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INTRODUCTION

The credit crunch has shaken our global economy, but it will recover. 'The Protein Crunch' is far more serious and, if we open our eyes, it is unfolding right in front of us. Our food – protein – comes from three sources: our water, land and seas. All of these natural resources are under increasing pressure from our burgeoning population: when more demand meets less supply, we arrive at 'The Protein Crunch'.

Every day, newspapers cover some element of this looming issue: mine water pollution in Johannesburg, Chinese land purchases in the Congo, a single tuna sold for $380,000 in Tokyo, floods in Pakistan and the food price riots that ignited North Africa. Few of us understand the causes of these crises and events, nor how they are all connected. This book is the story of the crisis we face, from the viewpoint of an unashamed capitalist and entrepreneur. My belief is it will make you think; my hope is that it will make you act.

I have spent the last 25 years of my life fighting and winning in the game of business – from running other people's multinational companies to creating and then selling my own. Two heart attacks later, I realised that the only game worth playing was that of living. I changed the struggles of the boardroom for a passion for life and moved to live full time on my farm in South Africa's beautiful Tulbagh Valley.

I decided to walk myself fit. It turned out to be a journey of understanding of both the environment and myself. As the seasons changed I saw the streams dry up in summer and then flood in winter. Where we had felled trees, I saw soil erosion that turned the rivers muddy as they carried away the soil. This lit in me a passion and a concern for the environment: I began to read everything I could find on our water, land and seas.

I then travelled the world to see for myself the damage man is wreaking on these three vital eco-systems. I began to understand the extraordinary and unexpected connections between the many things I saw: from the teeming masses of China's cities to the fertile plains of the Indus Valley and the dry rivers of America's Mid-West – to name but a few. I began to realise the complexity of Nature and how the environment has shaped our past and will determine our future. During my travels over the last three years, two stories made an impact on me.

The first is a story of how wolves brought back the aspen trees to America's Yellowstone National Park. The aspen trees have always been a feature of its landscape, but the established trees were ageing and no new trees were replacing them. The last wolf in the park was shot in the 1920s, since when the elk population expanded rapidly and grazed on the young aspen saplings before they could grow and mature. Since the re-introduction of the wolves in 1995, the elk population has been reduced and their natural grazing habits have returned. The elk, frightened of the wolf packs, no longer graze at the river edges or in woods but on the open plains. Young sapling aspen trees now survive and as they mature the woodlands are naturally re-establishing themselves.

The second story is of a small island in the Bering Sea between Alaska and Russia. In 1944, a coastguard introduced 29 reindeer to the remote St Matthew Island as a reserve source of food for the men working there. The base was closed at the end of the Second World War, and all the men left the island. Just 13 years later, as they grazed on the abundant and nutritious lichen that covered much of the island, the reindeer population had reached 1,350. Without any natural predators on the island, the population exploded over the next six years, so that by 1963 there were 6,000 reindeer. But then disaster struck: the deer had eaten all the lichen, and just three years later there were only 42 left – 41 females, one sickly male and no fawns. This is a cautionary tale of what can happen when a species multiplies exponentially. In destroying their habitat, the reindeer destroyed themselves.

Just a 100 years ago it would have been inconceivable to think that the human impact on the environment might become so great as to threaten the Earth and our own survival. We now stand at a turning point in our history and in the history of the Earth. Mankind has acquired the scale and the power to wreck the biosphere on which we depend – yet also the knowledge to fix it. Throughout history, humans have cleared land or fished out rivers, and after exhausting other natural resources, moved on. Now with nearly seven billion people on the planet we are destroying environmental systems everywhere and simultaneously. There is nowhere else for us to go.

It is increasingly apparent that our capitalist global food system is not functioning effectively. With nearly one billion people hungry and another billion people overweight or obese, something clearly isn't working. Having watched the recent credit crunch unfold, I saw many similarities in the way our environmental and food production systems were and are being stretched to breaking point. With food demand outstripping supply, food prices will inevitably increase.

Food price inflation brings with it civil unrest and political turmoil, as we have witnessed in the first months of 2011. Social order has already started to collapse in many failed states like Sudan and Afghanistan. In our interconnected global world, state failure may become contagious as environmental refugees migrate to survive. Our civilisation is on the brink of disaster.

I decided to write the story of what I had seen with a family friend, environmentalist and author David Lorimer. *The Protein Crunch* explains our impact on the earth's natural systems and its resources on which we all depend. As some of these ecosystems become less productive or fail altogether, the speed and severity of 'The Protein Crunch' will accelerate. The way we respond to these environmental challenges is a matter of life and death, first for the poorest then for the rest of us, not to mention future generations. Many civilisations have collapsed before ours, but will we be the first to foresee our demise and prevent it?

It seems that our brains are wired to react to emergencies, but if the threat is not immediate we find it hard to galvanise ourselves into action. It is as if we are floating down a river heading towards a waterfall, ignoring the roar of the water and waiting until we see the foaming water, before we react and then look for someone else to blame for our predicament. What the Earth needs is for many more of us to understand our predicament, in order to change our collective consciousness and start the sustainability revolution we need to survive. There will be no time to waste looking for scapegoats: we will need to move and make change happen fast.

Capitalism may have caused many of our existing environmental problems, but the best way of making this change happen quickly is to use capitalism itself. As a lifelong capitalist and now eco-entrepreneur, I have seen and become involved with some extraordinary businesses around the world. Three of these are both unusual and interesting: using fly larvae, Gibraltar-based Agri-protein recycles abattoir waste into useable protein for animal feed at a fraction of the price of existing natural sources; the UK's Oxitec genetically modifies and breeds sterile male mosquitoes, which when released breed with wild females that lay eggs that won't hatch, substantially reducing disease-carrying mosquito populations; the Urban Wind Farm in Belgium has borrowed wind-accelerating techniques from aircraft wing construction as well as braking technology from Formula One racecars to help generate clean power from urban rooftops. All of these could be billion-dollar businesses within the next 10 years. The next Bill Gates and Mark Zuckerberg will make their fortunes in the business of the environment.

Before my journey into the environment, I understood neither the unbelievable risks we are running nor the extraordinary opportunities for entrepreneurs and eco-capitalists like myself. Commitment is the only thing that drives change. When you commit you act, and the world changes around you, conspiring to help you

in ways you never thought possible. I am now committed full time to making a difference to the world we live in – through creating more awareness of the environment and excitement about the opportunities it can bring us all.

The clock is ticking. We are in a race between education and catastrophe. *The Protein Crunch* will help you understand the harsh reality of where we are and the exciting future we can make for ourselves.

Let's get busy repairing the future.

Jason Drew – May 2011
Tulbach, Western Cape, South Africa

CHAPTER ONE – **WATER**

Water is the most extraordinary thing. There is as much water on the Earth now as when time began. You cannot make more, you cannot throw it away, you cannot destroy it. Water just is.

The drip of water from your kitchen tap could have been in the blood of a dinosaur or the sweat of a slave, the breath of an eagle or the gills of a fish. Water is endlessly recycled and is the only compound existing in Nature in all its three states: as a solid, a liquid and a vapour.

The Earth's surface is over 60% water – as are we. We can live for weeks without food but only days without water. Water has powered civilisations and caused their downfall. It has fuelled the industrial revolution, enabled the current population explosion and helped create our consumer goods – yet we take it for granted. We have to change the way we think about water: we need to understand and manage our scarce water resources before they manage us.

We are becoming increasingly aware of our daily household water usage, but most of us remain clueless about the amount of virtual water we use. Almost everything we eat or the goods we use require vast amounts of water to produce.

The water we use in our daily domestic activities is often metered and paid for making us more aware of its consumption. Households in the United Kingdom (UK) without a water meter use nearly 55,000 litres per person a year, or enough to fill more than two petrol tankers. Metered households use nearly 10,000 litres a year less. In Canada, amazingly, they manage to use five times more water than the UK of which more than half is used to irrigate their gardens.

In a typical industrialised country, 60% of water used inside the house is for bathing and flushing the toilet; 25% for laundry; and only 10% for cooking and cleaning. The trend in Europe and the United States (US) is to more efficient flushing systems, as mandated on all new builds. This could dramatically reduce our water, and therefore energy, consumption.

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While we use a lot of water for bathing and flushing, we use almost as much in washing our clothes and linen. In the US top-loading washing machines are still used, rather than the front-loading European type designed to use 40% less water. The US and the rest of the world should mandate the use of front loaders as a first step towards saving water. New 'waterless' washing machine technologies would save both water in washing and energy in drying our clothes. Governments need to pave the way for these technologies by taxing the old technologies and subsidising the new.

Most of the Western world's water supply infrastructure is obsolete and requires repair, if not replacement. Imagine how much water is lost as a result of this poor maintenance and under-investment. In a water-scarce world, we need better solutions than the wasteful infrastructure upon which we currently depend.

When we waste water, we waste energy, causing pollution which can be avoided. The amount of energy required to produce and deliver clean water to households is substantial, and will increasingly feature in the cost of household water as energy prices rise

The minimum personal water requirement is around 50 litres a day, or roughly a third of what the average British household uses. In developing countries, a mere 20 litres per person per day is often

considered a luxury. In the West water is increasingly provided by private companies focused on maximising short-term profit and not the public good. In developing countries, privatisation of water supply is pushed in return for loan and aid extensions. Many people in these poor countries do not yet have access to effective water supply, let alone sanitation, and often pay more for their water than the rich in the West.

The advent of the modern megacities and their associated slums has led to sanitation issues not seen in the West since pre-Victorian times. Consider the many millions of street dwellers in Mumbai without access to sanitation: half a kilogram of excrement per person per day equates to thousands of tons of human waste just left on the streets.

A possible solution could be waterless composting toilets as a key to water sustainability when we begin to provide sanitation to the developing world. These toilets are odourless and waterless systems that convert human waste into reusable compost for our fields. This modern technology confirms what we have always known: human waste is a great fertiliser.

The amount of water we use around the house may seem a lot, but it's nothing compared to the virtual water we consume indirectly through the food we eat and the things we buy. An invisible trade in virtual water underlies the world economy from agriculture to consumer goods.

