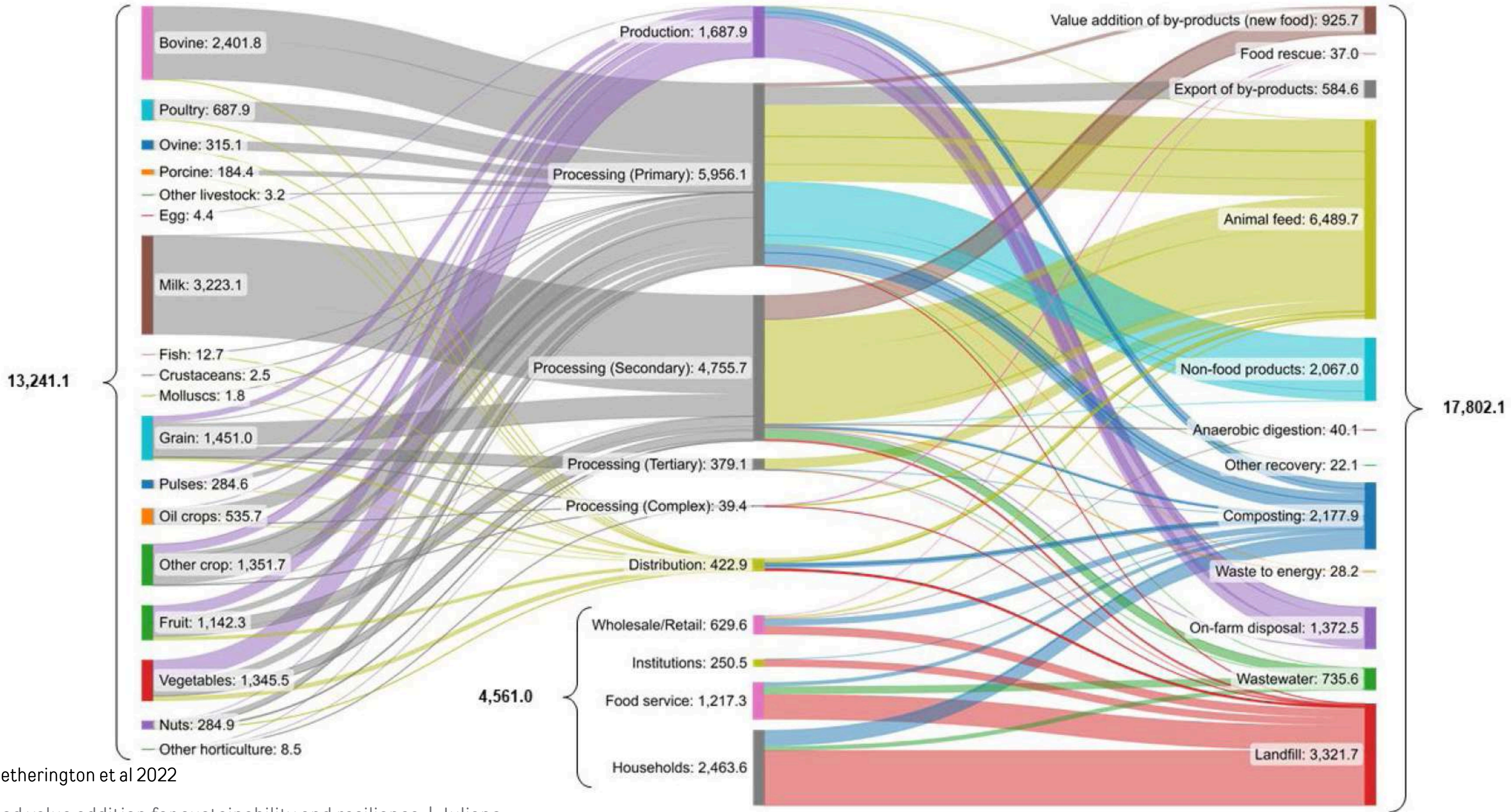


Food losses generated by each agricultural sector¹

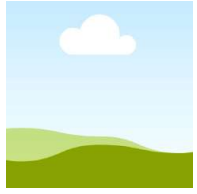
Stage of value chain where losses/wastage is generated¹

Hetherington et al 2022

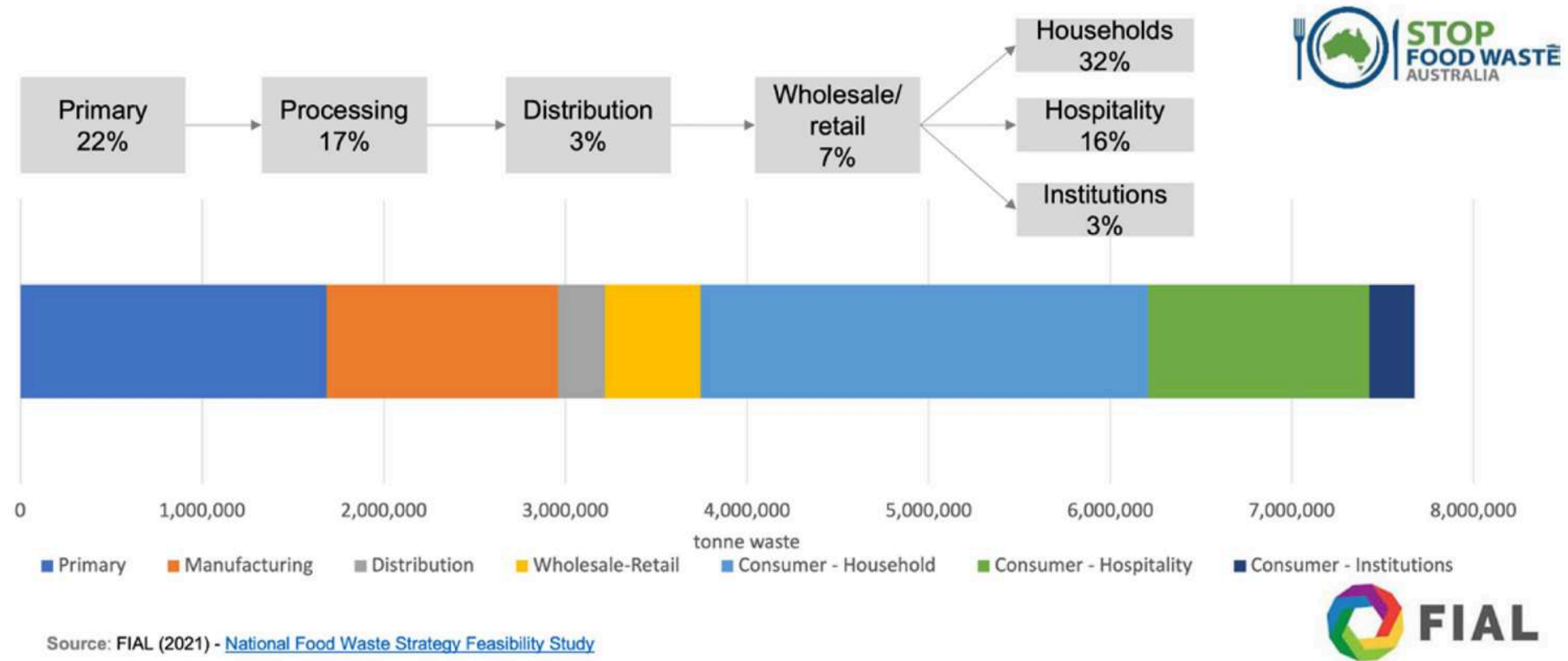
End destination of loss/waste material



Hetherington et al 2022



7.7 million tonnes, \$36B cost to the Australian economy
20Mt of CO₂e GHG emissions^{1,2}

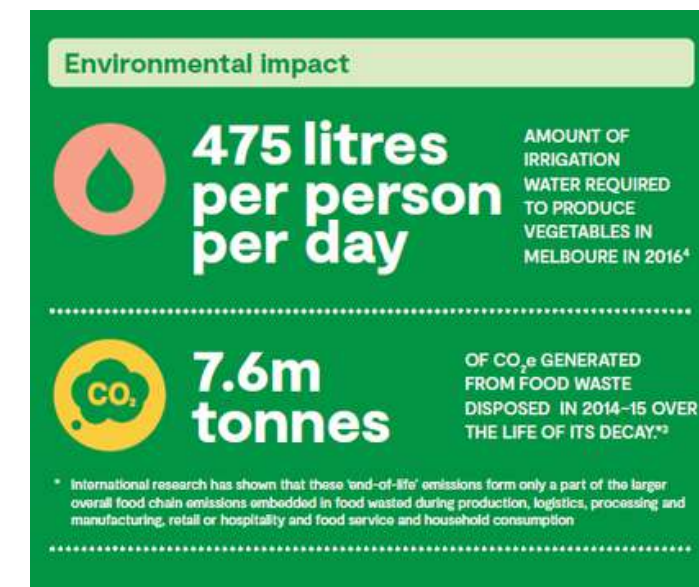
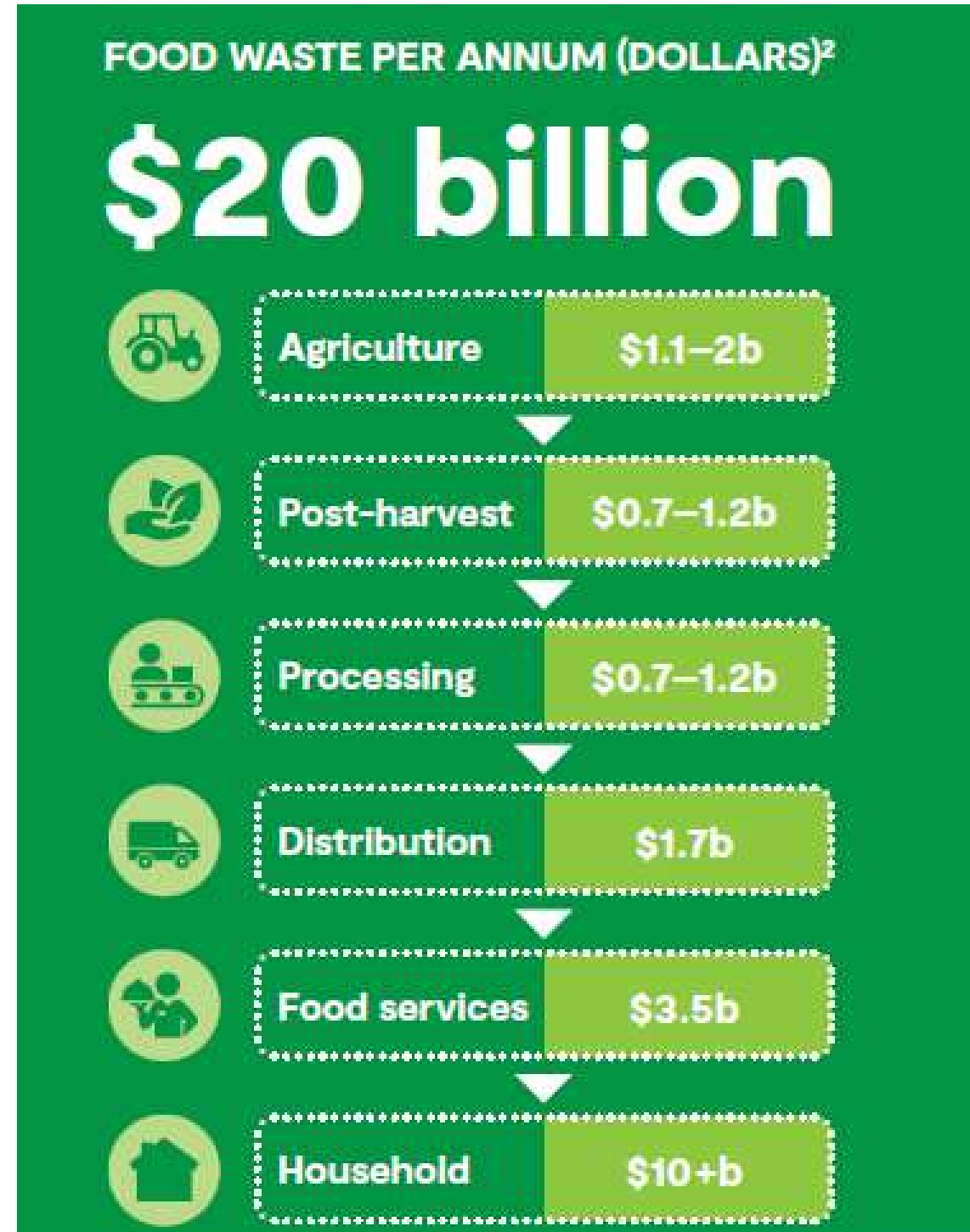


‘True cost’ of food loss is underestimated

Sources: 1) FIAL (2021) – [National Food Waste Strategy Feasibility Study](#); 2) Fight Food Waste CRC (2020) food waste GHG impact estimates for whole food value chain; 3) Foodbank Hunger Report for [2023](#)



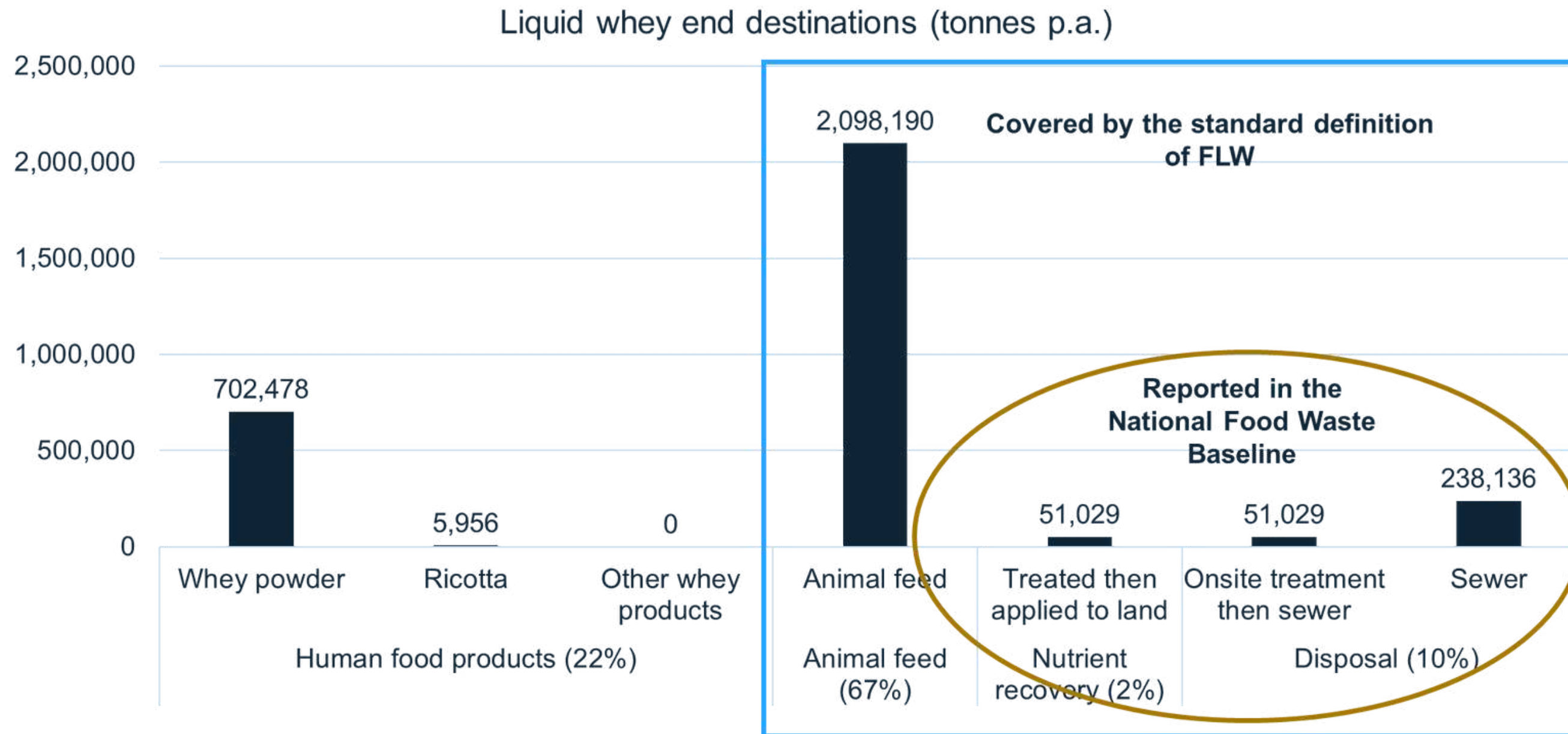
Roadmap to halve Australia's food waste by 2030



www.environment.gov.au/system/files/resources/fca42414-c4df-4821-b195-4948ad673f69/files/roadmap-reducing-food-waste.pdf



Whey is a significant FLW issue (opportunity) in Australia



Underutilised whey:
• 2.4m tonnes p.a.

