



## **Water - The New Carbon?**

### **Notes to Accompany Powerpoint Presentation**

#### **Purpose of Presentation**

The purpose of this presentation is twofold:

- to give an overview of the world's freshwater resource and an indication of where current trends are leading us; and
- to give an overview on what this means for water rich New Zealand.

#### **Outline of presentation**

The world's fresh water resource is examined under a number of headings.

These are:

1. World population statistics
2. Water statistics – how much is there?
3. Water use - locally and internationally
4. Trends in water demand and availability
5. Virtual water and water footprinting
6. World food supply and demand
7. Conclusion

#### **Introduction**

Current trends in fresh water supply and demand point to severe pressure being put on our water resource internationally. Some argue that this will lead to widespread famine, disease and war. They suggest a crisis will hit us within the next generation, and before the major predicted effects of climate change.

There is a constant theme running through any discussion on water and food supply. Food production is inextricably tied to water availability. Without water there is no food.

As a rough rule of thumb, it takes a litre of water to produce a calorie of food (the terms 'Calorie' and 'calorie' are interchangeable and 1 calorie = 4.2 kilojoules). A person's daily food intake will vary between roughly 2000 and 3000 calories. Therefore, at minimum, it takes between 2000 and 3000 litres of water to produce one person's daily food requirements – on top of their domestic water requirements for cooking, cleaning and physiological need.

To produce more food requires that more water be used. More people = more demand for food = more pressure on the world's water resource.

We take water for granted in this country because we are water rich. Over 80,000 cubic metres of freshwater runoff occurs per head of population per year in New Zealand – many times the average, putting us in the top 10 water rich countries in the world.

It is only recently that debate about the management of water has occurred here as a result of the resource being put under pressure for the first time, due to the significant increase in irrigation of pastoral and arable farms over the past 20 years, particularly in Canterbury, Hawkes Bay and the Waikato. Additionally intensification of land use is causing a decline in freshwater quality that needs to be reversed.

We take potable water supplies and well performing sewerage systems for granted nowadays, but we shouldn't. Both are recent phenomena.

Reticulated potable water supplies only became widespread in the second half of the 19<sup>th</sup> century, driven by civil response to epidemics of water borne diseases, particularly typhoid and cholera. As recently as the 1890's, cholera and typhoid outbreaks from water borne sources were relatively common in New Zealand.

Similarly the installation of reticulated sewerage systems in metropolitan areas has occurred only relatively recently. Again the drivers were epidemics of water borne disease resulting from discharge of raw sewage into waterways used for drinking water supply. As recently as the late 1950's we still operated night carts in parts of New Zealand.

These two initiatives together are estimated to have increased life expectancy by 15-20 years in western industrialised countries in the 19<sup>th</sup> century. Arguably this contribution was greater than that derived from advances in medicine during the same period (Pasteur's germ theory and its application by Koch et al, vaccines, antiseptics, etc).

While New Zealanders debate water property rights, methods of allocation and transfer, institutional arrangements, regulatory tools, changing patterns of land use and concomitant effects on water quality and demand management, our problems simply pale into insignificance by comparison with what is happening with water internationally.

## **1. World Population Statistics**

The trend in world population has been one of continuous growth since 400AD, interrupted with a couple of blips due to the bubonic plague pandemics in the 14<sup>th</sup> and 17<sup>th</sup> centuries. It started growing exponentially at the beginning of the 19<sup>th</sup> century and has more than tripled in the 20<sup>th</sup> century from 2 billion to 6.86 billion in January 2011. It is expected to increase by another 40-50 percent in the next 50 years and won't reach a stable state for another 150 years.

Rates of growth were fastest between the 1950's and 1970's before halving from a peak annual rate of 2.2% in 1963. This spectacular population growth over the past 150 years is attributed to the application of science to improving water and food supply, improved sanitation, and medicine. More latterly over the past 50 years it is also attributed to improved nutrition associated with the green revolution – improved cultivars and more widespread use of irrigation and fertilisers.

Sixty percent of the world's population lives in Asia and this proportion isn't predicted to materially change over the next 40 years. Asia is the big growth area, and it is here where food and water supply is under the most pressure.

The green revolution has finished but population pressure requires us to increase food production to feed these extra mouths.

