Extension of LCA into agriculture industries

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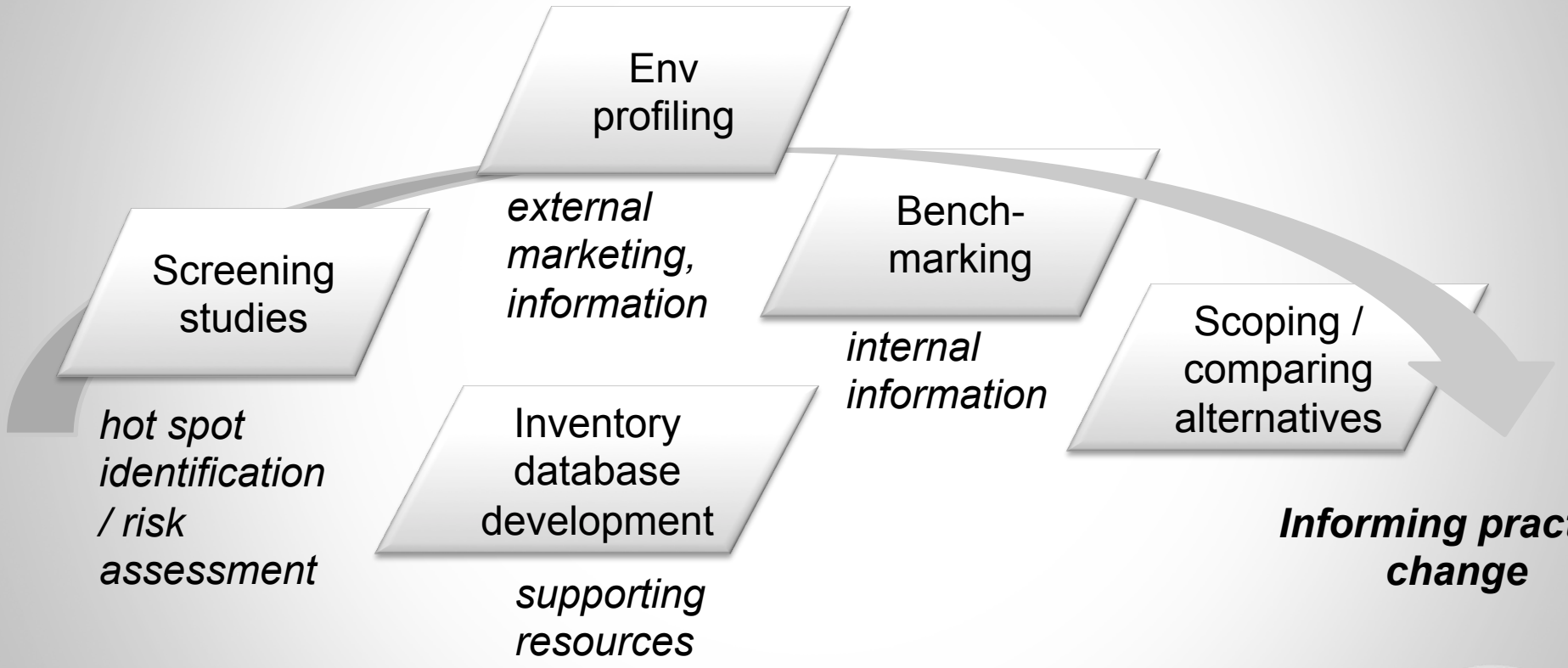
Extension of LCA into agriculture industries

- Is there a role for customised agricultural LCA tools?

- Modes of LCA extension into industry
- Industry LCA tools
  - Examples of existing tools
  - Case study - CaneLCA
  - Pros and cons
- Combined environmental and economic assessment