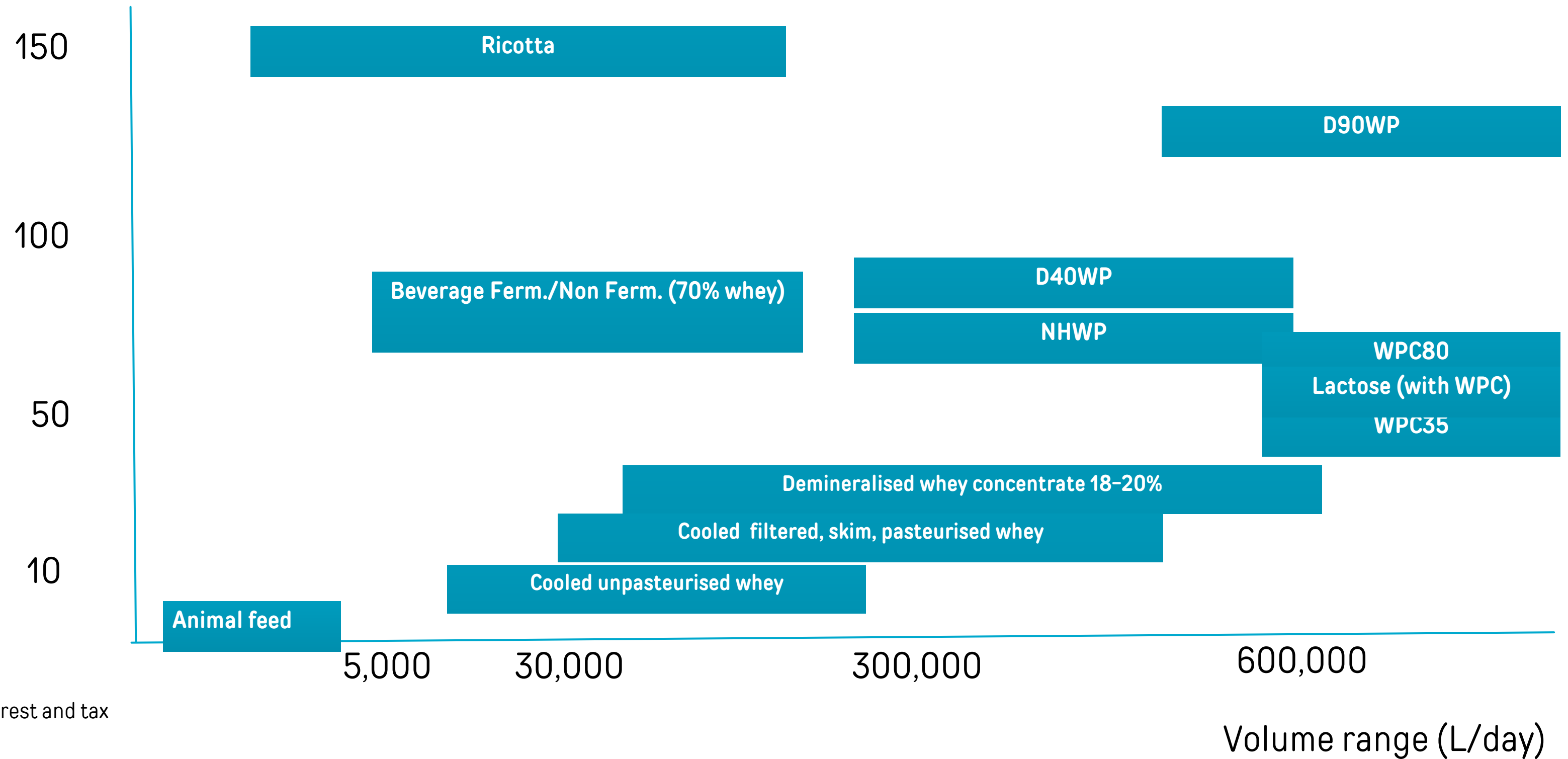
Potential new revenue:
• \$365m to \$1b

Data source: personal communication, PA Bontinck, Lifecycles, 9 December 2021.

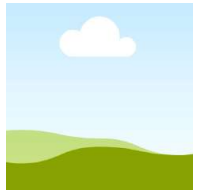


Whey value addition options

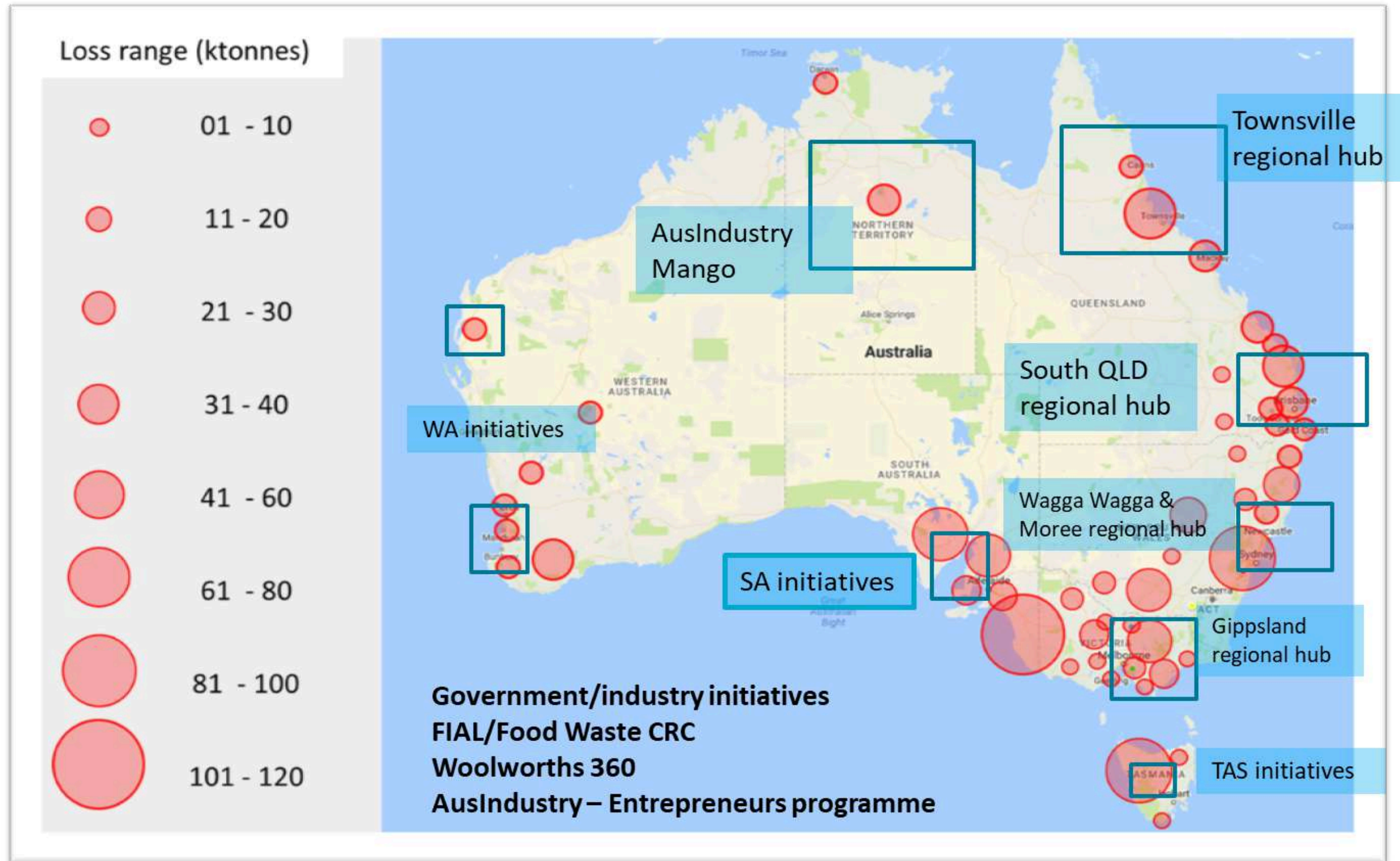
EBIT
(USD/t
liquid whey)



EBIT – Earnings before interest and tax
Average pricing from 2017

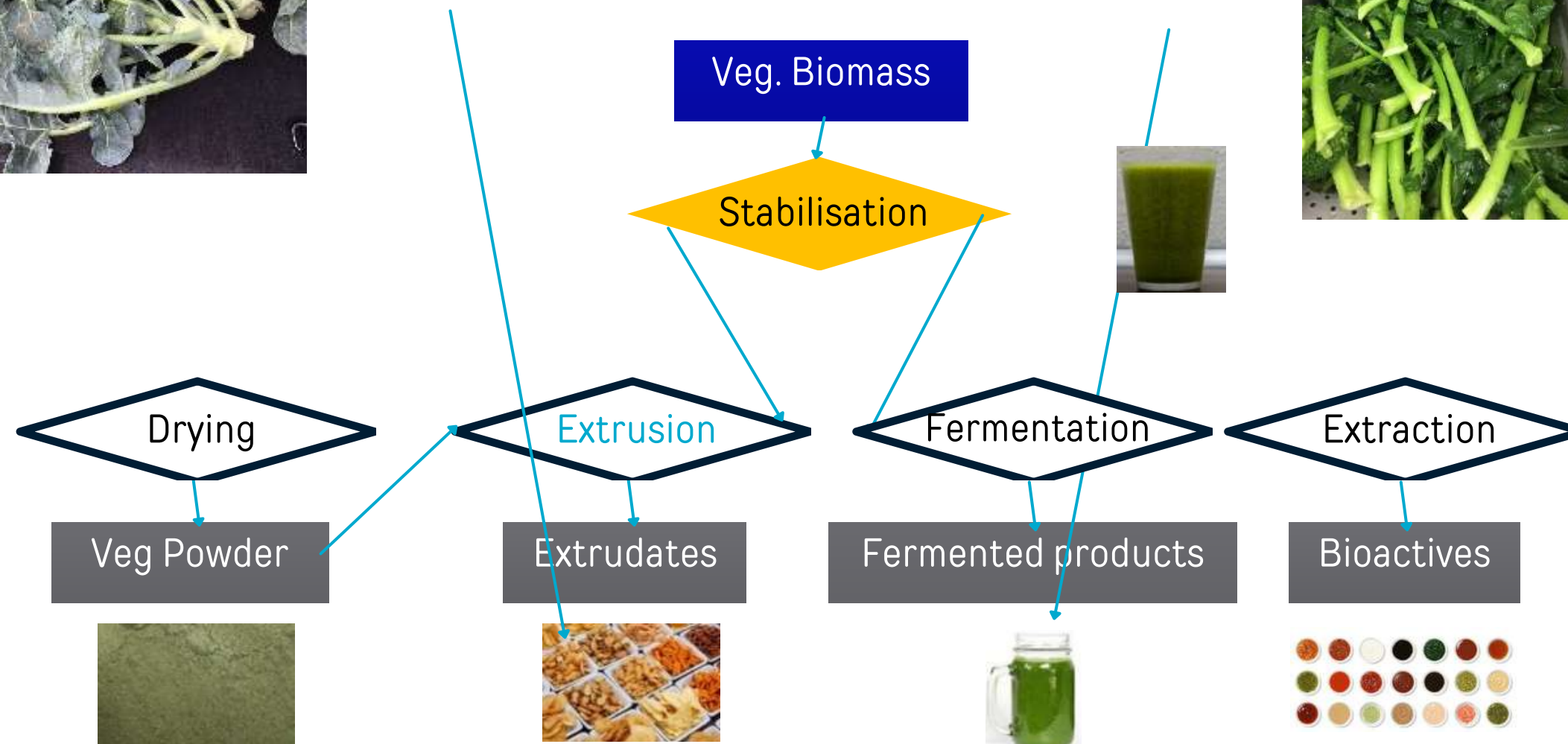


Fruit and vegetable losses





Horticulture processing strategies



Stabilisation/Pre-processing is the first step before any processing



Danyang Ying



NutriV

- Brought solution to key grower packer for large supermarket
- Non-retail and waste products is converted into vegetable
- Supported snack line launch of Goodies offering 2 serve

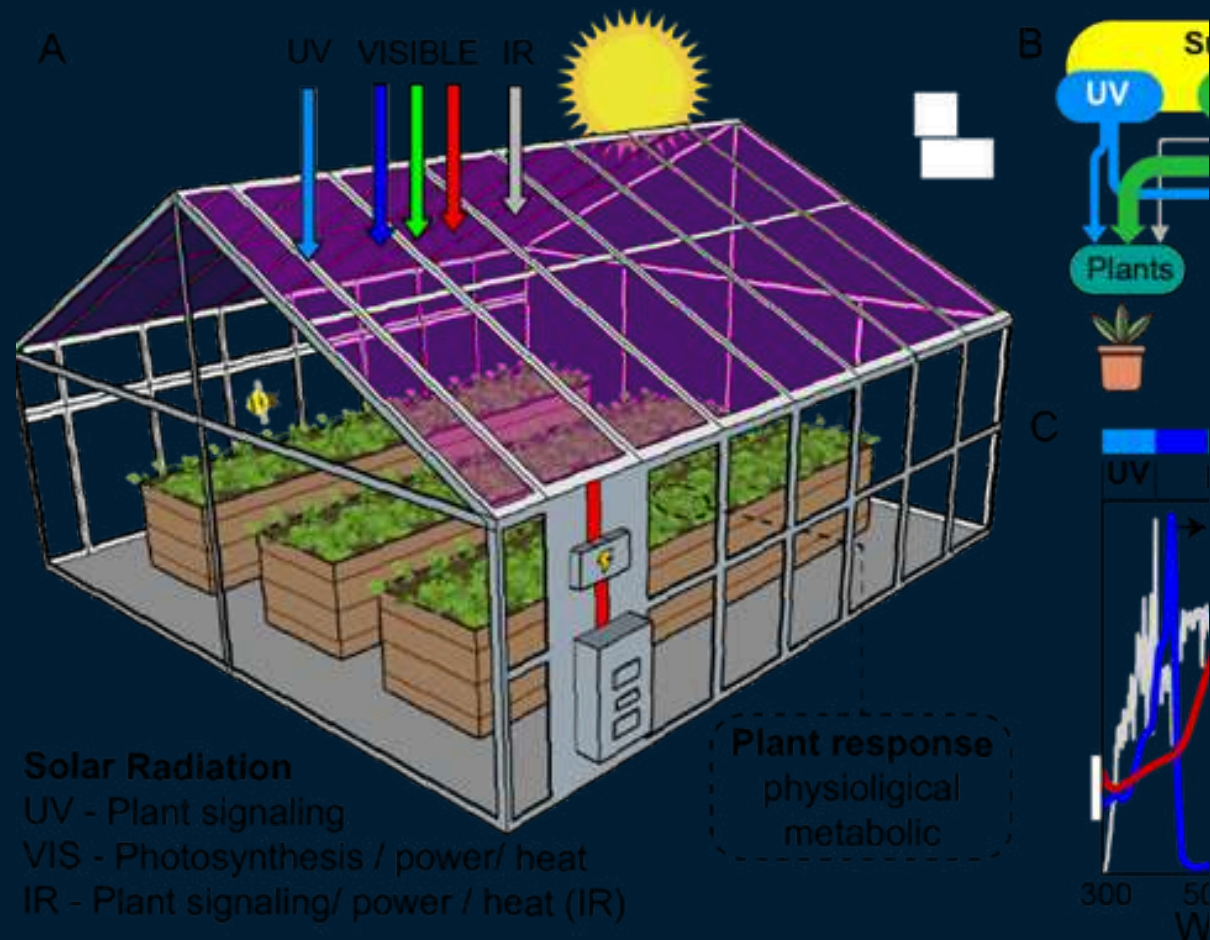


100% of
k

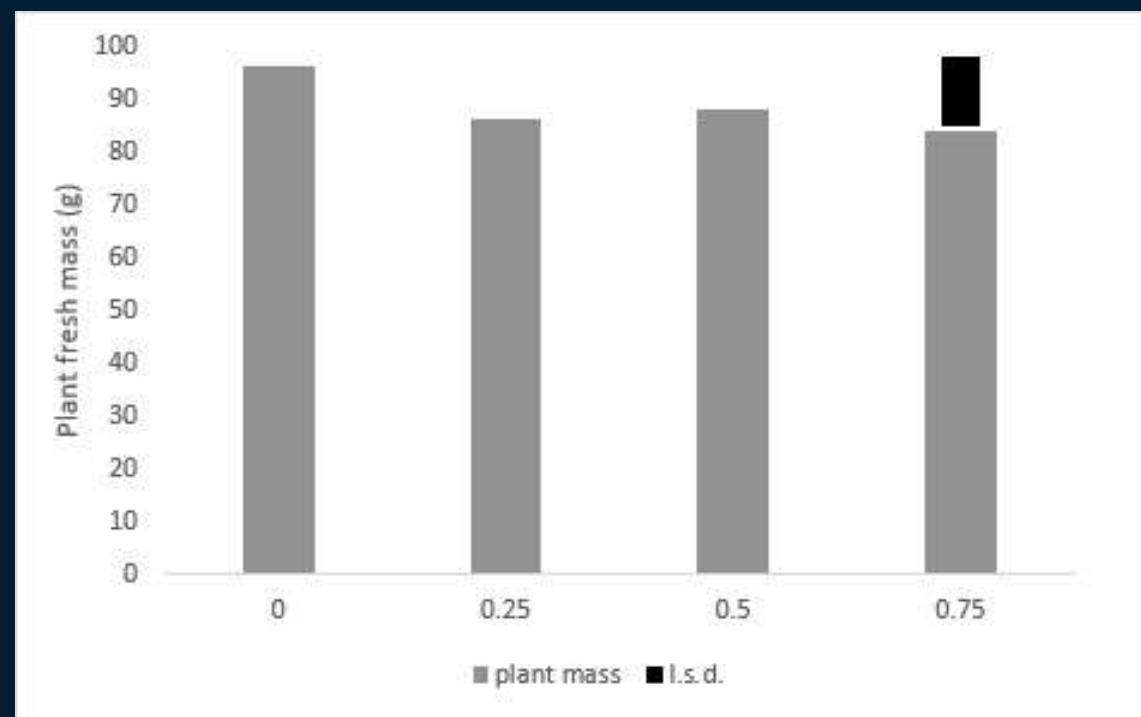




solar-films x greenhouse x crops



Flexi-solar strips x greenhouse x Cos lettuce. Plant growth 28 days under 0% cover (control) and 75% cover solar film shade treatments.



