FOOD FOR THOUGHT
OUR FOOD SYSTEM’S FUTURE THROUGH THE LENS OF SUPPLY AND DEMAND
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Alison Lee is in her second year working as a Tropical Landscapes Finance Facility Analyst for ADM Capital Foundation and provides ESG integration advisory for ADM Capital funds. Alison co-developed ADM Capital’s proprietary ESG toolkit that has been rolled out to all ADM Capital’s analysts. She was involved in various aspects of ADM Capital’s role in the US$ 95 million Tropical Landscape Finance Facility’s financing of RLU’s sustainable rubber plantations in Indonesia. Post investment, Alison has been deeply involved in monitoring and reporting on ESG issues linked to the project. Prior to joining ADMCF she was an Equity Research Associate at CLSA covering Hong Kong discretionary consumer and China education listed equities. She has a BA (Hons) from The University of Strathclyde Business School in International Business and an MSc from The University of Manchester in Industrial Relations.
INTRODUCTION

The World Resources Institute (2018) forecasts that 56% more crop calories will be needed above 2010 levels to feed a projected 9.8 billion population in 2050. To produce the additional calories, 593 million hectares of additional crop land is required. To put this in context, this is around twice the size of India. Yet, the additional calorie target must be achieved without the needed agricultural land. How can we address this challenge?

This paper aims to understand the future of our food systems through the lens of supply and demand in the global space. The table below shows the key themes.
DEMAND SIDE DRIVERS

Macro Trends – Demographic Shift
In this section, the major demographic movements in the near future is discussed. This include an aging population and a millennial dominated workforce. Population age sixty-five and above will outnumber young children below the age of five for the first time and millennials will dominate the global workforce, raising GDP in developing countries and strengthening religions’ impact on food.

Over 65 and Thriving
In 2020, we will face a mind-blowing demographic shift for the first time in human history. Globally, people ages sixty-five and over will begin to outnumber children under the age of five. These two generation groups will continue to grow in opposite directions (Figure 2). How will this demographic shift impact demand for meat and dairy?

![Figure 2: Young Children and Older People as a Percentage of Global Population, 1950-2050](image)

According to research conducted by Schutz and Franzese (2018), by using data from the Survey of Health, Ageing and Retirement in Europe and existing research on age and animal protein consumption, there is no strong correlation between meat consumption and old age. Where there is one, it is heavily country dependent. For example, Spain’s beef consumption decreases with old age but this is due to the negative health image of beef and conservative eating habits of older cohorts. In Denmark, Netherlands and Belgium, however, the share of people consuming meat products on a daily basis increases with age. In Austria, younger men consume more meat than older men. In Britain there are no correlation between age and meat consumption (Schutz and Franzese, 2018; Public Health England, 2016; Kanerva, 2013).

Interestingly, gender plays a role in meat consumption. Gender disparities can be observed in all countries in the study, where men consume more meat products than women. Although the linkages between meat and dairy consumption and old age in current research are inconsistent, we may assume healthcare and complementary options such as healthier food will grow in importance. A University of Oxford study (2016) found that a ‘healthy’ diet (i.e. one containing less meat) could prevent 5.1 million deaths a year globally by 2050, indicating that health concerns could lead to a decrease in demand for meat products.

The Avocado Toast Generation

World Data Lab (2018) forecasts that by 2020, millennials (people born between 1981-1996 as defined by Pew Research Center) will overtake Gen X (1965-1980) in terms of “spending power” (Figure 3). The largest proportion of millennials can be found in developing countries, including 33% in India, 31% in China and 33% in Indonesia (Figure 4).
**FIGURE 3**  
Global Millennials Spending Power is Set to Overtake Gen X by 2020 and Will Continue to Rise  
Forecast annual aggregate income, by generation

<table>
<thead>
<tr>
<th>Year</th>
<th>Millennials</th>
<th>Generation X</th>
<th>Post-millennials</th>
<th>Baby Boomers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>15</td>
<td>20</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>2025</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>2030</td>
<td>22</td>
<td>27</td>
<td>27</td>
<td>17</td>
</tr>
<tr>
<td>2035</td>
<td>24</td>
<td>29</td>
<td>29</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: World Data Lab, FT

**FIGURE 4**  
Millennials Make up a Large Portion of EM Countries’ Population

Latest available data. Definitions of millennials vary from country to country and data availability differs by region. Based on 2014 figures from China, 2016 figures from the US and 2015 figures from the remaining countries shown.

