REDUCING EMISSIONS, CONSERVING NATURAL CAPITAL AND IMPROVING FARM PROFITABILITY – BARRIERS TO AND SOLUTIONS FOR DELIVERING ‘WIN-WIN’ OUTCOMES ON THE LAND.

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ABSTRACT

Emissions from the Australian agricultural environment are a matrix of animal, animal waste, soil, fossil fuel, fire and synthetic fertiliser emissions. The volume of soil carbon has reduced over time while the variety and species of herbicide resistant weeds has increased significantly. Recovery of cultivated soil and lands that have become degraded are in focus from a research and practice perspective. Research and practices need to come together in trials that demonstrate the capacity of the agricultural environment to reduce emissions.

The described practice is complimentary to cropland and grazing land management techniques, restoring land with low carbon stocks or in a degraded state. The practice faces a barrier of distance and a required adherence to Australian standards to be successful. Solutions are evident in both aspects through increased use of services currently subsidised by Government, and Technology currently available and in use by a small but growing Australian Industry. The practice delivers win-win outcomes for all stakeholders.

Following the description of the practice the paper will address consultation questions 29 – 33 of the Action on the Land – Issues paper.

INTRODUCTION

Emissions as a result of cultivation to manage weeds and soil disturbance by introduced feral animal species, have been part of the Australian agricultural environment since first European arrivals in the late 1800’s. Emissions have increased significantly since the 1950’s with the combined use of mechanised equipment burning fossil fuels, synthetic fertilisers, the continued use of fire on crop residues. These changes coupled with an increased number of domestic meat & milk animals and size of the agricultural landscape used for crop, has had a negative impact on the amount of available soil carbon.[i] Table 1 highlights Australian soil carbon stock recorded between 2000 and 2013 and used to calculate average stock of organic C in the 0-30cm soil layer for types of land use as shown below.

Table 1- Average Australian stock of organic C in the 0 – 30 cm soil layer for types of land use

Land Use	Nature Conservation	Horticulture	Irrigate Horticulture	Forestry	Improved Grazing	Irrigated Cropping	Cropping	Minimal Use	Grazing
Mean Sc (t/ha)	83.25	67.14	64.67	56.86	45.88	44.32	35.36	28.98	24.35

The amount of organic C varies with the type of soil and volume of organic matter it contains. The proportion of active organic C defines the capacity of the soil to provide nutrients. Active organic C results from the interaction of living micro-organisms and new residue that is generally processed over a 2 – 3 year cycle.[ii]

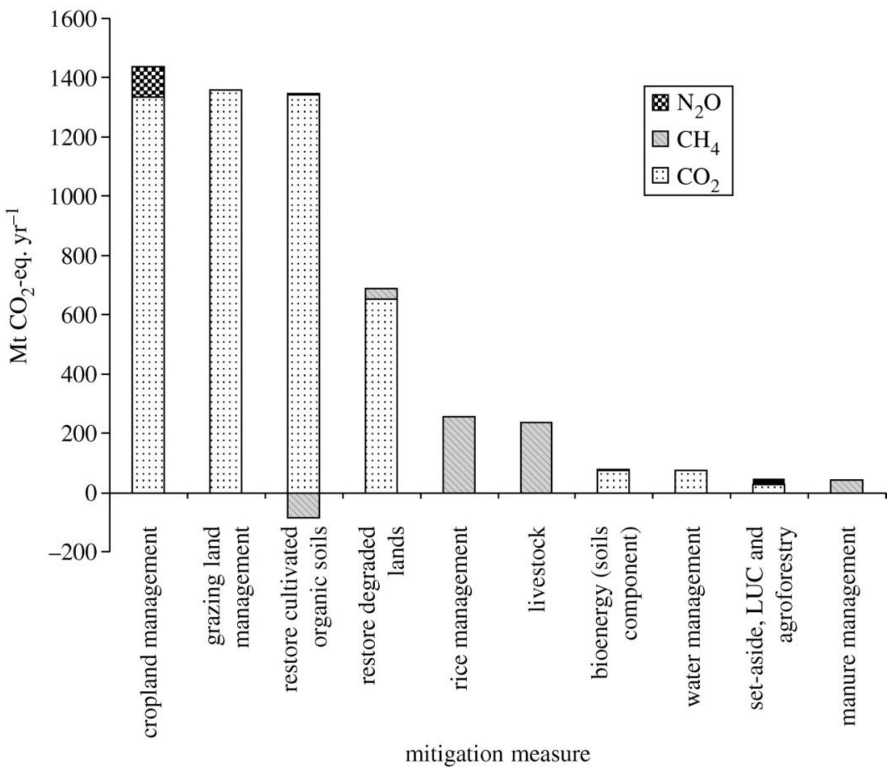
The recorded volume of organic C in Cropping land use types as recorded and shown in Table 1 is 57% lower than land used for Nature Conservation, reflecting a reduced capacity to provide nutrients to plants, which in practice are supplemented with synthetic fertilisers. There is a correlation between the availability of plant nutrients and ability of the plant to make use of current higher levels of CO2. The available soil nitrogen is a limiting factor in plants being able to make use of increased available CO2 .[iii]