Above ground biomass (g fresh mass) of plants grown under different shade treatments

using first iteration of printed solar films. Black bar indicates least significant difference at $p=0.05$. No treatments were statistically different to the control.

Semi-transparent solar films for glasshouses – concept
c.f. (Ravishankar, Charles et al. 2021)





circular aquaculture

issue

- Effluents from fish/prawn
- Diversification
- Green shortage & quality

solution

- Integrated system
- Microbials bioavailable nutrients
- Local, fresh, circular



Barramundi



Jade perch



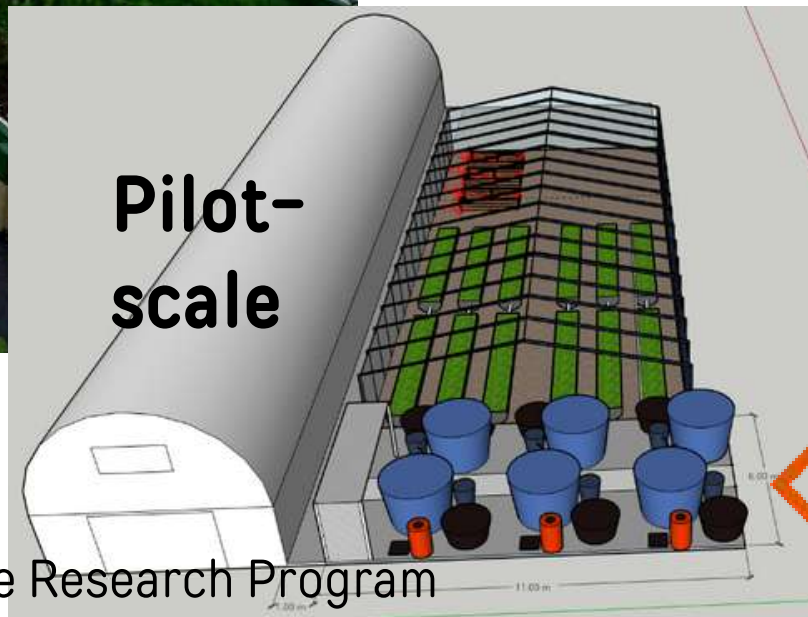
Small-scale

Started 2021
Nutrient Systems



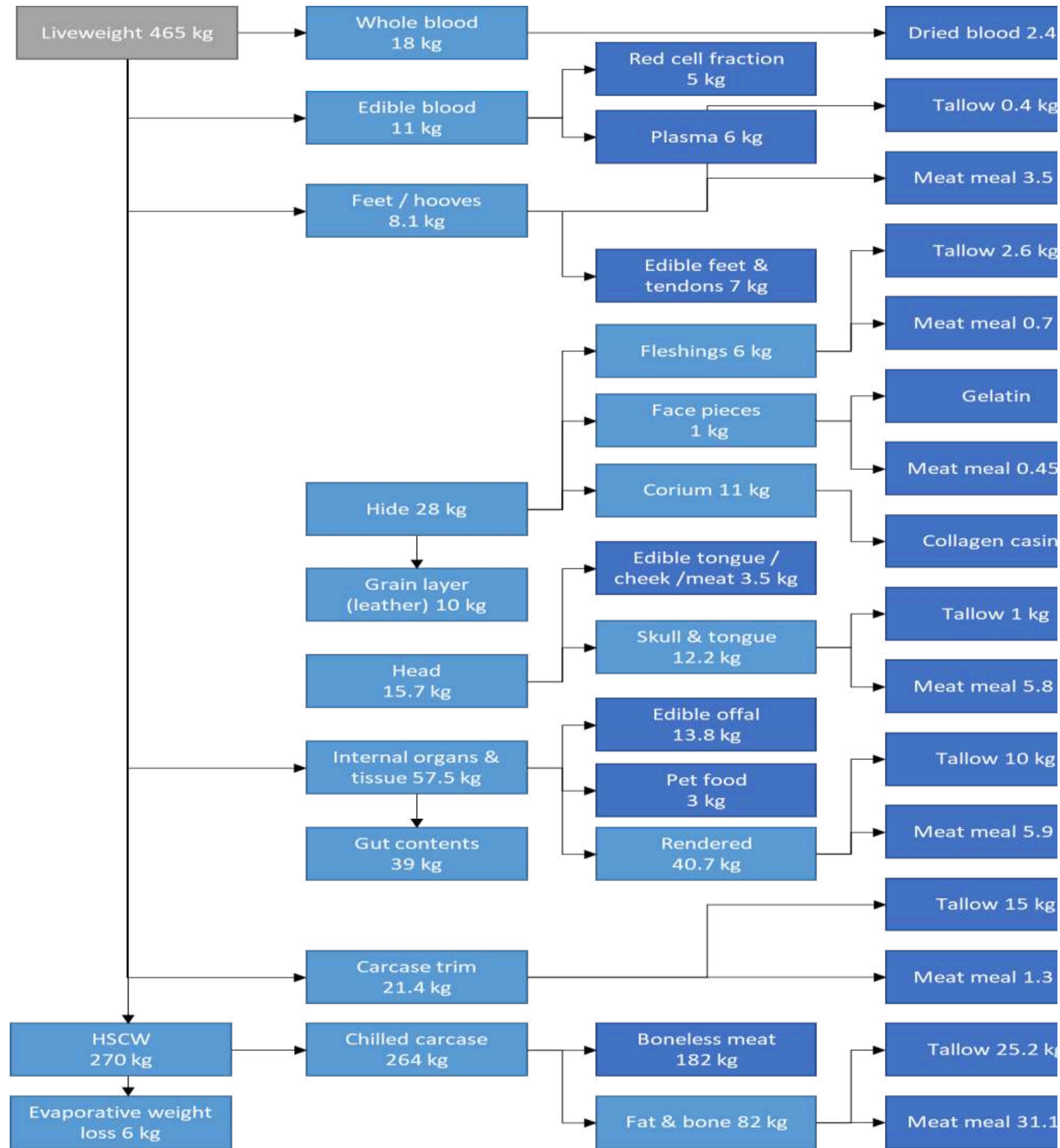
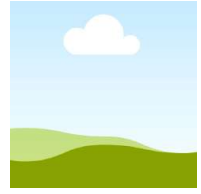
Industry survey and 4 trials
FPM Sprint (2) & New SIP approved
Future: Pilot-scale & Industry engage

Aquaponics



Pilot-scale



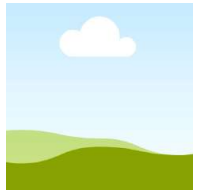


https://www.mla.com.au/contentassets/79c16798add246bfa3162b9411022e93/a.cop.0061_mla_coproducts_compendium.pdf

“Whole of carcass” utilisation

- cattle-derived collagen
- blood plasma co-products
- meat snacks
- red meat protein powder





Aarti Tobin

A high protein, low-fat, remarkably soluble hydrolysed meat protein powder which can be used as an ingredients across a range of food and beverages. The powder is **shelf stable, nutrient dense, allergen-free and functionally superior** to existing protein powders.

Our Novel Process





Sports Nutrition 

 Healthy Ageing

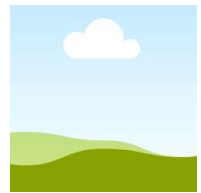


Protein Fortified Foods 


Food
Nutrition

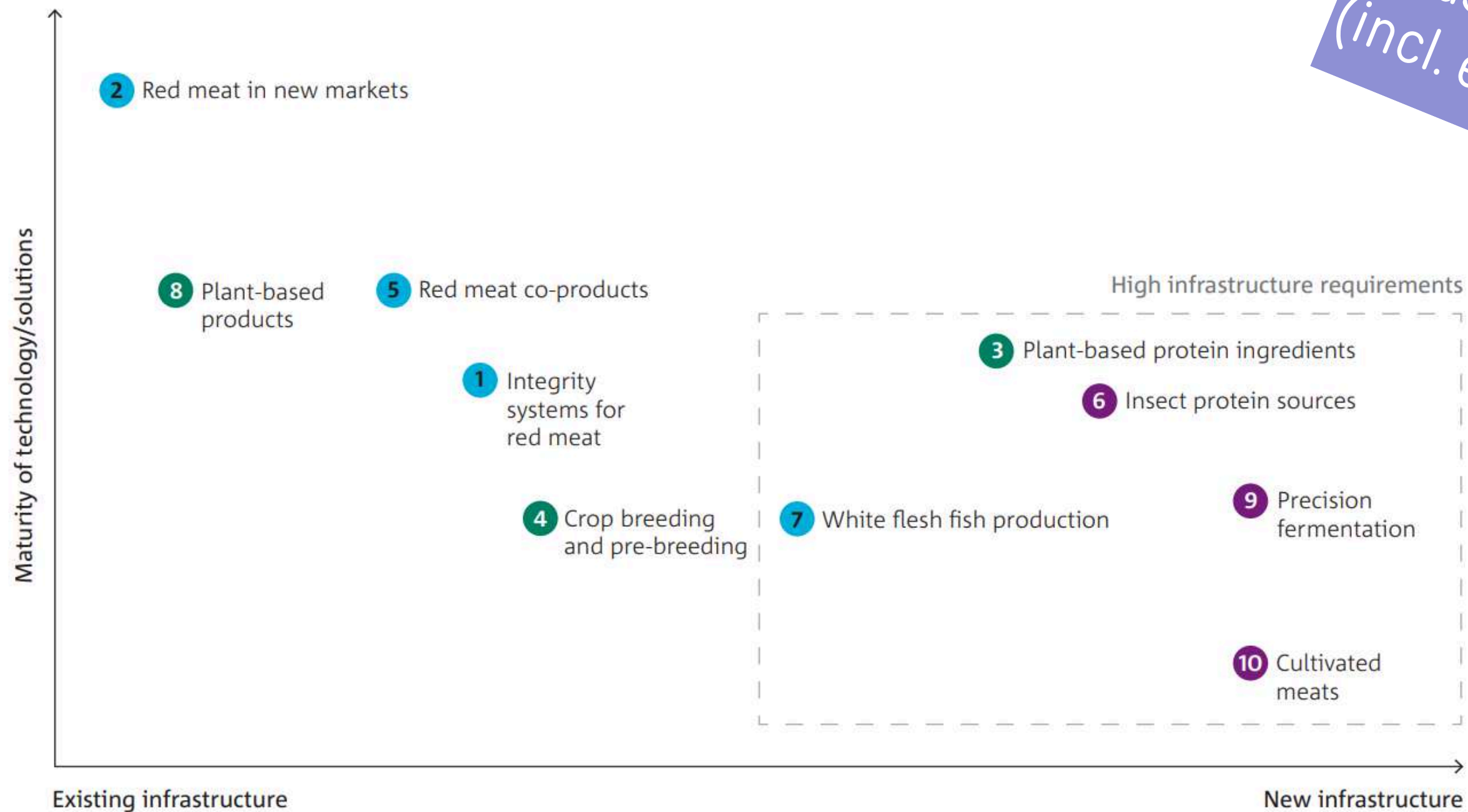
 Specialty Nutrition





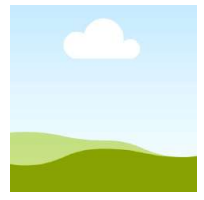
Australia's Protein Roadmap

Drivers: market access, building new industries, credentials (incl. environmental)

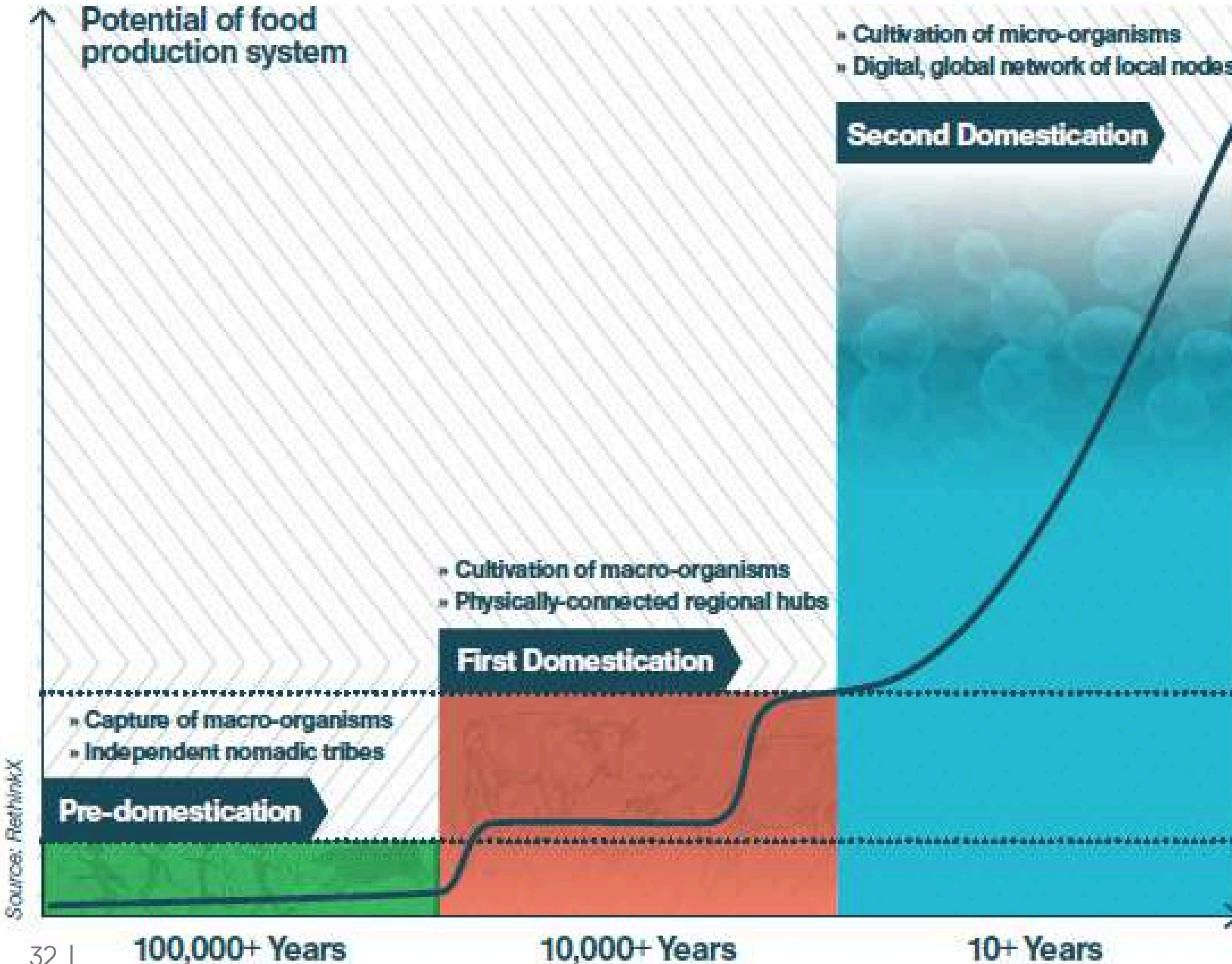


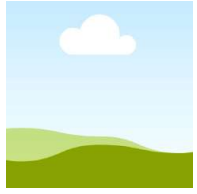
Maturity of technological solutions vs new infrastructure requirements for growth opportunities

