Action plan for Food security

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Summary

Here we look at a research proposal to help ensure food security with the threat of climate change. Safeguarding soil and water resources are critical; we look at achieving this by a pragmatic philosophy of combining practical expertise on soil regeneration, the study of soil biology and the wicking bed technology. We also look at soil carbon as a way reducing atmospheric carbon and helping farmers justify the costs of soil regeneration, particularly in developing countries.

Lessons from the past

Once again food security has become a major threat for a number of reasons, degradation of our soils, water shortages, the increased flood and drought cycle arising from climate change, loss of land to urbanisation etc.

The last food security threat triggered the green revolution. Based on improved plant genetics it certainly dramatically increased food production. But the results were not a total success, food surpluses in the affluent countries were not entirely beneficial, the high hydrocarbon and sugar in the foods resulted in widespread obesity and diabetes. The increased growth was not free but required large amounts of nutrients and water. The nutrients came from oil based fertiliser which damaged the microbiology which gives the soil its structure. The increased use of water came from non-renewable resources such as aquifers and ground water which are being rapidly depleted.

The benefits were not universal, the poor who did not have access to the technology or the required resources suffered most with their access to food actually being reduced so increasing the number of people suffering from starvation.

This time we need to learn from experience and examine the likely outcomes of possible solutions.

Are genetics the solution?

Again many of the world's agricultural scientist are pinning their faith on improved genetics, but this time genetically modified to incorporate features of water, heat and disease resistance. While improved genetics will play an important role in food security it just does seem viable that they will provide food security unless the key issues of soil and water are resolved.

Resolving these issues of soil and water are fundamental to resolving food security.

Water a central issue

Some thirty five years ago it was established that the key to regenerating soil is to maintain the soil moist (not wet) and continuously grow some form of vegetation.

We now understand that it is the micro-biological action, particularly the mycrorrhyzal fungi, which regenerate the soil. The wicking bed technology, in which water from an underground reservoir wicks up to the root zone, maintains the soil moist without saturation the soil, conditions essential for fungal growth.

But with depleted soils there are little nutrients for the fungi. Fungi simply will not grow and regenerate the soil unless they are fed. On a small scale this is easily achieved by adding waste organic material generally available on farm, but the challenge is to achieve this on a large enough scale to have an impact of food security.

Carbon Capture

The problem is partially technical; to source the large amount of organic waste, but also economic. Farmers are only going to adopt these technologies if it makes economic sense.

There are economic benefits from improved production but revenues from the carbon captured may provide the incentive for wide scale adoption, particularly for the low incomes farmers in developing countries. This in itself provides a further technical challenge in developing practical technology for estimating the carbon absorbed by the millions of small farmers. It would appear that the most practical approach is by monitoring the process rather than direct measurement.

This is after all the basis for modern quality control in manufacturing industry so it is logical to use this approach in monitoring carbon over millions of farms.

Soil and water

The problems of water are well understood and appear depressing.

Even without climate change we are exceeding our sustainable supply of fresh water. Climate change complicates the world's water balance. We have already experienced the impact of climate change of snow melt which normally provides much of the water at the right time for many of the world's population. Snow could almost be regarded as a miracle storing, at no cost, huge amounts of water in the winter, then releasing this water in the heat of spring and summer, just when the water is needed for irrigation.

The earlier snow melt from climate change, combining with the spring rains now often results in major flooding in the early season followed by excessive heat and drought during the summer crop harvest.

Agriculture is suffering from the increased severity of the flood and drought cycle, which appears to be a feature of climate change.

There are of course engineering solutions, not just dams but the many alternatives which in general we have failed to exploit, such as water harvesting, leaky dams etc. which typically result in storing water in the soil.

While the water availability may appear to be depressing there is one oddly optimistic reality. Agriculture (by far the largest user of water) is chronically inefficient with half the water lost by either soaking into the ground or by evaporation. Irrigation is dominated by flood which is intrinsically inefficient but even where more mechanised systems prevail there is still major losses due to poor scheduling. In fact poor scheduling results in the single largest loss of water.

