ANZ Research

Agriculture Insight

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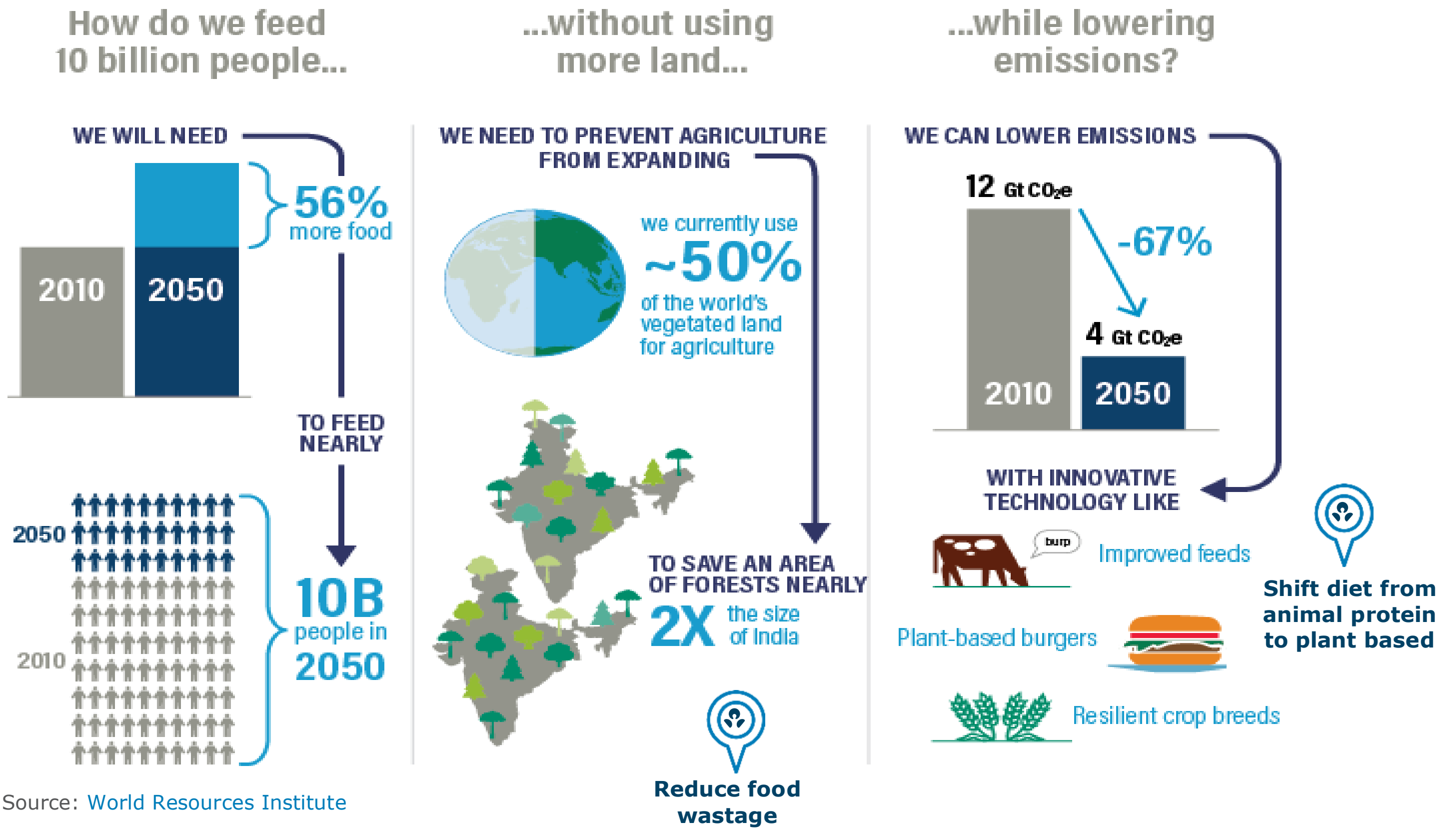
Confused by acronyms or jargon? See a glossary here.

Feeding the world sustainably

- Population growth, urbanisation and rising incomes suggest the world needs to increase food production by 50-60% by 2050 (from base year 2010) to ensure food security for a global population of ~9.7 billion.
- Food production systems are not currently sustainable, so in the future more food needs to be produced using less resources.
- Agriculture currently uses 40% of land and 70% of freshwater, and is responsible for 30% of global carbon emissions, so it is necessary to transform the sector to make it sustainable.
- Just increasing food production is not a sustainable solution. For food production to be sustainable other aspects need to be addressed, such as reducing food wastage via better supply-chain management, changing our dietary mix, and adopting technology to drive efficiencies throughout the food production supply chain.
- Technological solutions, including more digitisation and automation across the food chain, would help to achieve this goal.
- There are immense opportunities in the agriculture sector for investment throughout the supply chain to both increase food production and produce food in a more sustainable manner.