[Australia's Protein Roadmap – CSIRO](#)



The second domestication

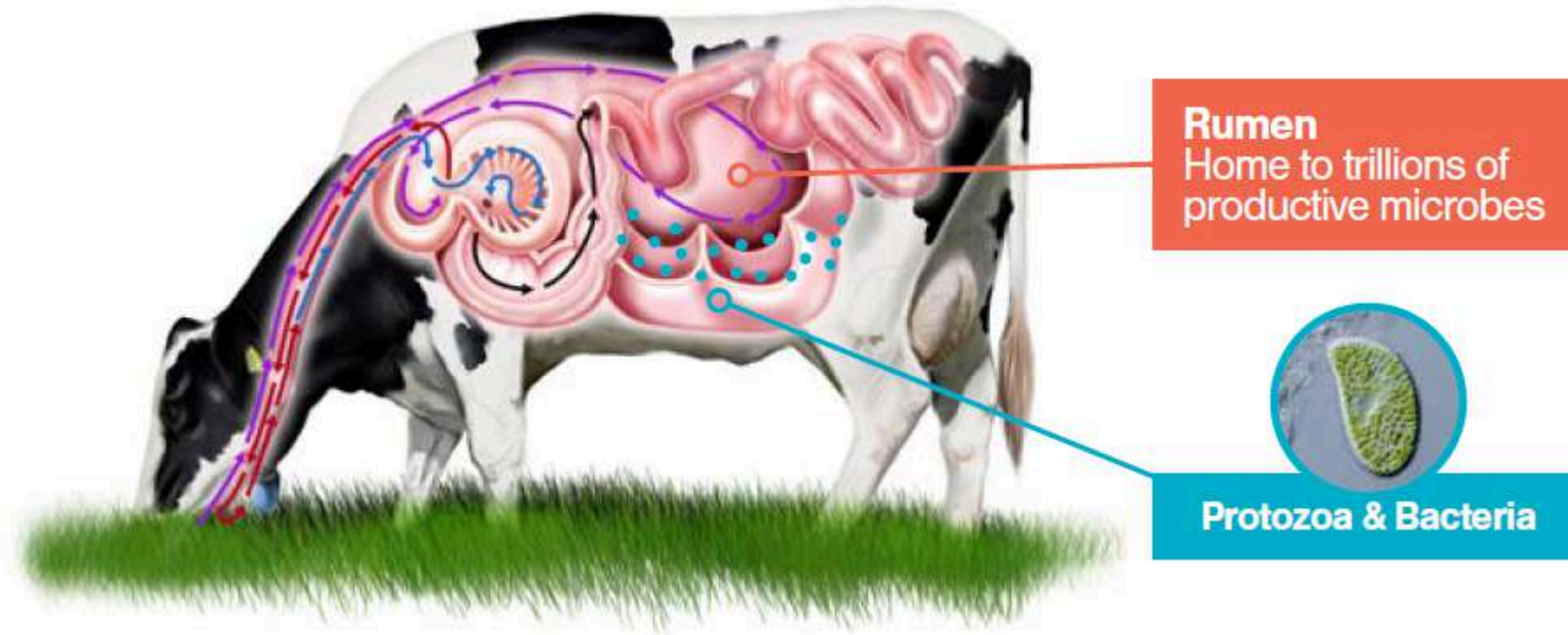




Capacity: 150–200 L
 Temperature: 37–42°C
 Feedstock Efficiency: 4%



Capacity: 200–40,000 L
 Temperature: Optimized
 Feedstock Efficiency: 40–80%

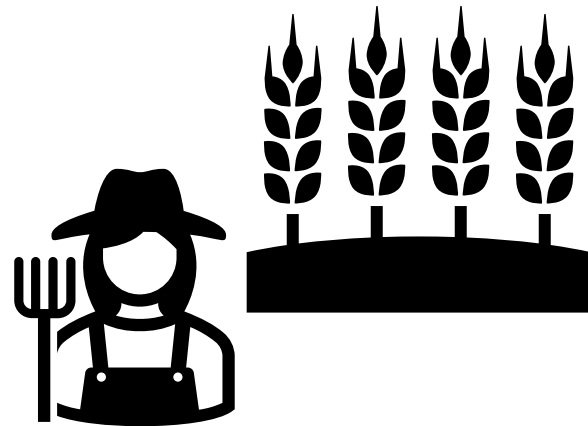


Source: RethinkX, Impossible Foods



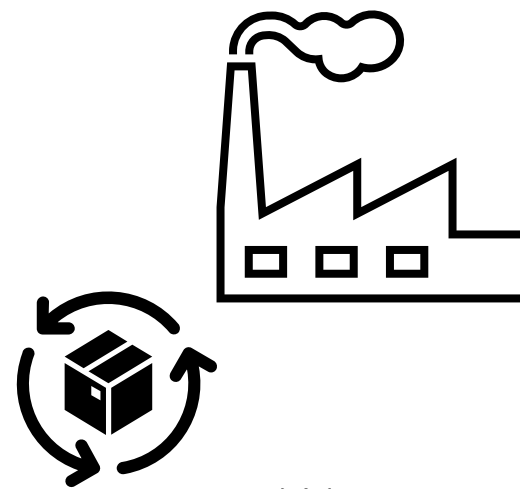
Environmental issues for agriculture and food

Agricultural production



- Land use change
- Biodiversity loss
- Soil degradation
- GHG emissions
- Water footprint
- Eutrophication (pollution/chemicals)
- Energy usage
- Crop loss

Processing and packaging

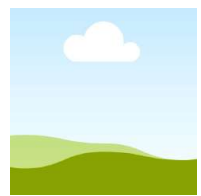


- Water and energy use
- Effluent/waste disposal
- GHG emissions
- Water footprint
- Contamination
- Packaging materials
- Chemical usage

Retail



- Packaging
- Food waste
- GHG
- Recycling



Environmental narratives and comparisons

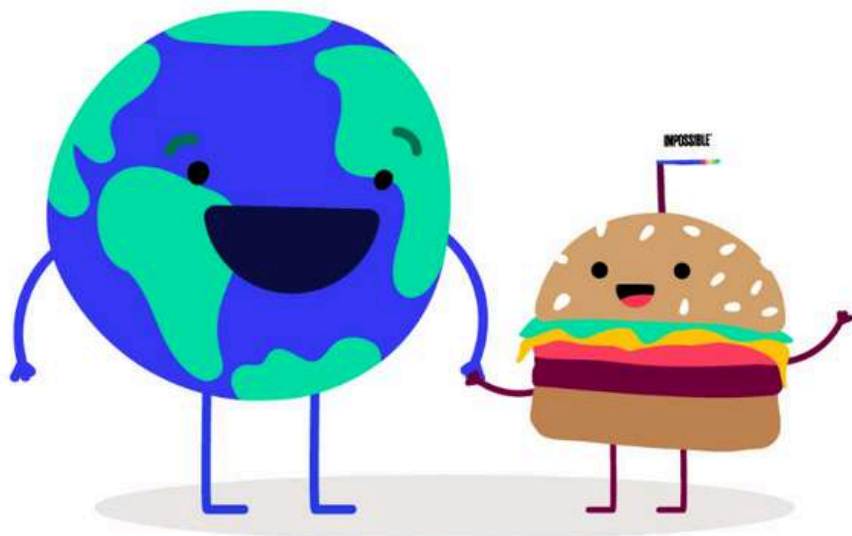


WoA: "world's first regenerative grown, carbon-neutral oat milk"

APP: "Creating sustainable proteins from plants that taste great and are good for you and the environment"

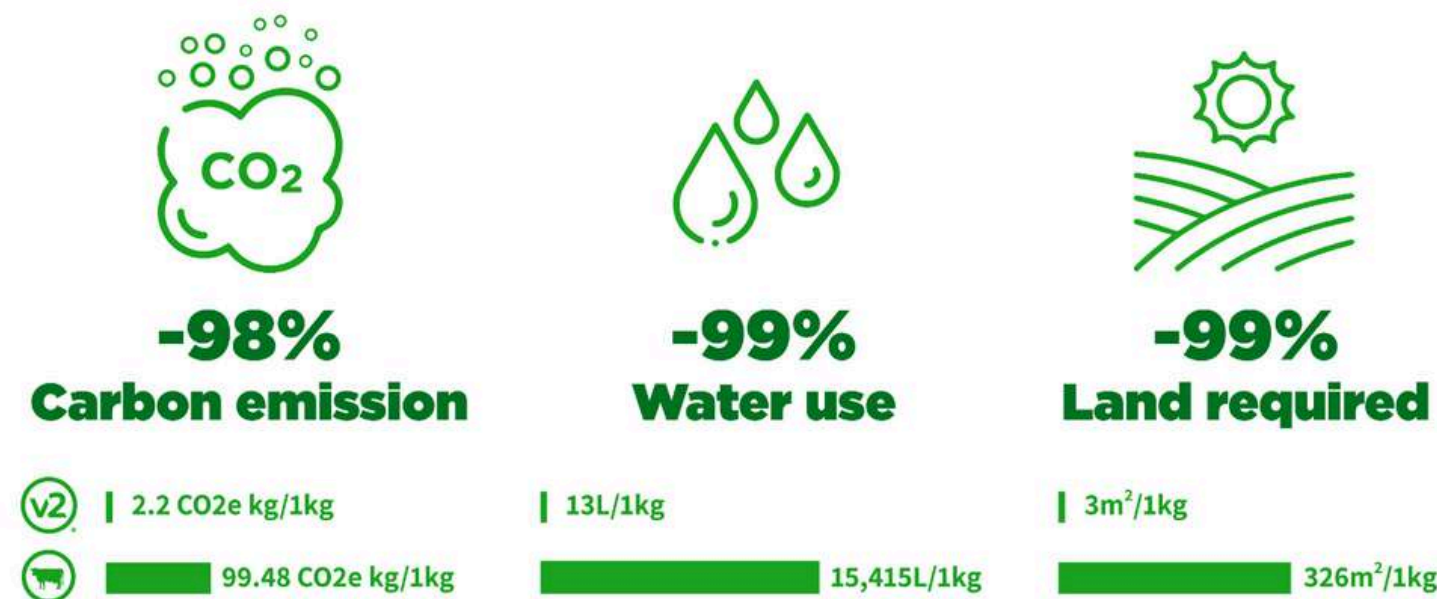
JUST Egg uses

98%
less water



Yes. And, in the process, we made eggs that are better for the planet, too.

WHY EAT PLANT-BASED?



Sources - v2food: CSIRO, (2021). Global Beef Averages: Poore & Nemecek (2018), Mekonnen & Hoekstra (2010).

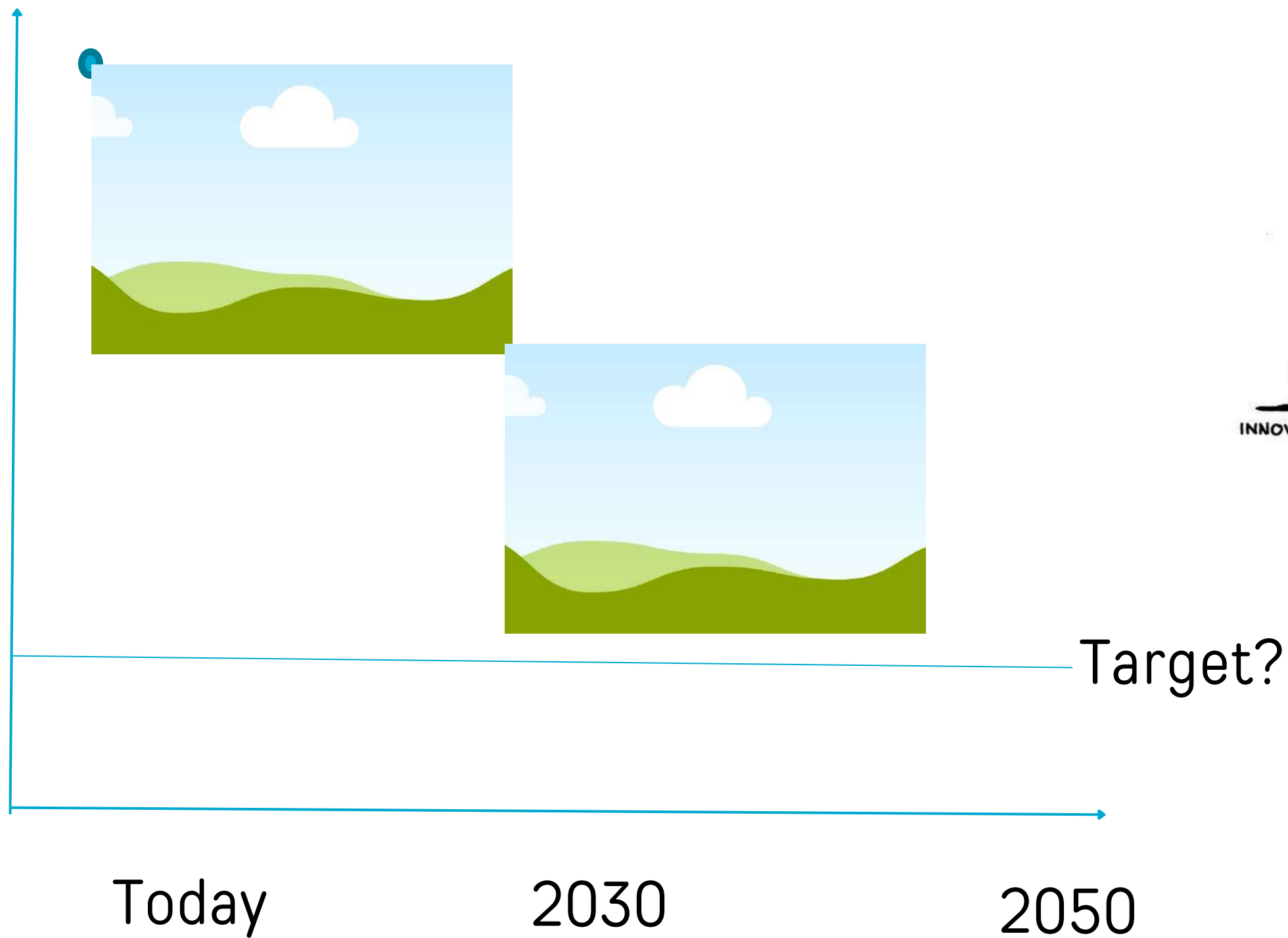
B2B: Potential barriers to trade?



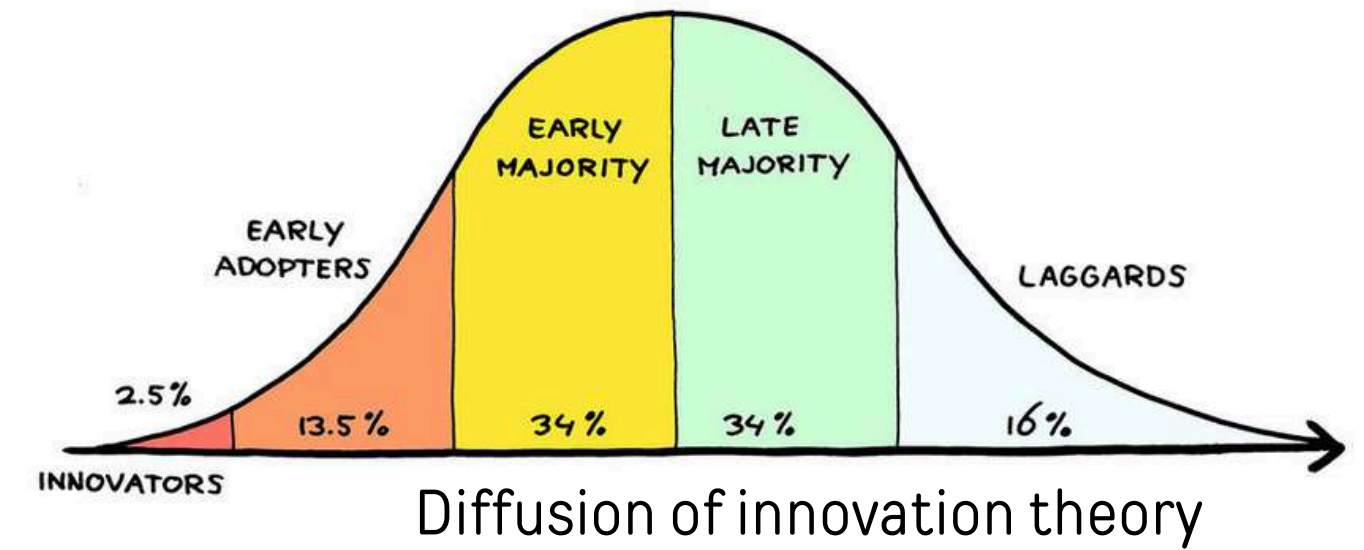
Can we monitor its own transition towards green agrifood chain targets?