MODES OF INDUSTRY EXTENSION



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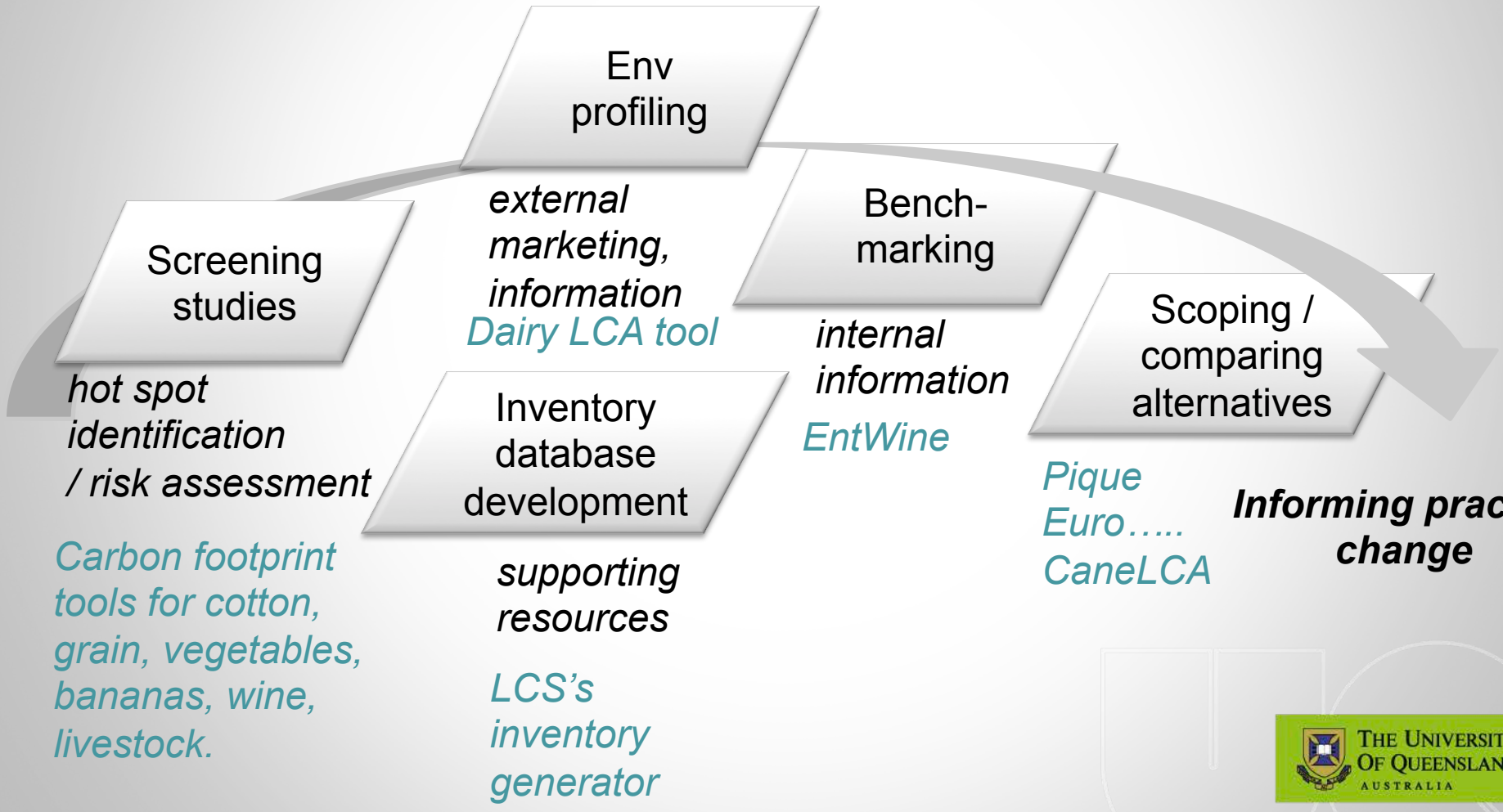
AGRI-FOOD INDUSTRY TOOLS



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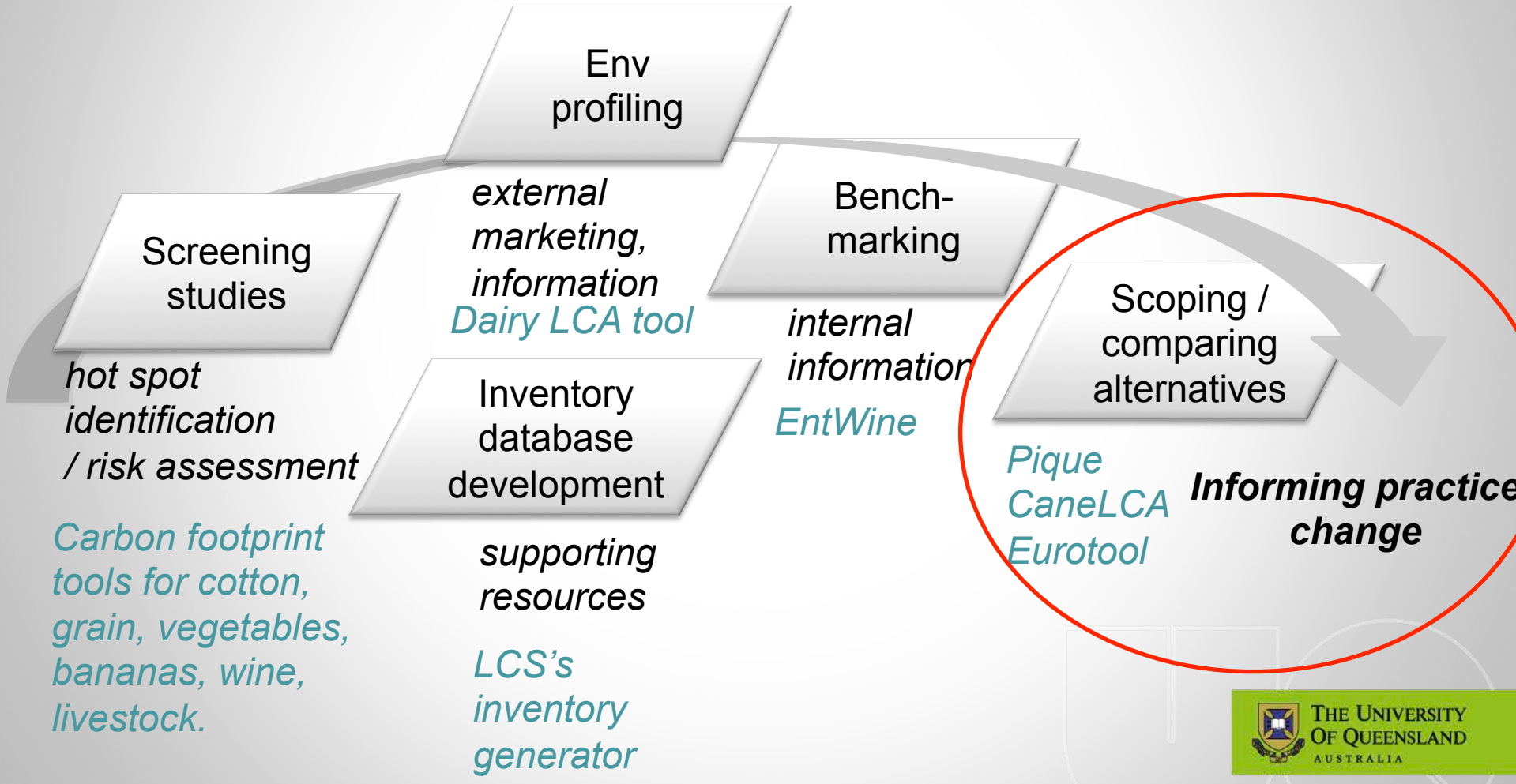
USE OF AGRI-FOOD INDUSTRY TOOLS



