# The benefits of Controlled Traffic Farming to assist adaptation to climate change for Australian crop production industries

## Submission to House Standing Committee on Primary Industries and Resources

**Inquiry into the role of government in assisting Australian farmers to adapt to the impacts of climate change**

## Submission on Behalf of

## Tasmanian Institute of Agricultural Research

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This document has been prepared by John McPhee, Extension Leader, Vegetable Research, Development and Extension Centre, Tasmanian Institute of Agricultural Research, and is submitted on behalf of the Tasmanian Institute of Agricultural Research

### Summary and Recommendations

Controlled Traffic Farming (CTF) has the capacity to both mitigate agriculture's contribution to climate change and allow farming enterprises to adapt to the impacts of climate change. Lower energy use, improved soil conditions and water use efficiency, increased plant growth, more effective zero-till planting and precision agriculture, and increased carbon storage are all benefits of CTF.

Widespread adoption of CTF will:

- increase farm resilience in the face of more variable and extreme weather events
- reduce the demand for inputs that will be adversely affected by climate change, such as water and fuel
- reduce greenhouse gas emissions, and therefore reduces agriculture's exposure to future mitigation policy impacts.

Beyond the clear environmental benefits of CTF, particularly in the context of climate change, widespread adoption will have significant economic benefits for all cropping industries.

Preliminary economic analysis suggests that the increase in annual gross farm income could be in the order of $1.1 billion in the grain industry and $2 billion in the vegetable industry through widespread adoption of CTF.

Research, development, extension and adoption assistance are required to varying degrees in different cropping industries in Australia. Government can play a valuable role in all of these areas through the provision of dedicated grant funds to all stages of the research – adoption continuum. While a wide range of government funding opportunities already exists to assist with various aspects of climate change adaptation and mitigation, dedicated funds to this particular area of cropping system development are needed, as CTF is effectively the basis on which sustainable and climate ready cropping industries can be built. CTF can increase the effectiveness of other approaches that assist the cropping industries mitigate against, or adapt to, climate change, particularly in the context of improved soil conditions.

Apart from the provision of funds for research, development and adoption, government has a very important role in providing leadership throughout the farming sector and related private and institutional bodies, such as private consultants, service businesses, government departments, R&D corporations etc. Recognition and promotion of CTF as the foundation for climate resilient cropping systems needs to be facilitated throughout all cropping industries. Government has a clear opportunity to encourage R&D corporations to prioritise farming systems research, development and adoption, and to facilitate training for farming sector service providers.

In the context of the inquiry Terms of Reference, this submission deals only with controlled traffic farming as the foundational technology to provide mitigation and adaptation strategies for crop production industries in Australia.

**Recommendations:**

- That the Federal Government provide dedicated funding mechanisms to support and promote controlled traffic farming in all facets of the research, development, demonstration and adoption continuum.
- That the Federal Government provide leadership in the recognition and promotion of controlled traffic farming as a priority foundational technology for crop production in Australia.

## Current and prospective adaptations to the impacts of climate change on agriculture and the potential impacts on downstream processing.

### Background

Controlled traffic farming (CTF) systems for crop production can significantly reduce agriculture's contribution to climate change, and at the same time, improve the resilience of farming operations in the face of changing weather patterns. In CTF systems, all machinery used in crop production is restricted to permanently located wheel tracks. A paddock farmed using controlled traffic can be thought of as a series of uncompacted "root beds" that are ideally suited to crop growth, separated by compacted "road beds" that are ideally suited to traffic. CTF can directly address soil erosion, soil structure decline and organic matter decline caused by conventional tillage and traffic practices. CTF can also improve water use efficiency and crop productivity, while

reducing energy and fertiliser related greenhouse gas emissions. The essence of CTF is as simple as – "Plants grow better in soft soil, wheels run better on roads".

Most of the past effort to improve the environmental performance of agriculture has focused on practices – e.g. zero-till. The time has come to move past practices and into farming systems, in various practices act in synergy to provide far greater benefits than are possible with the adoption of one practice. CTF is a system that leverages the advantages of a range of existing practices, such as zero-till.