Most of the population that will be added over the next 40 years will be in the least developed countries. This has implications for water use because poor countries cannot afford efficient water infrastructure – potable water supplies, reticulated wastewater removal and treatment, and integrated irrigation systems.

## **2. Water Statistics – for Both the World and for New Zealand**

The world's freshwater supply is finite. What we have is pretty well all we've got. Increased atmospheric temperatures allow for a little more to be stored as gas but not much.

How much is there?

While the bulk of the world's surface is covered in water, it is not widely known that only 2.5% of the water on the planet is held as freshwater. The rest is seawater. Of the 2.5% that is freshwater, 68.9% is held as snow and ice, 30.8% is held underground as groundwater, and only a miniscule 0.3% is held above ground as freshwater in lakes, rivers and in the atmosphere.

20% of this 0.3% is held in the Great Lakes system in North America.

The 2.5% that is freshwater is the equivalent of 35,000,000 kilometres<sup>3</sup>.

The 0.3% of freshwater that is available above ground is the equivalent of 105,000 kilometres<sup>3</sup>.

The water cycle is one of evaporation and transpiration into the atmosphere, cooling and then precipitation back onto the oceans and land.

Twenty percent of the water movement from the world's land mass is via evapo-transpiration. Eighty percent of ground and surface water flows out to the sea.

Sir Geoffrey Palmer once described New Zealand as being a very 'pluvial' country. He was right. Proportions of freshwater stored as surface and groundwater are respectively 100 and 2 fold higher than averages for the world.

World precipitation levels average 800mm per annum, whereas the average across New Zealand is 2000; 2.5 times the world average. Fiordland is one of the wetter areas of the world with annual rainfall averaging 6.5 metres, and parts receiving up to 12 metres, maybe more – right up there with the wettest places on the planet, variously attributed as being Cherrapunji in India, Llorca in Columbia, and Mt. Waialeale on Hawaii's Kauai Island, depending on which reference is used.

Available water per person can be measured as available surface water per person or annual runoff per person. Comparing figures for different countries demonstrates how blessed New Zealand is with water. Whichever way it is measured, water availability in New Zealand far exceeds international averages.

Average runoff per person per year across the world is 7100 m<sup>3</sup> - by comparison the figure for New Zealand is 80,000 m<sup>3</sup>.

### 3. Water Use Locally and Internationally

#### New Zealand Statistics on Water Use

We don't know exactly how much water is 'abstracted', i.e. taken from waterways and groundwater systems in New Zealand, because we don't measure it. This will change with the implementation of rules to require measurement of water takes.

A 2008 estimate put 5% of available water being consented for abstraction. In 2006 the Ministry for the Environment estimated that 10 kilometres<sup>3</sup> was abstracted. If this is correct then we only abstract 2.5% of annual precipitation c.f. the average across the world of 54%.

In New Zealand 77% of abstracted water is used for irrigation, 11% is used in industry, 9% is used for domestic purposes, and 3% is used for stock water.

Most of the abstracted water – 55% - is used for irrigation in Canterbury, and 18% is used for irrigation in Otago.

67% of consented water (water taken using mechanisms available via the Resource Management Act) comes from surface waterways, and 33% of consented comes from groundwater systems.

Actual use in New Zealand is estimated to be between 20% and 80% of the amount allocated via the Resource Management Act.

#### International Statistics on Water Use

See also

[http://www.unwater.org/statistics\\_use.html](http://www.unwater.org/statistics_use.html)

<http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTWAT/0,,contentMDK:21706928~menuPK:4602430~pagePK:148956~piPK:216618~theSitePK:4602123,00.html>

<http://www.unep.org/dewa/vitalwater/rubrique14.html>

Just over 50% of the available water is 'abstracted', i.e. withdrawn from natural waterways - rivers, lakes and underground, for use by humans. About 70% of water withdrawals are used for irrigation (in arid regions this figure goes up to 90%). Twenty two percent is used in industry, and 8% is used in households.

Abstracted water is mainly used for irrigation.

#### Domestic Water Access and Use

While basic needs vary, the UN recommends a minimum threshold of 50 litres a day per person for domestic consumption for physiological, cooking and sanitary needs.