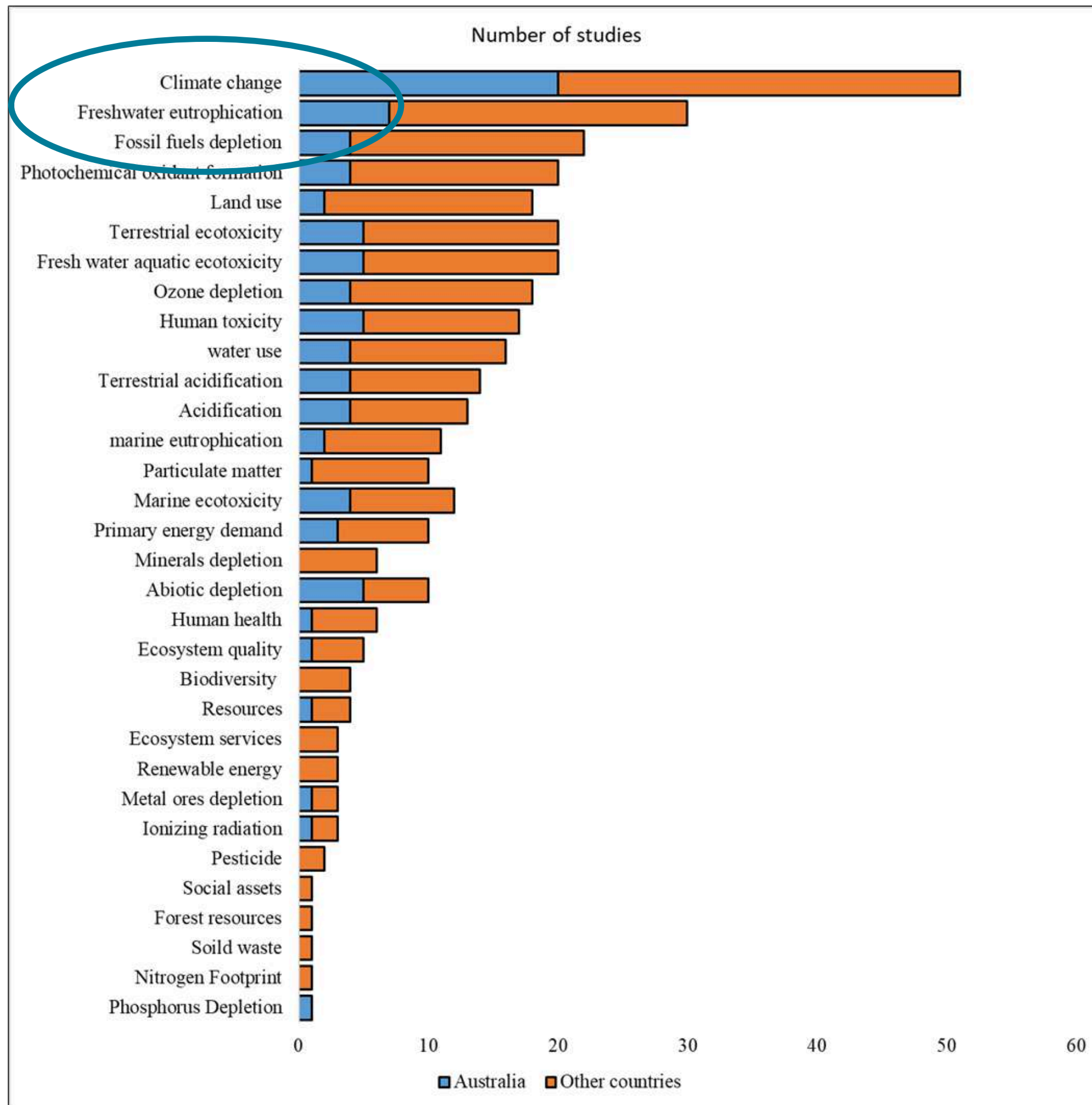
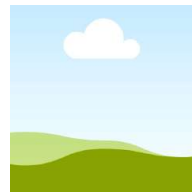
'Dynamic' compound or multi-metric env. footprint indicator

(dynamic data at various scales)



How to make cultural transformation across the system?



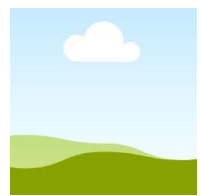


LCA indicators to promote plant protein based foods

- Apply multiple LCA-based impact category indicators.
- Aligning LCA-based indicators with planetary boundaries.



Nazmul Islam



Current LCA based data pools and tools

- LCA data pool



Agricultural data sets of AusLCI: Agricultural data sets have been developed as part of the AusAgLCI.



**Best Practice Guide for Mid-Point
Life Cycle Impact Assessment
in Australia**

ALCAS Impact Assessment Committee

Renouf, M.A., Grant, T., Sevenster, M., Logie, J., Ridoutt, B., Ximenes, F., Bengtsson, J., Cowie, A., Lane, J.

Version 2

(13/04/2018)

**GAP IN FOOD UNIT
OPERATION DATA**



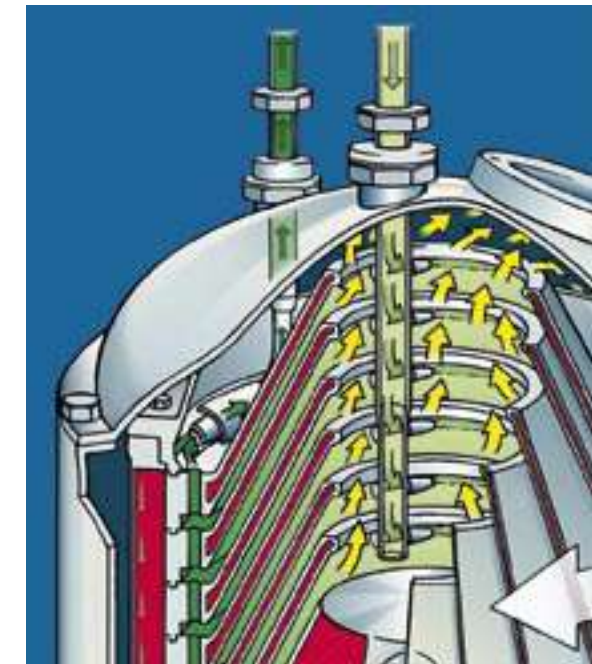
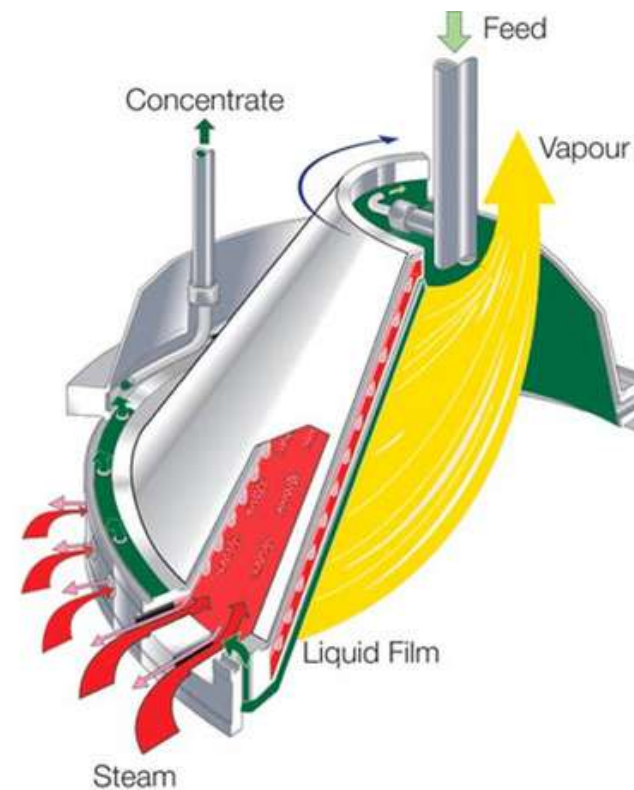
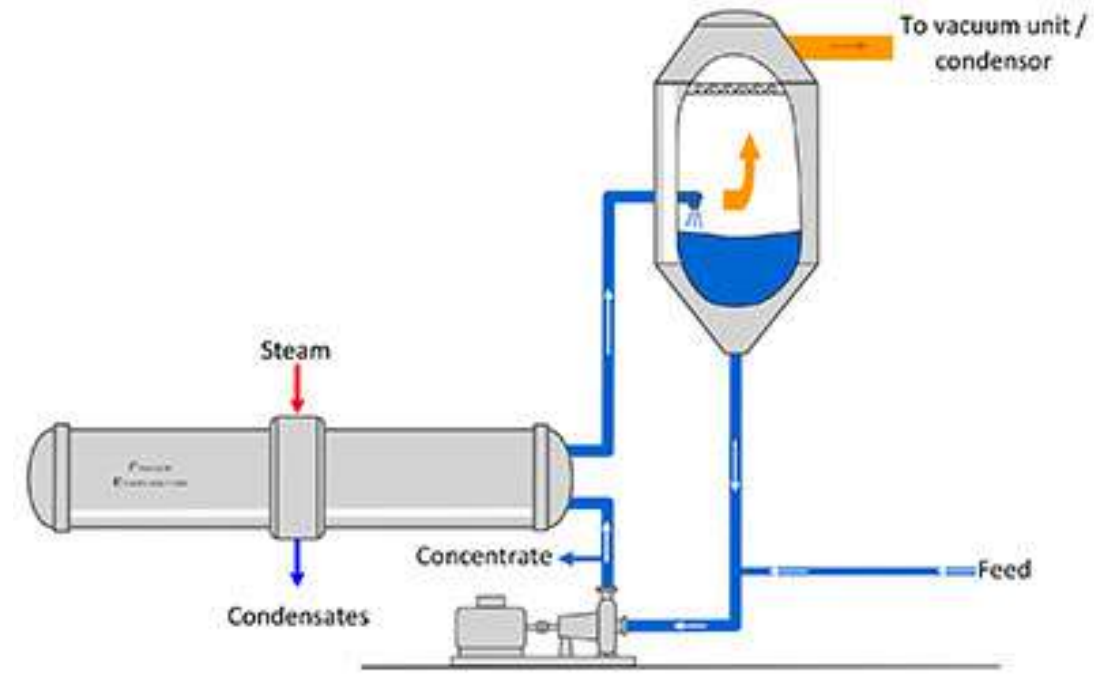
Different types of evaporators

Forced circulation

- not prone to clogging
- can handle suspended solids including crystals
- **typical applications include fruit and vegetable puree**

Centrifugal evaporator

- Centritherm®
- Rapid evaporation
- <1 second residence time with a 0.1 mm film
- Operating temp as low 35°C
- **Designed for heat sensitive products**

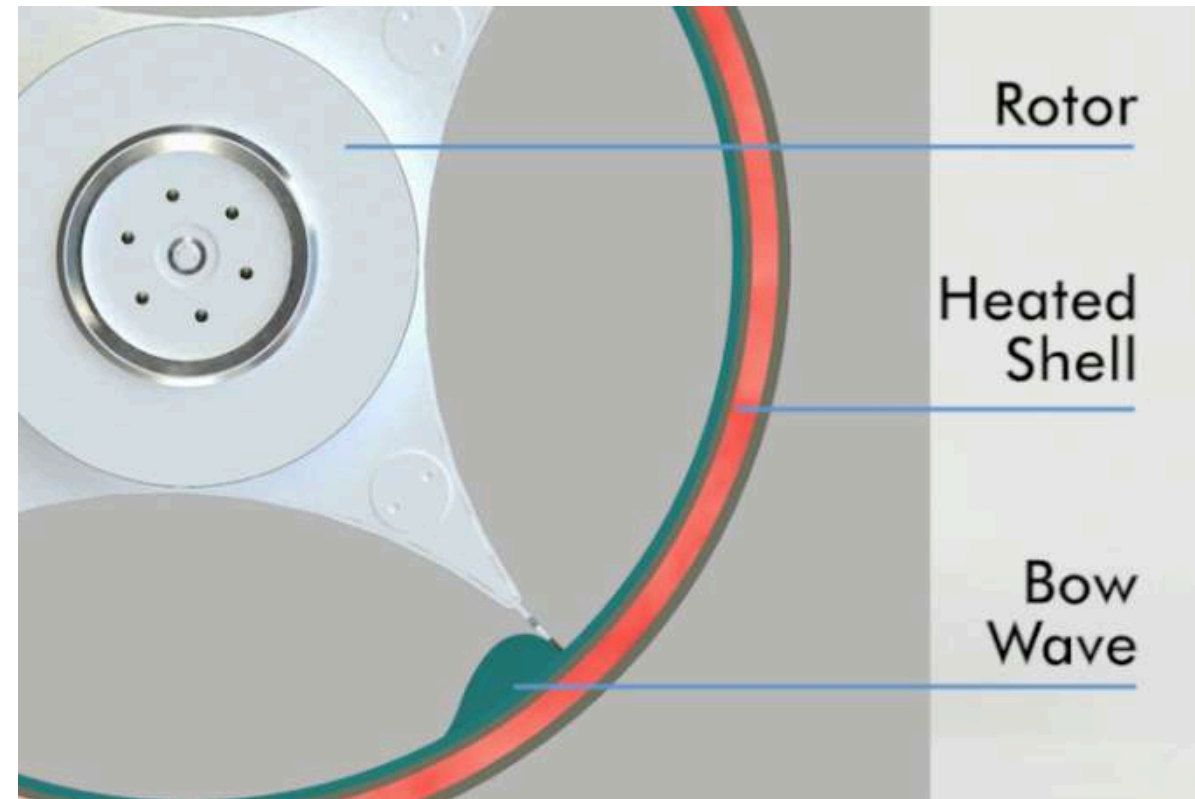




Different types of evaporators

Scrape surface

- can handle very high viscosities >50000 cP
- Able to dry products
- Low residence time
- Operate under high vacuum
- Can be installed vertically or horizontal



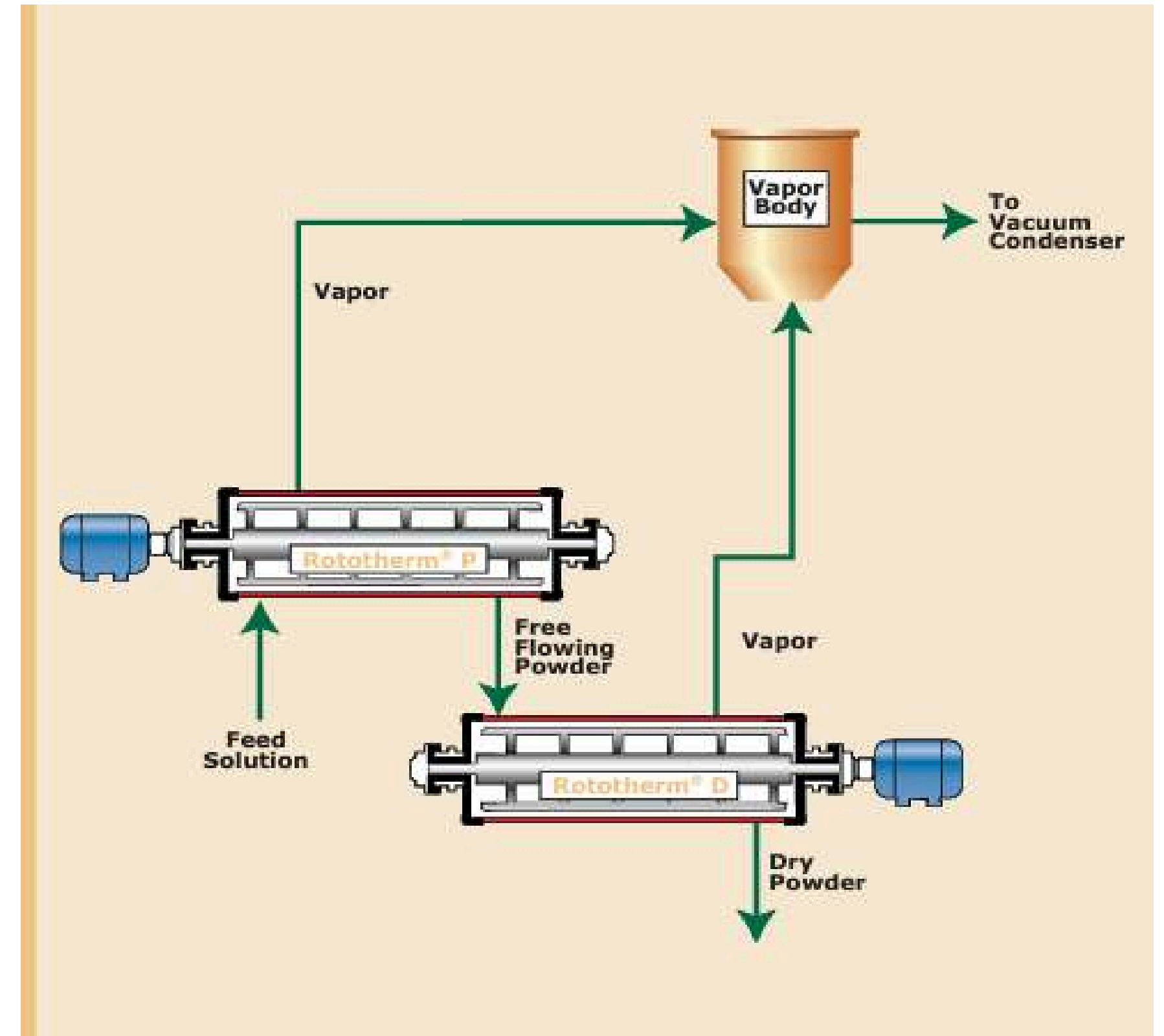
<https://www.sms-vt.com/technology/evaporation-technology/thin-film-evaporator>