Australian Government
Sugar Research and Development Corporation

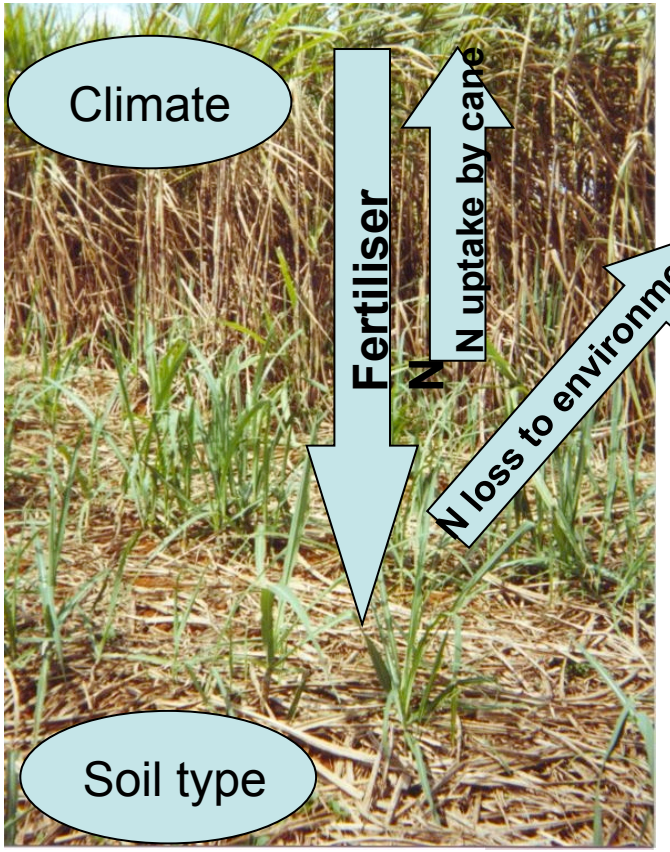
CaneLCA

LCA tool to support practice change in sugarcane growing

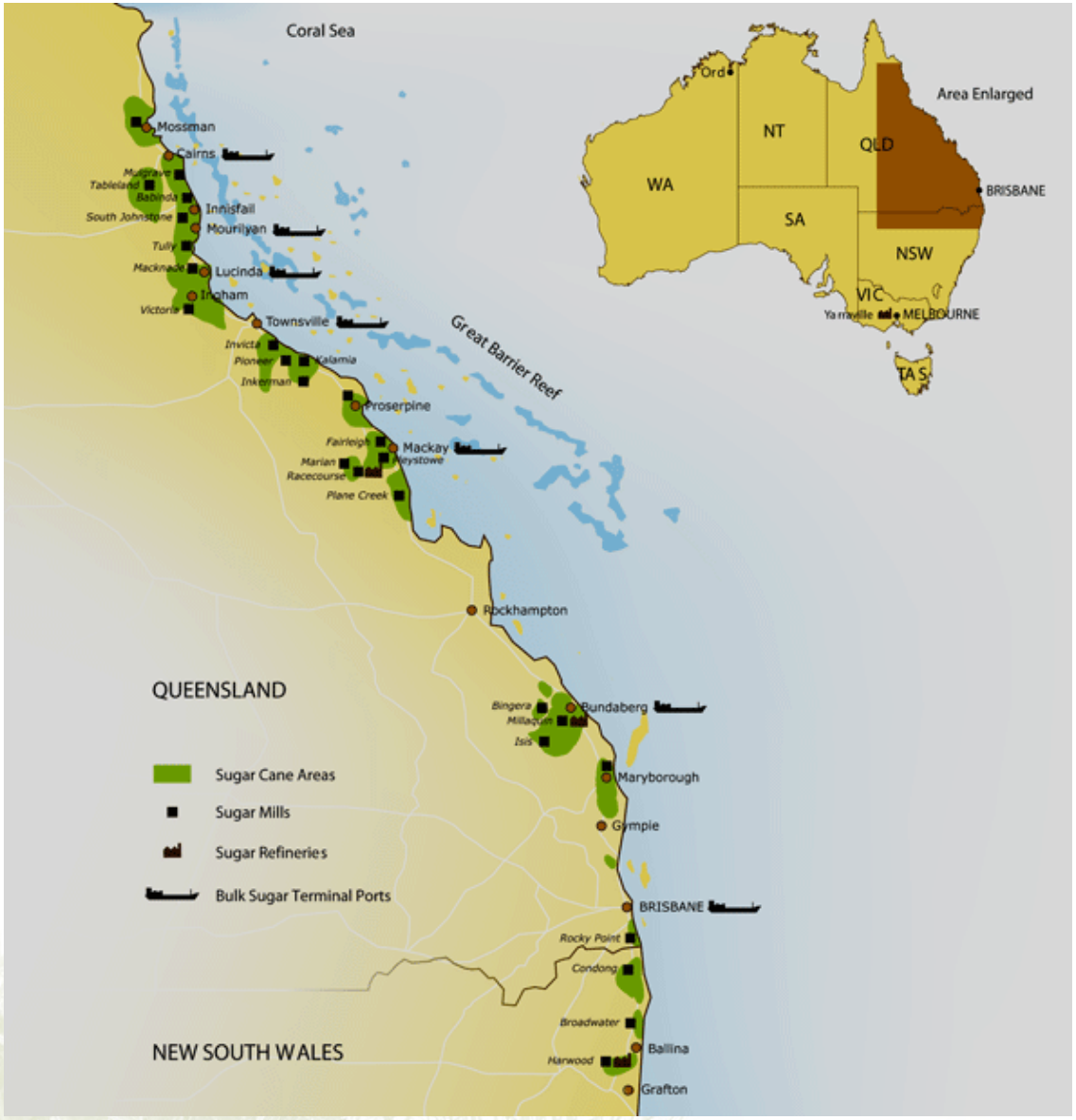
SRDC Project: No. UQ045

Investigators: Marguerite Renouf and Nicole Price, UQ
