Technology for food security

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Preface

Some thirty five years ago Australia suffered major dust storms with the loss of millions of tonnes of top soil. This lead me to wonder what would happen if the world lost all its top soil. Would civilisation as we know it collapse?

This prompted me to look for technologies for regenerating top soil which eventually led to the wicking beds for generating soil and making the most effective use of water. I have written extensively about this technology (www.waterright.com.au). The key is to maintain the soil moist, to ensure that some form of plants is growing on the judicious addition of organic material and soil supplements.

The technology has now reached a stage of maturity where it could be applied on a large scale, but this raises some pertinent questions on the economic, political and social aspects of these soil and water technologies. There are a number of questions which needs addressing.

Are we (civilised man) really in danger from the loss of top soil, or is it another Armageddon scare. Is it possible to find alternative sources of food that do not rely on soil, could food be synthesized or could we use large scale hydroponics?

What attitude should society and Governments take to soil? Should it simply be left to market forces and the self-interest of farmers to protect soil or should soil be looked on as a universal asset?

Nick Stern described climate change, in which the emitters of carbon dioxide bear no cost and just leave it to society to pick up the costs. Should the same argument be applied to the degradation of our soil? Is it a problem just for the farmer or is it an issue for the society as a whole?

Food crisis fact or fiction

The fear back thirty five years was that the loss of top soil would lead to food shortages. Has the food crisis materialised? The short answer is no, but the real answer is no but….

Right now there is a net global surplus of food; in fact the rich countries waste millions of tonnes of perfectly nutritious food each year. It is true that many people, (approaching a billion) have inadequate food, but this is not because there is no food available, it is the result of poverty (rich people don't starve), poor distribution, political dysfunction etc. These problems are not going to be resolved by improved technology; - in fact the great advances in food production technology which has resulted in the current food surplus and lower prices has worsened the lot of the poor who do not have the money to access the improved technology.

The economics of food distribution often dominate over production. Often perfectly nutritious, but marginally crops are left unharvested.

How have we avoided the threatened food crisis and is food supply really secure?

Soils and productivity

Two very different genre of technology have protected us from the impending food crisis.

One set of technologies, which has given us a net surplus of food are largely based on improved plant nutrition (by chemical fertilisers), increased irrigation and improved genetics. The reason for widespread adoption is simple, short term profits; - a modest investment in fertilisers gives an immediate increase in crop production; - but only in the short term.

In the longer term there is a slow but steady destruction of the soil structure. Again in the short term production can be maintained by an ever increasing application of fertiliser. With the continuous increase in the price of fertilisers, and the critical shortage of some key fertilisers, such as phosphorous, this becomes less viable economically. The effects are dependent on the inherent quality of the soil. Deep soils as in the savannah belt will maintain production with repeated application of fertiliser for a long period of time. Poorer soil will rapidly loose production. This implies that global food production would be concentrated into a small number of already wealthy countries. This is not a formula for political stability.

The other set of technologies such as no or minimum till farming, controlled traffic etc. are based on soil conservation. Many of the early pioneers of these technologies were based in Australia and were typically regarded as freaks by main stream agriculture. With good reason, these techniques simply could not compete in good years with the productivity of high input conventional farming. There was virtually no Government support, either in terms of financial incentive of investment in research to support these technologies. The techniques were developed by a small group of farmers who worked on a philosophy of improving soil even if it was at the expense of short term production.

This however changed dramatically with the advent of a series of long and severe droughts.   Crops in conventional farms either failed or were grossly reduced while the ‘soil farmers’ were able to maintain or improve production. Now virtually all farms in the drier regions of Australia have adopted these technologies and they have become the mainstream with Governments support and approval.

From my contacts I am not as all sure that the bulk of the farmers have embarrassed the philosophy of soil biology, they have just accepted the reality that organic soil can hold more water and that is the difference between not having a crop or profitability. There are many issues of biological farming, particularly weed management, that give conventional farmers real problems.

Water

Water is the other key ingredient for food production and again we have been consuming fresh water faster than it is generated by the massive draw down on our aquifers and the over allocation of river systems. This is a major problem for many Governments around the world with little sign of peaceful resolution.

The technology exists for highly efficient irrigation using such technologies as computer controlled irrigation scheduling based on soil moisture sensing. This can reduce water use by up to 50% while improving productivity. The commercial reality is that (around the world) flood irrigation dominates with significant loss of water beyond the root zone.