It takes about 1,000 litres of water to grow a kilogram of grain. It can take 24 kilograms of grain to produce a kilogram of beef. It therefore takes a tanker load of water to make a kilogram of steak. The export of beef from the US to the Middle East is as much a trade in water as it is in protein or meat. If sufficient water existed in the Middle East it would grow its own cattle!

The sunlight that fell on the Earth millions of years ago – and on the Middle East in particular – was transformed and stored in the form of carbon. Trees or plankton that died became the carbon deposits that we know as coal and oil today. While the US is exporting condensed ancient underground water in the form of beef, the Middle East is exporting ancient condensed sunlight – both scarce and non-renewable resources.

Most of the fresh water available to us is used for agriculture. It takes 1,000 litres – or one tonne of water – to produce a glass of milk or 5,000 litres of water to make a kilogram of cheese. Much of the water used in irrigating our crops and animal feeds is pumped from natural underground reserves or aquifers. Rainfall on the plains above replenishes these water sources slowly, or never where they are 'fossil' or ancient trapped water deposits. It is estimated that America's Mid-West pumps more water out of its aquifers each year than has fallen in rain on the plains that fed them, since the time of Christ.

Nearly 800 million people live on food produced from currently unsustainable underground water sources. There are, however, beacons of hope: in Rajasthan's Alwar District in India – farmers have been drilling deeper and deeper in search of water to pump onto their fields in the dry season. The reintroduction – through pressure from the village elders – of smaller fields with multiple ridges to catch monsoon water has improved the local water dynamics. Instead of drilling their boreholes 10-12 metres deeper each year, farmers are now withdrawing them closer to the surface as the aquifers replenish. This traditional practise of `water containment' means that less topsoil gets washed away; water seeps back into the ground naturally to replenish the aquifer; and while much of the water evaporates, it falls again as rain. This provides a sustainable supply of water all year round, not just during the monsoon.

Few of us are aware of the water needed to make the goods we buy: for example, it took more than 30,000 litres of water to make

your mobile phone. Water is needed to make most of its components – from the steel to the titanium, from the plastics to the glass and the packaging it comes in. The great dams in China are being built as much to feed its export industry as its agriculture.

A pair of denim jeans takes more than 10,000 litres of water to make, a cotton shirt almost half that. What about your wooden floorboards? Trees can consume up to 1,000 litres of water a day and will be decades old before they are made into something we walk on and take for granted. All around us we are condensing our precious water into the consumer products we use every day. Everything we eat and use is, in fact, a form of condensed or virtual water – even the water we drink takes water to produce.

The average person in Europe and the US uses about 4,000 litres of virtual water a day – as much as 20 times the amount of actual water we use around the house. This total water usage or our 'water footprint' combines both direct and indirect water use.

Everything we eat and use is, in fact, a form of condensed or virtual water – even the water we drink takes water to produce and clean it.

Water is not evenly distributed across the planet by location or time. In Britain people often complain that they have too much rain, yet more than a third of the world's population is already short of water. India, for example, gets almost all of its rain in huge, short downpours over a few months a year – its monsoon season. Five hundred million people live in countries with chronic water shortages. A further 2.4 billion people live in countries – mainly in Africa and Asia – where the water system is under stress.

Increased population and rising demand for water mean that by 2050, as many as four billion out of a projected world population of around nine billion will live in or migrate from countries chronically short of water. World demand for fresh water is expected to increase by 30% between 2000 and 2030 as people eat more water-intensive foods, such as meat, and purchase more disposable consumer goods. This means that there will be less water available per person, particularly for the poor.

Almost all of the Earth's water is in its oceans; only 2.5% of its water is fresh. Of this fresh water, 75% is stored in ice sheets and glaciers, now melting, and just 10% in accessible underground aquifers. As much water again is locked away deep underground as ancient 'fossil' rainwater – water that is never replenished. Amazing as it might seem, only 0.3% of our fresh water is stored in lakes and rivers and even less than that in the soil and atmosphere.

We therefore have a finite supply of fresh water. Slightly more than a quarter of our fresh water is not locked in ice caps; this is the water available for our use. The natural process of evaporation constantly recycles this water as rainfall. Our clean water mainly comes from evaporation, where water vapour is transformed into clouds and then falls as rain, sleet or snow on land or sea. Some of the rain soaks into the ground; some seeps slowly into our aquifers. Most of the water flows downhill as run-off, eventually returning to the sea where the process begins again.

Water is constantly in circulation. The heat of the sun causes 500,000 cubic kilometres to evaporate annually. This is 50,000 times more water than there is in Loch Ness and 250,000 times more water than is stored in South Africa's Voelvlei dam. This water vapour makes up 60% of atmospheric gases. Any increase in temperature means that the atmosphere absorbs more moisture.

As the cycle continues, extreme weather events are more common, as we have seen in 2010-2011 – with floods in Pakistan and Australia and mudslides in Brazil. Floods spreading over a wide area also cause

huge evaporation, as the shallow body of water warms more quickly than, for example, a deep, cool lake. This results in more water vapour in the atmosphere and even more rain. In this way one flood can lead to another.

Trees generate their own water and cause rain through evaporation. Clearing of areas like the once-proud cedar forests of the Lebanon has led to its desertification. Humanity is dramatically altering the nature of water and water flows. Deforestation is the consequence of man's demands for land and fuel, which have increased exponentially since the earliest civilisations, promoting both more floods and more droughts. The floods, often caused by deforestation, however, do not help replenish the groundwater and cause massive soil erosion, which in turn contributes to the creation of permanent deserts.

Clearance of forests and tree cover exposes the ground to the sun, which then heats and hardens it. Rain cannot easily penetrate hot, hard, dry soil. Warm ground creates a fast run-off of water which, in times of heavy rainfall, can result in catastrophic floods, as experienced recently in Pakistan. This so-called 'natural disaster' is, in fact, predominantly man-made.

In areas of natural forest with good tree cover, the soil is soft and cool and rain penetrates the moist soil. In established forest, as much as 85% of the rainfall is retained by either sinking into the ground, or through absorption by trees and other vegetation. Consequently, the level of groundwater and water tables are maintained, and water run-off and soil erosion are less.

A key function of tropical forests is to help create and recycle rain. Since the 1960s man has used chemicals to make clouds give up their water and make rain in target areas. Planes fly through clouds and release a chemical spray; the moisture in the cloud clings to these drops and the cloud releases its water as rain in a process known as `seeding'. Based on ongoing research into Terpenes, organic compounds released by trees during photosynthesis, it seems that Nature has been cloud seeding for eons. Trees and forests cause rain through these compounds they release into the atmosphere.

Removing the natural forests, with their multiple tree species, short-circuits the complete water cycle with devastating results. Each tree species accesses water differently, both from the ground and the atmosphere. Broad-leaf trees will capture mist on their leaves, causing water to drop to the ground in greater volumes than slim-needled pine trees. A variety of mixed-wood trees in a rainforest will harness all the available forms of water from ground dew to mist and fog. The continuing destruction of rainforests will lead to further disruption of regional climate patterns, and so produce less rainfall. The only remedy is a massive, international tree-planting campaign.

South Korea has reforested itself since 1950 – the world should follow its example.

Many of us are aware of the deforestation of the Brazilian rainforests and the campaigns to save them. We are far less aware of the African rainforests – equally enormous and important. These ecosystems are being destroyed, the forests felled with little regard for the environment and the wood shipped to China to fuel its manufacturing industries.

Like those of Tasmania, these African and Brazilian forests are being felled to produce wood pulp for the paper industry and to open up more grazing and agricultural land. Great strides have been made in the paper recycling industry: even the US – normally a laggard in green issues – has nearly tripled its rate of paper recycling to more than 55% in the last three decades. The Forest Stewardship Council (FSC) – an international non-governmental organisation (NGO) established in 1993 to promote responsible management of forests worldwide – is helping consumers purchase products from sustainable forest plantations, from which in time we may be able to satisfy most of our paper needs.

There are, of course, drawbacks with monoculture plantations of forests or crops. They are susceptible to disease and do not provide a natural habitat for the diverse wildlife that would inhabit a forest of mixed tree species.

Reforestation is possible and is happening on a surprising scale, with individual, local and even government commitment. South Korea, largely barren and devoid of trees in the 1950s, is now almost 65% forested and a great example of government leadership in reforestation. Turkey, cleared of many of its indigenous oak trees by successive wood-hungry empires, has undergone a radical one billion tree-planting campaign to reforest its marginal lands and prevent soil erosion and run-off. The acorns from these oak trees will once again be a source of protein for farm animals. This revolution in Turkey was inspired by two prominent businessmen, Hayrettin Karaca and Nihat Gokyigit. Spain has for centuries produced some of the most prized meats from animals fed on acorns.

In Niger, individual farmers facing drought and desertification have come up with their own version of reforestation. Many trees such as the invasive and non-indigenous wattle in South Africa and the acacias in north-west Africa are legumes, fixing nitrogen in the soil. By interspersing such trees on croplands the farmers increase natural fertilisation, provide shade to allow rain to penetrate the soil and prevent the soil from eroding during winds and floods.

Most of our fresh water is stored as ice and snow in the polar regions and in glaciers and snow caps in the world's mountain ranges. Fact: the snow caps and glaciers are disappearing. It does not matter whether this is the result of man-made global warming or part of a natural warming cycle. This change will lead to a fundamental alteration in the water cycle, and humans, who depend on this cycle, will have to adapt – whether they like it or not.

Mount Kenya has been snow-capped for thousands of years, but photographs over the last 100 years record its rapid disappearance. It is likely that by 2040 it will be gone! Tanzania's Mount Kilimanjaro has lost 82% of its ice in the last century, of which 33% has disappeared over the last 20 years. 'Kili' may be ice-free as soon as 2015.

Rivers across the world that run all year round do so predominantly because of winter rainfall stored on mountain ranges as snow and ice and released by summer melting. Without these frozen reservoirs, we will face a different pattern of water availability which will affect our agricultural systems that rely on constant water flow. In addition, winter rainfall without being stored as snow, will rush unabated through river systems and cause devastation by flooding.