Source: A.T. Kearney, Goldman Sachs and AB
David Dobbin, chairman of Diary UK, says he fears a “demographic time bomb” as “young people” increasingly choose plant-based alternatives over dairy. Only 10 years ago, there were around 21,000 diary farms in the UK. Analysts believe there could be fewer than 5,000 left by 2026. Furthermore, a study by GlobalData (2018) states that 70% of the global population is either reducing meat consumption or excluding meat from their diet. Fiona Dyer, consumer analyst at GlobalData, explained that the “shift towards plant-based foods” is mainly being “driven by millennials”, who are most likely to consider the food source, animal welfare issues, and environmental impacts when making their purchasing decisions.

A 2019 Global Deloitte survey found that the top personal concerns for both millennials and Gen X revolve around climate change and that could impact meat and dairy consumption.

Whilst these figures are impressive, and suggest that we may be heading towards a “less-meat world”, it is important to note that the heaviest proportion of millennials is located in emerging countries and their perspectives may differ greatly from counterparts elsewhere. An interesting white paper by eShop World highlights differences in millennial perceptions between developed and developing countries (Figure 5). According to the eShop research, developed countries’ millennials value authenticity and sustainable products, and are concerned with ethics and social issues. Conversely, in developing countries, millennials are more materialistic than previous generations as they have grown up in a rapidly growing economy and have experienced the transition from poverty. If these categorisations are correct, what does it imply in terms of dietary choices?
These millennials grew up in a booming economy, and watched Gen X (their parents) lose everything. Grew up in a rapid growing economy, and have experienced transition from extreme poverty.

The wealthiest generation their country has seen. Considerably poorer than their parents.

The US has the third largest millennial population in the world. World’s largest millennial populations are in India and China.

Other key markets include: Japan, France, UK, Germany and South Korea. Other key markets include: Indonesia, Brazil, Russia and Mexico.

Value authenticity and sustainable products; concerned with ethics and social issues. Often more materialistic than previous generations, having grown up in a culture of so little and only recently have the ability to afford more.

Anti-materialistic, but will spend on good quality, ethically sound products and are concerned with being seen as leaders in this respect. Keen to display status and wealth and are likely to invest in luxury brands. Happy to save for premium clothing and technology.

Key documenters of their own lives; they purchase experiences and products that complement their values. Value social status and individuality above social concerns.

High youth unemployment and less able to invest in cars/houses. Young people are better employed and better paid than previous generations.

Face crippling student debts, unaffordable housing, low wages and unstable jobs. Moving from a collective culture into a more personalised one and therefore value customisation.

Source: eShop World

A Very Hungry Emerging Middle Class

The connection between wealth and meat consumption has been identified in many academic studies. According to Our World in Data (2019), the share of calories from animal protein vs. GDP per capita indicates that as we get richer, we consume more animal-based foods, (Figure 6 and 7). However, there is a turning point for meat consumption and wealth. As our income reaches a “very high level”, we start to observe an inverted U-shape curve, where we see a decline in meat consumption (Vinnari, Vehema, and Luukkanen Jyrki 2006; Vranken et al.)
2014; Cole and McCoskey 2013). Few countries, however, have reached the GDP level required for a decline in meat consumption.

**FIGURE 6** Share of Calories from Animal Protein vs. GDP Per Capita, 1963-2013

**FIGURE 7** Share of Calories from Animal Protein vs. GDP Per Capita, 2013

Share of calories in the average diet sourced from animal protein (which includes meat, seafood, eggs and dairy products), measured as the percentage of daily caloric intake, versus gross domestic product (GDP) per capita, measured in 2011 international-$

Source: World Bank - WDI, UN FAO
According to research by ARE in 2018 (supported by ADM Capital Foundation), total meat and fish consumption in Asia will grow by 73% by 2050 to 233 million tonnes. It is projected that Indonesia’s total meat and seafood supply will grow by nearly three times between 2018-2050, a much faster pace than India over the same period (Figure 8). Thus, Indonesia’s meat consumption is expected to overtake India’s by 2036 (7.5 million tonnes), despite India’s much larger population size.