The hypothesis is that the restoration of organic C in soils and farm management changes will conserve natural capital, sustain farm profitability, reduce emissions and deliver win-win outcomes for all stakeholders.

DISCUSSION

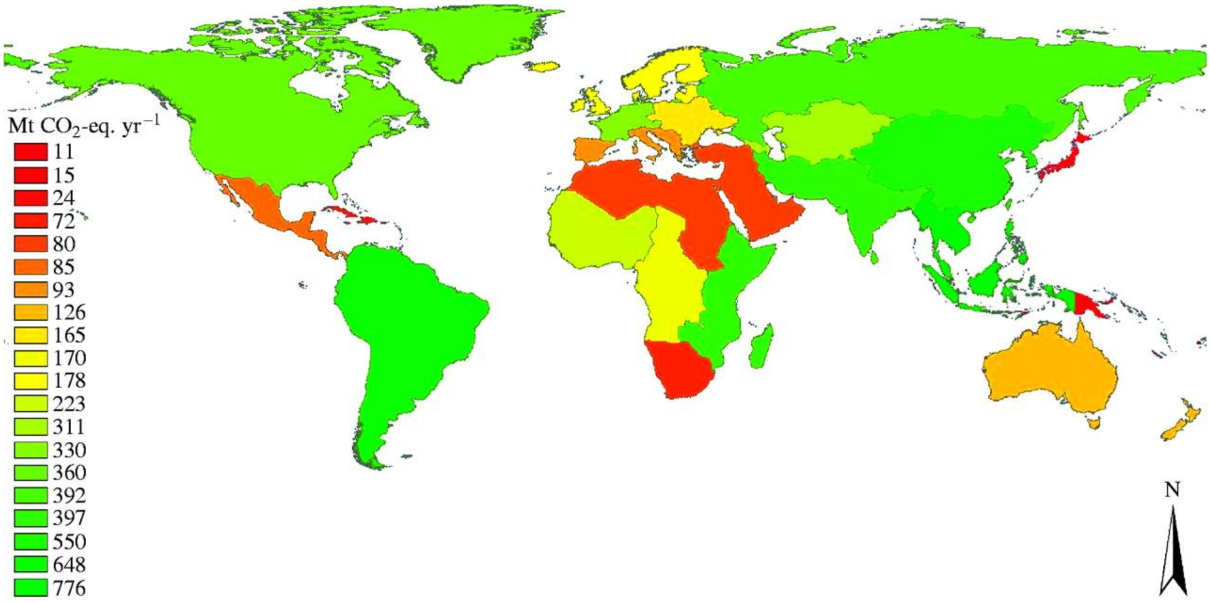
A study was completed in 2007[iv] to consider what Agricultural management practices if applied, would yield the greatest biophysical mitigation impact on emissions by 2030. 10 practices were identified (Figure 1) and modelled to demonstrate the mitigation total for all Carbon Dioxide, Methane and Nitrous Oxide emissions combined.