Take, for example, the Indus River that snakes through India and Pakistan to the sea: its constant flow of water is regulated by frozen reservoirs high in the Himalayas, as are many of China's rivers. This mighty river has been dammed and its water flow partially diverted along its length to provide irrigation for crops. The British built more kilometres of canals in Pakistan than they did railways in India to direct the waters of the Indus to irrigate Pakistan's once-dry but fertile plains. Access to water is already a source of tension between these two nuclear powers; what would happen to food production, electricity generation and industrial production if the Indus' summer flows were dramatically reduced? We have seen what happens when winter rainfalls are not stored: in August 2010, the resulting massive floods killed thousands of people and displaced millions as water flooded through the Indus Valley to the floodplains.

Many parts of the US are seeing changed weather patterns affecting rainfall, and reducing water availability. Reduced water supply

combined with rising demand from an increasing number of users forewarns a crisis. Irrigation rights are often 'over-allocated', so that water rights allocated to different regions through which a river runs now exceed the amount of water flow in the river. This can cause local conflict in individual countries, but war in other parts of the world where countries share river systems, such as the Nile or the Jordan.

Montana in the US is home to Glacier National Park, containing more than 150 glaciers when first surveyed in the late 1800s. There are now just 35 glaciers, half already reduced in size due to melting, and many of these are forecast to disappear by 2030. This crisis will have a direct effect on the flow of the rivers from the park, and therefore on irrigated food production downstream.

It is not just agriculture that is affected by reduced glacial run-off into our rivers – the impact also hits river fish. Warm water contains less oxygen than cold water, and with less cold water entering the river, its temperature rises. Increased water temperature affects the river's ability to support a natural balance of aquatic life.

Significant initiatives across the world are seeking to improve and repair the water cycle. From reforestation projects in the 50 countries working with the FSC to land management in several Indian states to promote aquifer replenishment, and many other initiatives, organisations and individuals are engaged in repairing our natural water systems.

Our biggest single use of fresh water is for irrigation in agriculture. Developing countries have the highest agricultural water usage, but even variations of use within the European Union (EU) are striking. Countries like Greece and Spain, with the highest water consumption, are also the most prone to drought. Climate change – whether man-made or natural – is likely to bring severe drought conditions to many parts of Europe by 2080, especially in the south.

The same drought risk applies in many African countries, with rapid population expansion requiring ever more of their already scarce water supplies. In Somalia the population is expected to increase from 8.8 million in 2000 to 31.8 million by 2050; in Sudan the projected jump is from 31.1 million to 59.2 million. Both countries rely heavily on woefully inefficient open and flood irrigation systems to produce their food supply. Rather than directing the right amount of water to the crops when they need it, these systems tend to overuse water and allow considerable evaporation and leakage from the open canals used for water delivery. With their water supplies already under pressure, and without massive investment, countries like Sudan and Somalia will struggle to feed their growing populations.

Without irrigation we cannot feed the world. We are already using and wasting much of the fresh water we have. Only 25% of the water in our rivers reaches the sea, as it is abstracted by agriculture and industry before it gets there.

Many rivers – such as the Colorado and Rio Grande in the US, the Yellow River in China and the Indus in Pakistan – are no longer running as far as the sea or may not run there much longer. We were taught as children that all rivers end in the sea – with the exception of Botswana's Okavango. We may have to re-map our rivers and rewrite our geography books in the near future.

Our overuse of rivers and their altered flow rates in summer will create a crisis in irrigation for agriculture and in drinking water for cities. Although only 17% of the world's cropland (270 million hectares) is irrigated, this land area produces more than a third of the world's food. Irrigation uses a staggering 70% of all the water drawn from rivers and underground reserves. In China half of all cropland is irrigated, and this land produces 80% of its grain harvest. Of all irrigated farmland worldwide, 75% is in developing countries and 25% in industrialised countries.

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Open canal irrigation processes can be made far more efficient by introducing drip irrigation, where water is directed to the roots of plants. This method uses comparatively little water with less waste. It is, however, an expensive system that many developing country agricultural systems cannot afford.

After World War II many countries needed to maximise production and end food rationing. Guaranteed product prices combined with incentives to use nitrogen-based fertilisers increased investment in output. A new generation of hybrid agricultural crops, from cereals to vegetables, further increased farming output per hectare. Many high-yielding plants of this 'Green Revolution' are, however, water guzzlers. The latest generation of genetically modified (GM) crops is now being developed to be pest- and drought-resistant and to use less water per unit of output.

Twenty percent of our fresh water is used by businesses. The power generation, chemicals, as well as the metal and paper industries consume vast quantities of fresh water in providing our heat and light as well as consumer goods. It takes 95 litres of water to produce a kilogram of steel and 324 litres to manufacture a kilogram of paper. Demand for water will increase substantially as more countries industrialise, adding further pressure on overall supply.

Industrial production processes also pollute our water systems and groundwater. Industrial chemicals are discharged into rivers, lakes and aquifers – including heavy metals like lead, cadmium and mercury. The deadly toxic chemical spill in Hungary in October 2010 highlights the danger to life – human, animal and vegetable. Thousands of people were affected, with hundreds of injuries and eight deaths as a toxic sludge dam linked to an aluminium plant collapsed. A national state of emergency was declared. The effects will take decades to clear from the river and food systems – particularly from the Danube.

In 1996 a leak of 1.5 million cubic metres of mine waste in the Philippines killed wildlife in a 27-kilometre stretch of river and raised the level of zinc in drinking water to dangerous levels. Rising water levels in disused mines near the megacity of Johannesburg, South Africa, now threaten the drinking water of the city's more than 10 million residents. As the water fills up the deep, disused mineshafts, it becomes rich in poisonous minerals and metals from these mines. Once the water levels reach the water table the consequences could be disastrous. South African President Jacob Zuma and former Minister of Water and Environmental Affairs Buyelwa Sonjica may face criminal charges in their personal capacities following charges brought against them by Nicole Barlow, chair of the Environment & Conservation Association of South Africa.

Fresh, clean water supplies are vital to soft drink and beer producers. It takes nearly 150 litres of water to make a pint of beer and three litres of water to make a litre of Coke. If access to clean water diminishes, these producers are in trouble. South African-based SAB Miller, for instance – one of the world's largest brewers – uses huge quantities of water from the Johannesburg area to make its beer. With the rising water levels in local disused mines threatening to pollute the area's water table, production could be seriously affected. Similarly, in August 2006 both Coca-Cola and PepsiCo in India suffered reduced sales as it was feared that the water they were using to produce their soft drinks was contaminated with pesticides. Several states in India banned their sale.

The industrialisation of agriculture has necessitated an increasing use of chemicals in fertilisers and pesticides. These chemicals run off into rivers and lakes as well as leaching into the soil and contaminating drinking water. Run-off into lakes and the seas can lead to a massive explosion of algae and weeds. These plants can, in turn, absorb so much oxygen that they deprive fish of the oxygen they need to survive. The recent mass deaths of sardines off the Californian coast in March 2011 or in the Louisiana marshes in September 2010 are just two of many examples.

The Mississippi River in the US has become so polluted with agricultural chemicals and household detergents that a huge area of the Gulf of Mexico has become an ecologically dead zone, incapable of supporting fish or any other form of sea life. Where our rivers still reach the seas, more and more of these dead zones are appearing, some 415 already exist, in estuaries around the world.

Traditionally in Africa and elsewhere, small dams were constructed to store seasonal rain for local summer use by farmers and communities. These usually have little impact on the environment. Damming of major rivers, however, has already harnessed and diverted 60% of the world's river waters for hydro-electric power, irrigation schemes and flood control. There are nearly 50,000 dams in the world, nearly half of which are in China.

The huge megastructure dams of the last 100 years have wreaked the most environmental devastation. Cumulatively, it is estimated that a staggering 80 million people worldwide have been relocated to facilitate controlled river valley flooding and dam construction, the most recent being the Three Gorges Dam across the Yangtze River in China. Since its construction began in 1994, the dam has displaced 1.2 million people, and upon completion in 2009 it had flooded 400 square miles of farmland.

The impact on fish, wildlife and plants, the reduction in fertile farming land along riverbanks and the hidden cost of damaging poorly understood ecosystems are immense. Forty percent of irrigated cropland relies on water supplied from dams, while hydro-electric power stations generate 20% of the world's electricity. These power stations, like all power stations, also use massive amounts of water for cooling their turbines.

Environmentalists have long been highlighting the destruction caused by large dam projects. More recently they have been joined by the World Bank, which since 1948, has spent around US$75 billion on dam projects in more than 90 countries. Many of these projects have delivered substantially less than they promised in terms of hydro-electric power, water supply and flood protection.

All too often, however, these dams are built in areas where the rivers are already muddy with topsoil eroded through deforestation. Silt builds up behind the dam walls, eventually reducing storage capacity; by preventing the flow of silt downstream, the fertility of floodplains is reduced while riverbanks are eroded. Some of these immense projects have a life expectancy of only 100 years or so before they are left as a valley full of dangerous silt – a lethal mud tsunami waiting to happen.

In times of excessive rainfall, and where reservoirs are already full, operators occasionally have to make large emergency releases of water, thus causing the very floods that dams are designed to prevent. Overall, the benefits of dams flow mainly to townspeople, while the impact of these projects falls most heavily on the rural poor, whose fields are flooded and rivers and wetlands spoiled.

The sheer scale and extent of some water diversion and dam projects contribute to the number of major rivers no longer reaching the sea. To help understand the volumes of water we are talking about: one cubic kilometre of water is the same as 350,000 public

swimming pools full of water, or more than a bath full for every man, woman and child on the planet.

Only a century ago, 25 cubic kilometres of water a year flowed down the Colorado River straight into the Gulf of California. The Colorado River supplies seven states and Mexico, and water rights have been regulated since 1922 when a total of 20.5 cubic kilometres was allocated between its users. Since this agreement was signed, the average flow has fallen to 16 cubic kilometres. From 1999 to 2003 the average flow was only half that at 8.7 cubic kilometres, with 2002 providing the lowest flow of a mere 3.7 cubic kilometres. Most of this water is diverted upstream, for agricultural use. It is clear that this situation is totally unsustainable, especially in the light of rising demand from the cities that border the river.