CTF requires a different level of thinking and management compared to conventional farming practices. Some growers have made the move to CTF – some are watching and waiting, while for most, it is not even in their mind-set. In some industries, the technical changes required are relatively simple and well established, even if adoption is not widespread; in others, there are greater challenges and development of the system is in its infancy. The wide scale adoption of CTF across all cropping industries would fundamentally change Australian agriculture. It would effectively re-invent the cropping industries and place Australia at the forefront of efficient and sustainable production systems.

There are three essential elements to an efficient and effective CTF system:

- a common wheel track width, or multiple of it, for all equipment, with similarly matched working widths, to ensure alignment of traffic zones
- satellite steering guidance for all equipment to ensure accuracy of field operations
- farm planning and layout to ensure management of erosion, drainage, irrigation, crop husbandry and field logistics

The following points highlight the range of benefits possible with the implementation of CTF:

**Key on-farm benefits**

*Machinery*

- Elimination of most, if not all, tillage operations
- Reduced fuel use and tractor time (typically 50 – 75%) (McPhee *et. al.*, 1995a, Bowman, 2008)
- Reduced investment in tractor power and tillage equipment inventory (McPhee *et. al.*, 1995a)

*Soil and water*

- Improved soil structure for crop growth and nutrient uptake
- Improved soil biology (Tullberg *et. al.*, 2007)
- Improved drainage, aeration and soil porosity (McHugh *et. al.*, 2008)
- Improved infiltration and water holding capacity, with more efficient capture and storage of rain and irrigation water by the crop zone and hence reduced run-off and erosion (Tullberg *et. al.* 2007; Peries & Bluett, 2007)

*Crop*

- Higher (typically 10 – 15%), more uniform yield (Dickson and Ritchie, 1996b; Chamen, 2008a,b)
- Improved crop quality and more even maturity
- Reduced soil borne disease due to better aeration, drainage and soil biology

*Farming system*

- Improved timeliness, giving more opportunities for double cropping with consequent benefits for profitability and increased organic matter production (typically < 1 week turn-around from harvest to planting of next crop) (McPhee, *et. al.*, 1995b; Dickson and Ritchie, 1996a)
- Easier implementation of zero-till crop establishment, allowing:
  - use of cover crops and crop residue retention, giving reduced soil erosion, increased soil organic matter, improved moisture retention and reduced weed pressure
  - lower energy use and labour requirements
  - use of semi-permanent drip irrigation where appropriate, giving improved water use efficiency and reduced foliar disease pressure
  - capacity for inter-row and relay sowing of crops (McCallum, 2007; Gooden, 2008)

**Broader environmental benefits**

- Reduced greenhouse gas emissions due to:
  - reduced on-farm energy consumption due to less tillage, lighter draft loads and more efficient use of tractor power (McPhee, *et. al.*, 1995a; Tullberg, 2008)
  - reduced nitrous oxide emissions through more efficient use of nitrogen fertilisers (Tullberg, 2008)
  - increased carbon capture in the soil due to better soil biology and residue retention, and reduced carbon losses as a result of less tillage
  - reduced energy consumption in the manufacturing and transport sectors due to lighter equipment and less fertiliser manufactured and transported
- Reduced impacts on civil infrastructure, riparian and marine environments and air quality due to reduced water and/or wind erosion
- Reduced demand on surface and ground water resources due to improved water capture and water holding capacity, and the option of drip irrigation where appropriate

**Current situation**

Australia leads the world in the development and adoption of CTF, primarily in the grain, cotton and sugar cane industries. Some estimates put adoption at 10% in those industries, indicating there is still a long way to go before CTF has moved past the innovators and early adopters into mainstream practice.

The situation in the intensive vegetable and mixed cropping industries (e.g. vegetables and cereals) is very different. The vegetable industry is more complex than grain and sugar in terms of machinery and crop rotations, and it will be more challenging to adopt CTF and zero-till. For

example, many farmers in the Tasmanian vegetable industry grow up to ten different crops, and in many cases, each crop requires its own suite of equipment, none of which are compatible in terms of wheel track or working widths (McPhee & Aird, 2007; McPhee, 2008).

However, important and significant steps have been made in the last 2 years through collaborative work by the Tasmanian Institute of Agricultural Research (TIAR), Tasmanian Department of Primary Industries and Water (DPIW), the private sector (specifically Serve-Ag Pty Ltd) and small number of local growers. This has seen the establishment of "proof of concept" paddock trials with a limited number of crops in north-west Tasmania. Some of this work has been funded by government (e.g. National Landcare Program) while some has been funded privately.