Figure 1. Sustainable agriculture production



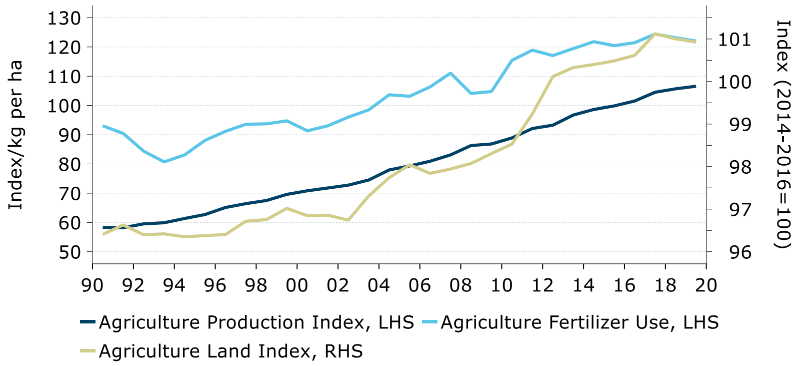
Source: World Resources Institute

Agriculture: the need to produce more with less

The world's population is estimated to reach 9.7 billion by 2050, providing a challenge for global agricultural production. On top of that, rising incomes and changes in dietary preferences towards proteins and fruits will put further pressure on food producers to accommodate this extra demand. Already today, nearly 10% of the world's population face food security challenges.

The expansion in food production over the past three decades to sustain the present population was achieved by expanding the area of irrigated land, converting forest to agricultural land, adopting new technologies, increasing mechanisation, using genetically modified seeds and very large increases in the use of fertiliser, pesticides and herbicides. This has resulted in plentiful production, but has come at a huge and unsustainable environmental cost to the planet.

Figure 2. Global agriculture production and land vs. fertiliser use



Source: FAO, Macrobond, ANZ Research

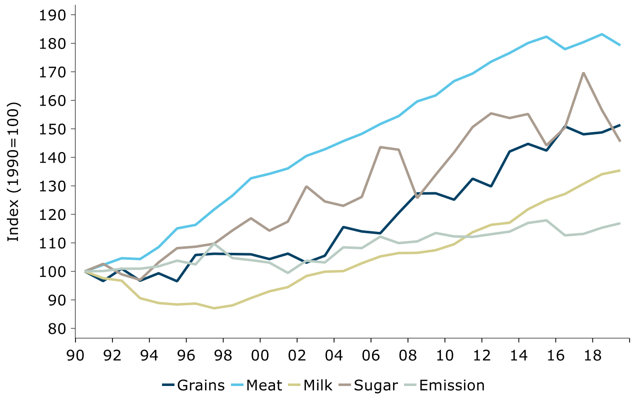
Food production now needs to grow amidst scarce resources, which means the world needs to "produce more with less". Unlike other sectors, agriculture is both a victim of and a contributor to climate change. Climate change is causing a rise in temperatures, and the frequency of droughts and unseasonal floods, which threaten crop productivity and heighten the risk of crop failure. The US Department of Agriculture estimates crop yield is diminishing by 2.5% per decade due to climate change.

Agriculture therefore has strong incentives – and is facing mounting pressure – to reduce its greenhouse gas (GHG) emissions. Many countries pledged to reduce methane emissions by 30% by 2030 in the latest COP26 meeting. Agriculture contributes nearly 45% of methane emissions, 80% of nitrous oxide emissions, and around 30% of total greenhouse gas emissions, via land-use change, farm-level production, and the processing of agricultural products. Emissions are highly concentrated in methane from ruminant livestock, manure management and rice farming. Nitrous oxide emissions come primarily from fertiliser usage.

In 2019, total emissions reached 16.5 billion tonnes CO_2 equivalent, according to the Food and Agriculture Organisation (FAOSTAT, 2021). This was made up 7.2 billion tonnes from farms, 5.8 billion tonnes from processing and 3.5 billion tonnes from land-use change. The World Resources Institute estimates global agri-emissions (from farm production and land use change) will increase to 15 billion tonnes by 2050 from the current level of 10.7 billion tonnes unless systems change.

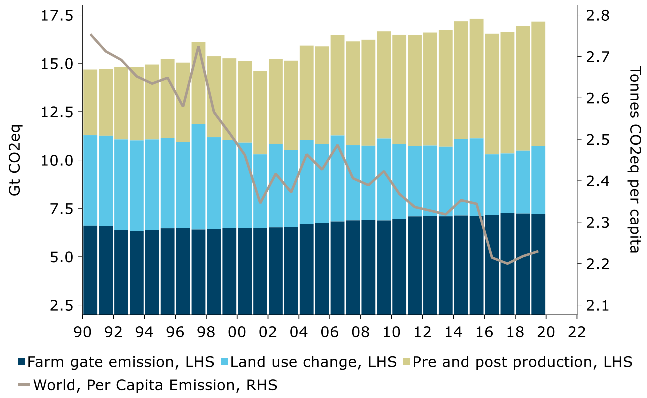
Figure 3 shows that emissions per kg of agricultural produce have been falling: grain and meat production grew nearly 60-80%, but emissions rose less than 20% in the past thirty years. Similarly, they've been falling on a per capita basis. But now the challenge is to produce sufficient food to feed the growing population, whilst reducing total emissions – not just growing them more slowly than production or the population. According to the FAO 2050 Outlook, agricultural emissions need to fall to approximately 3.5gt to achieve a sustainable scenario.

Figure 3. Global agriculture production vs emissions



Source: USDA, CAIT, Macrobond, ANZ Research

Figure 4. Global agri-food system and per capita emissions



Source: FAO, EDGAR, Macrobond, ANZ Research

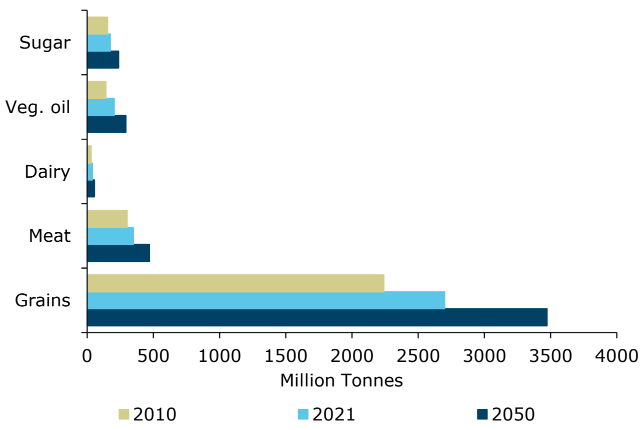
Reducing emissions from the agriculture sector will be tough compared to other sectors, as there is a need to ensure ongoing food security, biodiversity, the viability of farming communities and meeting nutritional needs. Therefore, a gradual transformation is required. But as we'll discuss later, there are some (relatively) easy wins, including reducing food wastage, considering what we eat, and applying new farming techniques, including crop intensification.