The low level of efficiency at first looks negative but in fact means there is opportunity to make major improvements.

This improvement can come from the relatively new technology of the wicking bed. This is a very simple technology of creating a subsurface reservoir of water which can wick (by surface tension) to root zone of the plants.

There is no loss of water beyond the root zone; the surface is near dry so there is very little loss by evaporation so virtually all the water supplied goes directly to the plant.

There are of course other technologies which are highly water efficient, such as subsurface irrigation with computer control based on soil moisture monitoring. However these are complex and expensive technologies which are only suitable for high technology application with expensive crops.

By contrast the wicking bed system while highly efficient is simple and is a technology accessible to all growers regardless of the level of technical sophistication.

But it would be very wrong to regard the wicking bed technology as just a water saving or irrigation technology.

Politics and flood irrigation

I am most familiar with the problems of flood irrigation and politics from experiences with the Murray Darling Basin; often described as Australia's food bowl. I believe that a similar pattern occurs in most major irrigation societies.

Irrigation, exclusively by flood, started in the Murray Darling Basin over a hundred years ago. The technical achievements can only be described as spectacular with the construction of many miles of open irrigation channels often simply by horse and cart and manual labour.

Politically it was less well managed with gross over allocation of water. For efficient irrigation flood requires the very rapid supply of large volumes of water. Irrigations may only occur a small number of times a season. The large open channels achieved these high volumes very effectively, but often with large losses of water both during irrigation but also as the channels dry out after each irrigation.

Farmers are responsible for the management of water on their land while delivery is normally controlled by the Government.

Now Governments very clearly understand the waste and environmental damage and are taking major steps to reverse past over allocations but in reality they only have direct control of the delivery system. The fact is that in Australia the farmers are a powerful lobby group and have fought very hard to maintain the status quo in water use and availability.

Governments have responded in the easiest way possible by spending large amounts of money to upgrade the delivery system, but still aimed at supplying the high flows required for flood irrigation.

However modern methods of irrigation, such as micro sprinkler, drip and also the wicking bed technology do not required huge slugs of water but a much slower but steady flow of water. This could be much more efficiently achieved by relatively small pipes, which is intrinsically more efficient than the open channels used for flood irrigation.

The technical reality is that if you want to make substantial improvements in water use efficiency you have to change both the method of on farm application and the delivery system.

Governments have improved the efficiency of the delivery system over which they have control but have not felt it politically viable to make the changes needed to the total system.

It is a bit like having a railway system powered by coal burning steam engines. It is certainly possible to improve the efficiency of steam engines by adopting ultra-high pressure boilers etc. The real solution is to invest in modern high speed electric trains, (or in Australia's case high speed trains from the city centres to the airports). Further investing in steam engines is just tying up capital preserving on obsolete technology.

This political stand-off has been going on for some forty years with little change. Climate change, with its flood and drought cycle may just be the psychological and physical trigger for the required change.

Fortunately the wicking bed technology is a natural substitute for conventional flood irrigation and only required very slow flow rates, making piped systems practical. Even more exciting is that early experiments indicate that it may be possible to convert the huge areas of furrow irrigation to wicking beds at very little cost or inconvenience. This needs further testing but the economic and social benefits of the water saving easily justify the research effort.

This is a key part of the proposal.

Part of the research would focus on refining machinery for the large scale installation of wicking beds at minimum cost.

Available nutrients

Studying and controlling the flow of nutrients must be one of the most critical issues in ensuring food security.

Irrigation is typically regarded as a way of providing water to plants. However water plays a far more important role in providing the right moisture conditions for microbiological activity to regenerate the soil.

Plants capture the majority of the mass from carbon in the atmosphere by photosynthesis, however they need a variety of minerals to undertake photosynthesis and this comes from chemicals and nutrients dissolved in the water.

Providing the solution to this dissolved nutrient problem is the key challenge for food security. Improved genetics may aid the efficiency of the plant but they need the fundamental ingredients obtained from the soil.