There is a heightened awareness amongst vegetable growers in Tasmania of the negative impacts of soil compaction and intensive tillage, and the interest in CTF as a potential solution to these issues has risen dramatically in the last 3 years as a result of numerous farm walks and other activities at the "proof of concept" field sites. However, many growers are challenged by the practicalities of conversion to CTF in the context of current incompatible machinery configurations, farm layouts and topography, particularly in the very productive landscapes of north-west Tasmania.

**The importance of CTF as a foundation for resilient farming enterprises**

The resilience of a farming enterprise is very dependent on the capacity of the soil to cope with changing weather patterns. For all the numerous benefits that come from CTF, it is fundamentally about creating and maintaining a robust soil condition that can cope with variable seasonal conditions. Soils under CTF have been shown to have:

- *Improved infiltration* – this improves capture of rainfall and irrigation water and reduces erosion. This is important for situations of reduced rainfall and intensive rainfall events.
- *Improved water holding capacity* – this improves the reliability of cropping in situations of variable rainfall and declining irrigation water supply, as pre-season rainfall can be more effectively stored for later use, or irrigation water can be applied more efficiently and effectively. It also allows more effective capture and storage of water from intense rainfall events.
- *Improved drainage* – this improves the reliability of cropping in situations of intensive rainfall, as water can drain from the root zone more effectively, thereby ensuring that aerated soil conditions are maintained for optimum crop growth.
- *Improved soil biology* – this improves the capacity of the soil to capture and store carbon, and enables the crop to make better use of soil nutrients.

CTF is an ideal adaptation to the challenges of climate change in the cropping industries. No other integrated cropping system offers the environmental and productivity benefits that are possible with CTF. For example, it has been estimated that adoption of CTF on 50% of grain cropping land in Australia would reduce carbon emissions by 11.5 million tonnes/year (Tullberg, 2008).

## The role of government in:

- **augmenting the shift towards farming practices which promote resilience in the farm sector in the face of climate change;**
- **promoting research, extension and training which assists the farm sector to better adapt to climate change.**

There is an urgent need to shift crop production practices to a more sustainable basis in the face of climate change. Controlled traffic farming provides a basis for that shift. Restoring soil to a healthy condition, unconstrained by the impacts of traffic-induced compaction, is the foundation for the effective application of numerous other farming techniques that can improve the resilience of cropping in the face of climate change (e.g. zero-till planting, more efficient irrigation etc.). Government can play an important role in facilitating the change to controlled traffic farming systems across all Australian cropping industries. The needs across different industries are not the same, and cover the full range of research, development, extension and change facilitation.

**Grain industry**

The Australian dry land grain industry is the "birth place" of CTF. The benefits are well known and have been amply demonstrated. For example, in recent drought seasons, CTF grain growers have achieved yields well above those of nearby conventional farmers. Some farmers have taken the lead in machinery modification to enable CTF adoption. What is required now is accelerated adoption of CTF in the grain industry. Three key needs must be met to achieve this:

- *Increasing awareness and understanding* – one of the best ways for farmers to gain a better appreciation of the implementation and benefits of CTF is to attend field days and visit other farmers already using the practice. One role for government in this area would be to provide funding for a series of "road shows" and field days to provide increased exposure opportunities for growers who are not yet aware, or convinced, of the benefits of changing to CTF.
- *Assisting on-farm R&D* – CTF, and the use of spatial technologies such as guidance, yield mapping etc., provide unprecedented opportunities for research and development to occur in real world on-farm environments.
- *Assisting the change process* – despite the image of the innovative Australian farmer, studies show that the vast majority of farmers are conservative in their attitudes to change. A systems level change like CTF is a significant challenge to most farmers, but systems level change is what is required to address the impacts of climate change in Australian agriculture. Government leadership is essential to provide the consistent and wide-ranging support require for such change. Government could facilitate the implementation of CTF by providing grant funds for growers to engage consultants to assist in the decision making processes surrounding changes to machinery and farm layout design.
- *Implementing the change* – the previous suggestion could be further enhanced with a second level program that provided pro rata (e.g. 1:1, 1:2 or some other ratio) assistance to growers to make the necessary changes to equipment and farm layout to enable a transition to CTF.