Peter Allsopp and Bernard Schroeder, BSES

Duration: 2010-2013


Climate
Fertiliser
N
N uptake by cane
N loss to environment
Soil type

Australian Government
Sugar Research and Development Corporation



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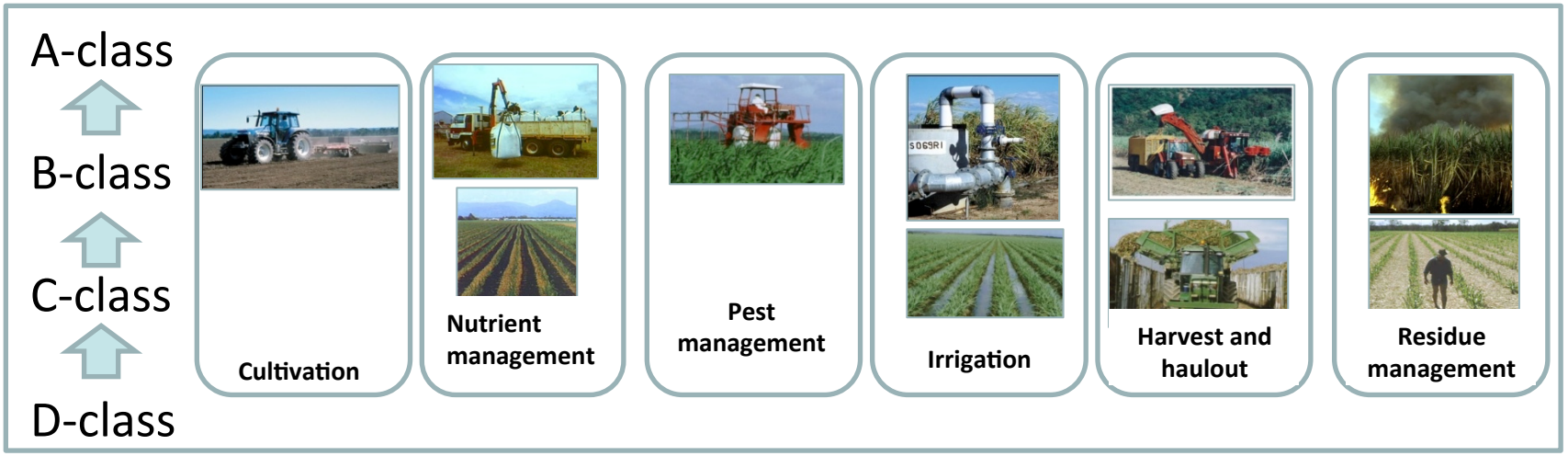
BSES
Sugarcane for the future