Figures for daily per capita use of water for domestic purposes:

- 10 - 20 litres in sub Sahara Africa;
- 130 litres in Brisbane;
- 200 litres in Europe;
- 400 litres in the United States.

In the few metered jurisdictions in New Zealand - there are only about a dozen - the figure is comparable with Europe – circa 200 litres per person per day. In non-metered jurisdictions in

New Zealand, such as in Waikanae, the figure is circa 700 litres p.p. per day, and in one Central Otago town it is 1169 litres p.p. per day.

About 1 billion people lack access to clean water and use about 5 litres a day—one tenth of the average daily amount used in rich countries just to flush toilets. For women and girls living in such conditions up to three hours daily is spent physically carrying (often contaminated) water from source to dwelling places.

Over 2.5 billion – 1/3 of the world's people lack access to adequate sanitation.

Adequacy of water supply and sanitation are coupled, since, without sufficient water for sewage disposal, cross-contamination of drinking water with untreated sewage is likely to occur.

Various estimates put human deaths at five million annually from water borne enteric diseases. Two million of these are infants and children. This is 10 times the number that dies annually from wars.

### Agricultural Use of Water

Most of the water used is for agriculture for food production. Approximately 2000 to 3000 litres of water is needed to produce enough food to satisfy one person's daily dietary needs (about 1 litre per calorie), over and above domestic water consumption (only about 2–5 litres of water are required for an individual's physiological needs).

At least 1 metre<sup>3</sup> of water is required to produce 1 kilogram of wheat.

A minimum of 3 metres<sup>3</sup> of water is required to produce 1 kilogram of paddy rice.

1 kilogram of grain fed beef requires 15 metres<sup>3</sup> of water.

It takes 40 litres of water to produce a slice of bread, 70 litres to produce 1 apple, 150 litres to produce a cup of coffee, and 15,000 litres to produce a kg of grain fed beef.

### Irrigation Use

Worldwide, 15% of cultivated land is irrigated, but this land produces 40% of the world's food. The productivity of irrigated land is 3.6 times that of non-irrigated land. The monetary value of the yield of irrigated crops is some 6.6 times that of non-irrigated crops.

In 1900, 40m ha of land was under irrigation. This grew to 100m ha in 1950 and over 250 million hectares today. Half of this area is in China and India. The exponential increase in land under irrigation parallels world population growth.

The bulk of irrigated land is in the most densely populated countries. Ninety percent of land under irrigation is in Europe, North America and Asia. In contrast, sub-Saharan Africa contributes less than 2%.

The point to be made is that without irrigation we could not feed the current world population.

## 4. Trends in Water Demand and Availability

Drivers for increased water use are:

- increasing urbanisation
- increasing population; and
- increasing wealth.

- Since 1900 the world's population has trebled but at the same time there has been a six-fold increase in water use per person.

### Urbanisation

In 1800, 2% of the world's population lived in urban areas. This figure increased to 30% in 1950. In 2009 - for the first time more people live in urban rather than rural communities. Sixty percent of the world's population will be urbanised by 2030. Urban populations can't grow their own food, and rely on reticulated water supplies and wastewater services. Both factors increase the demand for water.

### Increasing Population

Increasing population overall increases demand for water, with the average water requirement per person across the globe being 1243 metres<sup>3</sup> per annum.

### Increasing Wealth

As living standards increase per capita use of water goes up due to:

- increased consumption of manufactured goods and services, which require water to produce – 22% of water is used in industry;
- improved nutrition; and
- changing dietary habits.

Higher living standards equate with a greater demand for meat and dairy products, which requires more water to produce than cereals. As humans become wealthier their diets change, demand for goods and services increase, and per capita use of water increases exponentially.

### Overall Trends in Demand

Global water use rose six fold between 1900 and 1995, twice the rate of increase in population.

The total demand for food and fodder crops is expected to almost double during the next 50 years. The amount of water consumed in agriculture is predicted to increase by 70 – 90% by 2050.

Today, 60% of all food is produced under rain-fed conditions, and 40% from irrigated agricultural production. We are becoming increasingly reliant on irrigation to feed our human population.

### Trends in Water Availability

For further information if required go to:

<http://www.millenniumassessment.org/en/GraphicResources.aspx>

Overall water availability worldwide is declining as a result of:

- declining water tables;
- desertification and salinisation;
- pollution; and
- climate change.