The decline and death of the Aral Sea in Kazakhstan is perhaps the most catastrophic result of water diversion from the Amu Darya and Syr Darya rivers. Almost the entire flow of these two giant rivers – 110 cubic kilometres a year – was diverted in order to grow cotton in the desert. Until the 1960s, the Aral Sea was as large as the countries of Belgium and the Netherlands combined. The sea contained more than 1,000 cubic kilometres of water, with a reputation for its blue waters, picturesque beaches and busy fishing ports with an annual catch of 60,000 tonnes of fish.

Now, 50 years later, the Aral Sea has been reduced to three salt-saturated expanses, containing 10% of the sea's original water volume. The sea's fish have long since died, and its ports and beaches have been abandoned – some of these former ports are now more than 50 kilometres from the water. The area covered with water has reduced by two-thirds, exposing vast moonscape-like tracts of land.

The last 10 years have, however, seen a remarkable recovery as flows from the Syr Darya River have been restored. This raised local water levels by three metres, which was enough to begin reviving fisheries.

The near-disappearance of the Aral Sea, a man-made disaster on an unprecedented scale, has also changed the area's climate.

This is a real sign of hope that determined restoration effects can reverse some ecological collapses.

The near-disappearance of the Aral Sea, a man-made disaster on an unprecedented scale, has also changed the area's climate. The sea used to facilitate rainfall and moderate the temperature, creating cooler summers and warmer winters. The summers are now three degrees hotter, winters colder and longer, and cotton has to be planted in May rather than March.

The Murray River Basin in southern Australia is another disaster area, where thousands of giant gum trees have been cleared. Replacing trees with irrigated crops results in rising water tables, since there are no trees to use and breathe the groundwater into the atmosphere. As the water table rises, it brings deep water nearer the surface and with it billions of tonnes of minerals and salt. This mineral-rich or salinated water is rendering the soil infertile. The same effect is seen throughout the world where deep groundwater sources are used for irrigation. It is ironic that rice, cotton and sugar account for a third of Australia's water use, and that a country short of water is actually an exporter of virtual water.

The Henley-on-Todd Regatta, held annually in the renowned Australian town of Alice Springs, is yet another classic example of a river no longer flowing except in flood. For the last 50 years, men have paraded in bottomless canoes in the Todd's dry riverbed as a parody of the Henley Royal Regatta on Britain's river Thames. The Henley-on-Todd is the only regatta to have been cancelled because of wet weather – in 1993 there was water in the river!

Water in underground aquifers gradually accumulates over centuries through water seeping into the ground. Aquifer water

represents a form of slowly renewable capital, but in many places this water is being withdrawn much faster than it is being replaced. Groundwater is also the only form of drinking water available to about a quarter of the world's population, especially in cities. In the US, this percentage is 51%, while in Europe it reaches 75%.

Sanaa, the capital of Yemen, may become the first capital city in living memory to move because of a water shortage. The wells tapping the aquifer beneath the city are now as much as 1,000 metres deep and running on empty. Sanaa is likely to be a ghost city within the next decade. Across Yemen, Nature cannot replenish the aquifers fast enough to keep pace with the demands of a population set to double over the next 20 years. Local, often violent, skirmishing between water users is already common. The population will have to migrate from the mountains down to the coastal plains and look to desalinated water as an alternative supply – or more likely become water refugees in other countries.

The real problem globally is overuse of groundwater for irrigation. India, China and Pakistan pump out around 400 cubic kilometres of underground water a year, representing half the world's total use of underground water for agriculture. This rate of extraction exceeds the volumes of rainwater recharging those aquifers by somewhere between 150-200 cubic kilometres a year.

The result is a catastrophic fall of water tables. In Shanxi Province, China and beneath Beijing, the water table has fallen more than 70 metres. In Gujarat, India, a local water table is 150 metres down and is falling by a further six metres per year. Falling water tables have also led to land subsiding or sinking in parts of China and in Mexico. This can lead to the destruction of housing and civil infrastructure.

With diminishing underground water, farmers have to drill more boreholes and deeper every year – 21 million of them have been sunk in India alone over the last 20 years at a cost of US$12 billion.

Worldwide we are critically vulnerable, with almost one billion people currently eating food grown using the unsustainable extraction of groundwater. We are effectively living on borrowed time in the form of borrowed water. Even in the US, a third of its irrigation water comes from underground sources.

Water carries life, but it can also carry death. It is a continuing scandal that more than one billion people still do not have access to a safe supply of fresh, clean water. Research indicates that 2.3 billion people suffer from diseases linked to water. In developing countries this translates into 80% of all illnesses being water-related. Two hundred people an hour – more than 1.7 million a year – die as a result of unsafe water and sanitation.

Those of us who can simply turn on a tap can easily forget the many people who, several times a day, have to walk long distances to fetch and carry their water in containers. On average, these people use five litres a day, just sufficient for drinking and cooking but inadequate for the other uses most of us take for granted.

Untreated sewage leads to outbreaks of infectious diseases. In developing countries only a small amount of wastewater from sewage systems is properly treated, with most of it discharged straight into rivers, lakes and the sea. Many infectious diseases, like dysentery, cholera, typhoid and polio, are transmitted in drinking water contaminated by human or animal faeces. Children are particularly susceptible to diarrhoea, which can kill them through dehydration if nothing else. Disease can also be transmitted in water used to grow food crops.

In the 1970s, many boreholes were installed in Bangladesh in order to provide non-contaminated drinking water in an area where 250,000 people were dying every year from water-borne diseases. These wells were mainly sunk to depths of between 20 and 100 metres, where

In developing countries only a small amount of the wastewater from sewage systems is properly treated, with much of it discharged straight into rivers, lakes and the sea.

it turned out that the water was contaminated by arsenic carried by underground water from deposits in the foothills of the Himalayas. Consequently, some 12 million backyard wells contained poisoned water.

An insidious epidemic is creeping up on these Bangladeshi villages, as it typically takes 10 years for symptoms such as skin lesions and cancers to appear. The World Health Organisation (WHO) calls this the largest mass poisoning of a population in history, and tragically the Bangladeshi government has been slow to respond, leaving tens of thousands of people still at material risk.

In New York City, at the other end of the wealth scale, drinking water is no less important. A coalition of committed individuals, government, forestry departments, national parks and water management has come together to protect the watershed that provides the city with its drinkable water. From purchasing land to altering farming practices and reforesting the land, the city has come together to protect and create sustainability in its single most important life support system – water.

Whether man-made or not, global warming means that there will be more moisture in the atmosphere. This translates into heavier and more frequent downpours in temperate climates like Britain, and more extensive flooding in others as we have seen across the southern hemisphere in 2010: what goes up must come down!

The drought in Northern Spain in 2007 and fires in Greece in 2009 are ominous signs of things to come for Europe. Consider that Europe's heat-wave summer of 2003 represented less than a one-degree average variation on long-term average temperatures. A climate warmed by three degrees will have a devastating effect on not just agriculture but also on viticulture. In parts of France like Bordeaux and Alsace, warmer temperatures, up by over a degree in the last 30 years, already mean that grapes have more sugar and therefore higher alcohol levels, and consequently the character of these wines will change.

Nearly 500 million people rely on the water flows of the Indus and the Ganges, fed by glacial melt water from the Himalayas. Many glaciers in the Himalayas are melting rapidly, and some could disappear completely by 2035. The giant Gangotri Glacier in northern India supplies 70% of the Ganges flow during the dry season, and if it disappears, the Ganges will become a seasonal river which could cease to flow during the summer when water need for irrigation is greatest. Without this water, very little irrigation will be possible, and even more groundwater – already being over-extracted – will have to be used.

The same applies to the glaciers feeding the Yangtze and Yellow rivers in China. The Yellow River Basin is home to nearly 150 million people, and their fate is closely tied to that of the river because of low rainfall in the basin. The Yangtze is China's leading source of surface irrigation water, and helps to produce around half of China's rice harvest. These impending water shortages will restrict river-based irrigation, and subsequently lead directly to shrinking harvests.

In 2008 water supply issues in India affected production and, combined with ever-increasing demand, led the Indian government to retain part of its rice exports and to import wheat for the first time. The threat that changing water cycles pose to our industrial food production systems is likely to lead to conflict and fuels the risk of wars in the future.

Overall, water scarcity exacerbated by climate change is expected to reduce global food production by 350 million tonnes a year by 2025, equivalent to the current grain harvest of the US. Furthermore, the 3.2 billion people added to the world's population by 2050 will mainly be born in countries already facing water scarcity – and because 40% of the world's food supply comes from irrigated land, water scarcity means food insecurity.

The major storage system for fresh water outside the Himalayas is in the polar regions. Climate change in the Arctic is faster than anywhere on the planet, as the pollutants covering the once-bright, white snow no longer allow sunlight to be reflected back into space.

The North Pole is now ice-free in summer and the northern sea route to the East is navigable. Robert Swan, the British polar explorer, commented in 2010 that he was the first person to walk to both Poles and may be the last. Fifty years ago the ice of the Arctic Sea was nearly two metres thick, but by 2001 this had halved. Overall, the ice sheet has thinned as well as shrunk in area by 6%. The loss through thinning is, in fact, far greater than the loss in area and disguises the scale of this development.

The long-term trend is clear – the Arctic is melting. It is not unprecedented and has happened before, but it made the world a very different place. Despite some recent short-term stabilisation and a decline in the rate of melting, the long-term trend is currently irreversible and inevitable. Since the ice shelf reflects back 70% of the sun's radiation while open water reflects only 6%, this melting creates more melting as less sun is reflected, so temperatures rise, and so on in a continuous downward spiral. This is compounded by pollutants covering the snow causing it to reflect less heat back to space.

The ice cap and glaciers of Greenland are also melting at an unprecedented rate, creating immense lakes of fresh water. If too much of this water escapes into the Atlantic Ocean, it could shut down the already slowing Gulf Stream. This would have a dramatic effect on the world's climate, particularly that of Britain, which is directly moderated by the Gulf Stream. This moderation results in warmer winters and cooler summers than those of its continental neighbours on the same latitude.

More than 260 river basins are international, and 13 of these are shared by five or more countries. As many as 17 countries share the waters of the Danube. It's easy to see how disputes arise over the amount of water each country takes from shared rivers, or stores for itself in dams. There are currently many more positive interactions between countries on water issues than there are conflicts, including an international agreement between India and Pakistan over the Indus River.