Seven billion people, the current world's population, consume a lot of food which can only be produced by taking nutrients from the soil. In former times most of these nutrients would be recycled, now most of them end up in the sea via the sewage system.

Nutrients (with the exception of nitrogen) are produced by the breakdown of rocks and soil particles, largely by fungi, algae, mosses lichens and other micro-organisms. The parent rocks vary widely in their chemical composition some fortunate areas of the world have a balanced supply of nutrients which have accumulated in the soil by biological action over many years.

Large volumes of nutrient rich top soil have accumulated over millions of years in certain fortunate areas of the world, particularly the savannah lands. These have provided mankind with a sink of fertile land which we have been exploiting for many years.

Other less fortunate regions are unproductive agricultural areas suffering from a lack of specific trace elements, in many cases modern technology has identified these deficiencies and resolved the problem by the addition of the required trace elements creating productive lands.

Other areas of the world, particularly tropical forests, maintain an appearance of fertility by rapid recycling of nutrients but there is little depth to the soil which rapidly degenerates with any attempt at agriculture.

Modern oil or coal based fertilisers have proved able to supply large volumes of the bulk plant needs, particularly nitrogen but have often resulted in soils with a poor balance of all the required nutrients. Worse still the structure of the soil has been broken down such that it is no longer able to retain the nutrients or water resulting in large volume of nutrient rich run off causing major pollution problems with rivers and ground water.

The poor structure of the soil often means that even though the soil contains an adequate supply of nutrients they are simply not available to the plants.

Replenishing the nutrient cycle

The loss of nutrients is so large that many steps are needed to achieve nutrient balance.

The first is to maintain the moisture content (moist not wet) to encourage the growth of fungi whose hyphae emit enzymes which dissolve the rocks or soil particles and release soluble nutrients.

Permanent pastures are more efficient, appropriate pasture species can be deep rooted and it seems that mycorrhizal fungi do not extent much beyond the root zone. (Subject to research).

It also seems that animals play an important role in improving the soil.

Cropping soils, even with minimal disturbance farming, do not regenerate rapidly. There is simply not enough quality organic material, there is little nutrient in straw and crop residue. However strategic planting of deep rooted perennials can provide a permanent base for mycorrhizal fungi and certain plants (such as acacias) are highly efficient at extricating nutrients, particularly phosphorous, from deep in the soil.

Prunings or fresh wood chips can add significant nutrients to the soil.

Lower quality agricultural land can be used to harvest nutrients. This idea can be expanded using the wicking bed technology to recycle grey or sewage water. Safety consideration often prohibit the use of sewage however using a two stage approach to grew trees which are also mining nutrients from deep in the ground provides volumes of organic material rich in nutrients which can be incorporated into second stage wicking beds for food production.

This approach can be used with any available form of organic waste, particularly municipal waste.

Harvesting organic material from the sea, sea weed fish waste etc. is a further way of recycling nutrients.

Social values and Carbon sequestration

We should recognise our achievements, despite the world's population reaching 7 billion there are more people better fed with a wider variety of food (particularly meat) than ever before.

We have to recognise that climate change, particularly with the increased flood and drought cycle is a major threat to food supply of the bulk of mankind who are enjoying unprecedented prosperity.

But we also have to recognise that one of the great failures of the first green revolution was the increased poverty of the already poor.

This time we have the opportunity to aid low income farmers by providing them with the technology to harvest carbon.

This could be looked upon as a simple case of social equity, however the argument is much stronger than that. Vegetation absorbs very large amounts of carbon from the atmosphere, many times man made emissions from burning fossil fuel. This is happening right now with no help whatever from mankind. The tragedy is that much of this carbon is returned directly to the atmosphere, particularly aided by our modern agricultural technology.

The difficulty of achieving global agreement on reducing carbon emissions from burning fossil fuel is evident in any daily newspaper covering the international discussions. Carbon capture in the soil, on a global scale provides a way of offsetting these emissions for many years hence.

It is an issue of great importance for the future of humanity.

But what action is needed to make this happen and achieve results.