Different types of evaporators

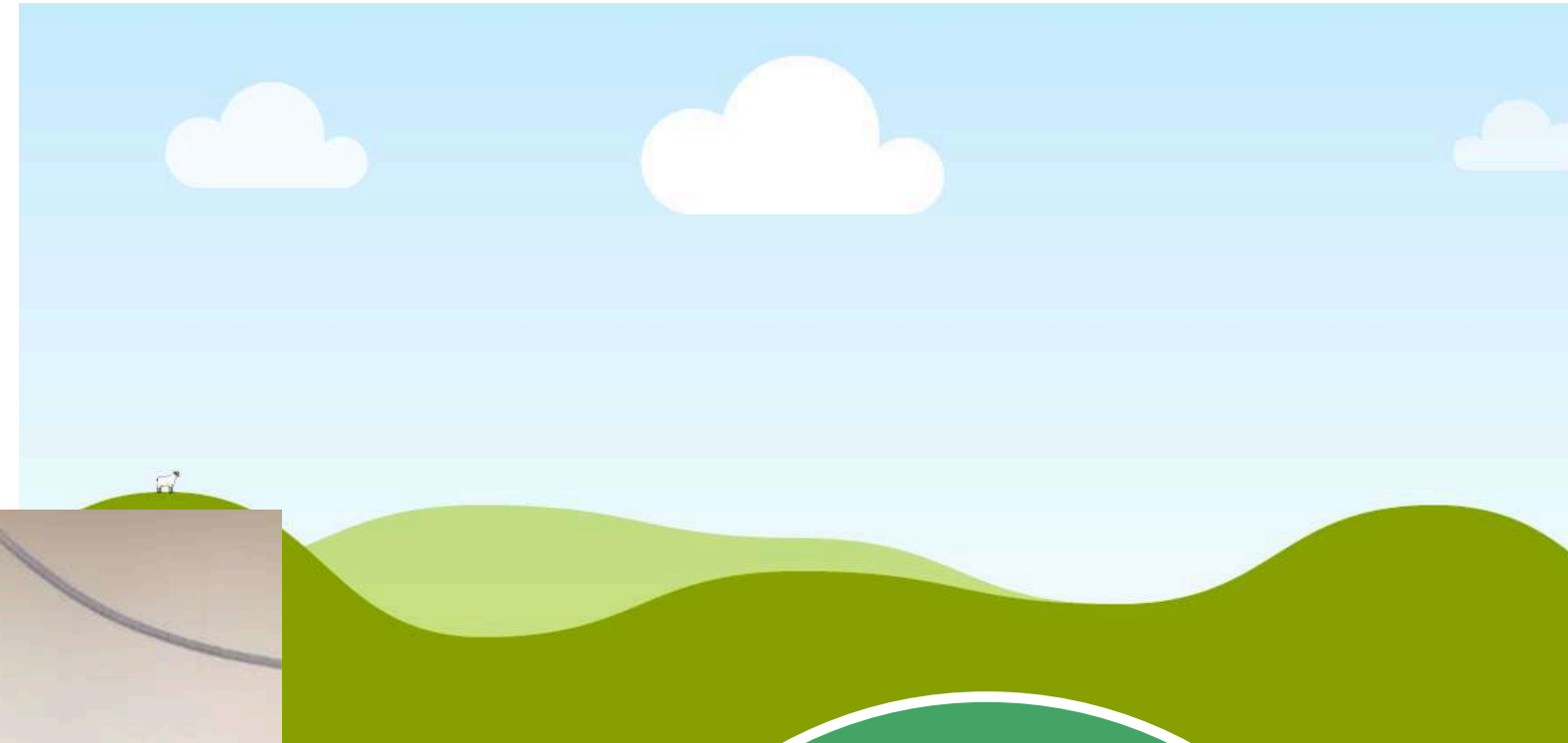
- Rothoterm evaporator
- avoids thermal degradation of heat sensitive materials
- quantity of solids in the dryer between 25% and 75% full.





Forward Osmosis

Forward Osmosis is a membrane based process that operates under low hydraulic pressure and uses selective membranes to concentrate liquids

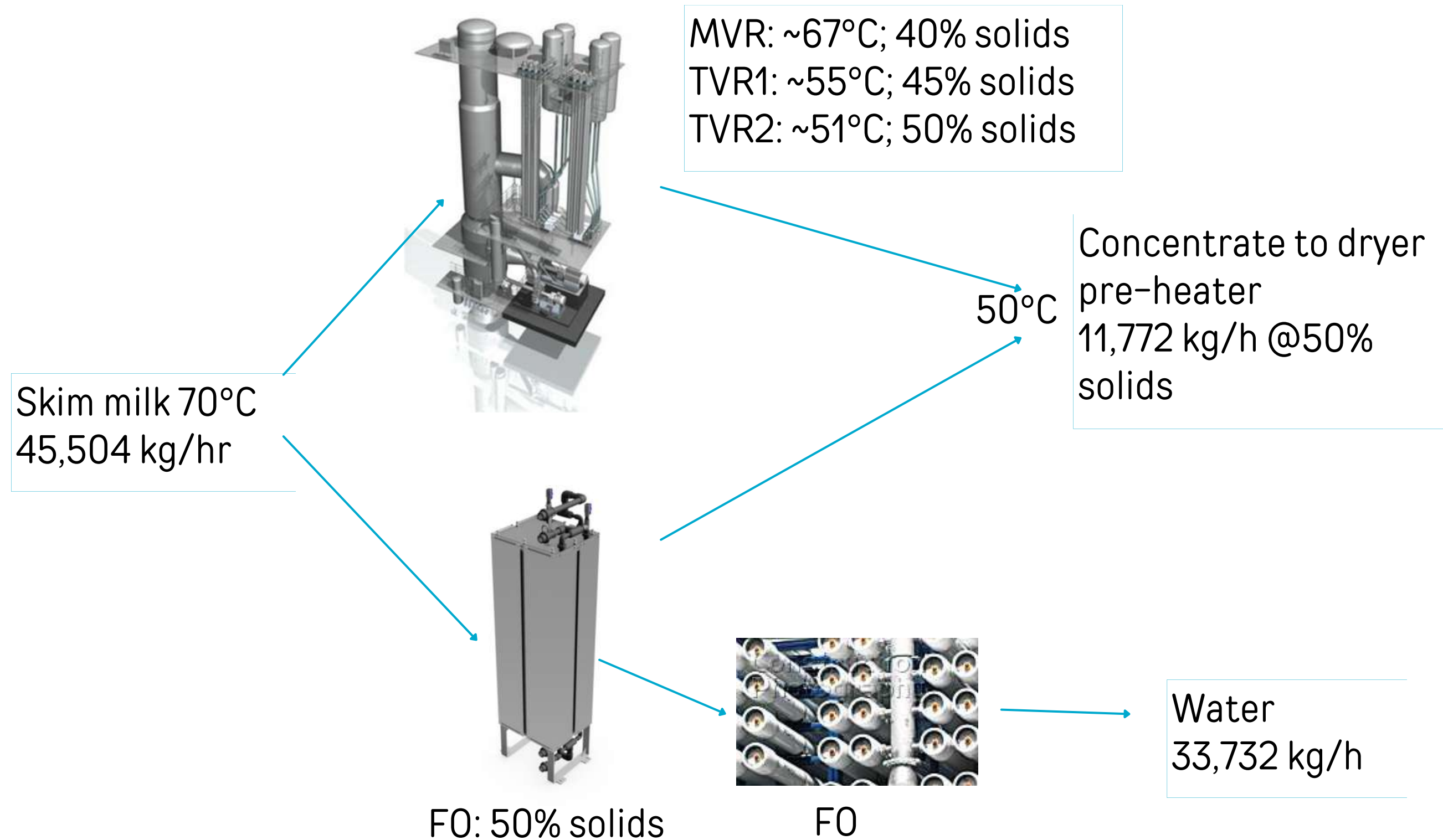


Key Attributes

- Cost effective
- Non-thermal concentration, proteins not denatured
- Retention of aroma compounds
- Enhanced functionality?
- Utilised early in the supply chain = reduced logistical costs



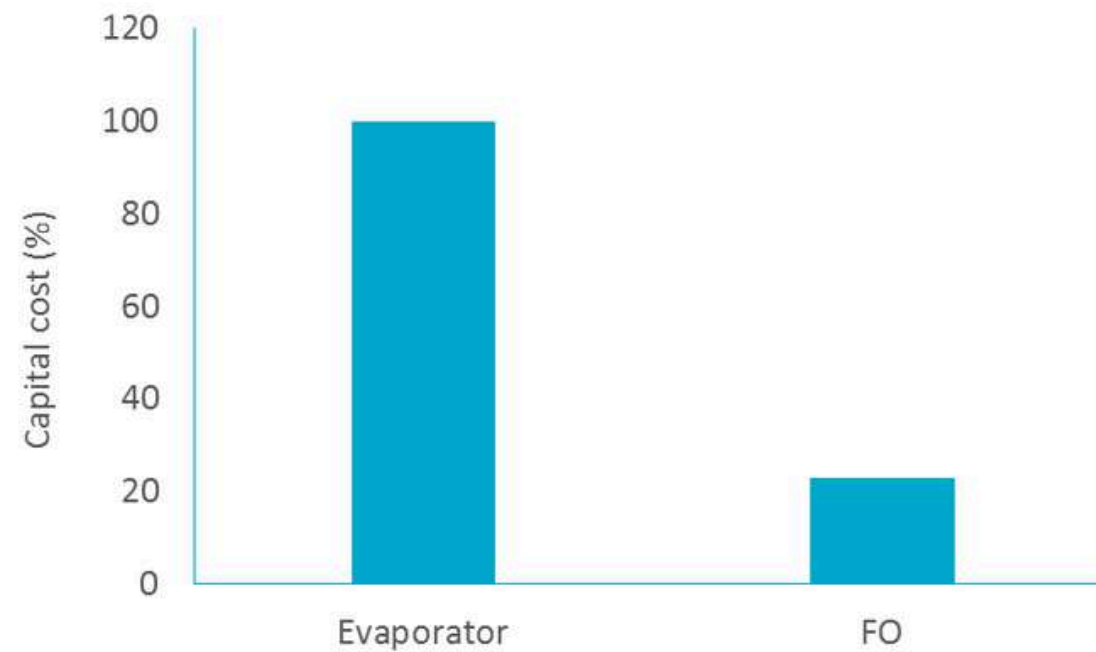
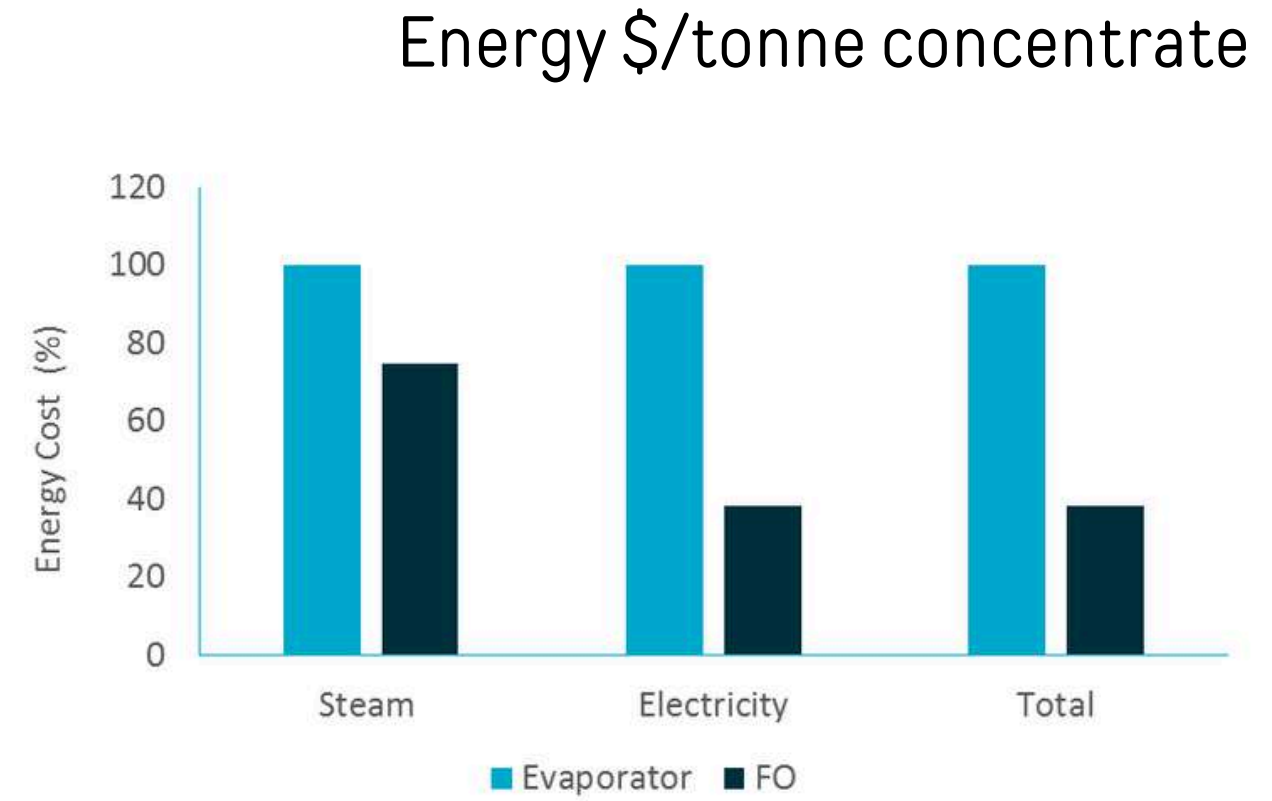
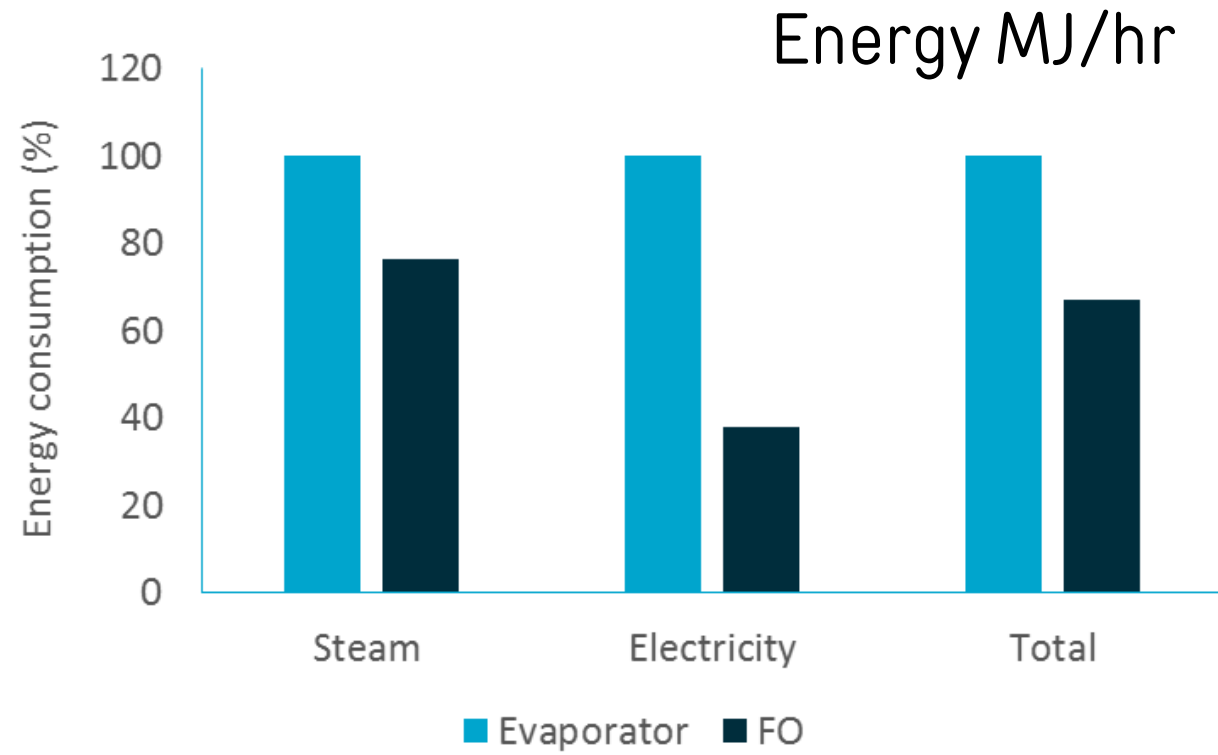
Comparison of FO with Evaporation





