# An Improved agricultural system for climate change

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## Abstract

Climate change will increase the intensity of the natural flood and drought cycle making agriculture more difficult and threatening global food production.

An improved agricultural system is described which could absorb large amounts of greenhouse gases mitigating climate change and make agriculture more robust in any flood and drought cycle.

Farmers would be providing a service to the community in removing greenhouse gases; they will need a financial incentive to adopt on the necessary scale. A practical system of carbon trading is proposed.

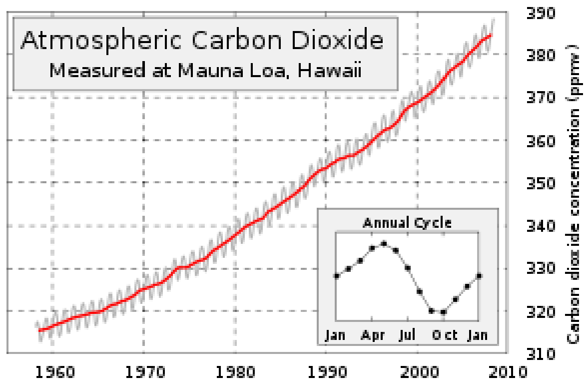

## Introduction

The consensus among climate change experts is that while climate change itself will not necessarily cause a flood and drought cycle it will certainly amplify the severity of natural weather related flood and drought cycles. This obeys common sense as hotter air can hold more moisture so there is less chance of rain but when rain does occur it is likely to be more severe.

This will put ever increasing pressure on global agriculture to produce enough food under difficult conditions to feed an ever increasing population.

Here we describe an agricultural system which will both make agriculture better able to produce food under more extreme flood and drought cycles but also absorb large amounts of greenhouse gases into the soil.

There are two basic arguments underlying this system. First vegetation is already absorbing some thirty times all man made emissions. This dramatic statement is easily confirmed from the Keeling curves which show a reduction in greenhouse gases during the Northern summer, when vegetation is active and a rise in winter.




*The Keeling Curve: Atmospheric CO2 concentrations as measured at Mauna Loa Observatory*

The reality is that most of this massive absorption of carbon dioxide is simply returned to the atmosphere by degradation of organic waste either by UV degradation or by the action of bacteria. While the obvious solution is simply to plant more trees the less obvious, but more practical way it to divert the decomposing material so it is retained in the soil. This not only reduces atmospheric carbon but improves water and nutrient holding capacity of the soil.

This can be achieved by changing the decomposition from the normal bacterial decay to a fungal dominated process. This can be achieved by controlling the conditions which favour fungi. Humidity, protection from UV, calcium, PH etc. are important controls.

The essence of the system is the wicking bed, in which subsurface water reservoirs are filled with organic waste (which would otherwise decompose by bacteria), which is then periodically filled with water which wicks up to the root zone. The filling and emptying of the reservoir provides a moist but not saturated soil with breathing action to aerate the soil.

A key part of this research is to monitor the amount of carbon absorbed into the soil and develop a simple method of predicting carbon absorbed which can be used to reward the farmers, for example by a carbon trading scheme.

## Aims

The first aims are to monitor the water, fertiliser usage and plant growth and compare with a reference bed using conventional growing methods.

The second aim is to measure the carbon absorbed into the soil and greenhouse gases emitted to the atmosphere and develop a simple and practical system of predicting carbon absorbed into the soil. This is important as administrators of potential soil carbon programs have struggled with technical difficulties and costs of soil carbon measurement. This has delayed the adoption of global soil carbon schemes which offer the most cost effective way of removing the tens of billions of tonnes of carbon which is currently being emitted globally.

## Creating the test site

The experiments are being carried out at the Farmland Irrigation Research Institute at XInXiang by Drs. Li and Qia under the direction of Zuebin Qi Vice Diretor and assisted by Colin Austin of Waterright.

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|  | The site selected was an area of approximately 25 by 35 metres (?) which had previously been used for wheat production.<br><br>This block had fall of approximately 1 metre(?) across the diagonal. |

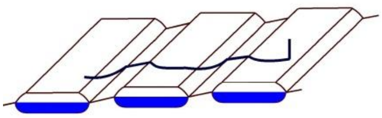
Normally beds are laid out along the contour line (like a traditional rice paddy field).

As the block was rectangular this would have given individual beds of varying length, normally not a problem but for experimental work it was felt better to have uniform lengths aligned with the axis of the block. This requires some earth moving.