The original development of the wicking bed technology was to improve water use and store more water in the soil.

Are there alternative sources of food supplies?

While some foods can be made synthetically there is no technology on the horizon that would appear remotely feasible to feed the world's population.

Some people, particularly those promoting hydroponics, have argued that the soils only function is to hold the plant upright and that all these major and minor elements can be provided as a solution to the plant roots. This ignores the fact that these nutrients in the hydroponic solutions have been derived from the beneficial action of soil elsewhere. It is essential to look at the total nutrient cycle.

The concept that we can feed the world by some form of mega hydroponics is absurd. Whether we like it or not mankind is totally dependent on soil which we have effectively been mining.

Soil – the only viable basis for food production

Whether we like it or not the only viable way of feeding the global population is from the combination of photosynthesis and soil biology.

Photosynthesis is the process of taking carbon dioxide from the atmosphere combining this with energy from sunlight to produce complex hydro carbons which provide the basis for food for all living creatures. We may now have a reasonable understanding of the chemistry and physics of the process but no one to my knowledge is suggesting that mankind could develop a viable alternative to photosynthesis for global food production, at least in the foreseeable future when the food crisis is likely to occur.

While the action may appear to be above ground with the leaves absorbing carbon dioxide and capturing the energy from sunlight the process requires chemicals and water which the plant obtains from below ground. These dominant chemical are N,P,K found in bulk fertilisers but also a concoction of trace elements which, while only needed in very small quantities, are essential for the process of photosynthesis.

There are also minerals which the plant does not need itself but are essential for human health which the plant conveniently (for us) absorbs into its structure and provides these essential ingredients in our food.

For billions of years these nutrients and minerals have been provided by the soil biology.

So how does soil actually work

Soil biology is complex with many different species but bacteria and fungi dominate. Bacteria are intrinsically small and short lived and are responsible for recycling much of the dead or dying organic material. They ensure the nutrients and trace elements are available for the plants or reuse; - an important and essential role but they have a relatively small influence on soil structure and regenerating replacement elements. They are recyclers and do not create new resources.

In a natural environment there is some leaching of these nutrients which ultimately end up in the sea. Unfortunately mankind with its agricultural system, waste, sewage disposal etc. has dramatically increased this loss to the sea. This is offset to some extent by the use of fish, sea bird droppings and seaweed based fertilisers but there is still a massive imbalance with major losses to the sea.

While bacteria recycle fungi make nutrients locked up in rocks and soil particles available to the plants.

The role of fungi

The world has survived for billions of years due to the action of that most unappreciated member of the soil community; - the fungi. While bacteria are the great recyclers it is the fungi that are capable of bringing new nutrients into the soil.

The fine hyphae of fungi exude enzymes which help dissolve the elements locked up in rock particles with the soil, making them available to the plants. They are continuously replacing nutrients and minerals lost to the sea.

The hyphae also provide a mechanical structure to the soil and also give it a pore structure which can hold large quantities of both water and nutrients.

Another unrecognised features of fungi are their size and longevity. They are the largest living organism and lock up very large amounts of carbon into the soil. In particular the mycorrhizal fungi exchange nutrients and water with the plant roots in exchange for carbohydrates and sugars. The volume of carbon locked up by this synergistic relationship is a significant proportion of soil carbon.

Bacteria provide a service by breaking down organic material but in the process they release significant quantities of carbon dioxide. Fungi are the great carbon sequesters.

Increasing fungal activity

So how should we go about designing a sustainable food production system which also helps control atmospheric carbon dioxide levels? By increasing fungal activity.

Soil biology is a continuous process of recycling and competition. Most of the components of the biological system already exist in the soil so propagating fungi is not quite like planting seeds to grow a plant crop; it is more a question of providing the right conditions for the fungal component to flourish.

Mycorrhizal fungi need to be kept moist, like bacteria they need oxygen and nitrogen but in smaller amounts, they also prefer a calcium rich environment.

The wicking bed technology was originally developed to both increase water use efficiency and to increase the storage capacity of the soil. Essentially an underground water reservoir is formed so water wicks up by surface tension to the root zone.

Experience has shown that they provide excellent condition for mycorrhizal fungi to develop.