Action Plan

Science has given us a great understanding of the nature of soil. But we are looking at a problem of great diversity needing many approaches for solution. The reductionist approach of science is needed to comprehend the many facets of this complex technology but the reductionist approach by itself is not adequate. It needs a holistic approach looking at the problem as a whole. This requires the skills of specialists whose expertise is essential but it also requires the skills of technical and economic managers who have the experience of working in a multi discipline environment, integrating the work of individual specialist to provide the overall system.

This approach, commonly referred to as the systems approach, is often not well appreciated in the reductionist environment of classic research, and often involves building teams which include non-specialists with experience of integrating complex technologies. This would include people with hand on experience on soil regeneration and food production such as farmers. Good progressive famers have to be competent in a wide range of technologies and have good observation skills on how the system is working as a whole.

There is a wealth of practical, if empirical, experience collected over man years by practical farmers experimenting to regenerate their soils. This experience can be collected and analysed using the scientific approach to develop an understanding of how these systems actually work. This is likely to lead to significant improvements in the technology.

This approach is totally consistent with the history of the development of technology from the early development of the steam engine with science leading to the rapid advance of technologies initiated by an empirical innovation.

In the last few decades we have made dramatic increases in our understanding of soil biology. But in reality we are only just scratching the surface with many organisms yet to be studied. But our biggest lack of knowledge is how it all works as a balanced eco system and having the technology and skills to farm the microbiology.

For example we well understand the importance of mycrorrhyzal fungi. But simply adding fungi to the soil may have little benefit. But we do know that adding worm eggs to the soil will help spread the fungi over a wide area. But worms will not proliferate without organic waste as food, but again this may not be available as a food source without the bacteria to break it down and make it digestible. It requires a complete working system to be really effective. Much of this is well understand at an empirical by people working at a practical level on soil reclamation, a better understanding at a scientific level would lead to a significant improvement in effectiveness of such treatments.

This can best be achieved by bringing together the empirical experimenters and the scientists into a working team.

So what works needs to be done

We already have extensive practical experience of the wicking bed technology and how it can improve both soil quality and food production with limited supplies of water. A better understanding of the mechanics at scientific level would clearly be beneficial.

However the key challenge is to learn how to apply this on a large scale and above all make is economic for individual farmers to adopt.

This would involve studying the complete nutrient cycle and identify the source of organic material which can be used in soil regeneration. On a bulk scale this would require setting up industrial scale processes for the organic waste. This is likely to require the cooperation of local Governments who have responsibility for processing waste and environmental protection.

Who should do the work? The Australian Government, to their credit has taken a world pioneering role in carbon capture into the soil. Australia has also adopted a leading role in the understanding of soil biology but there is another dimension. Australian farmers have been badly hit by a long period of drought and many famers have responded by developing innovative farming techniques to conserve water and the soil, in fact the practical pioneering efforts of these farmers is way ahead of developments in other countries. In particular the Carbon Farmers Coalition has played a critical role in bringing together these innovative farmers.

However Australia is a major exporter of food and contrast strongly with China which aims to support its large population from its finite land and water resources which presents the country with a major challenge. China is also the largest emitter of carbon and faces immense environmental problems, particularly pollution in its major river systems. It also is evident that China has a particularly well developed and pragmatic research capability with excellent large scale experimental facilities.

The conclusion is that a joint project should be established between China and Australia, which would utilise the research resources of both countries. But this needs to adopt a system of holistic approach so a steering committee is needed to give the overall perspective. This committee would comprise members of the research community of both countries but would also include representatives from the Carbon Farmers Coalition who can bring a very down to earth approach to managing the challenges of soil and water and others with practical experience of soil regeneration.

From the Chinese side it would seem sensible to invite representatives from the Local Governments who are likely to provide much of the organic material and who have responsibilities for river pollution.

As the University of Sydney and the Farmland Irrigation Research Institute in China have signed a memorandum of understanding on joint cooperation it seems logical for both organisations to approach their respective Governments for funding for this critical project and to invite key people to form the driving international committee.