A country is said to experience water stress when annual water supplies drop below 1,700 metres<sup>3</sup> per person. At levels between 1,700 and 1,000 metres<sup>3</sup> per person, periodic or limited water shortages can be expected. When annual water supplies drop below 1,000 metres<sup>3</sup> per person, the country faces water scarcity.

A third of the world's population now live in water stressed countries and numbers are increasing.

### Declining Water Tables

Many countries are over pumping aquifers and struggling to satisfy their growing water needs, including the big three grain producers — China, India, and the United States. These three, along with a number of other countries where water tables are falling, are home to more than half the world's people.

There are two types of aquifers, replenishable and non-replenishable (or fossil) aquifers. Most of the aquifers in India and the shallow aquifer under the North China Plain are replenishable. When these are depleted, the maximum rate of pumping is automatically reduced to the rate of recharge.

For fossil aquifers - such as the deep aquifer under the North China Plain, and the Saudi aquifer - depletion brings pumping to an end. Farmers who lose their irrigation water can return to lower-yield dry land farming if rainfall permits. In more arid regions, however, such as in the south-western United States and the Middle East, the loss of irrigation water will mean the end of agriculture.

Under the North China Plain, the average level of the deep aquifer is dropping nearly 3 metres annually, and in some areas it is falling at twice that rate. It is estimated that each year China uses 30 cubic kilometres more water than rain is replacing.

In parts of India water tables are falling by up to 6 metres per year – a more serious problem than in China because the margin between actual food consumption and survival is lower. In China average intake per person per day is 3000 calories, while in India the figure is less than 2500.

Much of the mid-west grain-production in breadbasket US states, Texas, Oklahoma, and Kansas, is dependent on irrigation from the vast Ogallala aquifer. Being used at a far greater rate than it is recharging, which is unsustainable, groundwater levels have declined by up to 40 metres over the past 50 years. As a result, wells have gone dry on many farms in the southern Great Plains. While this mining of underground water is taking a toll on US grain production, irrigated land accounts for only one-fifth of the US grain harvest, compared with close to three-fifths of the harvest in India and four-fifths in China.

Pakistan, with 158 million people (growing by 3 million per year), is also mining its underground water. In the Pakistani part of the Punjab plain, the drop in water tables appears to be similar to that in India. Observation wells near the twin cities of Islamabad and Rawalpindi showed a fall in the water table between 1982 and 2000 that ranged from 1 to nearly 2 metres a year.

This pattern is repeated across Iran, Saudi Arabia, Mexico, Israel and the Yemen. Mexico City has actually subsided by 9 metres over the past 150 years as a result of groundwater depletion

## Desertification

Desertification is land degradation caused by climatic variations and human activity – the latter from pressure on marginal land from growing crops and overgrazing. Desertification is widespread, increasing and as a result taking land out of production.

It is also an historic and cyclical phenomenon. Dated fossil pollen indicates the Sahara desert has been changing regularly between desert and fertile savannah, with advance and retreat dependent on yearly rainfall. Where human activity removes surface vegetation, desertification may become permanent.

According to United Nations figures, dry lands occupy 40% of Earth's land area containing 2 billion people. Between 10 - 20% of this area is degraded. Nearly 1/3 of the world's cropland has been abandoned in the past 40 years because erosion has made it unproductive.

The total area affected by desertification is estimated to be between 6 and 12 million square kilometres. For comparison the countries of Brazil, Canada and China are all between 8 and 10 square kilometres. This area is increasing by an estimated 200,000 kilometres<sup>2</sup> annually across the globe.

Effects of desertification include:

- lowered food production;
- increased downstream flooding, reduced water quality, sedimentation of rivers, lakes and wetlands;
- aggravation of health problems as people are exposed to dust; and
- forced human migration – e.g., as is occurring in Darfur.

Desertification directly affects over 250 million people - threatening the lives of some 1.2 billion people in 110 countries who are among the worlds poorest and who depend on land for most of their needs.

Desertification is found to some degree on 30% of irrigated lands, 47% of rain-fed agricultural lands, and 73% of rangelands.

Thirty six countries in Africa are affected by desertification or land degradation.

## Salinisation

Salinisation is reducing the land available for agricultural production worldwide, especially in arid and semi-arid climates.