What motivates farmers to regenerate soil

The technologies for regenerating soil are neither that expensive nor difficult. Cell grazing and minimal till farming are now a widely established management practise and the wicking bed technology is now widely used. However when we look at the motivation for adoption of these technologies the key motivator is an intense philosophical believe in the importance of maintain soils (and water holding capacity) rather than a simple economic argument.

Biological farming is economic but requires looking at the overall economics and not just simple production. Test have been under way at the Rodale Institute for thirty years and while they have demonstrated the economic benefits of organic farming the benefits are generally secondary rather than a simple increase in productivity.

The increase in the capital value of their land from an improved soils structure is well understood by many farmers but to the average famer just looking at the most obvious facts would conclude that the cheapest way of increasing profits is simply to apply more fertiliser. This is certainly what is happening in many parts of the world where the benefits of soil biology have not been well promoted.

Global food production is so vital should it be left to simple farm economics? Many Governments have certainly taken it upon themselves to introduce schemes to change agricultural practices and safeguard their nation's food supply.

Governments may need to be more active take in safeguarding their countries soils. Indeed when it comes to certain issues like recycling city waste and sewage Government action would be essential.

However there is one activity which may override all others; - that of climate change.

Climate change

Climate change, or more precisely the increased tendency to an increased flood and drought cycle, is simply going to accelerate our incapacity to grow enough food to feed the ever increasing world's population.

It is a depressing scene to watch the painful efforts of world Governments to reach agreement on action on climate change. There is still a minority of world leaders who refuse to accept that climate change is happening at all, let alone man made or even that the results will be negative.

Some argue that outcomes are still not clear and that countries such as Canada and Russia could be a major beneficiary of a warmer climate.

The increased tendency to flood and droughts may well be the trigger that cuts through the rhetoric and denial and leads to action. Of course deniers still argue that it is impossible to link any one flood or drought to climate change, what is undeniable is that there is a statistical increase in the flood and drought cycle.

Living in Queensland and having my test block inundated gives me a very personal appreciation of the damage that can be caused by flooding.

The increased flood and drought cycle may lead to the willingness to look at climate change in a new light. The key stumbling block in international negotiations is the attitude of the already industrialised countries to the pressure on the rapidly developing countries to alleviate poverty within these countries by industrialisation and the inevitable increase in carbon emissions.

This stalemate may be alleviated when the potential for plants to remove carbon from the atmosphere is better understood.

Plants absorbing carbon

Plants already extract very large quantities of carbon dioxide from the atmosphere, estimates vary but typical figures are some twenty to thirty times all man made emissions. At first sight (e.g. wrong) this would indicate that we would quickly run short of carbon dioxide in the atmosphere and as a consequence we would all freeze to death. A certain amount of greenhouse gases are essential to maintaining the earth habitable. Carbon dioxide is not a problem it is only excess carbon dioxide that presents a threat.

The reality is that the vast bulk of the carbon extracted from the atmosphere by the plants is returned by bacteria decomposing dead vegetation. Bacteria put many times more carbon dioxide into the atmosphere than all our power plants and transport systems etc. combined.

While Governments seem willing to spend large amounts of money researching ways of reducing carbon entering the atmosphere and less but still significant money researching ways of extracting it from the atmosphere there seems little appreciation that the simplest way of reducing atmospheric carbon is to reduce the massive release of carbon by bacteria into the atmosphere.

Fungi retain a much higher proportion of the carbon dioxide which ends up in a permanently stable form within the soil effectively capturing carbon, improving the soil structure and the ability to grow food and making it more resistant to wind and water erosion.

Many poor agricultural countries would benefit from carbon trading helping to avoid the poverty induced lack of food.   This would need the acceptance of the technology and the politics and technology of carbon trading to solidify.

At one stroke this would counter the two great challenges facing mankind, climate change and the degradation of our soils.

It would also help to resolve that other great social issue, the underfed millions in a sea of surplus. Carbon farming is a system which can be readily adopted by low technology farmers. It provides the poor of the world with some degree of food security while carbon trading provides additional revenue to the poor farmers.

The social equity of such a scheme cannot be challenged, however this is not a solution motivated by charity. The wealthy and historically major emitters, the wealthy industrialised countries would receive a major benefit. Climate change would impose a major cost on these wealthy countries (and individuals) even if only in their insurance premiums.

It seems an incredibly cheap insurance policy to pay the farmers of the world, many poor, to safeguard the world's food supply and mitigate climate change.