Food production needs to grow 50% by 2050

Although population growth is slowing, estimates are that nearly 2 billion people will still be added to the global population by 2050, with Africa and Asia together accounting for 83% of the total growth. The consensus suggests demand for food will increase by 50-60% in 2050 compared with 2010, due to a rising population and lifting per capita income.

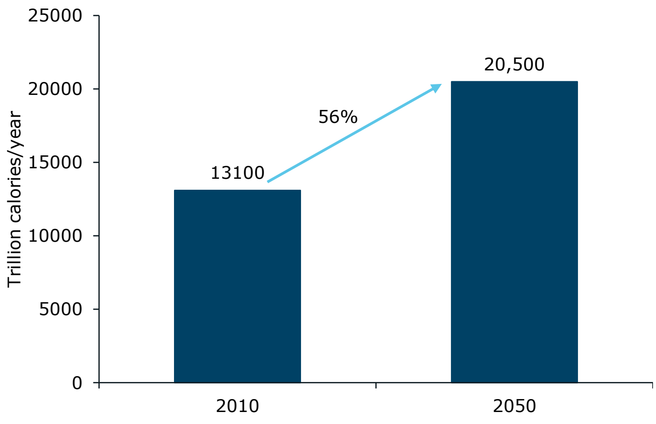
Based on per capita consumption, demand is estimated to increase substantially for all basic foodstuffs (Figure 4). If per capita demand for meat increases (as you would expect when incomes lift) then meat demand would lift even more. Dairy and vegetable oil production needs to rise in the range of 40-45% to meet demand over the next three decades. These categories of food production together will need to increase by 33% from 2019, but if we also consider fruits, vegetables, nuts and meat production as well, this number will be even higher. The World Resources Institute estimates food production needs to increase from 13,100 trillion calories per year in 2010 to 20,500 trillion calories per year, a 56% increase.

Figure 5. Global food production projections



Source: USDA, ANZ Research

Figure 6. Food production growth



Source: WRI analysis based on FAO (2019)

Degrading resources to threshold limit

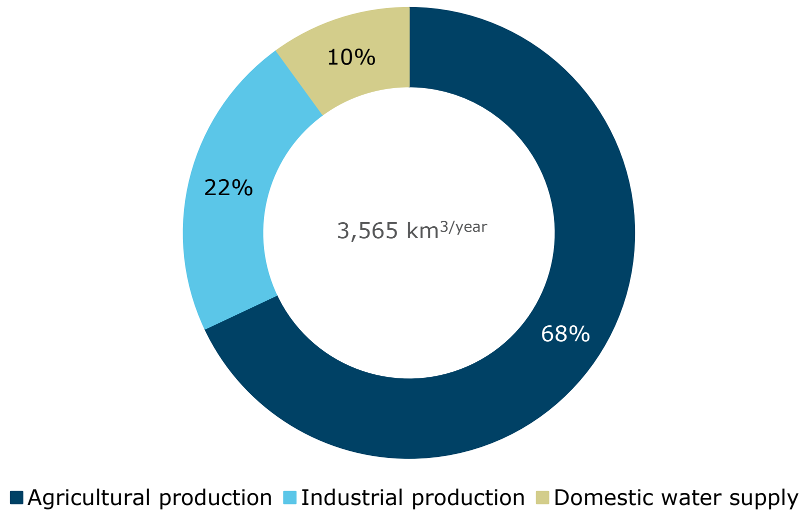
The agriculture sector uses 40% of the world's habitable land, 70% of its fresh water and emits 30% of the total greenhouse gases (GHGs), according to the FAO. Agriculture is also a major cause for water pollution, through leaching of nitrogen and phosphate into the water system. This occurs particularly in countries that are large producers of agricultural goods but have few or no regulations in place to protect water quality.

Water use depends on the type of food produced, as animal-based agricultural production has a higher water footprint. The method of irrigation also affects water use efficiencies. The FAO estimates that in the last century water withdrawal grew 1.7 times faster than general population growth. Such accelerated withdrawal brings into question the sustainability of water usage and indicates there is a higher environmental cost of producing proteins from livestock in regions where water is scarce.

Increased deforestation has led to the depletion of biodiversity in both flora and fauna. Deforestation not only releases stored CO_2, but also reduces the future potential to absorb carbon. FAO data suggests nearly 420 million hectares of forest has been lost since 1990, which is half the size of the US. The rate of deforestation has slowed in recent years to 10 million ha per annum (2015-2020) from 16 million ha per annum (1990).

Soil quality has been degraded as well. About 1500 million hectares of land is arable, and 33% of this land has been severely degraded over past three decades according to FAO estimates. The scope for future land expansion for food production is limited. Some expansion could happen in Sub-Saharan Africa and parts of Latin America, but this land will not necessarily be suitable for crops. The FAO projects arable land will potentially expand by 70 million hectares, or about 5%. Per capita land availability will therefore reduce from 0.192/ha to 0.149/ha by 2050, a 22% reduction.