Problems associated with soil salinity date from the dawn of civilization. The decline of the ancient Mesopotamian civilization — the first-known society to irrigate and farm land — has been linked to decreasing soil quality due to climate change and increased irrigation.

Estimates of the amount of soil lost to salinisation vary. The FAO estimates that 20,000 to 30,000 sq km are going out of production worldwide each year, whereas the United States Department of Agriculture estimates that the figure is 100,000 sq km annually. Closer to home, in Australia approximately 24,000 sq km of land is affected by salinity and 570,000 sq km of productive land is estimated to be at risk.

Very limited research has yet been conducted to quantify the economic impact of irrigation induced salinisation. Quantitative measurements have generally been limited to the amount

of land affected or abandoned. Estimates of the area affected have ranged from 10 to 48% of worldwide total irrigated area.

A discourse on the causes of salinisation is beyond the scope of this presentation. Salinity may be primary or secondary. Primary salinity is salt accumulation that occurs naturally in soils and waters. Secondary salinity refers to salinisation resulting from human activities, usually irrigated farming and land development. Irrigation is the worst culprit.

Many irrigated soils are 'sodic', with low water permeability increasing the probability of salt build-up over time. Because the landscape in irrigation areas tends to be flat, recharge of groundwater leads to an increase in water table levels. Lack of drainage can exacerbate salinity in land under irrigation.

### Pollution

Water pollution is a vast and complex subject, beyond the scope of this presentation. Overall water quality is declining worldwide by whichever measure is used, as a result mainly of intensification of land use for agriculture. Rates of decline are more rapid in developing countries. As in New Zealand, lowered water quality caused by intensification of land use is attributed due to increased nutrient loading, suspended solids (both biosolids and silt), and microbial contamination. Quantification of the effect of pollution on limiting water availability is not possible.

### Climate Change

There is enormous uncertainty about climate change and its effects. There is a close connection between temperature and the hydrological cycle. Rising temperatures increase evaporation leading to increased precipitation. Overall, the global supply of freshwater is predicted to increase.

Modelling indicates regional effects – dry areas will get drier and wet areas will get wetter.

On the assumption that there will be an increase in the Earth's temperature, the following effects are predicted.

- Some water, which has hitherto been stored as ice in glaciers and as snow, will melt. Snow and ice provide natural reservoirs, storing moisture over winter and releasing it during the spring and summer, and therefore potentially available for downstream irrigation and urban uses. Runoff will occur earlier in snow-fed river systems, increasing the risk of winter and spring flooding while reducing water availability in the late summer and early autumn.
- The build up of atmospheric CO<sub>2</sub> will cause increased acidification of oceans. When current and predicted levels of CO<sub>2</sub> occurred 25 million years ago, acidification in the oceans caused the extinctions of large numbers of species. The areas which are going to be hit most severely acidification are the coral reefs of the world. Coral reefs provide significant protein supplies to about a billion people.
- Sea levels will continue to rise.
- Precipitation and runoff will increase in far northern Eurasia and North America.
- The likelihood of heavy downpours will increase, especially in areas where there is an overall increase in precipitation.
- Some areas of the subtropics facing a substantial risk of declining water availability. In the wet tropics, densely inhabited Asian mega-deltas such as the Mekong and Ganges / Brahmaputra are at risk for increased flood damage due to the combined effects of sea-level rise and increased river runoff during the monsoon season.

- Periods of intense precipitation over other heavily populated low lying areas increasing flood-related risks to property, infrastructure and human safety.

### Summary of Trends in Water Supply and Demand

- Demand is going up.
- Supply is going down.
- One third of the world's population live in water stressed areas and this figure is increasing.

## 5. Water Footprinting and Virtual Water

### Water Footprinting

A water footprint is the amount of water used per person per year. The concept of water footprinting is increasingly being debated as a measure of the efficiency and sustainability of water use.

Comparisons can be made country by country. The average across the world is 1243 metres<sup>3</sup> annually.

The water footprint of China is about 700 metres<sup>3</sup> per year per capita. Only about 7% of the total Chinese water footprint falls outside China.

Japan with a footprint of 1150 metres<sup>3</sup> per year per capita, derives about 65% of its total water from outside the borders of the country.