Investing in sugar research innovation

Project aims

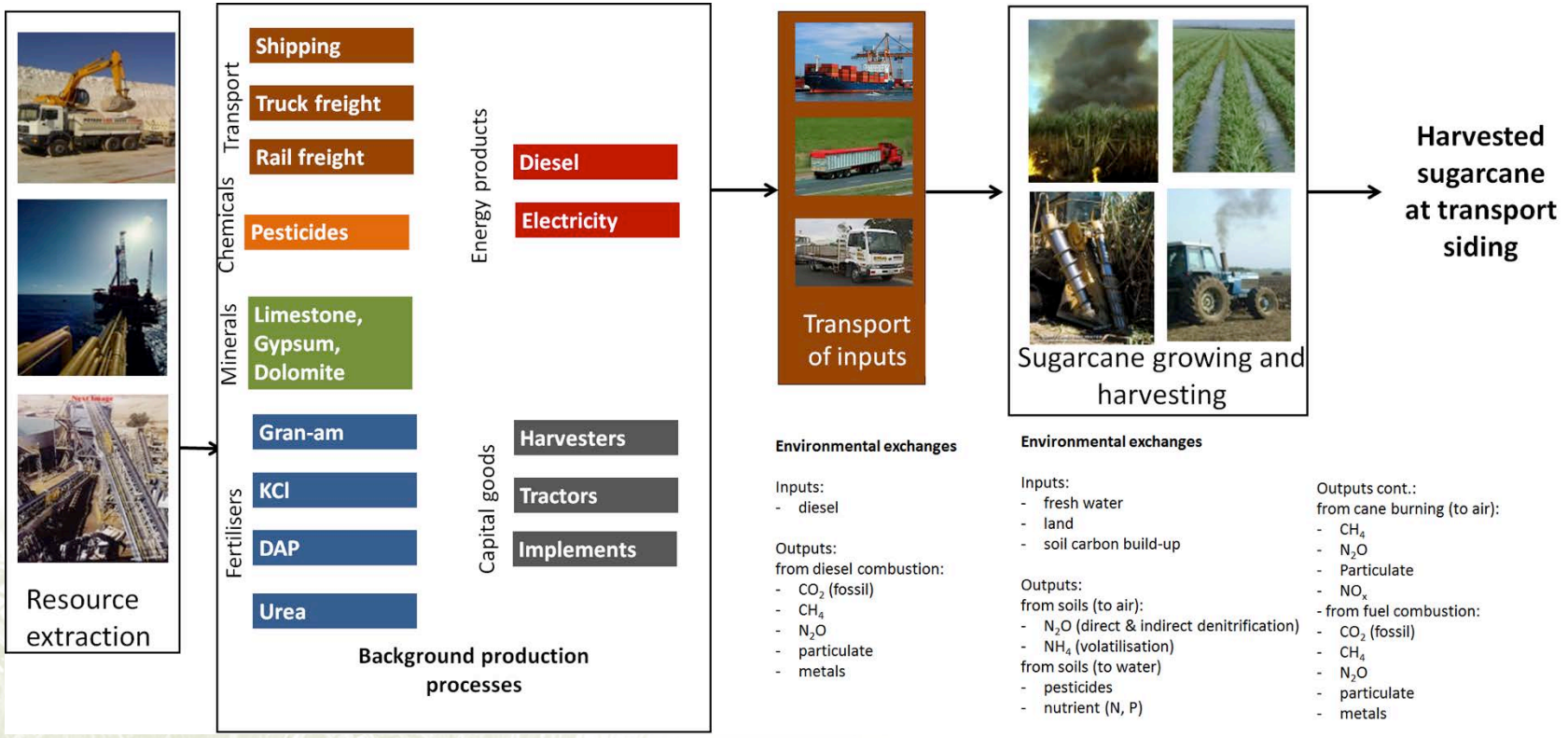
1. Assess the environmental impacts of different growing practices
   - **Do progressive practices have lower environmental impacts than conventional practices ?**



2. Develop a tool for assessing environmental performance
   - **Customised LCA tool for sugarcane growing - CaneLCA**

CaneLCA Eco-Efficiency Calculator
for Australian sugarcane producers
(Version 1.02)

‘Cradle to farm gate’ partial LCA



DATA INPUT (Sheets 1-8) Cane growing practices

data input by the user (per area)

1. Farm details
production details
farm equipment

2. Emission factors
define emission factors applied

3. Soil management
details of soil work:
- row width, tractor / implement used

4. Nutrient m'ment
- application rates for fertilisers, ameliorants, mill by-products
- tractor use for application

5. Pest management
- application rates for herbicide, insecticide, fungicide
- tractor use for application

6. Harvesting
type of harvesting
harvestor efficiency
residue management

7. Irrigation
water application rates
pumping energy use

8. Other activities
headland management
farm vehicle use

INPUT SUMMARY (Sheet 9)

calculated by the tool (per t cane)

transport effort (tkm)
-shipping
-rail and road frieght
-farm vehicle use
-shipping

machinery operation (MJ or kWh)
fuel / electricity use for:
-tractors, harvesters
-farm vehicles
-pumping

machinery production (kg)
-tractors, harvesters
-pumps
-irrigation infrastructure

water use (L)

agro-chemical inputs (kg)
-urea, DAP, Granam, KCl
-pesticide active ingredients
-lime, dolomite, gypsum

emissions (kg)
- N_2O to air (direct & indirect)
- NH_4 to air
- N & P to water
- COD (sugar) to water
- pesticides to water
- cane burning emissions to air

ENVIRONMENTAL IMPACTS

calculated by the tool (not reported)

Non-renewable energy input
(MJ/t cane)

Greenhouse gas emissions
(kg CO_2eq/t cane)
Carbon footprint

Eutrophication potential
(kg PO_{4eq}/t cane)

Ecotoxicity potential
(kg 1,4DCB_{eq}/t cane)

Water use
(kL/t cane)
Water footprint

RESULTS (Sheet 10) Eco-efficiency indicators

calculated by the tool (as a % of industry ranges)

ENERGY USE

CARBON FOOTPRINT

WATER USE

WATER QUALITY RISK - from nutrients

WATER QUALITY RISK - from toxic substances

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Translates operational information into LCA inputs

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Water use
(kL/t ca
Water foc

Focuses on important aspect (not just GHG)

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calculated by the tool
(as a % of industry ranges)