Population growth and the corresponding increasing demand for water mean that disputes over river water are increasing. Downstream countries are more vulnerable and can object to plans proposed by upstream neighbours. The waters of the Nile are shared among Egypt, Sudan, Ethiopia, Uganda, Kenya and Rwanda. Treaties brokered by Britain in 1929 and 1959 gave Egypt and Sudan 90% of the water and a veto over any attempt by the countries nearer the source to divert water for their own use.

Egypt is wholly dependent on the lifeline of the Nile, without which it could not support its population, expected to rise from 68 million in 2000 to 114 million in 2050. Not surprisingly, Egypt regards its water supply as a security issue and has traditionally used military threats to maintain control over the Nile. This could be catastrophic for Ethiopia where 80% of the water of the Nile originates.

Ethiopia suffers from a chronic lack of water for its crops, which has condemned nearly 60% of its people to near-starvation. Its population – as, ironically, with most populations facing poverty – is expected to increase rapidly. All the countries bordering the Nile face soaring populations: within 15 years there will be almost 800 million people in the Nile basin. Where more meets less, there is inevitably a recipe for conflict over limited water resources.

Water has already been the cause of armed conflict in modern times between Israel and its neighbour Jordan. Water is the most important resource throughout the Middle East. The Six-Day War in 1967 was largely a response by Israel to Jordan's proposal to divert the river Jordan for its own use. The land seized by Israel gave it access to the headwaters of the Jordan, and also control over the aquifer beneath the West Bank. This increased Israel's water resources by nearly 50%. Israel currently extracts up to 75% of the flow in the Jordan River, leaving only the remainder to reach the West Bank. As a result many Palestinians living there are forced to survive on as little as 35 litres a day. Water levels in both the Sea of Galilee and the Dead Sea are falling as the river flow is diverted by man. There are now plans to pump seawater to the Dead Sea to maintain its levels and preserve its ecosystem.

Water is often used as a weapon of war, with the deliberate destruction of dams, pipelines and the contamination of drinking water.

Water is often used as a weapon of war, with the deliberate destruction of dams, pipelines and the contamination of drinking water. Examples include terrorists threatening to blow up a dam in Tajikistan in 1998; Iran diverting water to flood the Iraqi defence positions in the 1980-1988 Iran/Iraq war; Bosnian Serbs poisoning water supplies in Sarajevo in 1992; and Saddam Hussein's army poisoning and draining the Tigris-Euphrates river estuary to dislodge the Marsh Arabs in coastal Iraq.

Our supply and use of water is a challenge that will only intensify over the next 20 years. We need a 'Blue Revolution' to follow on from the green or agricultural revolution of the '60s and '70s to help us manage water before it manages us. The World Water Council's projections of water usage in 2025 make it clear that a 'business as usual' approach will simply make a bad situation even worse, as agricultural, industrial and domestic demand continues to expand in line with our rising population.

Our Blue Revolution needs to start now, with cutting out unnecessary and wasteful domestic water use. The water we do have will have to be used and reused, including the use of urban wastewater and short-interval water recycling. Carving up our fields once again with hedgerows and harnessing monsoons and other highly seasonal water with smaller-scale, farm-level dams and storage systems will help moderate the effects of the changing water flow patterns. This will not only help reduce soil erosion, but also help replenish our aquifers.

We react to crises as they arise – without taking the necessary action to avoid them.

We need to allow and encourage the next generation of genetically modified water-wise crops to be developed without the anti-GM sentiment so easily generated in the developed West. World Bank funding must be diverted from funding dam construction to helping smaller-scale farmers at national-level move to drip irrigation systems.

We should all take note of the reforestation success stories and emulate them in many more countries. We need to achieve globally, and in a far shorter time span, what they have achieved quietly over the last 50 years.

The British government announced plans in February 2011 to sell off the state-owned forests. The politicians completely misread public sentiment, however, and did a complete turnaround when they

realised the massive public opposition. More than 500,000 people signed an online petition, and with both celebrity and press support the proposal was scrapped. This once again shows that people, not their governments, will drive the change we need to save the planet – ecosystem by ecosystem.

Despite limited and weak political will, there is ongoing powerful environmental action driven by ordinary people – people like us. We can all make a difference, no matter how small, by acting right now. It's as simple as turning off the dripping garden tap. It is likely that we will end up on a path to sustainability not because of our governments, but despite them.

CHAPTER TWO – **LAND**

When we talk about land, particularly farmland, what we really mean is the relatively thin layer of soil that covers our rocky planet in patches and supports life as we know it. Soil is formed from the weathering of rocks into rock particles combined with organic matter from decaying plants. This soil then retains water and promotes plant growth which helps prevent erosion.

During the ice ages, glaciers scooped minerals and rocks from underground and mixed these with organic matter on the surface, creating much of the nutrient-rich soil that prompted an explosion of plant life. As the glaciers receded, more topsoil was created through plant decay, leaving us with a fertile, abundant planet.

Soil takes centuries to accumulate. Think of a huge pile of leaves in your garden left for the winter to break down and rot, or the straw mulch around your roses. A large pile of biodegradable matter makes only thimblefuls of compost: this is how long it takes for Nature to make soil. Soil is formed at a rate of 2.5cm every 250-1,200 years, depending on climate, plant cover and local geology. It can take between 3,000 and 12,000 years to build up enough soil to make cultivatable land.

The depth of soil coverage varies enormously because it is created, moved and destroyed by glaciers, wind, rain and, most recently, man. Rain naturally moves some soil from wooded hillsides down to lower ground, creating fertile valleys and floodplains.

This slow accumulation process means that soil is created on an almost geological time scale. Without soil mankind cannot survive: soil is a non-renewable, finite resource that we must maintain and preserve for future generations.

Soil has three basic aspects: its physical structure, its chemical content and its biological activity. These three elements are intricately interconnected. The physical structure and therefore quality of soil depends on the proportions of organic and inorganic material in its composition – varying, for example, from soils that are mostly sand to purely organic material like peat. The mineral content in soil determines its nutritional quality and that of the plants growing in it. The biological activity in the soil – the patterns of life it sustains – is the most complex and least understood of its three facets.

Soil is unlike any other natural resource that humans use. It is neither an industrial component nor some inert resource to be exploited like an extracted mineral. It is alive and constantly changing, pulsating with organisms that thrive on its organic content. It is this life that makes it soil and not lifeless sand.

Over a decade that same hectare would be covered with worm casts just over five centimetres deep.

Living naturally in all our soil are nematodes – what we could call worms – tube-like creatures with a digestive tract. We don't know how many species of nematodes exist in Nature; some 30,000 species have been identified to date. Nematodes range in size from those that are invisible to the eye to the common earthworms we often find in our gardens. Each cubic metre of soil contains up to 10 million nematodes – or 10,000 in an average plant pot.

As nematodes work, they ingest and churn the earth, breaking down and distributing organic matter from the surface throughout the topsoil. On a single hectare nematode or worm casts can bring an astonishing 25 tonnes of soil a year to the surface. Over a decade that same hectare would be covered with worm casts just over five centimetres deep. These droppings are rich in nitrogen, calcium, magnesium and phosphorus, all important nutrients for healthy soil and agriculture.

By tunnelling through the soil, nematodes provide passageways through which air, water and nutrients can circulate and help prevent soil compaction. This is important because soil microorganisms and plant roots need air and water which together nourish the plant. Traditional farming methods involve ploughing the land, scattering seeds, and then covering them. The newer no-till farming method inserts seeds directly into the unploughed soil. The unploughed soil allows the nematodes to do the job of aerating the soil instead of the plough.

Nematodes also need food in the form of decaying organic matter, which they then turn into humus. No-till farming uses previous crop residues and other organic matter as a dressing that nourishes the soil rather than the plant, which then feeds itself. Both the plants grown in humus-rich soil and animals then fed on these plants develop their own natural resistance to disease.

Darwin remarked that while the plough was one of the most ancient and valuable of man's inventions, long before it existed the land was in fact regularly ploughed, and still continues to be, by earthworms. He doubted whether there were many other organisms which played such an important part in the history of the world, and consequently in human life.

In addition to nematodes, there are also between 100 million and one billion bacteria in a cubic metre of healthy topsoil. Many of these bacteria are responsible for the decomposition and recycling of nutrients and minerals in the soil. Bacteria also interact with air and water in the soil, and with plant roots. These bacteria enable the plants to access nutrients and therefore to grow.

All of us can instinctively feel the difference between healthy living soil and inert, dead, sandy or dusty soil. The consistency and texture of soil immediately resonates with us all: healthy soil is soft, dark, moist and cloying in composition and smell, whereas unhealthy soil is coarse, dry and granular, dusty-smelling and runs through your fingers.

In his quest to conquer Nature, man has failed to understand the long-term and complex nature of soil. Industrial agricultural practices are degrading and destroying this non-renewable resource. We are slow to learn from the wisdom of our ancestors, who understood how to work with and live from the soil. Modern farmers across the world are re-learning how to work with Nature, as their current farming methods are delivering diminished yields from tired soils. While modern, post-war agricultural methods using nitrogen-based fertilisers have fed the macronutrient or chemical aspects of soil, these are destroying the soil's natural microorganisms.

Since the great famine of the early 1960s, farmers in China started the intense use of nitrogen-based fertilisers. This has led to a catastrophic decline in the number of nematodes in the soil and has halved the amount of cropland once considered high quality. This destruction will necessitate the input of huge amounts of organic matter to restore the soil's structure and productivity.

Similarly, potato farmers on South Africa's West Coast have faced falling yields since early 2000, and are now reverting to applying compost rather than industrial fertilisers to restore yields. They have recognised that their soil productivity has fallen through overuse of nitrogen fertilisers that reduce the soil's natural nematode and bacteria populations.

The United Nations' Food and Agriculture Organization (FAO) has identified imbalances and deficiencies in the physical, chemical and biological conditions of soil resulting from growing single-plant crops over large areas (monoculture), compacting soil with heavy machinery and applying agrochemicals indiscriminately. Soil conservation strategies must be an integral part of sustainable agricultural development. The FAO has been promoting the benefits of no-till farming around the world through farmers' unions in individual countries. This is getting through to farmers, as the rates of adoption of no-till land management are increasing rapidly.