Figure 1- Mitigation measures to reduce emissions in the Agricultural landscape



Applying all of these practices to each region of the world with a target date of 2030, considering IPCC good practice guidelines, and applying these to world climate types and regions (Figure 2) enabled an average estimate for potential emission reduction on a global basis.

Figure 2 – Potential biophysical mitigation of emissions through improved agricultural practices by 2030



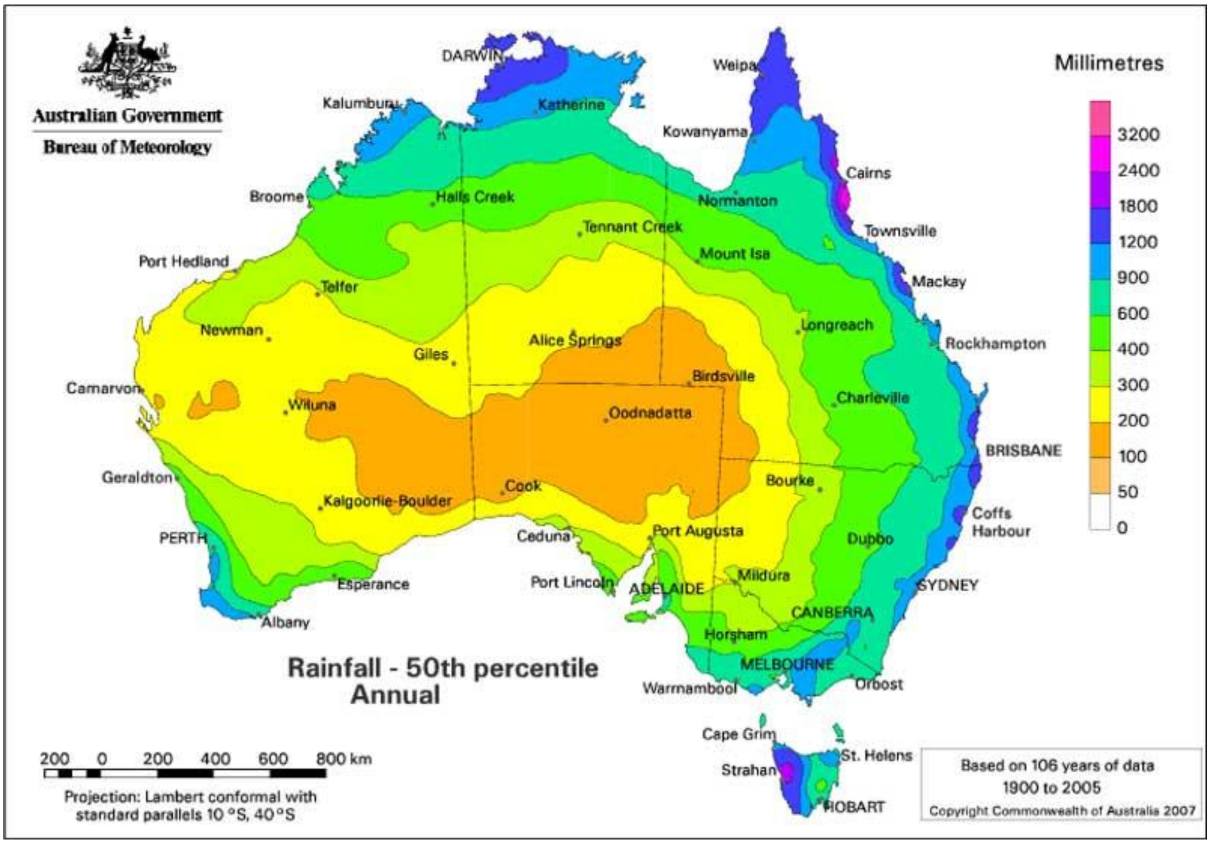
The capacity of the Australian agricultural landscape is rated at 126 Mt CO2 equivalents per year. This calculation considers the application of all 10 practices as outlined in Figure 1 – Cropland management, Grazing Land management, restoring cultivated organic soils, restoring degraded lands, rice management, Livestock, Bioenergy (soils component), Water management, Land set aside / lock up & agroforestry and manure management.