Comparison of FO with Evaporation

Energy and cost



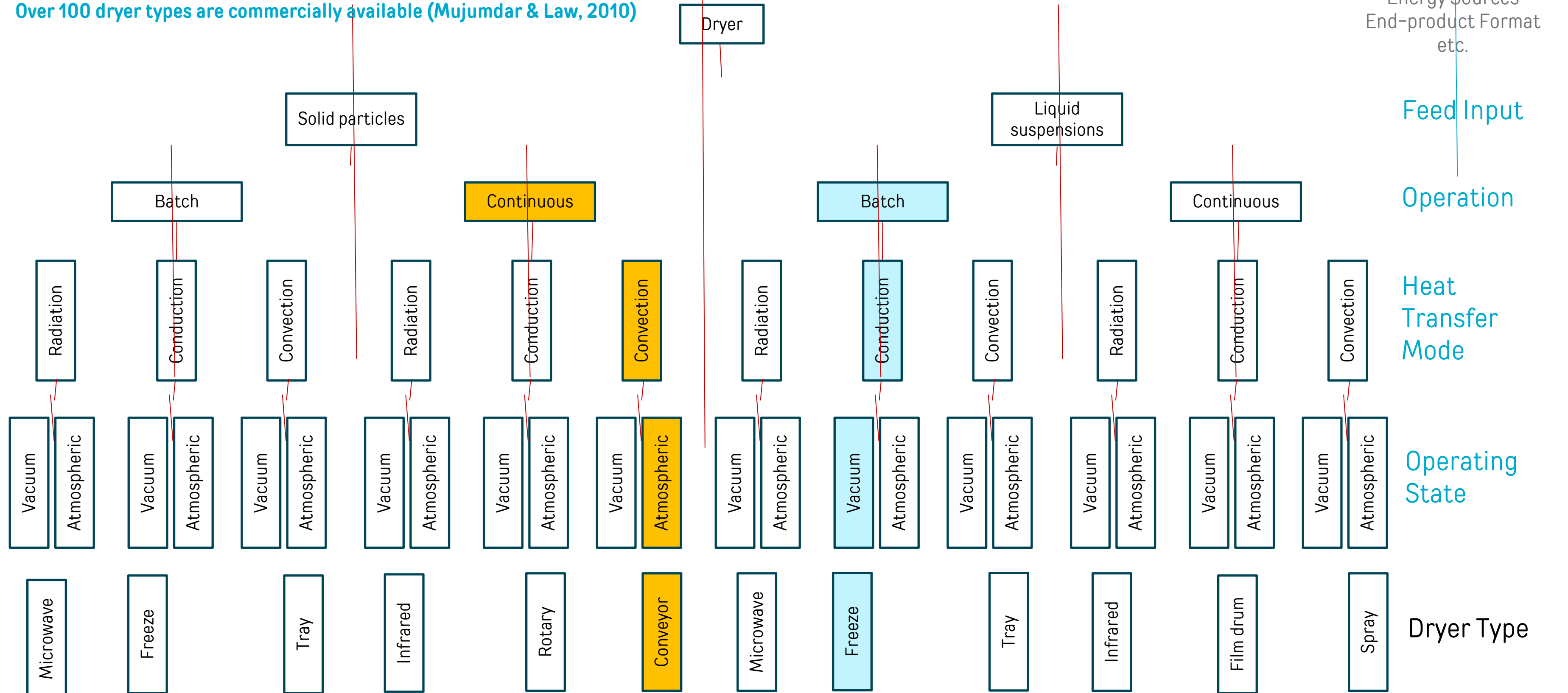
Steam - \$0.08/kg
Electricity - \$0.29/kWh

Evaporator CIP energy
not included



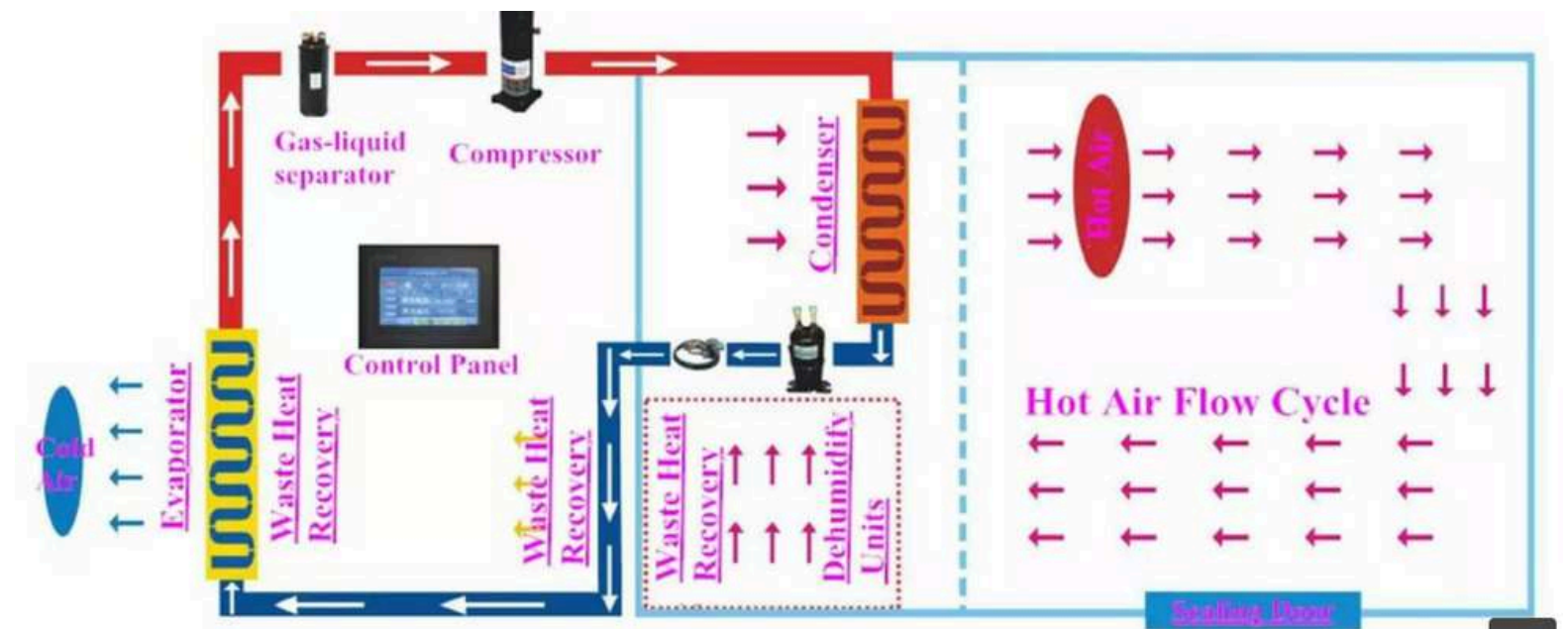
Simplified classification of dryers

Over 100 dryer types are commercially available (Mujumdar & Law, 2010)





Heat pump drying





Microwave tunnel dryer

REV technology scales with your business



REV10 kW

Freq: 2450 MHz
Vacuum: 12-300 Torr
Size: 7.9 x 5.8 ft
(2.4 x 1.8 m)
Ceiling: 10 ft (3.1 m)

**BEST FOR
R&D and
small-scale
producers**



REV60 kW

Freq: 2450 MHz
Vacuum: 25-300 Torr
Size: 38.3 x 12.5 ft
(12.2 x 4.6m)
Ceiling: 15 ft (4.6 m)

**BEST FOR
large-scale
producers**



REV100 & REV120 kW

Freq: 2450 MHz
Vacuum: 22-300 Torr
Size: 55.7 x 14.8 ft
(16.6 x 4.6 m)
Ceiling: 15 ft (4.6 m)

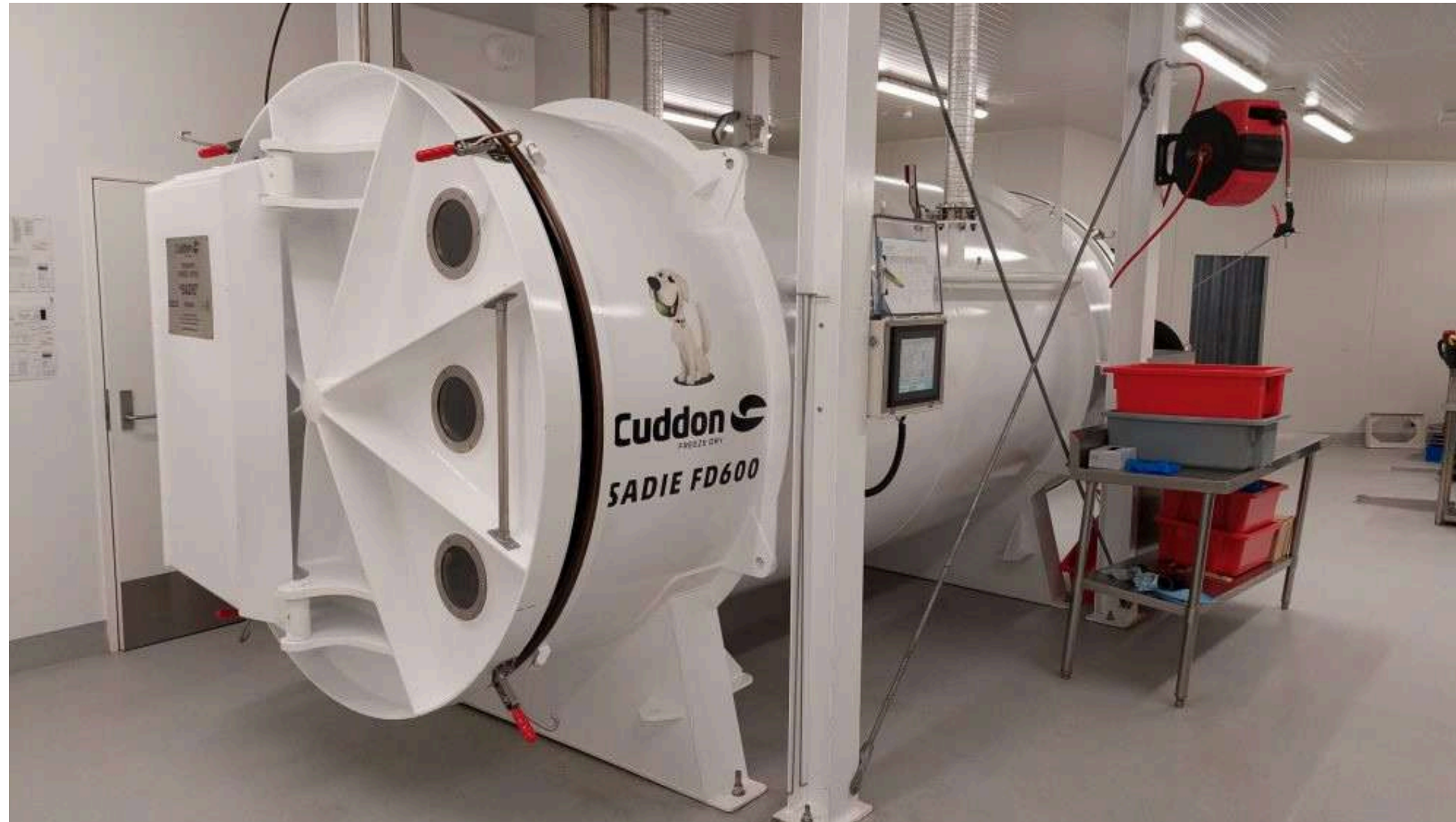
**BEST FOR
industry
leaders**



<https://youtu.be/0sAY2AcVWkl>



Freeze drying innovation



Low cost and emissions freeze drying using CO2 as refrigerant



Spiral flash dryer

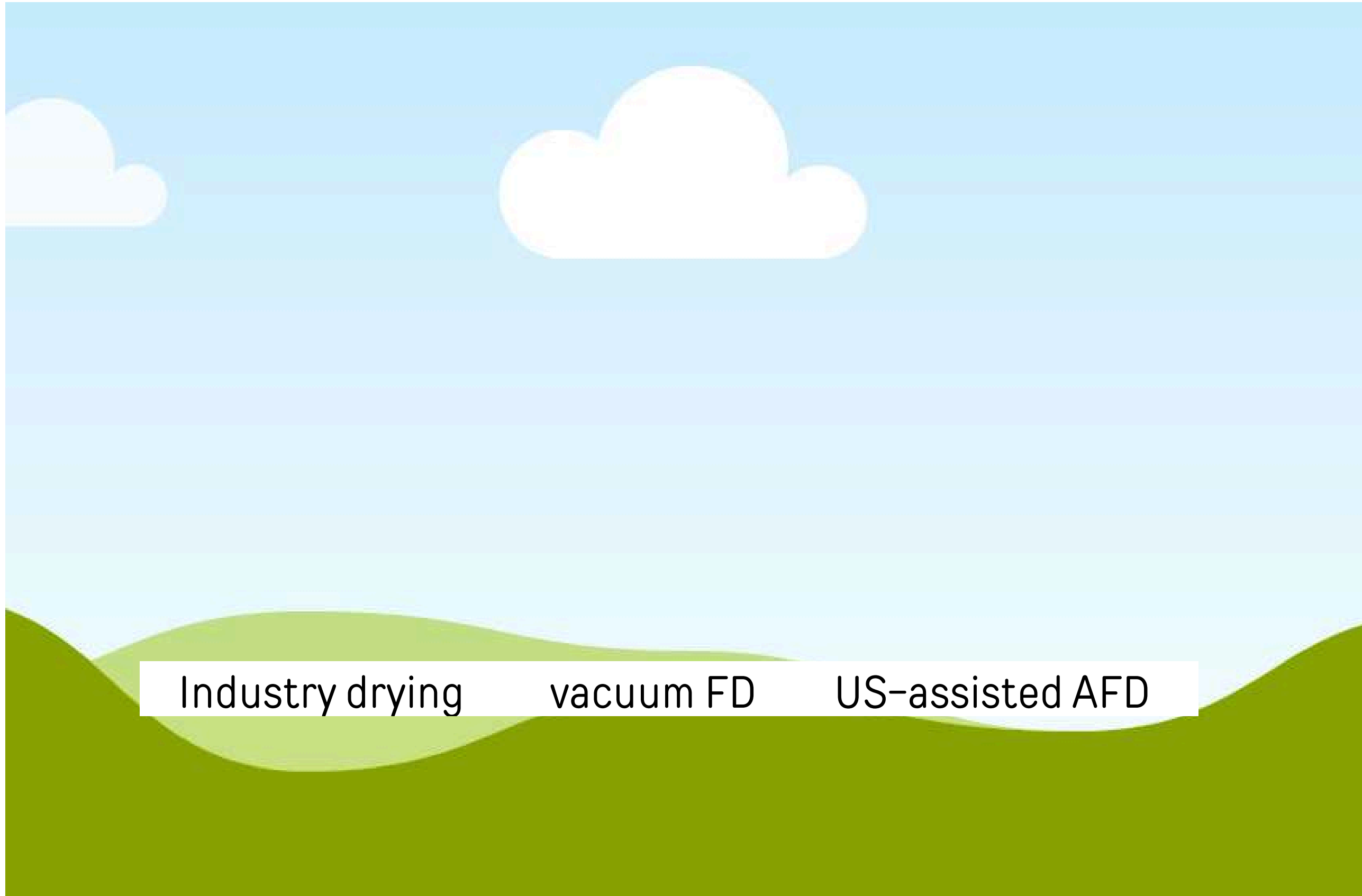


Filter caked materials, flakes, pastels, slurries, fibres, gels



Case Study: Drying of medicinal cannabis

(other products tested: fruits, meat, coffee, mushroom, soy protein concentrate)



VALUE PROPOSITION:



FASTER PROCESS

- about 3 times faster than Industry
- similar drying rate as FD



ENERGY EFFICIENT

- 35% less energy consumption compared with FD
- 20% less energy consumption compared with Industry