**Vegetable and mixed industries**

The vegetable industry and mixed farming enterprises (e.g. vegetables and cereals, poppies or similar crops, as occurs in Tasmania) are at a very different stage of development regarding CTF. There are a number of technical and logistical issues to address in the implementation of CTF in these industries, and for many growers, the whole concept is in the "too hard" basket. However, out of all the cropping industries, the vegetable industry probably stands to gain the most from CTF. The vegetable industry's current reliance on intensive cultivation practices is the complete opposite of what can be achieved with CTF, and the productivity, economic and environmental benefits of CTF in this industry will be significant, once the barriers to implementation are overcome.

Preliminary economic analysis for the Tasmanian vegetable industry suggests there is potential to increase farm gross margins by 50% using CTF, compared to current conventional cropping systems. Such an increase across the major vegetable crops in Tasmania would represent an additional $50 million per year of gross farm income. While direct extrapolation of such figures to the national scene is not an exact science, it does suggest a potential increase in gross vegetable farm incomes of some $2 billion per year if the entire industry converted to CTF.

Research and demonstration work currently underway in Tasmania shows that it will be possible to implement CTF in the vegetable industry, provided the correct measures are in place to encourage conversion and adoption. It is generally agreed that if CTF can be successfully implemented in the Tasmanian vegetable industry, given the complexity of machinery configurations and topography, then it can be adopted in any industry in any region.

Large areas of land in central Tasmania will experience a change from dryland cropping and grazing to irrigated agriculture over the next 10 years as proposed irrigation schemes are brought on line. These areas will undoubtedly grow high value vegetables to warrant the investment required. Due to the nature of the soils (i.e. poorly structured, low organic carbon, duplex soils and salinity risk), there is a high probability that production in these new areas will not be sustainable using current farming methods. The development of these areas provides an ideal, and unlikely to be repeated, opportunity to introduce and implement CTF from the start, and therefore provide the basis for a sustainable production system. Such an approach is fundamental to the establishment of sustainable enterprises, and the time frame for implementation is very short, with the Tasmanian government actively promoting initiatives for new irrigation areas.

There are a number of key needs that must be met to progress CTF in the vegetable and mixed industries:

- *Demonstration of integrated CTF systems over several seasons* – unlike the grain industry, few vegetable growers are self-sufficient in their machinery, as some crops (e.g. peas, beans, poppies) rely on expensive, specialized harvest equipment that is owned by contracting companies. This makes it difficult, if not impossible, for a grower to independently transition to CTF. Likewise, few companies are prepared to invest in the changes required to expensive harvest equipment until the benefits of CTF have been demonstrated across a range of crops. There is a role for government to provide significant funding support for medium–term demonstration projects that focus on the equipment changes and integration required in the vegetable industry.
- *Assisting the change process* – as interest and knowledge in the vegetable industry builds on the basis of the demonstration program suggested above, government could facilitate

the implementation of CTF by providing grant funds for growers and contractors to engage consultants to assist in the decision making processes surrounding changes to machinery and farm layout design, in a similar fashion to that suggested above for the grain industry.

- *Implementing the change* – in line with suggestions for the grain industry, a second level program could be developed that provides pro rata assistance to growers and contractors to make the necessary changes to equipment and farm layout to enable a transition to CTF. Funding programs offered by AusIndustry are a good example of how this could be done.

**Service sector, organisations and infrastructure**

- *Private and government service providers* – the service sector in Australian agriculture is, by and large, conservative, and to a large extent, focused on the provision of "simple remedies" to production challenges. Simple remedies are as limiting as individual practices if not integrated into system level thinking. There is a role for government in facilitating and funding training for the service sector, with the objective of embracing and extending system change, based on CTF, to cropping farmers.
- *Organisations* – many private and government organisations provide funding and lobby for the cropping industries. CTF must become a priority for all of these organisations in the context of industry-wide climate change adaptation. Government could take a leadership role by insisting that CTF farming systems must be a part of R&D portfolios related to environmental management and climate change in the cropping industries.
- *Infrastructure* – regardless of the industry, successful adoption of CTF is dependent on access to high quality Global Navigation Satellite System (GNSS) signals and data for machine guidance. The uptake of GNSS guidance for tractors and harvesters in Australia has been rapid. Almost without exception, growers have maintained their independence and bought individual guidance systems to suit their needs. Victoria has taken a lead in the establishment of a Continuously Operating Reference Station (CORS) network that will ultimately cover the state, and render the use of individually owned base stations obsolete. Unfortunately, in the meantime, Australian farmers, at the behest of equipment manufacturers, have spent some $100 million on about 4,000 individual base stations – enough equipment to cover the entire nation with a high quality CORS network. There is an ideal opportunity for government to show leadership, and in conjunction with the private sector, facilitate the establishment of CORS networks nation-wide, at least in the major cropping areas. Such infrastructure would be invaluable in the expansion of CTF and would lead to significant efficiencies in farming operations, not to mention a range of other emergency services, infrastructure and environmental benefits.