**Figure 8** Meat and Seafood Consumption Drivers in Indonesia and India

Consumption changes towards a “meaty” diet could also be influenced by globalisation (Popkin, 2003; Popkin et al, 2012), meaning wealthier populations from emerging markets eat a more “Western diet”. This shifting pattern can be observed in China, where Chinese consumers have drastically increased consumption of dairy products and are decreasing their consumption of grain-based foods (Dong and Fuller, 2010). Indonesia has also shifted from a fish-based diet to a diary-heavy and meat-heavy diet (Fabiosa, 2005). Furthermore, the establishment of supermarket chains and easy access fast food restaurants has made it more convenient for emerging market consumers to follow a Western diet.

The growing demand for animal protein by volume from major “new money” nations such as China, India and Indonesia will heavily impact the world’s resources and our current supply chain will not be able to support demand.

**Religion and Meat**

In the previous section, we have discussed Indonesia's meat and seafood consumption overtaking that of India’s. A key reason is the predominantly Hindu culture’s relationship with meat. Religious practices may restrict an individual’s consumption patterns and dietary choices. For example, Hinduism prohibits the consumption of beef, while Islam forbids pork. Some Buddhist monks are allowed to consume meat, whilst for others meat is forbidden. Adventists, meanwhile, follow a vegetarian diet.

Figure 9 displays a breakdown of country, religion, and types of meat consumed, providing overall meat consumption trends.
An interesting working paper by Hong (2018) on “The Effect of Religion on Meat Consumption and Greenhouse Gas Emissions” discovers that Hinduism and Islam significantly affect meat consumption and GHG emissions. The author estimates that for every 1% increase in Muslim population, GHG emissions per capita from pork consumption decrease by 3.45%.

**Global Meat and Dairy Demand Projections**

In the last 15 years, global consumption of beef, veal, poultry and pork is estimated to have risen by 30%. OECD and the FAO project that demand for meat will continue to grow, primarily due to rising population and income levels in developing countries. In developed economies like the US, demand is also expected to increase, albeit at a slower pace. Overall, global meat consumption is projected to rise by over 13% in the next ten years (OECD/FAO 2018). Meeting this demand will continue to exacerbate environmental, health and social impacts as producers scale up and intensify their production.

In terms of dairy products, the OECD/FAO (2018) projected a 22% increase in world’s milk production for the period of 2018-2027. The largest contribution to demand will be from India and Pakistan. In 2027, these two countries are expected to jointly account for 32% of the global milk consumption.
Dairy demand in developed countries has been shifting for several years towards butter and dairy fat and away from substitutes based on vegetable oil like margarine. This trend can be attributed to a more positive health assessment of dairy fat and a change in taste. As income and population increase, and diets become more globalised, more dairy products are expected to be consumed in developing countries.

In developed countries, per capita consumption of milk solids is projected to grow from 22.2 kg in 2015-17 to 23.1 kg in 2027, compared to an increase from 10.6 kg to 13.5 kg in developing countries. There are, however, significant regional disparities amongst developing countries, where predominantly fresh dairy products are consumed; this contrasts with developed countries, where consumer preferences tend towards processed products.
DEMAND SIDE DRIVERS

The reason for China’s low per capita consumption of dairy products is partially due to the fact that 90% of the population is lactose intolerant. The correlation between lactose intolerance and per capita consumption could be observed in the maps below (Figure 12 and 13).

**FIGURE 12** Map of People with Lactose Intolerance

**FIGURE 13** Per Capita Milk Consumption, 2013

Average per capita milk consumption, measured in kilograms per person per year. This includes the milk equivalents of dairy products made from milk ingredients, but excludes butter. Data is based on per capita food supply at the consumer level, but does not account for food waste at the consumer level.