Figure 7. Freshwater withdrawals



Source: Hoekstra and Mekonnen (2012) (consumption); OECD (2012) output from IMAGE model (withdrawals)

Figure 8. Freshwater withdrawals

Commodity	Deforestation (2001-2015, Mha)	% share
Cattle	45.1	68%
Oil palm	10.5 (of which 6.2 were direct)	16%
Soybeans	8.2 (of which 3.9 were direct)	3%
Cocoa	2.3	3%
Plantation rubber*	2.1	3%
Coffee	1.9	3%
Plantation wood fiber**	1.8	3%

*- Rubber data is available for Brazil, Cambodia, Cameroon, DRC, India, Indonesia, Malaysia

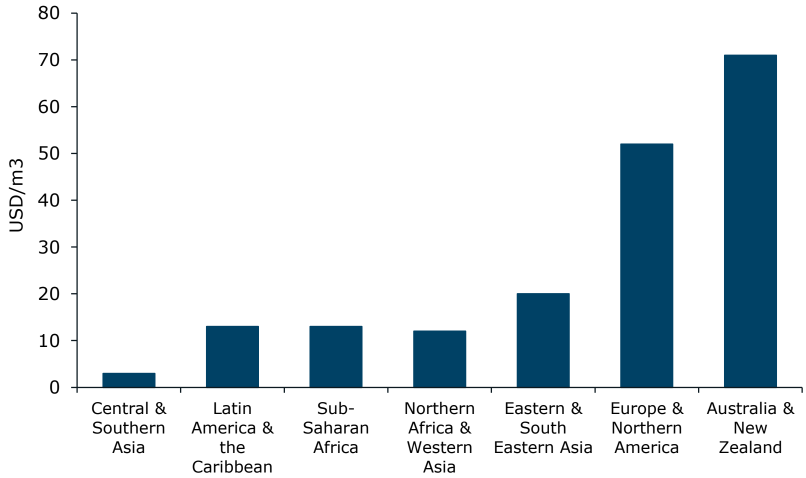
**- data available for Argentina, Brazil, Cambodia, China, Indies, Indonesia, Malaysia, Rwanda, South Africa and Vietnam.

Source: WRI analysis based on FAO (2019)

Water scarcity is another problem the world has to grapple with. The UN anticipates over half of the world's population will live in areas of water scarcity by 2050. Meanwhile the Global Water Institute estimates 700 million people could be displaced by intense water scarcity by 2030.[1] The UN attributes 72% of water withdrawals to agriculture, 12% to industrial uses and 16% to municipalities for households and services.

Water-use efficiency varies considerably across the globe. The UN defines water-use efficiency as the value added in US dollars per volume of water withdrawn. Global water-use efficiency increased from 17.28USD/m3 in 2015 to 20 USD/m3 in 2019, which means 16% more revenue generated from the same amount of water used. The indicator shows water-use efficiency tends to be higher in developed countries where there has been more investment in water application technology.[2] However, some countries with acute water shortages are also very efficient at using the limited resources they have available. Generally, water efficiency is very low throughout Asia.

Figure 9. Water-use efficiency (2019)



Source: FAO Aquastat, ANZ Research

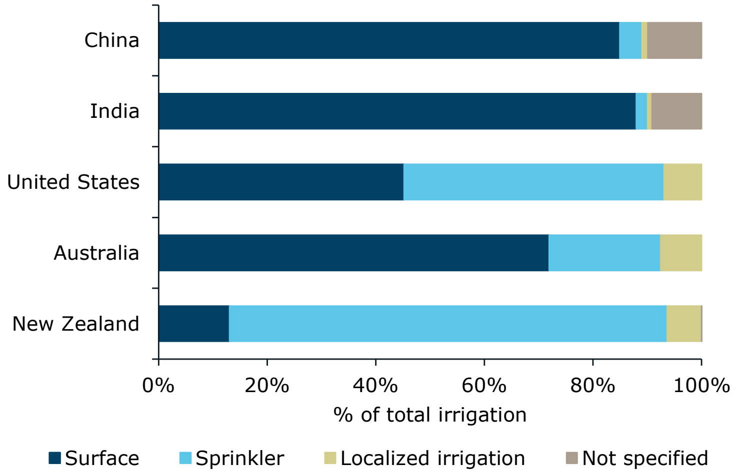
Some countries do have the ability to increase irrigation, but most countries do not. But improvements in the method of irrigation could dramatically increase water efficiency. China and India each have nearly 70 million hectares of land under irrigation, but this is mainly surface irrigation, which is not nearly as efficient as sprinklers in terms of water usage.

[1] Hameeteman, E., Future Water (In)security: Facts, Figures and Predictions, Global Water Institute, 2013

[2] https://sdg6data.org/indicator/6.4.1

The 2020 United Nations World Water Development Report states "Combining climate change adaptation and mitigation, through water, is a win-win proposal, improving the provision of water supply helps combat both the causes and impacts of climate change".

Figure 10. Land covered by various irrigation methods



Source: FAO, ANZ Research

All up, the statistics paint a grim picture. With the global agricultural industry having reached a critical threshold limit there is a heightened need to restore natural resource usage to sustainable levels. This means limited land expansion, less use of water, less use of fertilisers, and a reduction in GHGs emissions (which can most easily be achieved with less livestock). The UN's FAO expects that globally 90% of the growth in crop production will come from intensification (80% in developing countries), in particular with higher yields and increased cropping intensity.