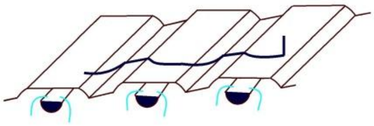
Next decision was the type of wicking bed.

It is worth reviewing the various designs of wicking beds.

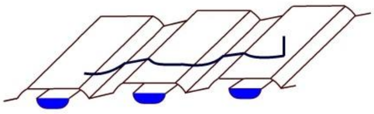
## Selection of type of wicking bed



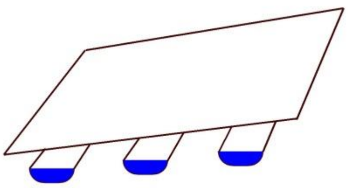
**Closed beds.** Plants are grown inside closed wicking beds. The depth of the water bed should be no more 300mm and the depth of the tops soil is normally 300mm or less. This is fine for shallow rooted plants like vegetables. Closed wicking beds are very water efficient as there is no loss to leakage beyond the root zone and evaporation losses are minimal. Scheduling is simple, just fill the beds, wait until the water level drops then refill.



**Open beds.** Deep rooted plants, such as fruit trees can be grown outside an open wicking bed. Water wicks up, across and then down to irrigate the plants. Excessive topping up of the water zone will results in water leaking beyond the root zone so scheduling is more important.



**Combination beds** can be used to grow shallow rooted vegetables inside the bed and deeper rooted plants outside the bed. This gives great flexibility, for example a second crop, such as vegetables can be grown in a fruit orchard.

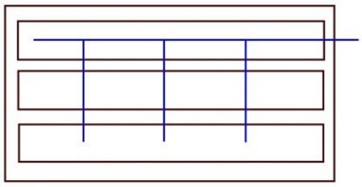


**Flat beds** may be more practical in fields worked with large machinery. Deeper beds which leave the surface flat can then be used.

Raised beds are generally preferred because of the protection from flooding.

## Spreading the water

Water will not flow far through most soils (may be a metre or so). However water can flow a much greater distanced through the porous organic waste (such as wood chips), may be 10 or even 20 metres. But for any greater lengths either a pipe or equivalent (such as bubble wrap) must be used. Pipes are the most expensive component in a wicking bed so this may be expensive.



An alternative is to have just one pipe in the highest bed and as many overflow lines as needed. Overflow pipes can be added as needed after construction as often the flow characteristics of the organic waste may not be known at the design stage.

Water simply flows from the higher beds through to the lower beds.

It was decided to use a combination bed with the possibility of multiple overflow lines.

## Maintenance

The water reservoirs are filled with waste organic material, such as wood chips or pruning's. These will slowly decompose so the beds will need topping up from time to time. The philosophy is to maintain a rich organic matrix which aids plant growth. Frequent working of the soil destroys the structure so a no till approach is preferred. Adding worms and mycrorrhyzal fungi will aggregate the soil and disperse nutrients throughout the bed without working the soil.

Compost zones or bins can be used to add this top up organic material and used at part of the watering system so a compost tea is supplied to the plants.

## Experimental results

### Water use and plant productivity

To be completed when result available

### Carbon absorbed in the soil

To be completed when results available.

## Carbon capture – the realities

The aim of the Kyoto protocol was to reduce global emissions, yet globally we are putting more carbon dioxide into the atmosphere at a faster rate than ever before.

The simple fact remains that with the current state of technology and the rapid industrialisation in developing countries, burning fossil fuels will increase to meet the world's energy needs. We can only hope this may change with improvements in energy technology, but at this moment in time the effects of climate change, specifically the amplification of the flood and drought cycle are reducing our ability to feed the global population. This will only get worse in the immediate future.

Absorbing atmospheric carbon into the soil is a simple and practical solution immediately available to us.

Changing our agricultural system so that it absorbs rather than emits carbon is viable on the scale needed to offset the tens of billions of tonnes. Governments thought the world are aware of the possibilities of soil carbon but are struggling to develop national, let alone the much needed international schemes.

One reason is the inherent difficulty in measuring soil carbon. It is hoped that this research report, which provides a simple process for accounting for soil carbon provides the core technology for the creation of an international soil carbon scheme.

Another restriction is focusing on existing agricultural technologies developed to improve farming outputs. We need to look at new technologies with the broader focus of capturing carbon as a tool in controlling climate change.

It is worth reviewing some of the historic problems.