ENERGY USE

CARBON FOOTPRINT

WATER USE

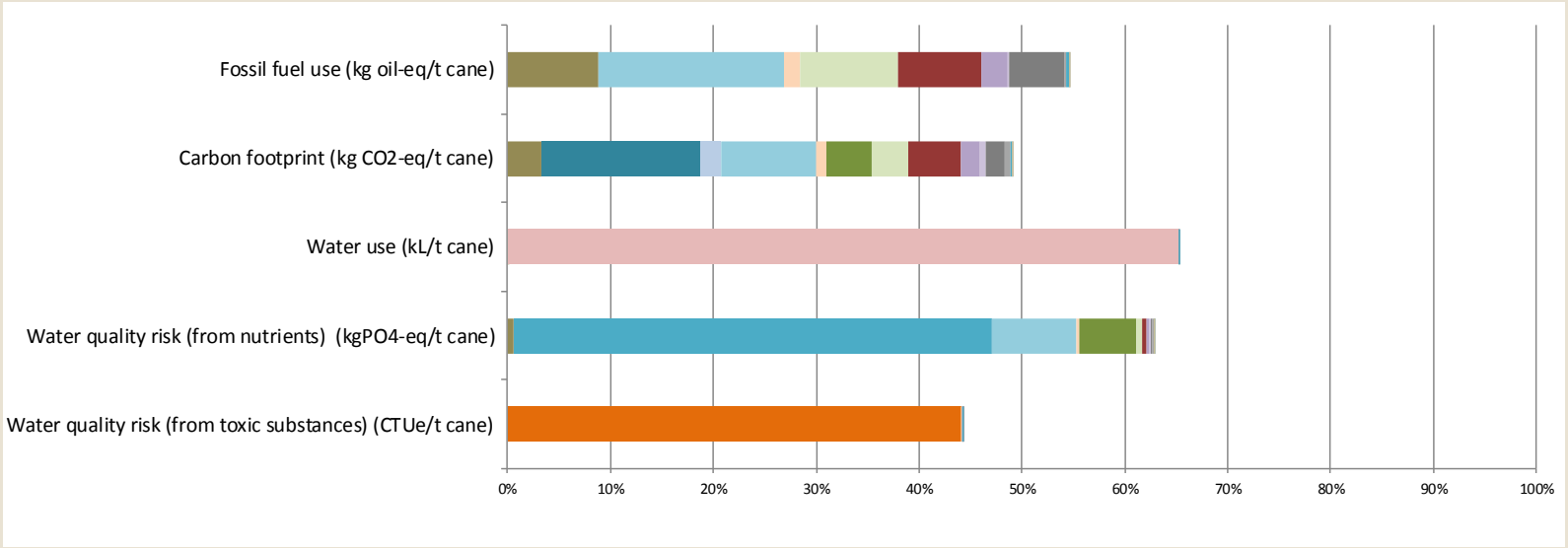
WATER QUALITY RISK - from nutrients

WATER QUALITY RISK - from toxic substances

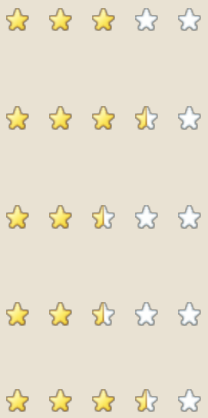
Presents LCA outputs in meaningful terms

Example of results

Environmental profile of the sugarcane operation (% of industry maximum)



Eco-efficiency Rating



Tractor, truck, vehicle operation
- Fuel use

Nutrient management
- Nitrous oxide (N_2O) from denitrification of N (to air)
- Carbon doxide (CO_2) from carbonation of lime (to air)
- Nutrient (N and P) emissions (to water)
- Production of fertilisers and ameliorants

Pesticide management
- Emissions of herbicide (to water)
- Emissions of insecticide (to water)
- Emissions of fungicide (to water)
- Production of pesticides

Harvesting
- Cane burning emissions (to air)
- Organic emissons (to water) from sugar loss
- Cane harvester operation
- Harvester operation for other crops

Water management
- Energy for pumping water on farm
- Water supply (including energy for upstream pumping of water)

Capital goods
- Production of machinery
- Production of on-farm irrigation infrastructure

Transport
- Transport of fertilisers (shipping from overseas)
- Transport of fertilisers and ameliorants (road freight)
- Transport of fertilisers and ameliorants (rail freight)
- Transport of fertilisers and ameliorants (local truck delivery)
- Transport of pesticides (shipping and road freight)

Results are not absolute values, but relative to industry range

Examples of user input fields

4. Pest and Weed Management

4.1 Practices

est and weed management practic	Meeting code of conduct	

4.2 Pesticides applied

4.2.1 Herbicides

							Active Ingredient 1			
Area descriptor	Name of herbicide product	Time of application	Area treated (ha) OPTIONAL	No. of applications	Application rate of herbicide product (L/ha or kg/ha)	Units (kg/ha or L/ha)	Active ingredient (AI 1)	AI content (g/L or g/kg)	Application rate (kg/ha)	Total applied (kg AI)
Plant cane	Diruex	Spike	20	3	0.3	kg/ha	Diuron	900	0.27	16.2
Plant cane	Atradex	Spike	20	2	0.5	kg/ha	Atrazine	900	0.45	18.0
Plant cane	Atradex	Spike	20	1	2	kg/ha	Atrazine	900	1.80	36.0
Plant cane	2,4-D Amine	Spike	20	3	1.5	L/ha	2,4 D Amine	625	0.94	56.3
Plant cane	Paraquat	Spike	20	3	1.5	L/ha	Paraquat	250	0.38	22.5
Ratoon cane	Diurex	Stooling out of hand	80	2	0.5	kg/ha	Diuron	900	0.45	72.0
Ratoon cane	Atradex	Stooling out of hand	80	1	0.5	kg/ha	Atrazine	900	0.45	36.0
Ratoon cane	Atradex	Stooling out of hand	80	1	2	kg/ha	Atrazine	900	1.80	144.0
Ratoon cane	2,4-D Amine	Stooling out of hand	80	2	1.5	L/ha	2,4 D Amine	625	0.94	150.0
Ratoon cane	Paraquat	Stooling out of hand	80	2	2	L/ha	Paraquat	250	0.50	80.0
Ratoon cane	2,4-D Amine	Out of hand	80	1	1.5	L/ha	2,4 D Amine	625	0.94	75.0
Fallow	Glyphosate	Cane knockout	20	2	3	L/ha	Glyphosate	450	1.35	54.0
Fallow	2,4-D	Cane knockout	20	2	0.5	L/ha	2,4 D	625	0.31	12.5