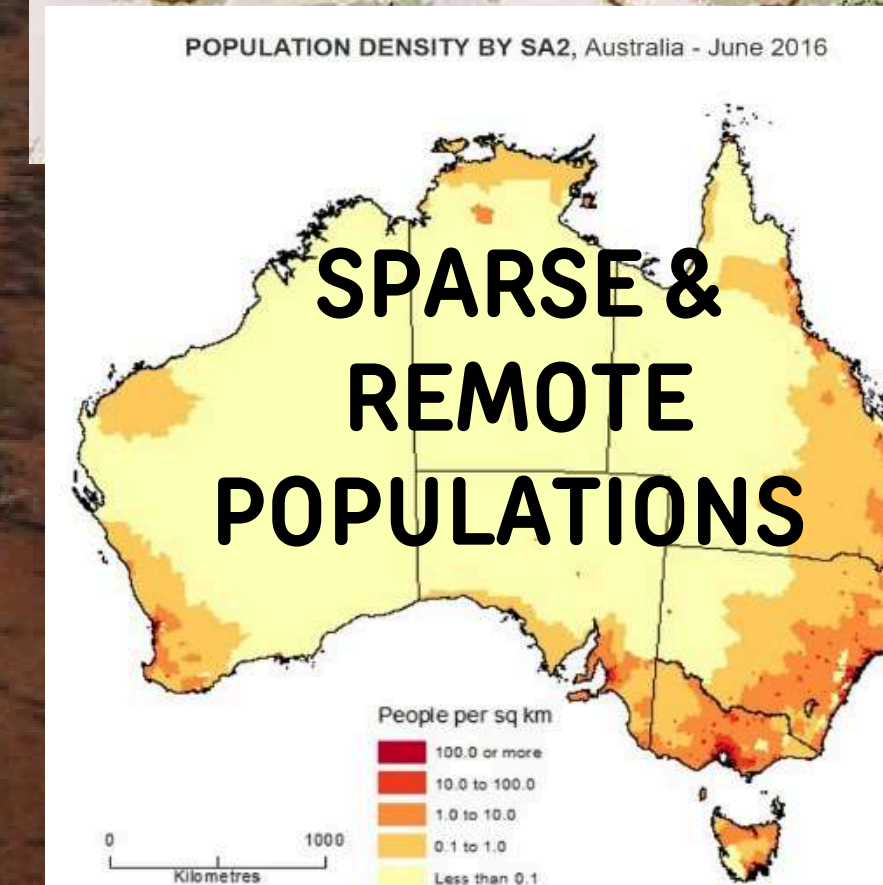
PREMIUM QUALITY

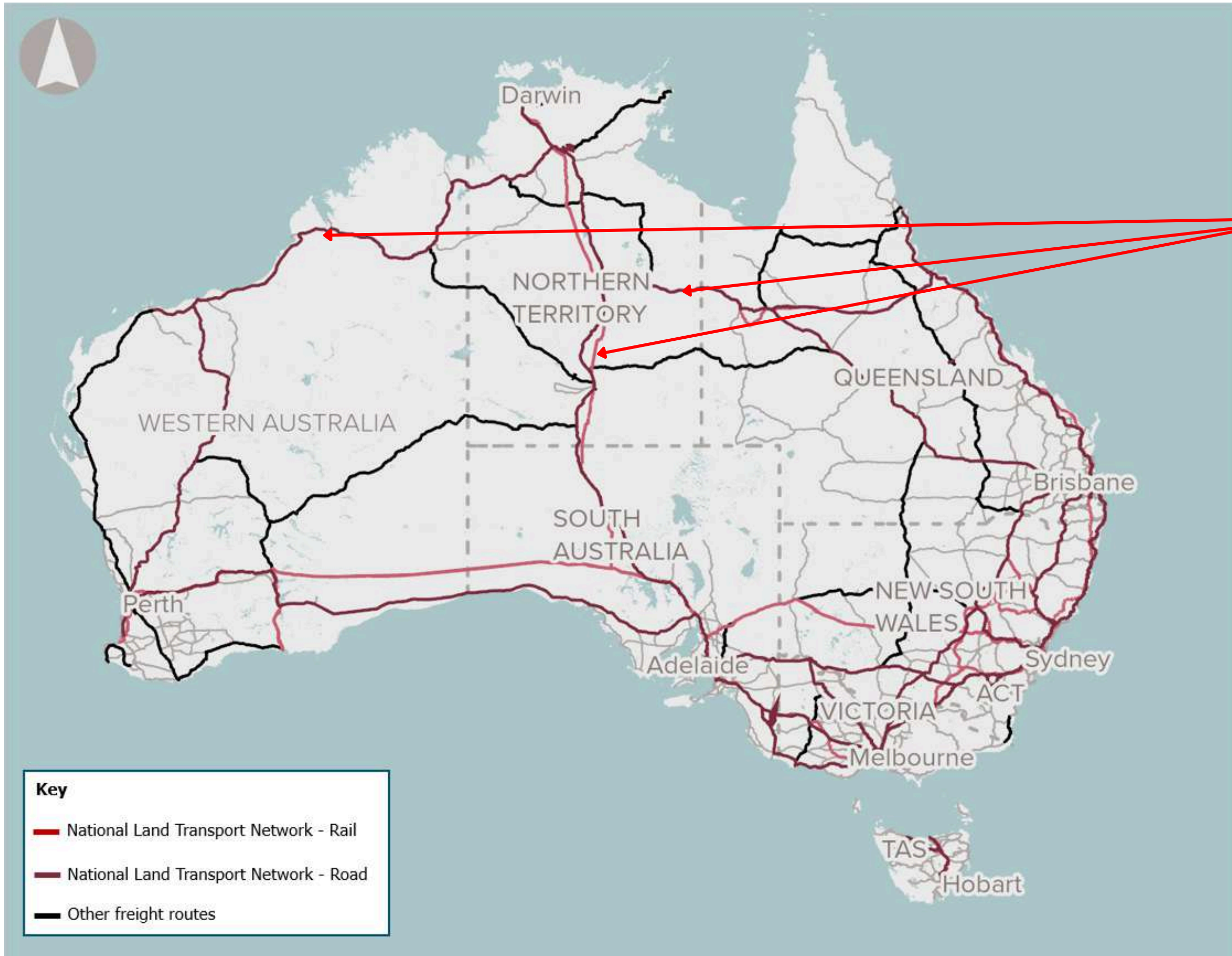
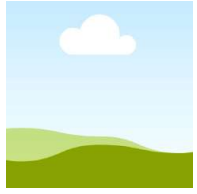
- ~100% cannabinoids retention (similar with FD)
- about 13% better retention of cannabinoids than Industry



How to ensure supply chain resiliency?

- Australia – has developed a level of food security complacency
- Food processing in remote northern Australia is limited to small niche businesses and bakery goods
- Most of Australia's food processing is located in southern Australia
- Long supply chains for northern Australia (3000 – 4000 km), are vulnerable to a wide range of perturbations –i.e. climate and fuel shocks





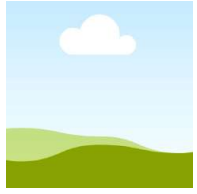
Key Northern Australian food supply conduits

Northern Australia Food Technology Initiative



Shelf-stable foods provide increased food security options for populations where cool storage of fresh foods is either problematic or non-existent.





Potential shelf-stable product types

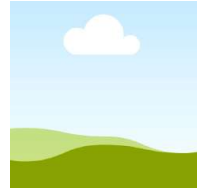
- **Functional meal ingredients:** Ready-to-use, pre-prepared food ingredients for consumers (e.g., meat powders), as well as for manufacturers and other food service organisations.
- **Snacks and convenience foods:** Opportunities including fruit powder and ready-to-drink juices, plus ready-to-eat snacks such as dried beef and fruit straps.
- **Pet food/pet snacks:** Opportunities from waste meat and fish produce, including human-grade premium pet food products for cats and dogs.
- **Health, wellbeing and beauty products:** Northern provenance ingredients for cosmetics, protein powders (meat-based, but possibly also jack fruit); and nutraceuticals that include plant/fruit powders and collagen powders; 'Indigenous-ceuticals' from First Nations foods such as Kakadu plum powder/puree).
- **Ready meals:** Home and out-of-home use, such as by campers, defence forces, aid/relief agencies, as well as caterers and others in the food service industry. Also potential for supplying manufacturers of complete ready meals with key meal components (e.g. meat, gravy and vegetables).



Markets and products for shelf-stable foods

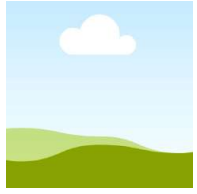
- Global demand for shelf-stable foods is increasing
- For wet and dry product lines
- For human and animal/pet consumption
- Improvements in food technology + household food security concerns
- **APAC Region**
 - shelf-stable meats \$US 8.7 B
 - shelf-stable seafood \$US 5.5 B





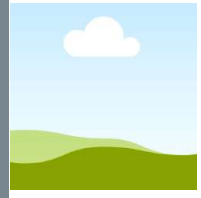
In pack shelf stable food





High Pressure Thermal Processing – Success through industry-research partnership

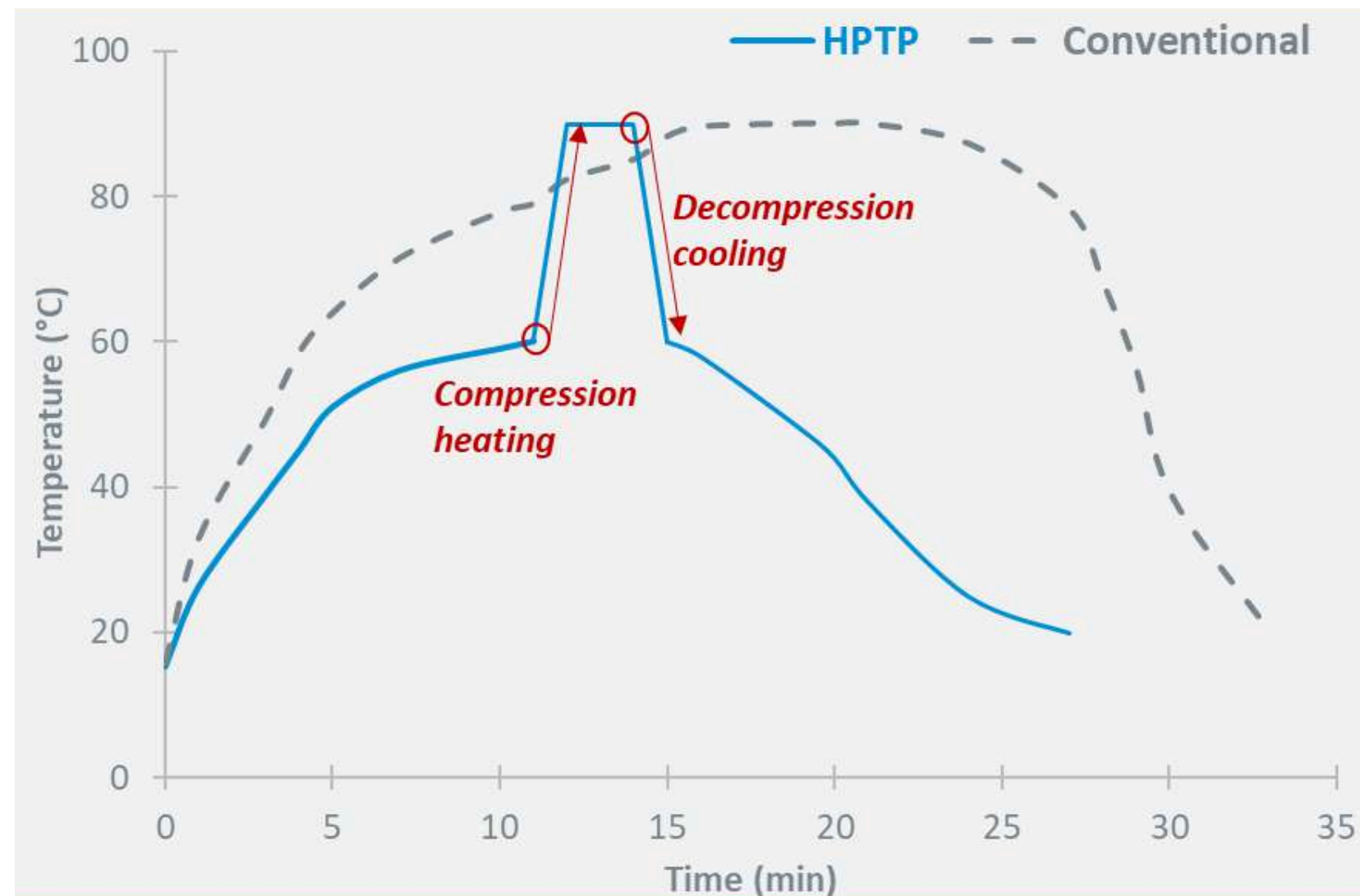




High Pressure Thermal Processing

The temperature of the product and the pressurisation water increases instantly due to heating from compression.

Minimises the negative impacts of thermal processing on food products.



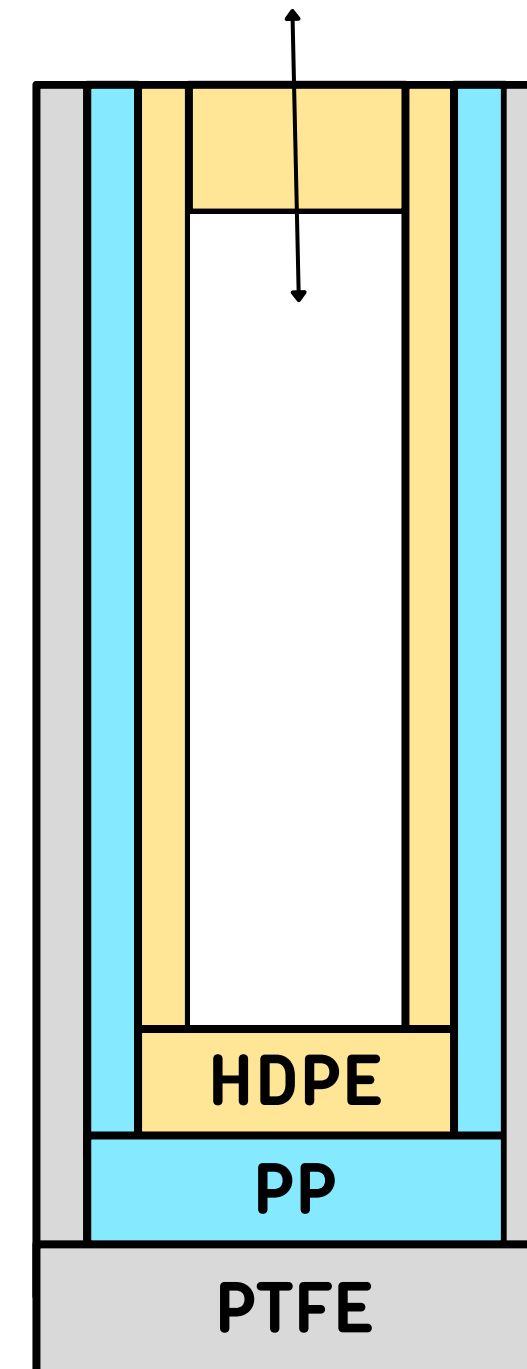


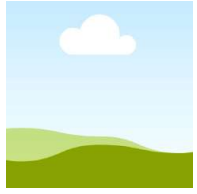
Equipment development

A multi-layered canister that facilitates HPTP in a cold HPP machine

Optimised heat retention through:

- Triple layer of **insulating** material
 - PTFE:** Lowest compression heating
 - PP:** Compression heating \approx water
 - HDPE:** Compression heating $>$ water; active heating!
- Sealed with moving piston: locks out cold water & allows pressure transmission





Canister available through Hiperbaric!





Microwave assisted sterilization



129mm x 129mm x 31.2mm
8.5oz fill weight (~250g)



171mm x 129mm X 25.7mm
10.5oz fill weight (~300g)



241mm x 125mm X 40mm
Bottom Gusset Pouch (~300g fill weight)



171mm x 129mm X 32.5mm
13.9oz fill weight (~410g)



171mm x 129mm X 32.5mm
12.7oz fill weight (~375g)



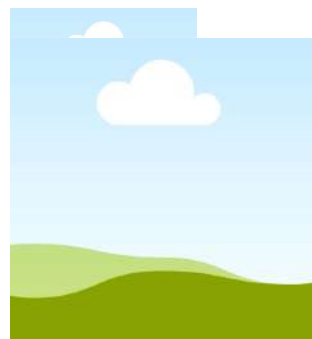
184mm x 133mm
Pillow Pouch (~230g fill weight)





Take home messages

- Supply chain resilience through
 - Food waste avoidance (shelf life extension) and upcycling
 - Developing of shelf stable foods to address food insecurity in remote locations
- A multi-indicator approach is required to agree on sustainable targets
- Novel evaporation, drying and sterilisation techs can drive the change



Thank you

Agriculture and Food

Pablo Juliano

Group Leader | Food Processing and Supply Chains

pablo.juliano@csiro.au

<https://people.csiro.au/j/p/pablo-juliano>