The USA water footprint is 2500 metres<sup>3</sup> per year per capita.

The International Standards Organisation is working on protocols for measuring water footprints. These will include assessments of the environmental effects of using water to produce specific products in specific locations.

### Virtual Water

Virtual water refers to the water used in the production of a good or service that is traded. It is also known as embedded water, embodied water, or hidden water.

For example, when a country imports one tonne of wheat instead of producing it domestically, it is saving about 1,300 metres<sup>3</sup> of real indigenous water. If this country is water-scarce, the water that is 'saved' can be used for other ends. If the exporting country is water-scarce it has exported 1,300 metres<sup>3</sup> of virtual water since the real water used to grow that quantum of wheat will no longer be available for other purposes.

The volume required to produce a specific product will depend on the production system in the country of origin, including climatic conditions and agricultural practices.

The virtual water content of a litre of milk produced from rain fed forage in Taranaki is much smaller than that produced under irrigated conditions in the Murray Darling basin in Australia. It has a significantly lower environmental effect than the Australian equivalent.

Virtual water is increasingly having an impact on global trade policy and research, especially in water-scarce regions, and is redefining discourse in water policy and management.

There are shortcomings in the virtual water concept.

- It relies on an assumption that all sources of water, whether in the form of rain or provided through an irrigation system, are of equal value.
- It assumes that water that would be released by reducing a high water use activity would be available for use in a less water-intensive activity. For example, the implicit assumption is that water used in rangeland beef production would be available to be used to produce an alternative, less water-intensive activity. As a practical matter, this may not be the case, nor might the alternatives be economic.
- It fails as an indicator of environmental harm because it does not provide any indication of whether water resources are being used within sustainable extraction limits.
- The use of simple virtual water estimates therefore offer no guidance for policy makers seeking to ensure that environmental objectives are being met.

Despite these shortcomings, the concept is likely to provide New Zealand with increasing competitive advantage in the marketplace going forward.

## 6. World Food Supply and Demand

For more information go to:

<http://www.fao.org/docrep/004/y3557e/y3557e06.htm#e>

<http://maps.grida.no/go/searchFree/q/%22grain%22%20OR%20%22food%20production%22>

So far world agriculture has been able to respond to the rising demand for crop and livestock products. The world's population doubled between 1960 and 2000 and levels of nutrition improved markedly, while the prices of rice, wheat and maize - the world's major food staples - fell by around 60 per cent, i.e. supply outstripped demand.

More recently the world's food inventory has declined - significantly. In 2008 food reserves reached the lowest reserves as a proportion of consumption in all the years since records have been kept. Reserves are now around 14% of consumption, which implies 38 or 39 days of food reserves.

Over the last 40 years, world annual consumption of cereals for both food and animal feed has doubled to 2.2 billion tonnes. The rate of increase in demand is now slowing, but overall demand continues to grow. Best estimates for food demand are for an increase of 50% over the next 20 years. By 2050 food demand will double.

There is considerable debate on whether future production will keep pace with demand. The FAO predicts that globally, there is enough land, soil and water, and enough potential for further growth in yields, to make the necessary production feasible.

Globally, producers have satisfied market demand in the past, and the FAO predict they will continue to do so. The FAO predicts continuation of the current situation where about 0.8 billion people are inadequately fed, because of low incomes. The lower the income per capita, the greater the proportion spent on food. So people living on \$1 dollar per day spend up to 60% of their total income on food.

Other groups take a more pessimistic view, pointing out past discrepancies between FAO predictions and actual production. These groups claim FAO figures do not sufficiently take into account emerging constraints on food production, such as water scarcity, the cumulative effects of soil erosion, desertification, salinisation, and climate change.

In 2009 Britain's chief science advisor, Sir John Beddington, predicted we were 20 years away from a perfect storm created by increased demand, the increased cost of energy, and supply side constraints associated with insufficient water and land.

Falling water tables are already adversely affecting harvests in some countries, including China, the world's largest grain producer. China is over-pumping three river basins in the north. Combined with the conversion of cropland to non farm uses, and the loss of farm labour in provinces that are rapidly industrialising, China's grain production potential is under pressure.