Feeding the world sustainably

The world has less than 10 years to meet the 2030 UN agenda for Sustainable Development. Agricultural emission reduction and sustainable production growth could be possible by reducing wastage, a shift in diet from animal-based to plant based, agricultural intensification, building carbon sinks via reforestation, and adoption of technology across the food supply chain.

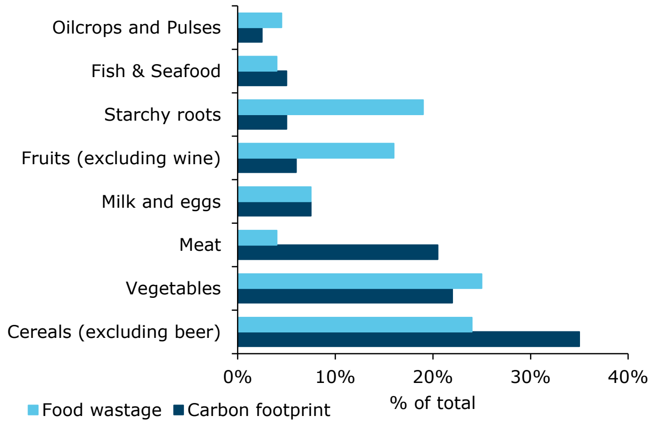
Reducing food wastage

Nearly 1.3 billion tonnes (33% of total food production, FAO 2011) gets wasted at different stages of the food supply chains. This number is expected to more than double, according to the Food Waste Index developed by the UNEP (UN Environment Programme). This is not only wastage of food, but also wastage of natural resources and GHG emissions. Wastage happens at every stage of the food supply chains. In developed nations, much of the wastage happens at the consumption level, while food losses in developing countries tend to occur at the production and post-harvest stages.

At a global level, nearly half of the food wastage occurs either at either the production or post-harvest storage level and a third occurs at the consumption level. The remaining 17% of wastage happens at the processing and distribution level (FAO, 2011). Food wastage also adds to the carbon footprint, contributing nearly 8-10% (4.4 $GtCO_2$ – higher than India's GHG emission) of emissions and 20% of total emissions from the sector.

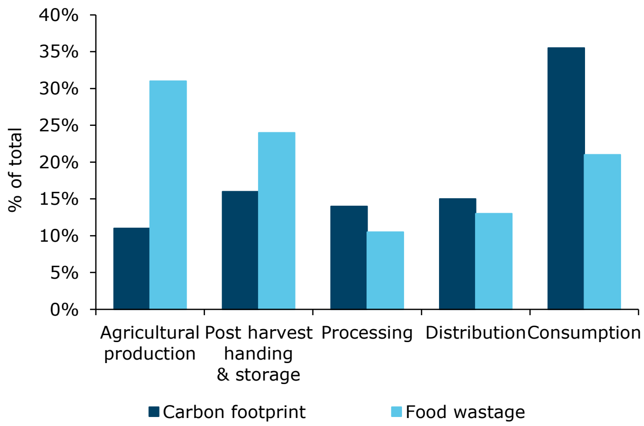
According to the World Resource Institute, reducing food waste by 25% by 2050 could narrow the food gap by 12% and reduce GHG emissions by 15%. This could be possible by setting food wastage targets and improving food storage in developing countries. The UN Sustainable Goal commits countries to halve per capita food waste at the retail and consumer level by 2030.

Figure 11. Contribution of each commodity to carbon footprint and food wastage



Source: FAO, WRI, ANZ Research

Figure 12. Contribution of each phase of food supply chain to carbon footprint and food wastage



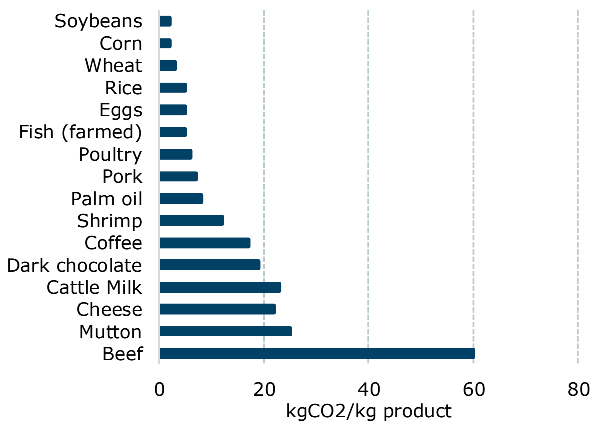
Source: FAO 2020, ANZ Research

Shifting from animal to plant protein

Given the significant contribution of livestock to global emissions and the high quantities of water required to produce meat, a shift from ruminant protein to less resource-intensive plant protein should be taken seriously as a strategy to mitigate emissions from the agricultural sector. At a global level, beef production is ten times more carbon intensive (Figure 10) than poultry and 30 times more carbon intensive than plant protein. This suggests a shift from animal to plant protein could improve resource utilisation. But we do need to be careful when looking at units of measure that don't consider the differing nutritional value of foods.

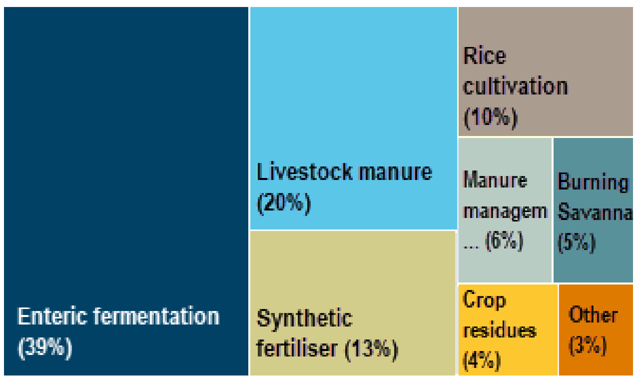
Also the intensity of emissions does differ considerably between countries and farming systems. Emissions from beef produced in NZ tend to be well below the global average. Some studies have put NZ beef production at half the global average but the results depend on whether a full life-cycle assessment is considered or whether just on-farm emissions are counted. A report from the FAO says that lowest emission intensity in milk and meat production corresponds to temperate zones where productivity is high and enteric fermentation is low due to high digestibility of feed in these zones.