A focus on the largest potential emission mitigation practices – 600+ to 1400+ Mt CO2 eq yr globally, identifies Cropland management, Grazing land management, Restoring cultivated organic soils and Restoring degraded lands as the largest contributors to emission reduction, natural capital preservation and sustaining farm profitability. The described practice brings these together in a win-win solution for all stakeholders.

Considering the four practices in combination, Grazing land management contributes to emission reduction by ensuring grazing leaves a grass cover over the soil and minimises soil disturbance.[v] Cropland management contributes through stubble retention providing a soil cover, No Till to minimise soil disturbance and crop rotation introducing nitrogen fixing legumes into the rotation reducing the need for synthetic fertiliser.[vi] Restoration of cultivated organic soils and restoring degraded lands through the addition of treated organic matter, increases soil organic C benefiting crops and grazing land and ensuring the soil has the necessary nitrogen to enable plants to make use of current higher levels of CO2.[vii]

Organic matter is readily available where human populations live and rainfall is higher. An analysis of this in an Australian context is demonstrated in Figure 3 highlighting the coastal eastern, northern, south east and south west areas of Australia as having highest population and rainfall.

Figure 3 – Rainfall, Cities and Towns in Australian regions



The available organic matter in its raw state is unsuitable for application without further treatment. Treatment in the form of thermophilic aerobic composting produces organic matter in both form and nutrient quality suitable for addition to the soil (Table 2) but the production process must be carefully managed and monitored to avoid potential high levels of emissions.

Table 2 – Composting emission outputs and treatment benefits

Treatment effect	**Aerobic Windrow composting**	**Anaerobic composting - Landfill**
Emissions	8.6 – 85.2 kg/T	1200 kg/T
Outputs	492kg/T organic matter, N 17kg, P 3.4kg, K 7.4kg, S 2.4 kg, Ca 15.6 kg per cubic metre	492kg/T organic matter
Weed seeds	90% reduction over 268.5 hours at 115 degrees F	90% reduction over 268.5 hours at 115 degrees F
Carryover plant disease pathogens	Reduced disease pathogens	Reduced disease pathogens

Australian standard AS4554-2012 for Composts, Soil Conditioners and Mulches provides the solution in the form of general and specific requirements to manage compost emissions.

Table 2 also highlights the outputs per Cubic metre of organic matter composted. In order to sustain farm profitability the described practice calls for the part replacement of synthetic fertilisers with compost as organic fertiliser. A comparison of the fertiliser inputs and costs associated with this change (Table 3) reveal a similar nutrient and cost outcome when applied on a part compost part synthetic basis with a 492 kg/ha increase in organic matter applied to the soil.