At this point, the harvests of wheat and rice, India's principal food grains, are still increasing. Within the next few years, the loss of irrigation water could override technological progress and start shrinking the harvest in some areas.

Whichever scenarios are applied, water comes under increasing pressure.

One way food importing countries are dealing with this is by seeking to outsource food production for local consumption by buying or leasing arable land overseas – with varying success.

In 2008 in a well publicised case, Daewoo Logistics, a South Korean business, sought to lease 1.3 million hectares – half of Madagascar's arable land - in order to grow food to export back to Korea. This wasn't very popular with the locals who overthrew the president in a coup in early 2009. The new leader cancelled the deal.

Examples of deals that have stuck include Egypt and Kuwait buying 1.5 million ha of the Sudan, Kuwait buying into Cambodia, and Djibouti buying into Malawi. These countries are buying virtual water to manage risk to their own citizens.

At the time of writing Chinese interests are reputed to be buying the Crafar Farms in New Zealand along with milk processing capacity.

## 7. Conclusion

Going forward there is need for significantly increased food production globally. This is mainly associated with increased wealth, urbanisation and population growth in Asia.

Available arable land per person is decreasing. Therefore there needs to be significant gains in agricultural productivity in order to meet future demand. The rate of increase in agricultural productivity is slowing – not increasing.

It is likely that the long term trend towards cheaper food will be reversed as we start to run into resource constraints – i.e. shortages of land and water.

Will this make water the new carbon?

Future international trade in food is being made easier by free trade agreements such as the one New Zealand signed with China 12 months ago.

Of equal significance is the demand by consumers for safe food produced in sustainable ways with good trace back systems – witness the Sanlu melamine scandal. Large retailers are now imposing their own standards ahead of regulators.

There are only a few developed countries that are net food exporters. New Zealand is a net food exporter – of virtual water exporter. By international standards our water and land resource is not under any significant pressure.

This provides us with significant strategic advantage.

New Zealand's trade prospects are very bright.

## Appendix 1: Water Wars

Water has been used as a weapon of war. There aren't many examples of wars specifically fought over water. The only recorded incident of an outright war over water was 4,500 years ago between two Mesopotamian city-states. However, there are examples of conflict over resources directly related to water scarcity. The Civil War in the Sudan is one example. The root cause of the conflict is a lack of resources - drought and desertification in North Darfur. This has led the Arab population in the north to abandon land that has become unproductive and move into South Darfur, where they have come into conflict with local African farmers.

Water is taking over from oil as the likeliest cause of conflict in the Middle East.

All these nations depend on three river systems (Nile, Tigris and Euphrates, and the Jordan), or aquifers, some of which are fossil water that cannot be renewed.

In general, a country with less than 1,700 cubic meters per capita is regarded as experiencing water stress, while less than 1000 cubic meter is regarded as water short.

The list of water scarce countries in 1955 was seven, including three Middle Eastern countries: Bahrain, Jordan and Kuwait.

By 1990, 13 were added, among them eight from the Middle East: Algeria, Israel/Palestine, Qatar, Saudi Arabia, Somalia, Tunisia, United Arab Emirates, and Yemen.

UN studies anticipate another 10 water stressed countries by the year 2025. Seven of them are from the Middle East: Egypt, Ethiopia, Iran, Libya, Morocco, Oman and Syria. This means that by the year 2025 eighteen countries in this region will suffer from water shortages.

### Annual renewable fresh water available per person in cubic metres

Country	1955	1990	2025
Kuwait	147	23	9
Qatar	808	75	57
Bahrain	1,427	117	68
Saudi Arabia	1,266	306	113
UAE	6,196	308	176
Jordan	906	327	121
Yemen	1,098	445	152
Israel	1,229	461	264
Tunisia	1,127	540	324
Algeria	1,770	689	332
Libya	4,105	1,017	359
Morocco	2,763	1,117	590
Egypt	2,561	1,123	630
Oman	4,240	1,266	410
Lebanon	3,088	1,818	1,113
Iran	6,203	2,203	816
Syria	6,500	2,087	732
Turkey	8,509	3,626	2,186
Iraq	18,441	6,029	2,356

Sudan	11,899	4,792	1,993
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Population growth in the Middle East will put more pressure on its water resource.