Figure 13. GHG intensity for different produce



Source: FAO, WRI, ANZ Research

Figure 14. Greenhouse gas (GHG) emission share

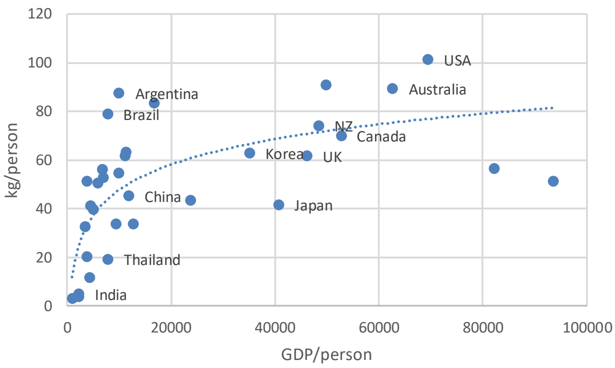


Source: FAOSTAT 2020

Meat consumption is positively related with income growth, meaning as incomes grow in emerging countries, demand for meat will potentially increase. Meat is also more nutrient dense than many other proteins, and its taste is often favoured; hence there is always going to be demand for meat. But how much of this will show up in meat production volumes, and how much in relative prices, is an important question. Global meat per capita consumption has increased from 29kg in 2000 to 34kg in 2020. There has also been a shift from red meat (beef and lamb) to white meat (poultry). Poultry has a more favourable feed-to-meat conversion, a shorter production cycle, and is normally cheaper than red meats.

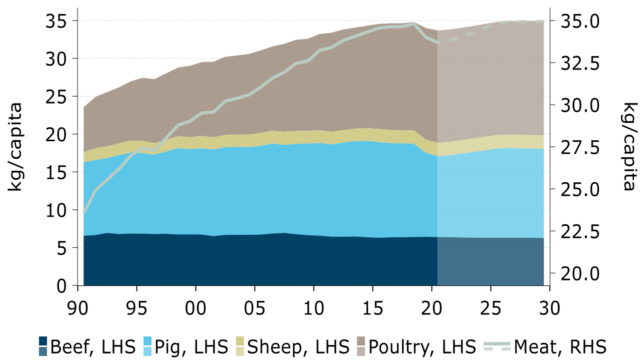
A growing preference for vegan diets has seen per capita meat demand decline in countries like New Zealand, Canada, Paraguay and Thailand, though per capita consumption still remains relatively high in some of these countries. There is a growing need for developed nations to cut down their meat consumption. India, China and other emerging nations' per capita consumption is far below the global average of 34kg per person, and protein consumption in these countries is likely to grow. If meat consumption continues to grow as it has in the past 20 years, then it should expand by 37% by 2040 and 45% by 2050. This additional demand will further increase GHG emissions and water scarcity pressures if we don't make changes.

Figure 15. Per capita meat consumption vs GDP per person



Source: OECD, Macrobond, ANZ Research

Figure 16. Per capita meat consumption trend and projections



Source: OECD, Macrobond, ANZ Research

While the IPCC estimates a total shift to vegan diets could reduce GHG emissions by ~8GtCO_2 by 2050, it is clear this will not occur. But the GHG mitigation could be also achieved by making less drastic changes to diets. Decreasing red meat consumption in favour of seafood and poultry could be one way to reduce the carbon footprint of the global agriculture sector. Plant-based meat is another option to shift to a more sustainable diet. A more nuanced approach would consider the emissions from the particular product being consumed. The actual emissions profile can vary hugely from country to country and farm to farm. This is the type of information environmentally aware consumers will be seeking.

Diets	Definition	GHG mitigation potential (GtCO2eq/year)
Vegan	No animal source food	7.9
Vegetarian	Meat/seafood once a month	5.9
Flexitarian	Limited meat and dairy	5.1
Healthy diet	Limited sugar, meat and dairy	4.6
Fair and frugal	Limited animal source food and rich in calories	4.0
Pescetarian	Diet consisting of seafood	4.0
Climate carnivore	Limited ruminant meat and dairy	4.4
Mediterranean	Moderate meat but rich in vegetables	3.0

Source: Intergovernmental Panel on Climate Change

Crop intensification

The FAO estimates growth in food production in the past 30 years was achieved by increasing yields, increasing area and increasing cropping intensity. More than 70% of the increase came from yield enhancement and 12% from cropping intensity and the rest from an increase in arable land.

Yield variation in crops is very high. The major factors determining yields are technological (agricultural practices, managerial decision, etc), biological (diseases, insects, pests, weeds) and environmental (climatic condition, soil fertility, topography, water quality, etc).

The World Resource Institute estimates an additional 500 million ha of land would be required by 2050 (from the base year of 2010) to feed the world's population. Such expansion is simply not possible, so the world is left with the option to augment crop intensity and productivity gains. Simply applying more fertiliser is not a good option either, due to its environmental impacts. Other resources like water and soil are also becoming scarce, so the best way is to increase resource efficiency. That means producing more food per hectare and per litre of water consumed.