## Inherent problems of soil carbon schemes

### Measurement

Technology exists to measure soil carbon at a specific location and time. However soils vary widely even over a small distance so many reading are needed to obtain a reasonable value for total soil carbon on just one farm.

Readings are typically taken at a standard depth, but the creation of soil carbon raises the level of the soil, the top soil becomes thicker and less dense, (more fluffy). We only have to look at the great savannah belts around the world where the soil is many metres thick. Ignoring this change in thickness of the top soil underestimates the amount of carbon sequestered.

### Number of farms and the required scale

We are currently emitting tens of billions of tonnes of carbon into the atmosphere. Soil carbon is a low density operation, the amount of carbon captured per square metre is relatively low so large areas are needed to sequester the tens of billions of tonnes we are emitting. This will need several million square kilometres of farmland, and will inevitably mean the involvement of the developing countries. The industrialised countries will end up paying developing countries to absorb their carbon emissions.

On a basis of equity this is highly desirable but does present logistical problems. Farms in developing countries are often small family run operations covering just a few hectares. This means millions of farms would be involved with the scheme. The concept of measuring soil carbon, on an ongoing basis over millions of farms is daunting. This is made more difficult when many farms are not familiar with the high tech processes like soil carbon monitoring.

### Additionallity and permanence

At the time when the Kyoto protocol was initially formulated, soil carbon was not considered. The two concepts of additionality and permanence were developed for other application where they may be relevant but are simply technically unsound for soil carbon.

Many far sighted farmers are already adopting soil conservation strategies which increase soil carbon levels. The strict application of the Kyoto protocol would mean these progressive farmers would receive nothing while farmers adopting destructive practices would be financially reward for their bad practices. This makes no sense and is counterproductive.

The net outcome of the concept of additionality is actually a deterrent to farmers adopting soil carbon technology and the results are totally negative at a time when the worlds needs every possibility of combating climate change.

Permanence is another concept based on faulty technology. Soil carbon is dynamic with carbon entering and leaving the soil. It is a dynamic situation; - what really matters is the net carbon in the soil and any particular point in time. The fact that old carbon may be leaving the soil and fresh carbon entering is irrelevant, just the total carbon is relevant.

## Proposed solution

Farmers absorbing carbon are providing a service to the global community. A very small proportion of farmers are financially able, let alone willing, to do this for the benefits of the global community with the only reward improvements in their soil. Most farmers will not or cannot afford the extra costs involved. To achieve the scale (tens of billions of tonnes of carbon dioxide) requires large scale adoption which will only be achieved by financial incentives. An appropriately designed carbon trading scheme can achieve this incentive.

It is unrealistic to expect the millions of farmers involved to manage the complexity of carbon trading. Aggregators (organisation servicing a large number of farms) are needed. With the enhanced capabilities from scale they can provide the needed services of technical support and payments to the farmers. They can generate revenue from their role in carbon trading.

It is impractical to measure the increase in soil carbon on every farm. A system of calculating the change in soil carbon based on the amount of organic material added to the soil is proposed. The rate of decomposition would be measured in controlled laboratory measurement. This gives a net absorption of carbon to determine payments. The validity of the system can be checked by periodic field measurements by the aggregator.

This would result in a high initial payment to cover the initial cost of installation and lower payments later based on the periodic top up of the organic material and the amount of decomposition.

Aggregators can also source the supply of waste organic material. There are many references on the internet to the large amount of waste in Chinese cities. It is also visually obvious that Chinese cities have significant areas of greenery which appear to be pruned on a regular basis.

It is also obvious that sewage is a major issue, particularly in the inland cities near the major rivers. A system using waste and polluted water to irrigate deep rooted trees to produce a ready supply of prunings is used in Australia. Health and safety are major concerns in using recycled water, this system isolates contaminated water from food production turning a liability into an asset.

A further role for the aggregator is to manage insurance for change beyond the control of the farmer. Many small farms near cities are being taken over for urban development. A question that may occur to a small farmer is what happens to the money he has been paid for sequestering carbon if the land is taken over for another use, possibly beyond his control. This is certainly a question which needs addressing. The logical answer is that the redeveloper of the land should be responsible for any emission from the land, but the legal framework has yet to be developed. While this issue is being resolved the aggregator, working over many farms can insure isolated farms from any injustices.

There are clearly many political issues, both nation and international which need addressing. The aggregator can play a valuable role in examining the viability of these ideas facilitating the adoption of the new technology by providing services and protection for small farmers.