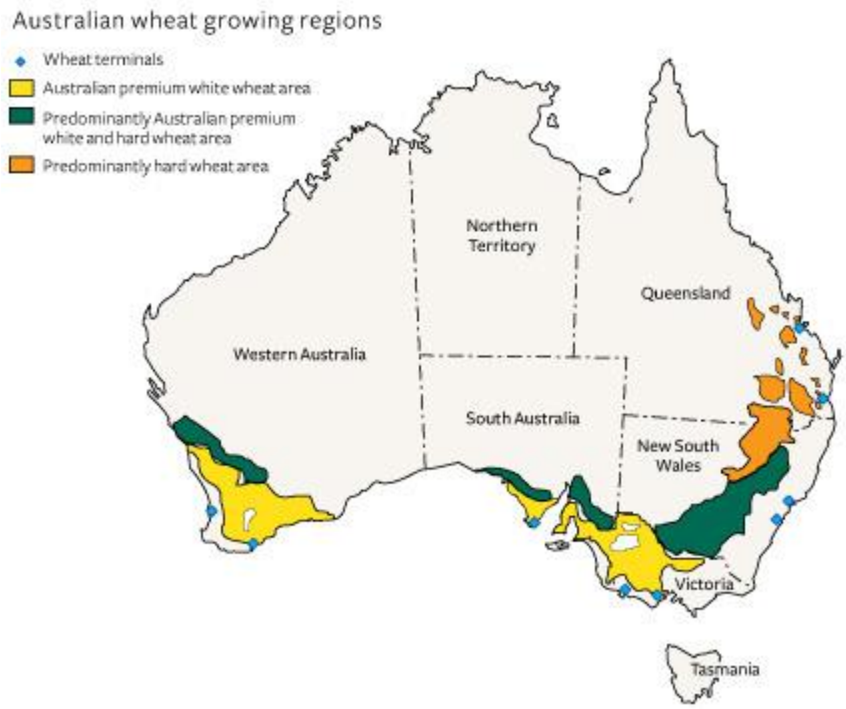
Table 3 – Input and costs comparison of compost and synthetic fertiliser

Nutrient	**Compost 1 Cm3/ha**	**Grassland synthetic kg/ha**	**Cropland synthetic kg/ha**
Nitrogen N	17 kg	-	39
Phosphorus P	3.4 kg	12	52
Potassium K	7.4 kg	46	-
Sulphur S	2.4 kg	-	-
Calcium Ca	15.6 kg	30	-
Organic matter	492 kg	-	-
Cost / ha	$50	$101	$110
Notes: Based on Grassland having two applications, Potassium sulphate & Single Superphosphate then Lime, Cropland having two applications Single Superphosphate then Urea.			

With an understanding of organic matter availability, the method of treatment and the quality of outcomes as outlined in Tables 2 & 3, consideration is given to the supply side of the solution.

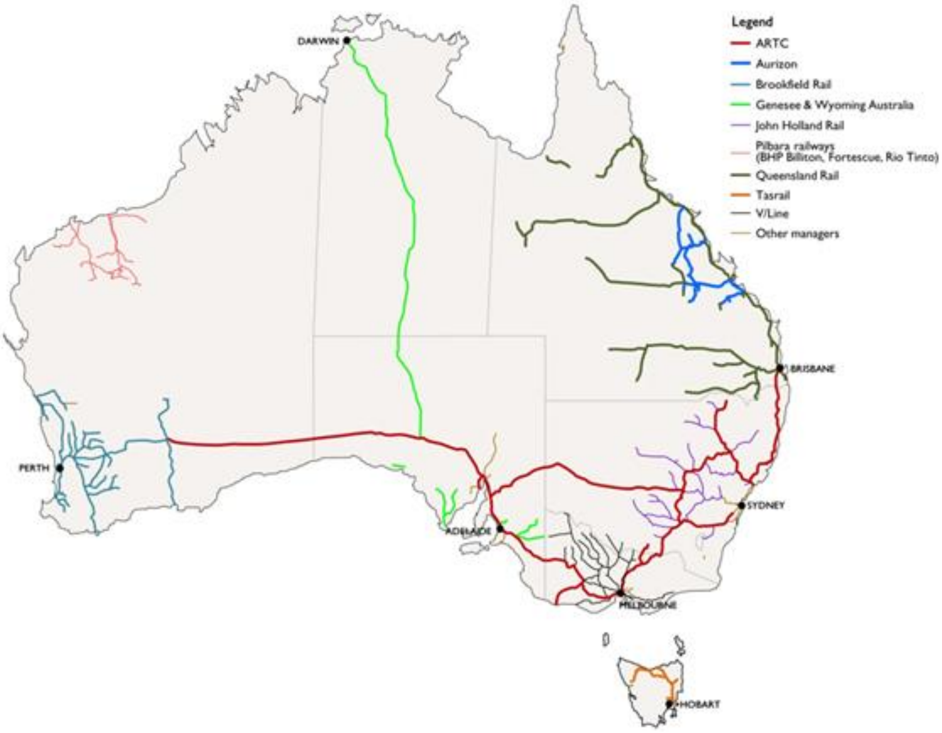
As highlighted in Figure 3 the supply of raw organic matter occurs in greatest volume on the coastal eastern, northern, south east and south west areas of Australia where the highest population and rainfall events occur. This is in contrast to the cropping regions (Figure 4) of Australia, which predominantly occur in the 400 – 600mm rainfall areas.[viii]