More precise use of fertiliser is required so that a larger proportion of the fertiliser applied is absorbed by the plants and less filters through the soils and pollutes waterways. Use of technologies such as urease inhibitors reduces losses of ammonia from urea and maximises the nitrogen available for plant uptake. In 2019 approximately 35% of the urea used in NZ had a urease inhibitor coating.

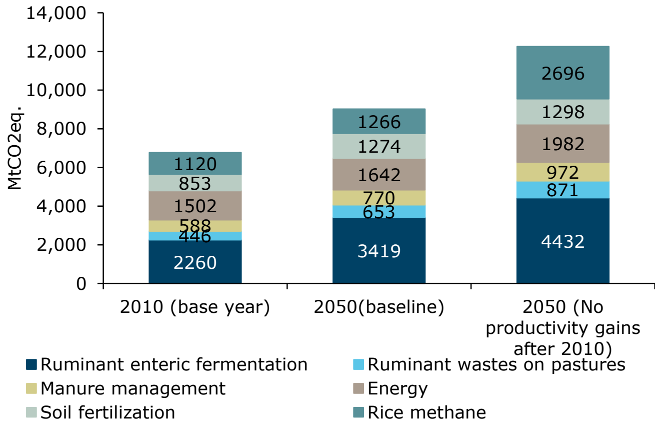
To improve crop yields one needs to understand the factors which impact yields, recognise the factors which are limiting yield, and then be able to apply a solution or mitigation in a timely manner. Often a lack of timely data or lack of knowledge means crops yields are well below their potential. These factors can be overcome through investment in measuring and recording equipment, accessing data and information, and education.

Improved genetics of both plants and animals can also lift productivity. For centuries the performance of crops and animals has been enhanced by selective breeding from the best-performing species. This process can be sped up further by genetic manipulation (commonly known as engineering or genetic modification). The most common use of genetic modification is to enhance crop production or make them tolerant to herbicides and pesticides, which makes crop management easier.

Crops need to be more resistant to floods and drought – as these natural calamities are becoming more frequent. Many countries allow genetically modified (GMO) crops, including the US, China, and more recently Australia. Most European countries, including Russia, do not allow GMOs, and neither does New Zealand.

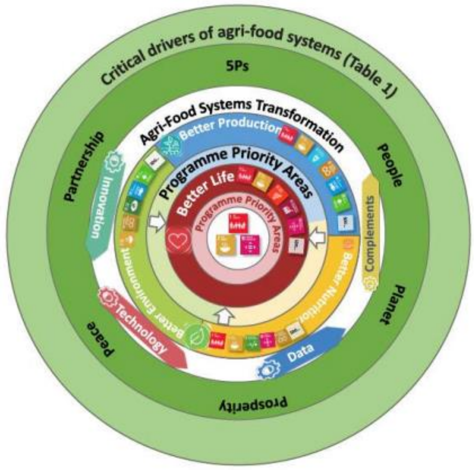
Crop intensification relates to the proportion of the arable area that is able to be harvested. Some regions already produce two or three crops a year, and there is potential to increase crop intensity in many other regions. Certain crops are complementary due to differing nutrient requirements, which mean yields can also be influenced by the order that crops are planted.

Figure 17. Agriculture production emission



Source: GlobalAgri-WRR model, WRI, ANZ Research

Figure 18. FAO's strategic results framework



Source: FAO
*Table 1- better production, nutrition, environment and life

Adopting technology across stages of the supply chain

The world needs a technological revolution in the agriculture sector throughout its supply chain to produce more in a sustainable and efficient way. Adoption of technology and precision farming (PF) can help farmers to optimise the production process by using less land and inputs and emitting less GHG and other negative externalities. This will be done by using a combination of sensors, satellite navigation and positioning technology, and the Internet of Things (IoT). Such technological advancement can potentially reduce inputs and environmental impacts.

There is huge potential for technology adoption and new investment to address the environmental constraints in the coming decades. The FAO projects USD83 billion net annual investment in agriculture in developing countries. It foresees some USD20 billion going to crop production, USD13 billion to livestock production, and a further USD50 billion to downstream support services such as cold and dry storage, rural and wholesale market facilities. According to AgFunder, investment in agrifood technologies increased to USD51.7 billion, nearly double 2020 levels. That would be a continuation of current trends: farm tech investment increased to USD7.9 billion in 2020, despite recession, from USD5.6 billion in 2019.

Vertical and urban farming

Vertical and urban farming can assist with land constraints in urban cities and places where land is not suitable for farming. Vertical farms use less land and also reduce water requirement by nearly 60-70% as compared to traditional farms. Hydroponics, aeroponics and aquaponics are different types of vertical farming methods, which are gaining traction across the world. This also means food is produced locally, reducing the cost of transportation and the carbon footprint.

However, the key hindrance is the high capital expenditure required compared to conventional farms, as well as high operational costs. However, the productivity in second-generation farms is 55x that of conventional farms, according to Agfunder.

A reduction in operational costs can make this type of farming economically viable. Lighting and labour each account for 30% of operating costs, according to Agfunder. If LED efficiency increases in the coming years, the cost for lighting could reduce by more than 10%. Vegetables grown indoors tend to use a lot more electricity than those grown outdoors due to the need for temperature control. How this impacts the carbon footprint of the product will depend on how 'green' the source of the electricity is.