Calculation factors

8. Calculation factors

8.1 Environmental emission factors

	Species lost to the environment	Assumed emission factors (EF) Value	Unit	Source	User's value
Emissions to air	**Nitrous oxide** (N_2O) from **direct** denitrfication of nitrogen (N):				
	applied as conventional fertiliser	0.0125	kg N_2O-N/kg N applied	DOE, 2014	
	applied as controlled-release fertiliser	0.0125	kg N_2O-N/kg N applied	DOE, 2014	
	in cane harvest residue	0.0125	kg N_2O-N/kg N applied	DOE, 2014	
	from legumes (fixed and in residue)	0.0125	kg N_2O-N/kg N applied	DOE, 2014	
	Nitrous oxide (N_2O) from **indirect** denitrification of nitrogen (N):				
	gaseous N species that are redeposited on soil (NH3 and NOx)	0.0100	kg N2O-N/kg N redeposited	DOE, 2014	
	soluble N species lost through leaching and runoff	0.0125	kg N2O-N/kg N leached/ ruoff	DOE, 2014	
	Ammonia (NH_3) from volatilisation of:				
	fertiliser-N surface-applied to bare soil	0.1313	kg N/kg N surface-applied	Chapman, et al., 1995	
	fertiliser-N surface-applied to trash blanketed soil	0.2313	kg N/kg N surface-applied	Chapman, et al., 1995	
	dunder-N surface-applied to bare soil	0.0875	kg N/kg N surface-applied	Chapman, et al., 1995	
	dunder-N surface-applied to trash blanketed soil	0.1625	kg N/kg N surface-applied	Chapman, et al., 1995	
	CO2 from carbonation of limestone (CaCO3)	0.3960	kg CO2/kg limestone applied	DOE, 2014	
	CO2 from carbonation of dolomite (CaMg(CO3)2)	0.4530	kg CO2 /kg dolomite appied	DOE, 2014	

Calculated parameters

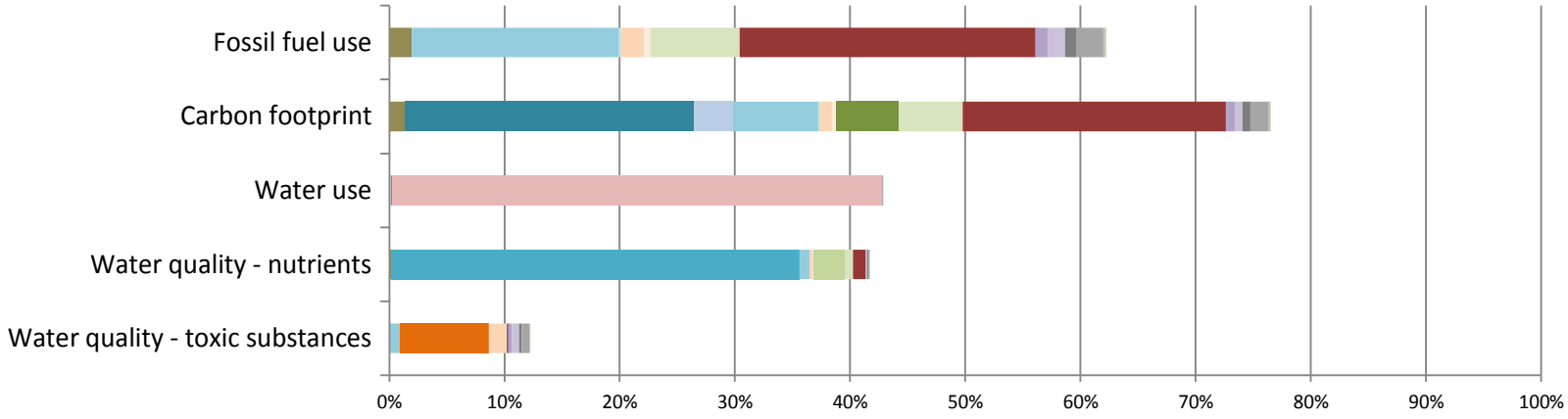
2. Fuel use for on-farm tractor, truck and vehicle operation

					Plant cane	Ratoon cane	Calculated parameters
Soil work	Soil work for crop establishment	Diesel / bio-diesel	L		3,351	431	0.66 L diesel / t cane (soil work)
Nutrient management	Applying nutrient products	Diesel / bio-diesel	L		208	288	0.05 L diesel / t cane (nutrient app.)
Pest management	Applying pesticides and weed control	Diesel / bio-diesel	L		400		0.04 L diesel / t cane (pesticide app.)
Harvesting	Harvest and haulout of cane and break crops		L		2,361	6,851	1.00 L diesel / t cane (harvest / haulout)
Other activites	Headland slashing	Diesel / bio-diesel	L		60		0.01 L diesel / t cane (slashing)
	Farm vehicles	Diesel / bio-diesel	L		1,500		0.16 L petrol / t cane (farm vehicles)
		Petol / ethanol	L		0		0.00
	Total farm fuel use	**Diesel / bio-diesel**	**L**		**17,750**		**1.93 L diesel / t cane (total)**
		Petol / ethanol	**L**		**0**		0.00