The transformation of our agricultural and food systems from agriculture to agri-business over the last 50 years has seen a massive re-engineering of Nature and natural processes by man. Livestock were once integrated into land management; mixed and varied crops preserved the soil and prevented erosion. Waste and by-products, whether animal or vegetable, were converted into compost for the soil. Rainwater was stored and managed and animals were left to develop their own immunity against disease.

Specialisation works well in industry, but not in farming and Nature. It is the interaction of a wide variety of plants and animals that maintains Nature's balance.

These conditions are almost the exact opposite of modern agricultural practices, which promote vast plantings of monoculture crops like wheat. Separating animals from the plants fails to preserve the soil structure. Where animals are integrated they will eat crop residues and fertilise the soil with their manure. In much of industry, firms specialise in making one product or even a single component of that product. This sort of specialisation works well in industry, but not in farming and Nature. It is the interaction of a wide variety of plants and animals that maintains Nature's balance, in which no one species (other than man) dominates.

Man has tamed four meat animals (pigs, chickens, cows and sheep), exploited four main fish types (salmon, cod, bass and tuna) and four main cereals (wheat, rice maize and soya). Where there is a natural or man-made abundance of anything, Nature registers this as an imbalance and provides disease or predators to restore the balance.

The monocultures that we have developed require the continual application of pesticides or injections of antibiotics to maintain good plant and animal health. Without this constant artificial intervention our crops would go to ruin and our animals would die. Farming has followed and mimicked industrial business practices, outsourcing to specialist firms many key factors of production. There are specialist seed producers, and businesses exclusively breeding day-old chicks or producing only seed oysters for others to mature. Our food production systems have graduated from small-scale, labour-intensive and largely sustainable systems to industrial-scale, highly specialised and capital-intensive businesses.

Modern farming methods stem from man's obsession with the science of agriculture. Soil analysis and its preparation in industrial farming focuses on the three macronutrients – nitrogen (N), phosphorous (P) and potassium (K) – and as a result is often called 'NPK' farming. The less vital or secondary macro- and micronutrients as well as the biological health of soil are largely ignored. In allowing soil to be used as a commodity, to which we add man-made chemical macronutrients, we have created an agriculture industry divorced from its foundation and future – namely, healthy soil. Mined phosphate rock may peak in the next 20 years and alternatives are vital because without phosphorous fertiliser wheat and other grain yields could halve per hectare.

... just a few grain crops, including wheat, rice, maize and soya, which together account for 70% of all food calories produced for human consumption.

Industrialisation and specialisation have led man to focus on just a few grain crops, including wheat, rice, maize and soya, which together account for 70% of all food calories

produced for human consumption. These crops were adapted from wild plants by early man, and improved by farmers through selective breeding over generations. More recently, these plants have been genetically modified by scientists to produce, for example, more grain per stalk, or to be pest- or drought-resistant.

Monoculture has increased the prevalence of animal, plant – and indeed human – disease. Instead of promoting health and immune system responses to disease, we call in the sprayers, vaccines, antibiotics and serums. This policy is failing us. Protecting crops from pests by means of pesticides and insecticides merely preserves unfit plants.

Our industrial approach, with its inherent flaws and man-made antidotes, has led to an unsustainable explosion in short-term land productivity that has enabled us to feed billions more people. It represents a transfer of the soil and Nature's accrued capital value to the current account profitability of those exploiting it.

The cost of environmental degradation or damage is not accounted for by farming or agri-businesses. In business, using a hidden balance sheet to inflate your profit and loss account is what caused Enron's collapse. In agriculture it will lead to temporary success in increasing production and profitability. All goes well as long as the soil can be made to increase yields, but soil fertility does not last forever; eventually the land is worn out or depleted. Then the accounting trick is exposed and the enterprise collapses.

This mechanisation of agriculture has freed once land-locked labour to move to the cities and fuel our urban and industrial economies. The industrialisation of our fields and high streets has happened hand-in-hand. As food retail outlets have grown in scale, so have our farms. In our own neighbourhoods, we have witnessed the disappearance of small shops and their replacement with large supermarkets and immense hypermarkets. The diversity and individuality of the small-scale has given way to larger, more uniform retail chains by a process of elimination through business efficiency and competition. As these supermarkets squeeze their supply chain (farmers) ever harder and often out of business, the agri-conglomerates, with their industrial scale and access to capital, take over and industrialise farming.

This revolution in our farming and food distribution systems has delivered many benefits. It has created an increase in production and a reduction in the price of food in the face of increased demand. Broadly speaking, food production has kept pace with the rapid increase in world population. It could conversely be argued that the advances in agricultural yields have created our global population explosion. Either way, the food system still does not work for many of our people and is showing signs of stress. As a whole, the system currently leaves just over a billion people on the edge of starvation – up from a `low' of 788 million in 1996.

The Soil Association was founded in Sussex, United Kingdom (UK), in 1946, as even then forward thinkers, from farmers to botanists, began to understand the effects that mechanisation, plant monocultures and intensive animal rearing would have on the soil – and the potential long-term effects on agricultural production. This early awakening led to the emergence of the later organic movements. In agricultural philosophy, there is a sharp and perhaps unnecessary divide between the two camps. One side advocates the extension of existing modern agricultural methods, including the large-scale development of biotechnology and further genetic modification of monocultures. The other camp proposes a return to or rediscovery of the nature of food production, from crop rotation and organic soil nourishment to genetic diversity in crops and animals. This camp includes those like HRH the Prince of Wales, who argues that modern farming methods are fundamentally unsustainable despite their success to date.

Traditional agricultural methods recognise and use the cycles of Nature. Our modern agricultural approach is based on our understanding of mechanisation, science and technology and delivered through specialisation, automation and control. We invented mechanisation and now seek to understand ourselves and the living world in terms of our own invention. This results in an approach to agriculture based on the science of manipulation rather than the science of understanding, an economics of exploitation and a corresponding agriculture of extraction. This approach focuses on maximising short-term return with little regard for the future.

The last few years have seen the emergence of a new approach to agriculture called agro-ecology. Agro-ecology is not associated with any one particular method of farming or management practice, such as the use of natural enemies in place of insecticides, or polyculture in place of monoculture. Agro-ecologists do not unanimously oppose technology or inputs in agriculture, but instead assess how, when, and if technology can be used in conjunction with natural systems to deliver productivity, sustainability and equitable outcomes.

Using this approach, soil is not treated as an inert medium to which computer-controlled factors of production – like fertilisers – are applied. Soil is regarded as a living system in which nematodes and bacteria work to produce and maintain healthy, nutrient-rich soil. This is perhaps nothing more than using common sense in farming. In places like Madagascar, where agriculture has been relatively undisturbed by modern methods, agro-ecology is the norm. Madagascar's deforestation and massive soil erosion are a different problem. These simple ecological principles for soil management include the enhanced recycling of plant and animal matter and creating shade and windbreaks for soil protection through planting mixed woods. These woods in turn support a diverse range of animal and plant species, keeping the soil in a natural state.

Agriculture needs to be closely embedded in wider local ecosystems. Effective agro-ecological designs can help integrate the components of natural systems into man's requirements for agricultural production. By working with Nature rather than trying to impose our designs on natural systems, overall biological efficiency is improved, biodiversity is preserved, and the productivity and self-sustaining capacities of these agro-ecosystems are maintained.

The interconnectedness of systems in Nature continues to surprise us. In Yellowstone National Park in the American West, the wolf was hunted to local extinction some 90 years ago. Since then the number of aspen and cottonwood trees has dramatically declined, resulting in deforestation. In the absence of their natural predator, the elk population expanded and grazed down the small aspen and cottonwood saplings, preventing renewal of these once endemic trees. The absence of these trees also led to soil erosion and fewer wild birds and beaver dams.

The successful re-introduction of the wolf in mid-1995 from packs in Canada has led to increased bird and beaver populations, reduced soil erosion and better fish stocks. The aspen and cottonwood trees are flourishing again, particularly along the riverbanks.

Optimising agro-ecological processes will strengthen the natural resistance of crops against pests and disease. It will also decrease environmental toxicity by reducing the need for man-made chemicals and pesticides. Recycling our organic waste – creating effective nutrient recycling back to our gardens and fields – is starting to happen in European cities like London and Berlin. In many European cities it is now mandatory to separate organic waste from household waste; the organic waste is then composted and made available for use on our soil. This recycling initiative reduces landfill and creates a valuable product. It should become the norm worldwide.

With increasing urbanisation and mass food production systems, modern man has little interaction with Nature and often sees it as an outside force to dominate and conquer. From the urban garden to the gigantic farms and harvesting machines of the prairies, man has sought to manage and manipulate Nature for his benefit. Where his manipulation becomes a battle against Nature, humanity will eventually find himself on the losing side.

Agriculture must rapidly become part of the solution to our environmental challenges rather than a cause of environmental degradation. We need to develop an agriculture of agro-ecological systems that enhance the environment. Like Nature, farming is inherently cyclic and capable of self-renewal when properly managed. When run like a machine, as it so often is these days, farming becomes destructive, designed to suit the capitalist model of exploitation of 'free' natural capital. We ignore, at our peril, the inescapable connection between fertile soil and healthy crops, and healthy animals and healthy human beings.

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Einstein observed that the problems created by a particular way of thinking cannot be solved by the same kind of thinking. The problems created by industrial farming cannot be solved by the application of industrial solutions. In future it is likely that only agro-ecological farming operations will survive, as the cost of working against Nature will be too high. Overcoming Nature requires the application of increasingly expensive and ineffective industrial solutions from fertilisers to veterinary drugs. Those working with natural systems will end up with better quality produce and will not need these inputs in such large quantities, reducing production costs. Competition in quality and price will then eliminate those farmers who don't work in harmony with Nature.

There are three main factors influencing our disappearing farmland: soil erosion, soil salinisation and human settlement. As these factors drive more of our agricultural land permanently out of production, it will be hard to maintain, let alone increase, global food production levels.

Soil erosion is defined as the removal of topsoil faster than the soil forming processes can replace it. Consequently, as long as rates of soil creation and depletion are equal, there is no long-term problem. The reality is, however, that much of our global farmlands are facing huge soil erosion.