Figure 4



In the grain industry the barrier to grain reaching the 9 terminals for export or domestic distribution as shown in Figure 4 is distance, which varies depending on farm and port location. Grain freight subsidies have contributed to the function and update of the rail (Figure 5) and road networks and enabled a sustainable return to growers.

Figure 5- Australia's railway network



As a result, the road and rail network provides an established transport link between cropland regions and the supply locations of treated organic matter. Operationally, grain transport regularly runs empty from Port to grain receival points (upcountry) with full loads returning to Port year round. The opportunity exists to make use of upcountry runs to carry treated organic matter as compost to cropland regions while adding volume to the rail network. Handling will vary between grain and compost and whether in practice the network reuses coal rolling stock, by adding these to grain wagon sets as coal transport declines or there is a change in wagon type, is left for consideration by others.

In order to maintain the Cost / ha relativities required as shown in Table 3, freight subsidies will need to include this type of freight albeit on a backload basis. The benefits of the solution result in win-win outcomes across the board –

- Governments receive increased value for money from freight subsidies
- Compost manufacturers will be able to access substantially increased markets
- Compost distributors will have access to necessary supply to meet demand
- Farmers will be able to purchase compost at rates both cost (quantity) and nutrient (quality) competitive
- The Rail network will carry increased freight volumes
- Local regional businesses will deliver compost from rail line to farm and spread compost
- Excess green and organic waste generated in cities, coastal and tropical regions has reuse

- Ongoing Jobs will be created, such that if 1 Cubic metre of compost is applied each year to 32.1M Ha of cropland[ix], demand will be 32.1 M cubic metres per annum. Short term jobs are created in the construction of handling facilities both at supply and upcountry locations
- Organic C will increase in the soil layer
- Plants and Trees will have access to soil nutrients to draw on to make better use of higher levels of CO2 in the atmosphere
- CO2 in the atmosphere will be returned to soils
- The Rail network can be made emissions neutral through use of biofuels or emissions positive through electrification
- The end supply and application services can be made emissions neutral through use of biofuels
- Previously cultivated soils and degraded lands are on a path to restoration for land use types that are most in need
- The practice can be readily incorporated into Cropland and Grazing land management practices
- Landcare and other volunteer groups involved in land restoration could be granted a volume of treated organic matter as a necessary tool in their land restoration work

CONSULTATION QUESTIONS: ACTION ON THE LAND – ISSUES PAPER

<table>
<tr><td>Q.29.

Answer</td><td>What role, if any, could soil conservation laws, policies and agencies play in promoting land management practices that increase the storage of carbon in soils?

A change to soil conservation laws such that Green or Organic waste cannot be added to Landfill would ensure supply.

A change in soil conservation policy to recommend healthy levels of organic C in the 0 – 30cm soil layer for land use types and soil types by region.

A change so soil conservation agencies in conjunction with agricultural research agencies and Industry run trials, demonstrate, explain, engage, provide information and assist both farmers and volunteer land restoration groups to achieve outcomes.</td></tr>
<tr><td>Q.30.

Answer</td><td>What barriers exist to uptake of soil conservation projects through the ERF?

Supply of sufficient tools in the form of treated organic matter to agricultural and land restoration groups to do the work of increasing organic C.