Israel's population is projected to grow to about 8 million in 2025, while Palestinians in the west bank - because of their higher birth rate - are likely to reach just under seven million. They share the same water resources which they both now say are not enough.

Libya's population is projected to increase to 12.9 million in 2025. Egypt's population will reach 101 million in 2025.

In the Middle East water withdrawals as percentage of renewable water supplies are among the highest in the world, while the renewal rate is slow because of the arid nature of the land.

Water resources in almost all cases (with the exception of some aquifers), cross borders, and are being mined by multiple sovereign states in the basin.

There are few agreements on how it should be shared. Upstream countries believe that they should control the flow of the rivers, taking what they like, if they can get away with it, e.g. Turkey. Downstream, where the states are often more advanced and militarily stronger, this assumption is challenged, e.g. Egypt and Israel.

It is a recipe for confrontation.

There is no provision in international law to stop larger stronger countries imposing their will, in regard to water, on weaker, smaller neighbours.

Water policies in Jordan, Lebanon, Israel, the Palestinian Territories and Syria have been in the front line of conflict in the Middle East for generations. The Jordan River flow through the most hotly disputed territory of all, and is bordered by countries that have history of using force to gain their ends.

In 1964, an Arab summit conference decided to divert the headwaters of the Jordan - in effect, depriving Israel of its main supply. At the same time Israel built a pumping station on the western shore of the Sea of Galilee and began to mine the resource. Cross border raids on water schemes followed between Israel, Syria and Jordan.

To implement the 1964 Arab summit resolution, work began on the Syrian and Jordanian side of the border, despite Israel's warning that it would consider it an infringement of national rights. In the end, Israeli air strikes into Syria forced the Arabs to call off their scheme by destroying the proposed dam site.

Had the project been completed, Israel would have been deprived of 550 million cubic meters of water per annum.

General Ariel Sharon, later an Israeli Defence Minister, had no doubt what those skirmishes were all about. "People generally regard 5 June 1967 as the day the Six-day war began," he said. *"That is the official date. But, in reality, it started two- and-a-half years earlier, on the day Israel decided to act against the diversion of the Jordan."*

While a Jordanian on average uses 80 litres per day, Israelis use 300 litres, from the same river and the same aquifers – a source of friction. Israelis take 80 percent of the annual flow of 615 million cubic metres of water from mountain aquifers – seen as being stolen by Palestinians.

More recently, Turkey stopped the flow of the Euphrates. Officially, the interruption was to fill the lake in front of the Ataturk Dam; in fact, it was a demonstration to Syria of what might happen if President Hafez al-Assad continued aiding the Kurdish rebels in south-east Anatolia. Halting the flow of the Euphrates into Syria also brought water shortages in Iraq. Turkish planners thought that would not matter, as Syria and Iraq were bitter enemies.

Faced with this common threat, however, old antagonisms were forgotten; the Iraqi and Syrian media united in denouncing Turkey, and military leaders from both countries drew up plans for armed retaliation. After three weeks, the river was allowed to flow as usual, though the stoppage had been planned to last a month.

When all the Euphrates projects are complete, the Turks intend to harness the Tigris. That will have a direct effect on Iraq, again forcing Syria and Iraq into alliance.

Today, Egypt is regarded as the most moderate Middle Eastern nation. But it is as ready as any other country to use force to protect its vital resources. It worries about dams that might be built in the Ethiopian highlands, which could affect the flow of the Nile, and about grandiose plans for a canal that could tap the sources of that river in central Africa.

Egypt worries about Sudan, whose fundamentalist government is increasingly friendly with Iran. Egypt may intervene in Sudan if the flow of the Nile was threatened.

The high Aswan Dam has a lake stretch of 500 kilometre up stream and 60 kilometres wide in places. It can store two years of water that used to be available for the annual flooding (and fertilisation) of the lower Nile region.

Since the dam was built, almost all the 130 million tones of silt that used to flow downstream annually has been deposited in front of the dam. A dam burst would destroy Egypt.

With a long history of antagonism and mistrust, Middle Eastern leaders are reluctant to reform their agriculture policy, switching their subsidised home produced with imported cheaper food. At present almost all grow cereal crops - with little economic sense, not to mention the devastating effect on both surface and underground water.

That is unsustainable. Peaceful solutions to allocation of water by country seem increasingly unlikely.