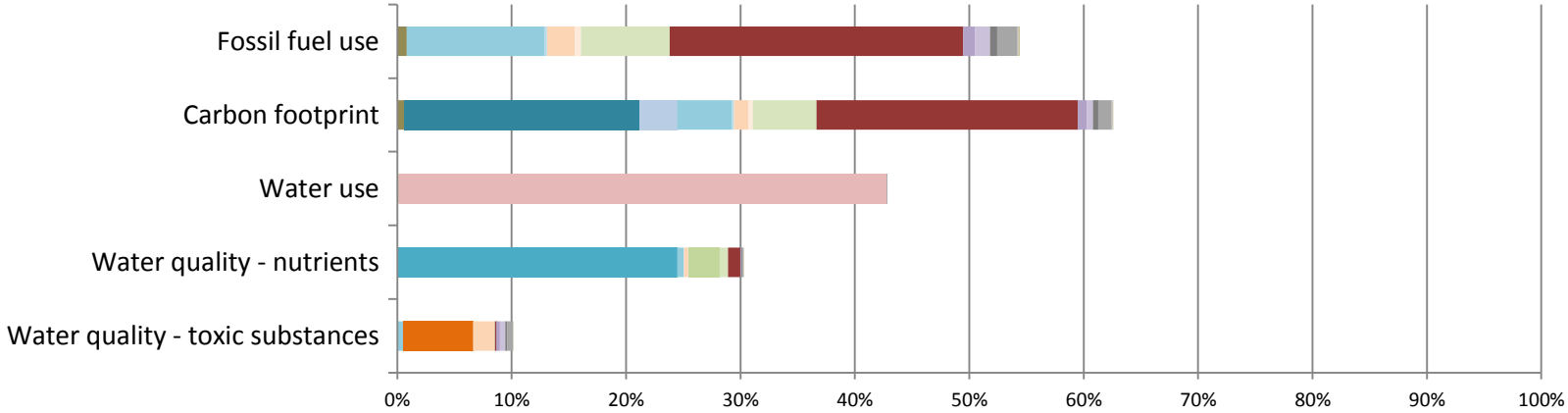
3. Nutrient management

					Plant cane	Ratoon cane	Calculated parameters
Nutrient products applied	Mill by-products and organic fertilisers	Dunder	m^3				0.00
		Mill mud	m^3				0.00
		Ash	m^3				0.00
		Mill mud/ ash mix	m^3				0.00
	Syntheic fertilisers	Urea	kg		2,581	24,511	2.94 kg urea / t cane
		Diammonium phosphate (DAP)	kg		7,668	8,742	1.78 kg DAP / t cane
		Potassium chloride (KCl)	kg		9,550	19,597	3.17 kg KCl / t cane
		Ammonium sulphate or sulphuric acid	kg		826	8,475	1.01 kg Gran-am/ t cane
	Ameliorants	Lime (agricultural)	t		40		0.00 t lime / t cane
		Dolomite	t				0.00
		Gypsum	t				0.00

Central C-class (before)



Central B-class (after)



Soil management	Tractor operation for soil work
Nutrient management	Nitrous oxide (N_2O) emissions (to air)
	Carbon doxide (CO_2) from lime (to air)
	Nutrient emissions (to water)
	Production of fertilisers and minerals
	Tractor operation for applying nutrient products
	Truck operations for applying nutrient products
Pesticide management	Emissions of herbicide (to water)
	Emissions of insecticide (to water)
	Emissions of fungicide (to water)
	Production of pesticides
	Tractor operation for applying pesticides
Harvesting	Emissions (to air) from cane burning
	Organic emissons (to water) from sugar loss
	Cane harvester operation
	Harvester operation for fallow crops
Irrigation / dewatering	Pumping
	Machinery operation for irrigation
	Extraction of water from managed water resources
Other farm operations	Tractor operation for slashing
	Farm vehicle operation
	Production of farm assets
	Water heating for treating seed cane
Transport	Transport of fertilisers (shipping from overseas)
	Transport of fertilisers and minerals (domestic freight)
	Transport of fertilisers and minerals (local delivery)
	Transport of pesticides (shipping and freight)

APPLICATIONS TO DATE

Industry policy applications:

- Validate the environmental benefits of best management practices
- Evaluate environmental benefits alongside farm profitability

Research applications:

- Evaluate innovative N management strategies

OPPORTUNITIES AND CHALLENGES

PROS (Opportunities)	**CONS (Challenges)**
Flexibility to evaluate many different practices and parameters	Obsolescence / duplication of tools
Reporting results on relative terms '**hides' uncertainties**	Ongoing maintenance and updating
Promotes **industry ownership** of LCA	Agriculture-only focus rather than product life cycle
Value is in **identifying trade-offs**	May need to link to agronomic models to be most effective
Can readily be **linked of farm profitability** (economic) evaluation	
Most suited to analysis of practices at farm, farming system scale	Does not capture variation / statistical distribution so less useful at industry scale

CONCLUSIONS

LCA methodology is reaching enough maturity to consider making LCA more accessible to agriculturalists

Increasing activity and sophisticated in the design of ‘progressive’ agricultural practices

Are customized / streamlined LCA tools a useful mode for doing engaging agricultural industries?

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