A transportation cost barrier between the point of manufacture and end use, refer to Figures 3 & 4.

The communication and promotion of benefits as outlined in the described practice.</td></tr>
<tr><td>Q.31.

Answer</td><td>Are there opportunities for improved linkages between climate change mitigation and pest and weed management policies to maximise climate and NRM outcomes?

Yes. The linkages demonstrated in –

A. Table 1 linking the organic C currently in agricultural land use types compared to the capacity as demonstrated in the nature conservation land use types utilising treated weed biomass and other organic matter to increase organic C
B. Figure 1 linking management practices in cropland, grazing land, cultivated</td></tr>
</table>

	soils, & degraded soils to emissions reduction impact C. Figure 2 linking improved agricultural practices to the world wide biophysical emission mitigation potential D. Figure 3 linking the locations of organic matter supply and manufacture to the regions and land use types of organic matter need or demand E. Table 2 linking the emissions reduction, organic matter availability, nutrient availability, weed seed destruction and carryover plant disease pathogen reduction of organic matter treatment in accordance with Australian standards compared to landfill, supported by a change in soil conservation laws to ensure treated organic matter and nutrient availability is not lost to landfill
Q.32. **Answer**	To what extent do publicly-funded agricultural R&D and extension programs focus on the reduction of emissions and the opportunities to simultaneously mitigate emissions and improve productivity? Internet searches demonstrate multiple trials on the value of bio upgrades to the soil and multiple trials on the value of bio upgrades to improve productivity. There are fewer trials where soil conservation agencies and agricultural research agencies bring plant productivity together with soil nutrient availability to utilise higher levels of CO2 emissions that further increases soil carbon availability for crops and reduces the need for synthetic fertilisers. There is little or no connection to changing agricultural management practices that reduce CO2 atmospheric levels to help restore weather event cycles and moisture availability in Australian regions to those experienced prior to large increases in CO2 emissions from the 1950's.
Q.33. **Answer**	Are there opportunities to re-orientate publicly-funded agricultural R&D and extension programs towards reducing emissions from NRM and agriculture? Yes. A specific skill matrix is required to re-orientate R&D and programs towards reducing emissions. The skill matrix requires biological (thermophilic aerobic digestion, monitoring and certification), agronomy (organic & synthetic fertiliser management, organic C management), meteorological (atmospheric emission levels, changes, tracking and rainfall distribution) and practice knowledge (timing, actions, function) to be brought together to enable the Agricultural, Recycling, Transport, & Technology Industries, with support from Government, to understand problems, remove barriers, deliver solutions and implement practices.

SUPPORTING INFORMATION

Table 1- Average Australian stock of organic C in the 0 – 30 cm soil layer for types of land use

Raphael A. Viscarra Rossel, Richard Webster, Elisabeth N. Bui, Jeff A. Baldock, 27 April 2014. Baseline map of organic carbon in Australian soil to support national carbon accounting and monitoring under climate change

Table 2 – Carbon emission outputs and treatment benefits

Data sources:

Compost analysis - SESL Australia,Total Elemental Analysis, Aussie Compost Co. 1 Jun 2016.

Aerobic windrow emissions - Florian Menlinger, Stefan Peyr, Carsten Curtis, March 2008. Green House Gas

Emissions from Composting and Mechanical Biological Treatment, DOI: 10.1177/0734242X07088432 ·

Weed seed and carryover plant pathogen treatment effect - Ed Zaborski, University of Illinois, August 24, 2015. Composting to Reduce Weed Seeds and Plant Pathogens.

Landfill emissions – Australian Government, Clean energy future, 28 March 2012. Emissions from landfill facilities fact sheet.