## The role of rural research and development in assisting farmers to adapt to the impacts of climate change.

There are a number of research and development priorities for CTF and its role in addressing the impacts of climate change. The need for these research foci varies between industries, depending on the current level of development and adoption of CTF in the industry. A number of production practices will likely need to change because of the changes to soil condition that occur with the implementation of CTF. Research into these changes will provide guidance for growers dealing

with fundamental changes to the way in which they farm. Key areas of research, particularly for the vegetable industry are:

- *Irrigation management* – changed soil structural conditions will influence the infiltration and storage of water applied through irrigation, and will likely lead to different recommendations for irrigation scheduling and management. Irrigation strategies will need to be developed which account for the different soil – water – plant relationships. Preliminary anecdotal evidence suggests less water will be required for irrigated crops, with application schedules that are different from those currently used.
- *Soil-carbon* – CTF offers an opportunity to increase soil carbon storage, which has important implications for climate change mitigation. The extent of this benefit is hard to judge at this stage, and research will be required to enable growers to account for stored soil carbon in future emissions trading schemes.
- *Nutrition and fertiliser use* – the establishment of friable soil conditions through the use of CTF will change the way in which plant roots explore the soil, and thereby have an impact on how, and from where, plants access nutrients. This will, in turn, influence the optimum placement method and location of fertilisers.
- *Seeding technologies* – the separation of wheel induced soil compaction away from the crop growth zone presents an ideal opportunity to adopt zero-till seeding practices, with consequent benefits for soil, water conservation, carbon storage and energy use. While zero-till is well established in the grain industry, it is almost unheard of in the vegetable industry. A significant amount of research will be required to establish reliable methods of zero-till crop establishment for vegetables, particularly those with small-seeds.
- *Double cropping* – the timeliness benefits offered by CTF present the opportunity for increased double cropping, and possibly relay cropping, where the next crop is inter-row sown before the current crop is harvested. This will be a novel cropping practice in some industries, particularly vegetables, and will require research and development into practices that can be applied at the farm level.
- *Varieties suited to friable soil conditions* – plant varieties currently used in agriculture have been selected and bred based on their performance in conventional cropping systems. There is growing evidence that CTF establishes not only a different soil environment but also different management regimes, thereby requiring plant varieties with different characteristics (Brand *et. al.*, 2008).
- *Economics* – regardless of the climate change benefits of CTF, adoption will be largely influenced by economics. There is an urgent need across all industries to investigate and document the economic benefits arising from the implementation of CTF.
- *New approaches to CTF and equipment integration* – the diversity of vegetable industry machinery poses a number of integration challenges to the development of an effective CTF system based on existing conventional machinery. Wide span (or gantry) systems hold many benefits for CTF in vegetables, but are not commercially available at present. Local development of the component parts of such a system would be a valuable contribution to the overall progression of CTF in the vegetable industry, and would place Australia as a world leader of these technologies.

The role for government in all of the areas listed above is to provide, through existing and/or new channels, funding that is dedicated to research and demonstration that will support the increased

development and adoption of CTF in all cropping industries. An important aspect of any new funding options is to provide capacity to purchase and modify capital equipment for CTF research and demonstration. Many existing funding avenues will not allow purchase of capital equipment, and yet without the equipment, and the capacity to modify it to suit CTF operation, it is basically impossible to demonstrate to growers the advantages that can be gained from conversion to CTF.

It is important that the government effort and assistance in the area of CTF is dedicated and targeted, because CTF is of such fundamental importance as a basis for sustainable cropping systems. Many other techniques for climate change mitigation and adaptation will function differently, and probably sub-optimally, in the absence of established CTF systems. CTF is a platform for management and new approaches to cropping that will deliver numerous economic and environmental benefits.

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