Robots and drones

Robots can ameliorate labour shortage problems. The use of robotics in agriculture is still in its initial phase, but the use of agbots is picking up and this trend will deeply influence food production systems in coming years. Some agbots are already deployed in the fields, being used to harvest fruit, milk cows and plough fields, as well as weeding, planting and irrigation. Dairy farmers are already using robots for milking cows, but this is yet to become common practice. Lightweight robot tractors are now replacing traditional tractors. The lighter machines will also reduce soil compaction and can assist with re-aeration of the soil.

Drones can perform multiple tasks throughout the crop cycle and can also be used as pollinators. Drones fitted with cameras and sensors can provide vital information about soil condition and crop health, with these data helping with precision farming. This information allows optimised distribution of inputs such as seeds, fertilisers and pesticides. Drones can also spray fertilisers and pesticides and are more precise than manual spraying, thereby reducing the quantity applied. Drones can also be used as pollinators in areas where bee populations have declined drastically. They are also being used in the livestock industry to monitor herds, check water points and move livestock. In New Zealand the use of drones to monitor ewes at lambing is becoming increasingly popular, as large areas can be quickly monitored with minimal intrusion. The size of the market for agricultural drones is currently estimated to be about USD1 billion and is expected to grow to USD32.4 billion, according to a PwC report (PwC, 2016).

Artificial Intelligence/IoT

Digitisation is happening across the industry. Agriculture is all about precision – applying the right solution at the right time. Automatic recording of data allows for much more data to be collated and analysed. Data collection for different variables can play an important role in applying fertilisers, selecting seeds, irrigation based on soil analysis and other uses. Sensors and other devices can collect these data and save in the cloud. This can be potentially accessed by a variety of users including authorities monitoring resource use.

Water consumption and soil moisture levels are increasingly being monitored by remote sensors, which can then be utilised by farmers and environmental agencies alike.

Blockchain

Blockchain technology is used for food safety and authenticity in the agriculture sector by tracking the food from field to fork. It not only brings transparency to opaque agriculture supply chains, but could be utilised to provide better price signals to farmers, by financially rewarding sustainable farming practices. In New Zealand an initiative called Trust Alliance New Zealand (TANZ) is using blockchain technology to provide a way to track produce from New Zealand farms to global markets.

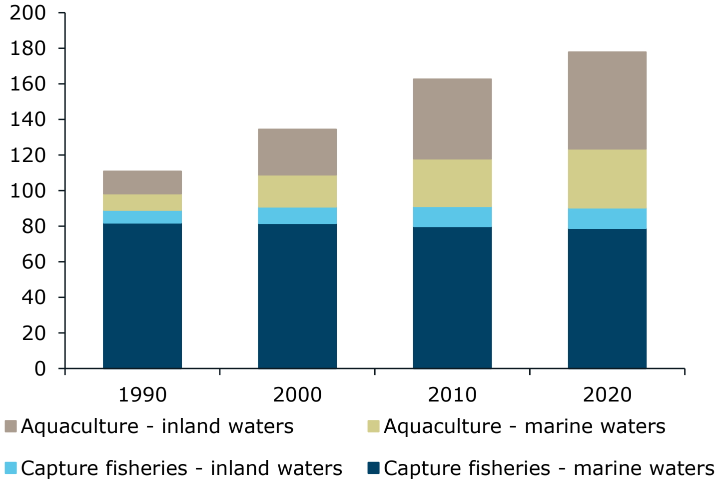
Farming our oceans

Aquaculture now produces about half of the total seafood consumed globally (with the remainder being wild catch), following exponential growth over the past decade. Fish are farmed both on land (freshwater species) and within our oceans (marine farming). Farming fish can be a sustainable and more reliable way to supply fish, but this is highly dependent on management practices.

Aquaculture is Australia's fastest-growing primary industry, accounting for 34% of the total value of seafood produced, while in New Zealand aquaculture accounts approximately a quarter of total seafood export earnings.

Aquaculture is considered to be one of the most efficient and sustainable forms of food production and is expected to continue on its rapid growth path. At present the industry is still very small compared to other forms of protein production, but fish consumption has been rising much more quickly than population growth. Depletion of wild fishing stocks means there will be more reliance on aquaculture in the future.

Figure 19: World capture fisheries and aquaculture production



Source: FAO

What does this mean for Australia and New Zealand?

Australia and New Zealand have more land available for food production, on a per capita basis, than most other countries. New Zealand also has a bountiful supply of water, although it lacks storage facilities. Utilising natural resources to their fullest potential in a sustainable manner is both a key challenge and an opportunity for Australia and New Zealand.

As food shortages increase and the environmental impacts of agriculture start to be priced into the cost of producing food, there will be upward pressure on the relative price of food – particular foods that use a lot of land, water, and create large emissions. Meat will become more expensive (particularly red meat), relative to other foods, which should result in lower consumption per capita in the regions where meat consumption is currently very high. It also increases the incentive to really understand consumer behaviour, so that the highest value can be extracted from every gram of protein produced.

Within both New Zealand and Australia there is likely to be further intensification of agriculture and horticulture where it can be achieved without detrimental environmental impacts. In other areas we may see reduced intensification, particularly lower stocking rates, as there is an increased focus on mitigating the impacts of climate change, improving water quality, and lifting animal welfare standards.

Investment in technology to both collate and analyse data and deliver inputs more precisely will be critical, as will large-scale investment that provides improved environmental outcomes and better utilises natural resources. New Zealand farmers will be taxed on their GHG emissions by 2025, and regulations surrounding water quality are being stepped up. This provides an incentive to farm in a way that is efficient from both an economical and environmental point of view.

It will be a huge challenge to feed the growing global population as well as transition food production to sustainable systems. Investment in technology, knowledge and a willingness to try new farming methods will be key to achieving this goal.

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