Table 3 - Input and costs comparison of compost and synthetic fertiliser

Data sources:

Synthetic Urea price – Clint Jasper, 29 January 2016. Global fertiliser prices in freefall, but Australian farmers not benefitting yet

Potash price – Gary Schnitkey, Department of Agricultural and Consumer Economics, University of Illinois, December 15, 2015. Current Fertilizer Prices and Projected 2016 Fertilizer Costs

Single Superphosphate price - http://www.stonegateagricom.com/s/PhosphatePrices.asp, 2012.

Synthetic fertiliser analysis - http://www.impactfertilisers.com.au/product, 2016.

Figure 1- Mitigation measures to reduce emissions in the Agricultural landscape

Pete Smith, Daniel Martino, Zucong Cai, Daniel Gwary, Henry Janzen, Pushpam Kumar, Bruce McCarl, Stephen Ogle, Frank O'Mara, Charles Rice, Bob Scholes, Oleg Sirotenko, Mark Howden, Tim McAllister, Genxing Pan, Vladimir Romanenkov, Uwe Schneider, Sirintornthep Towprayoon, Martin Wattenbach, Jo Smith Published 27 February 2008. Greenhouse gas mitigation in agriculture, DOI: 10.1098/rstb.2007.2184

Figure 2 - Potential biophysical mitigation of emissions through improved agricultural practices by 2030

Pete Smith, Daniel Martino, Zucong Cai, Daniel Gwary, Henry Janzen, Pushpam Kumar, Bruce McCarl, Stephen Ogle, Frank O'Mara, Charles Rice, Bob Scholes, Oleg Sirotenko, Mark Howden, Tim McAllister, Genxing Pan, Vladimir Romanenkov, Uwe Schneider, Sirintornthep Towprayoon, Martin Wattenbach, Jo Smith Published 27 February 2008. Greenhouse gas mitigation in agriculture. DOI: 10.1098/rstb.2007.2184

Figure 3- Rainfall, Cities and Towns in Australian regions
Bureau of Meteorology, Commonwealth of Australia 2007

Figure 4 – Australian wheat growing regions
http://www.evergreen-implement.com/webres/Image/Australia/aus_whtregion.gif, 2017.

Figure 5- Australia’s railway network
Australia’s railways by network manager, Bureau of Infrastructure, Transport and Regional Economics, 2013.

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[ii] soilquality.org.au fact-sheet has been funded by the Healthy Soils for Sustainable Farms programme, an initiative of the Australian Government's Natural Heritage Trust in partnership with the GRDC, and the WA NRM regions of Avon Catchment Council and South Coast NRM, through National Action Plan for Salinity and Water Quality and National Landcare Programme investments of the WA and Australian Governments. 2017.

[iii] Decade-long soil nitrogen constraint on the CO2 fertilization of plant biomass, Peter B. Reich & Sarah E. Hobbie

(2013) doi:10.1038/nclimate1694 Accepted 28 August 2012

[iv] Pete Smith, Daniel Martino, Zucong Cai, Daniel Gwary, Henry Janzen, Pushpam Kumar, Bruce McCarl, Stephen Ogle, Frank O'Mara, Charles Rice, Bob Scholes, Oleg Sirotenko, Mark Howden, Tim McAllister, Genxing Pan, Vladimir Romanenkov, Uwe Schneider, Sirintornthep Towprayoon, Martin Wattenbach, Jo Smith Published 27 February 2008. Greenhouse gas mitigation in agriculture, DOI: 10.1098/rstb.2007.2184

[v] Simon Eldridge, Soil Scientist, NSW Agriculture, Richmond, March 2004. Soil management for dairy and beef cattle grazing

[vi] K Thiagalingam, Jun 21, 2016. No-till technology and legume rotation for sustainable crop production in the Douglas Daly region of the Northern Territory, Australia.

[vii] Daniel R. Taub (Biology Department, Southwestern University) 2010

Effects of Rising Atmospheric Concentrations of Carbon Dioxide on Plants

[viii] http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/1301.0Feature%20Article212006

[ix] http://www.abs.gov.au/ausstats/abs@.nsf/Products/7121.0~2010-11~Main+Features~Land+Use