Some 25 billion tonnes of soil are being washed away each year into rivers and oceans – more than three tonnes of soil for every human on the planet.

This erosion is predominantly man-made. Destructive agricultural practices such as mechanised ploughing are responsible for just over one-third of all soil erosion. A further one-third is due to overgrazing, with the remainder due to deforestation and land clearing.

Ploughing cropland loosens the topsoil and increases the surface area exposed to the sun. It also breaks the root systems that help bind the soil together. The surface crust of soil then dries and disintegrates more easily to be carried by the wind and rains into our rivers, turning them muddy. Some 25 billion tonnes of soil are being washed away each year into rivers and oceans – more than three tonnes of soil for every human on the planet.

Recent UN (FAO) estimates put the annual loss of productive farmland worldwide at 7 million hectares, an area nearly the size of Ireland. A further 910 million hectares of once-rich land – collectively an area the size of Canada – are already moderately degraded, which means that their productivity has declined.

It is estimated that 20 percent of the world's topsoil was lost during the period 1950-1990, and that more than a third of all cropland is losing topsoil more quickly than new soil is forming. Overall, cropland represents 10% of the Earth's land surface (some 1.5 billion hectares) and grassland a further 20%.

Overgrazing on marginal rangelands reduces the plant and root cover needed to hold soils in place. Where soil erosion occurs on these often semi-arid marginal lands, they rapidly become barren or desertified and almost permanently lost to agricultural production. Nigeria is losing nearly 350,000 hectares of cropland and rangeland to desertification every year as a direct result of both farming and excessive livestock populations. Nigeria's human population expanded from 37 million in 1950 to 151 million in 2008, while its livestock population grew from 6 million to 104 million over the same period (16 million cattle and 88 million sheep and goats).

On the African continent in 1950, there were roughly 227 million people and around 300 million heads of livestock. By 2009 this had grown to one billion people and 862 million livestock. More and more animals are kept to feed our growing population.

The prize for global livestock population growth has to go to the goat. Goats can survive on land where many other animals cannot, as they will eat almost anything. Overgrazing with cattle and then sheep deteriorates the rangelands to a point where goats are the only viable livestock. Like canaries in coalmines, goats are often the harbingers of environmental devastation.

As rangelands deteriorated, the goat population in Pakistan increased six-fold between 1961 and 2009. China now has a combined sheep and goat population of 281 million. In the United States where rangelands are in better condition and still able to support larger animals such as cattle, there is a sheep-goat population of a mere 9 million animals.

The marginal rangelands separating the Gobi Desert from arable farmland in China is now predominantly grazed by goats. Ninety percent of China's grasslands have been degraded, while grass production is down 40% since the 1950s. Overgrazing and the establishment of 'alien' or foreign weeds – the seeds of which were brought in by the winds – have disturbed the natural ecosystems. The desert now expands into these rangelands – engulfing or desertifying some 1,400 square miles a year of once-productive land.

Degradation of these grasslands also contributes to floods, as water is no longer held in the soils by the vegetation. Water falling on the vast, rolling plateaus of western China – such as the Tibetan and Loess plateaus – runs off, carrying this soil into the great rivers, such as the Yellow River and the Yangtze. Overall erosion in China is affecting 19% of its land, and the total soil loss amounts to five billion tonnes a year.

The situation in India is no better, with nearly a quarter of its productive land slowly turning into deserts. Similar problems, even if on a smaller scale, are now affecting countries like Algeria, Chad, Kenya, Afghanistan, Iran and Iraq. Declining soil fertility and health in Lesotho, Haiti and Mongolia have resulted in reduced yields and forced these countries to become dependent on food imports and international aid. Reduced yields and increased demand can only lead to commodity and food prices rising, which affects each and every one of us.

Deforestation for firewood or to create grazing land is the third main cause of physical soil erosion. In developing countries, especially where steep, marginal land has been cleared of forests for timber and cultivation, slopes are left exposed to the effects of heavy rain.

Deforestation can result in disasters invariably described as `natural'. The cost to human life as a result of deforestation is all too clearly illustrated by mudslides in Brazil in early 2011, which killed more than 500 people. Clearing of trees along the Indus Valley has led to a build-up of silt in the river system, which then could not cope with the unusually heavy monsoon rains of July 2010. More than 2,000 Pakistanis lost their lives and millions more were displaced as 20% of the country's land was flooded.

All these types of environmental degradation end in topsoil being carried away by water. This muddy water affects not only aquatic life and other ecosystems, but also man's use of the rivers and their waters.

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The two largest reservoirs in Pakistan lose around 1% of their storage capacity every year as they fill up with silt as a direct result of water-borne topsoil. Over time as these reservoirs silt up, their storage capacity will reduce and therefore so will the water available for irrigation and drinking.

The largest annual transfer of soil – amounting to 1.6 billion tonnes – is delivered by the Huang River into the East China Sea. Sediment accumulating in rivers has cut navigation channels by 50% and therefore reduced the size of boats that can operate on them.

It is not only water that erodes unprotected or degraded soil from our land. Wind erosion also occurs when the soil has little or no vegetation to hold it in place. Unprotected soil can be blown off by storms at a rate of up to 150 tonnes an hour from each hectare of land. Dust and sand storms are becoming increasingly prevalent the world over as marginal lands are stripped of their remaining vegetation.

The first major dust storm or 'Dust Bowl' in modern history was in the mid-western United States between 1930 and 1936. It caused major damage to America's agricultural systems. Deep ploughing of the Great Plains displaced its deep-rooted grasses that previously secured the soil and trapped moisture – even during droughts. This deep ploughing was made possible by early mechanisation and fed by a desire to grow crops rather than maintain the indigenous grasslands for animal grazing. The newly turned soil, combined with reduced rainfall, turned the fields to dust that blew away in huge, rolling clouds. This degradation of the land caused a mass migration of people from rural areas to the cities and extraordinary economic hardship during this transition.

Today 21st-century dust bowls are in the making. A town in north-west Texas, ironically named 'Happy', is the unfortunate harbinger of bad news. This farming community relies on water from the aquifer under its land to water its crops. Local officials announced in March 2010 that the aquifer was dry. The immense Ogallala aquifer in fact slopes, and is deep underground at one extremity and nearer the surface just under Happy. The water from this aquifer, if spread across the US, would cover all 50 states nearly 50 centimetres deep. While the rest of that region will be able to continue farming for some years to come, residents of Happy are concerned that their land will dry up and echo the desiccation across the Great Plains in the thirties. The people of Happy have understood that to farm using an unsustainable source of water is just that – unsustainable.

Annual dust storms are now a regular occurrence in eastern China as the remaining vegetation on marginal rangelands is eaten and the Gobi Desert expands. A particularly severe dust storm in March 2010, affecting an estimated 250 million people, blew straight across the Chinese mainland and into South Korea. The choking dust clouds blocked out sunlight and caused widespread breathing difficulties for those in its path. A number of dust storms originating in China have been tracked as far as the east coast of the United States.

Dust bowls can form either as a result of overgrazing, as in China today, or from over-ploughing, as in the US in the 1930s. During the 1960s the then-Soviet Union unwittingly created a dust bowl of its own. In an attempt to make a grain belt centred on the Kazakhstan region, the former USSR ploughed up grasslands and diverted rivers to irrigate the grain. As the rivers ran dry, the crops failed and a dust bowl ensued. Drought and overgrazing are already laying the foundation for dust bowls in the Sahel belt across North Africa – a fragile scrubland that separates the Sahara desert from the more fertile lands of the equatorial belt to the south.

Conservation and restoration projects are already underway in parts of India and China. We have to support and encourage these initiatives. In India, 6 trillion tonnes of soil are lost annually from the 80 million hectares under cultivation. Unprotected land may lose between 120 and 300 tonnes of soil per hectare in a single year.

The Loess Plateau in north-central China is home to over 50 million people. It takes its name from the dry, dusty soil created by years of overgrazing and unsustainable farming. Over a 10-year period, from 1994 to 2005, the area was extensively rehabilitated. This process began with the extensive planting of trees, especially on hilltops. Planting trees prevents water erosion and flooding from run-off, allowing the soil to retain moisture while the growing trees also act as a windbreak. Gradually terraces were built and the soil structure was restored and enriched with organic matter. Water was carefully conserved and food grown for local communities, increasing local employment. This exemplifies the agro-ecological approach – where the whole landscape is restored and once again made productive. Every such project enhances the food security and wealth of local communities.

The soil left on our land is also being taken out of use for food production at an alarming rate. There are four main causes:

excessive mineral build-up or salinisation in the soil; wasteful production of biofuels; man's increasing use of land to accommodate a rapidly expanding global population; and climate change.

Irrigation with deep groundwater rich in minerals can lead to salinisation of the soil – an ongoing problem for some 6,000 years. There are two main causes of salinisation. First, where land is cleared of trees and shrubs that are resistant to saline water, groundwater levels rise and bring saline water to the root table, affecting those crops not adapted to salt. Where no groundcover is planted and when fields are fallow, this effect is exacerbated as more water sinks into the ground, which raises the saline water table.

Secondly, salinisation can be caused by repeated application of mineral-rich (salinated) water drawn from deep underground onto topsoil where salt builds up. This is particularly prevalent in drier areas such as the grain belts of China and the US, or in areas of India where they cannot effectively store their rainfall for later use and rely on underground water sources. At least 20% of all irrigated land is already salt-affected. As we engineer our food crops to require less irrigation, we also need to engineer salt-tolerant varieties.

In Australia there have been multiple environmental impacts which, if we allow current trends to continue, offer a preview of what we are up against. Australian soils already have low-nutrient and high-salt levels, which translate into poor growth rate and low productivity.

High mineral salt concentrations make it harder for the roots of plants to absorb water, as well as having a more general toxic effect on certain crops. Drip irrigation poses less of a problem, as less water is used on the soil. Broadcast irrigation systems, however, using overhead sprinklers or other means, saturate the ground with more water than can be absorbed by plants' roots. Minerals seep into the soil, increasing the rate of salinisation.

This form of soil degradation already affects nearly 10% of cleared agricultural ground in Australia and is forecast to rise to 25% by 2030. Almost eight million hectares of irrigated land in India – 20% of its land – are now affected by salinisation; the comparable percentage in China is already 10%.

The second factor taking land out of food production is its alternative use for biofuel production. The principal commercial biofuels are ethanol, derived from sugar cane, and agri-diesel, derived from palm oil. They were originally touted as an ecologically sound means of combating climate change through their substitution for fossil fuels. The subsidies available to farmers to grow these biofuels made them very attractive. Land previously used to grow crops for the human food chain was diverted to grow the more profitable biofuel crops. In the US an understandable political imperative is to reduce dependence on foreign oil supply. The US spends more than $170 billion a year on importing oil, mostly from unfriendly nation states whom they are enriching.

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Current ethanol production in Brazil takes up 6 million hectares of land, but the target is 30 million hectares producing 100 trillion litres of ethanol per year. Malaysia and Indonesia are the primary producers of palm oil, with 6 million hectares already under cultivation between them. In Indonesia alone a further 18 million hectares of forest are being cleared for palm oil production, with yet a further 20 million hectares under threat. All this adds to the destructive effect on a country that has already lost 72% of its ancient forests.

In 2008 some 18% of grain production in the US was devoted to biofuels. This could otherwise have fed 250 million people with their average grain requirements. In 2009 more than a quarter of the US grain production was used in biofuels.

This substitution of food crops for fuel crops was a major factor in the rise of commodity and food prices in 2007-2008. The subsidies for biofuels have escalated the pace of the destruction of woodlands and forests. At that time decisions were being made on the basis of short-term profits, political imperatives and subsidies rather than long-term sustainability: the food crisis meets the energy crisis.

The real issue here is not creating an alternative, but reducing the chronic American addiction to cheap fuel. If the true cost, including the environmental damage of the fuel, was included in the retail fuel price, America would suffer a material price shock. Like Europeans who have far higher fuel prices, they would have to trade in their gas guzzlers for fuel-efficient cars.

The average American household's electricity bill is less than one-third of that in Europe. Electricity pricing does not reinforce the energy-saving culture that it does in Europe. If Americans were to switch to low-energy lighting, the US could close down several coal-powered power stations, save money and reduce its carbon emissions.

From the early '90s US car manufacturers like Ford produced fuel-efficient engines and cars all over the world, yet at home they continued to sell the standard large-engine gas guzzlers, convinced that American consumers preferred them. They misread their home market, as many of their consumers switched to the then more fuel-efficient Japanese motorcars, and they are now playing catch-up.

The third factor taking farmland out of production is man himself. Most cities have expanded from early settlements often located in fertile areas near rivers and estuaries. With industrialisation, urbanisation and rising populations comes more demand for infrastructure, factories and housing. Increasing wealth requires more roads for cars, more shopping centres and car parks and more leisure facilities such as tennis courts. More than 40 new golf courses were planned for 2010 in China's Gaungdong province alone.

This demand for land takes prime cropland out of production and leads to declining production levels. If trends from countries that have undergone rapid industrialisation are anything to go by, then China's grain land area will shrink by around 50% over 40 years, or at a rate of about 1.2% a year. Japan used to be self-sufficient in grain, but as it has grown wealthier and used up its farmland, it now has to import 70% of its requirement.

Already millions of workers in China have migrated from the country to towns, and they all need housing. Rising divorce rates and the one-child policy are increasing the number of households in China. Increasing affluence also means that people will want more space.

For every 100 million workers, around one million factories will need to be built, each of which takes up space and requires its own access roads and parking. Then there is a corresponding expansion of the road infrastructure: 1.15 million cars were sold in China in 1990, rising to 15.5 million in 2010 alone, and the 2011 figure is expected to top 20 million. In addition, appropriation of land for mining, forestry and even aquaculture, as well as rubbish dump sites, has contributed to polluting the soil and reducing and damaging cropland.

The fourth factor that may substantially reduce our productive farmland is climate change. We have experienced ice-free periods in history, but sea levels then were some 70 metres higher. As we enter another period of climate change, one of the major consequences will be rising sea levels.

Most productive farmland is on low-lying ground and around estuaries, rich in topsoil washed down from higher ground. As sea levels rise the resulting flooding will therefore have a disproportionate effect on farmland and on food-producing soils. A few degrees' rise in global temperature will see both polar and Greenland ice melt – releasing water into the seas and raising sea levels by several metres. A rise of a metre or less would devastate the rice-growing river delta areas of Asia, on which much of the population depends for its staple food. Such a small rise seems almost certain in our lifetime, given the far larger predictions of most climate scientists. Since most humans live in low, coastal areas, existing inland farmland will be further affected as people move to higher ground.

Our disappearing farmland and climate change are creating uncertainty around global food supply. Food insecurity is driven by rising populations unable to be sustained on the land and water resources within a country's borders. Wealthy but food-poor countries concerned about their existing and future food security are increasingly buying or leasing land offshore to grow crops.

Saudi Arabia, for example, was able to grow up to three million tonnes of grain per year during the last 20 years, but they have now all but exhausted the underground aquifer that provided water to irrigate their crops. Crop yields declined by two-thirds between 2007 and 2010, and it is estimated that the last harvest of grain will take place in 2012. Without agricultural investment abroad, Saudi Arabia would be particularly vulnerable to market supply. Saudi Arabia may be oil-rich but it is water and food-poor. Despite its large landmass, it cannot sustain its 28 million people.

Generally, the investor country acquiring land in another country puts the unused land into production by investing heavily in infrastructure to service the project. Agreements typically leave some of the produce in the country albeit at market prices. It is not necessarily about price but rather security of physical supply for the investing country.

This approach involves using not just the host country's land but also its water – in a sense it is a financial land and water grab that in the past may have been achieved by war. Where the country also has huge labour resources such as China, it also exports its labour to work the farms, providing few – if any – benefits for the host country. It is estimated that some one million Chinese labourers are working on farms in Africa; in Zambia, for instance, Chinese-operated farms produce a quarter of the eggs sold in Lusaka.

Offshore investment in agricultural production of this nature helps to establish and ensure a semi-reliable physical supply of agricultural produce. The reliability of these schemes must be qualified since – as we have seen in India, Russia, Chile and other countries – when local harvests fail, the host country bans produce exports. Between 2006 and 2009, 15 to 20 million hectares were acquired in Africa by foreign sovereign states for production of food staples such as wheat, maize and rice for export to their home territories.

The world's largest offshore land investor is China, with 2.8 million hectares in the Congo alone. Controversially, China's holding in the Congo is devoted to the production of palm oil for biofuel, which is energy- rather than food-related. This highlights China's unease about its growing dependence on foreign oil with its rapidly expanding car fleet. China's total global holdings are hard to estimate as many of these deals are deliberately kept out of the public eye.

In the offshore land investment rankings, China dwarfs other investors. South Korea has nearly

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800,000 hectares; United Arab Emirates around 780,000 hectares; and Saudi Arabia and Qatar, around 450,000 hectares each. This foreign land investment in Africa equates with France's total agricultural land.

Sudan has said that it will reserve up to 20% of its agricultural land for the Gulf States, even though some of its own population is starving and the country already receives international food aid. One can only wonder what deals were negotiated to facilitate such a human catastrophe.

For the host country, an offshore investment can represent a welcome boost to developing its agricultural infrastructure. In some cases local opposition has prevented prospective investment, as in Madagascar where resistance led to the overthrow of President Marc Ravalomanana in March 2009. In Kazakhstan, China's proposal to lease one million hectares to grow soya for animal feed and other grain crops led to mass protest by affected locals in March 2011 – and the proposal was dropped.

China has 22% of the world population but only 7% of global arable land. This fact alone makes China vulnerable. With its shrinking land base and water shortages this risk is increased. A huge emerging middle-class now able to afford meat is fuelling the demand for cereals as animal feed and compounding the problem.

Most of these offshore investor land deals have been brokered by the sovereign wealth funds of these states. Agricultural `offshoring' is becoming a vital political priority and the practice will continue to expand as wealthy countries seek to ensure their food security.

British farmers spend £500 million a year on pesticides, and it costs a further £120 million to clean the residues out of drinking water.

Food is not as cheap as it may seem in the shops; in reality you pay in many ways – mostly indirectly – for the food you purchase. You pay once at the supermarket checkout and again through income taxes which provide subsidies for farmers, and pay for cleaning up the direct environmental as well as health side-effects. The long-term environmental costs are still unaccounted for at this stage – and therefore remain hidden. British farmers spend £500 million a year on pesticides, but it costs consumers indirectly a further £120 million, recovered through the cost of water, to clean the pesticide residues out of drinking water. The true cost of food is not internalised in the price you pay, but is shifted elsewhere.

Few people are aware of the costs of damage caused by pesticides, microorganisms and other disease agents. Conservative estimates put the annual costs in Britain alone at well over £1 billion for damage to the atmosphere, water, biodiversity, landscapes, soils and – last but not least – human health.

Recent academic research has shown a significant loss of minerals and trace elements in fruit and vegetables over the last 50 years as soil health has declined. The old adage of an apple a day no longer applies. You now need to eat three apples in order to provide your daily-recommended intake of minerals such as copper or zinc.

People are now eating more prepared foods than ever before. These foods are devoid of micronutrients and packed with chemical additives such as colourings, flavourings and preservatives. These dietary and food quality changes have contributed significantly to rising levels of diet-induced ill health. Where people are eating too much of the wrong food, they do not get an adequate supply of basic nutrients – leading to what is technically known as `overconsumptive undernutrition'. Our current farming and food system continues to fuel this trend.

With land – even more so than with water – we face issues of overexploitation of a finite resource. We have misunderstood the nature of soil as we have industrialised and grown distant from it. Unlike water and desalinisation, there is no back-up for our soil. There are hydroponic solutions that would enable life to continue but would not save our lands.

Our challenge is that our land is already under pressure at the same time as our population is increasing along with its demand for food, while at the same time climate change is expected to have an adverse effect on grain yields. The current agricultural food system as a whole cannot keep pace and is unsustainable. Our `use and abuse' of food, with more than one billion people overweight alongside one billion on the verge of starvation, is obscene.

To feed our growing population we have little choice but to develop agro-ecological initiatives to restore our croplands; reforest our hills and river systems; stop wasting the produce of our land; and recycle the nutrients we throw away as landfill back into our soil.