Source: UN Food and Agricultural Organization (FAO)
SUPPLY SIDE DRIVERS

A Reality Check – Our Current Food Supply Chain

One of the UNFCCC’s key goals is “to ensure that food production is not threatened” and that production happens within a “time-frame sufficient to allow ecosystems to adapt naturally to climate change”. In a report by Break Through (2018), the authors critique The Paris Agreement’s recognition of the “fundamental priority of safeguarding food security”. So how does our food production system look today? Is it in a “time-frame sufficient to allow ecosystems to adapt naturally to climate change”?

WRI (2018) predicts a 56% calorie gap between crops produced in 2010 and those needed in 2050. Currently, our agricultural system is already extremely resource intensive, covering around 43% of the world’s ice and desert free land. Of our arable land, 87% is for food production whilst the remaining is used for bio fuels, textile crops or allocated to non-food uses such as leather and wool (Poore & Nemecek, 2019). There exists a 593 million-hectare gap between global agricultural land area in 2010 and expected agricultural expansion by 2050.

Regarding GHG mitigation, there is an 11-gigaton gap between expected agricultural emissions in 2050 and the target level needed to stay below 2 degrees. The current production and consumption chain, which includes transportation, waste, fertilizer manufacturing, agriculture, processing, retail and household food management, contributes to 19–29% of all anthropogenic greenhouse gas emissions. Based on 2008 levels, that is a total of 9,800-16,900 million tonnes of carbon dioxide (CO\textsubscript{2}) emitted each year (Vermeulen et al. 2012). These emissions can fundamentally alter the species composition of the earth’s natural ecosystems, reducing biodiversity and ecological resilience.

Breaking down the food supply chain, the farming stage contributes 61% of overall food production GHG emissions. If related deforestation activities are included, contribution rises to 81%. Looking beyond GHG emissions, the farm stage contributes to 79% of acidification and 95% eutrophication, which is caused by an increased deposit of nutrients to estuaries and coastal waters which leads to harmful algae blooms, poor water quality, loss of marine animals and dead zones (Poore & Nemecek, 2019).
Greta Thunberg recently criticised rich countries for using ‘creative carbon accounting’ to claim ‘net zero’ status. Creative carbon accounting can also be used for companies when reporting their GHG emissions. When talking about food supply chain, it is important to acknowledge companies’ accountability for scope 3 emissions. For food and beverage companies, scope 3 emission represents 89% of total GHG emission (Ceres, 2019). Simply put, scope 1 emissions refer to the direct emissions from owned resources, such as factories, offices and company vehicles. Scope 2 includes the energy purchased to power such owned assets. Scope 3 includes everything else, such as raw material production, transportation, and waste generated from leased assets.

Ceres (2019) conducted a study to analyse the top 34 public American and Canadian food and beverage companies to assess the disclosure of their GHG scopes. Out of the 34 companies only 9 companies have accounted for scope 3 emissions and have set explicit targets to reduce them.

GHG emissions aside, agriculture is also highly water intensive. According to China Water Risk (2019), producing a 18 oz steak requires 17 bath tubs worth of water. Water is used to produce not only agriculture but also electronics, energy, clothing and other consumables. In fact, agriculture
water use accounts for 70% of all water withdrawal globally (World Bank, 2017). According to China Water Risk (2018), China and India will not have sufficient water to ensure food and energy security in their current export-led economic growth model. Renewable water resource is defined by the FAO as “the average manual flow of rivers and recharge of aquifers generated from precipitation”. In order for China and India to achieve a per capita GDP of US$50,000 and above (around where US sits today), at least 1,543m$^3$ of water/pax is required. While US has an abundant renewable water resource of 9,538m$^3$/pax, China and India only have a total of 2,018m$^3$/pax and 1,458m$^3$/pax respectively. While US’s current water use is only about 16% of its total water available, to achieve the same GDP per capita, China would have to use three-quarters of its total water resources and India, all of it (Figure 14).

**Figure 14** Limited Water Resources Per Capita Constraint Development Choices

<table>
<thead>
<tr>
<th>Country</th>
<th>Water Resources Per Capita</th>
<th>Water Use Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>2,018</td>
<td>432</td>
</tr>
<tr>
<td>India</td>
<td>1,458</td>
<td>602</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1,306</td>
<td>1,034</td>
</tr>
<tr>
<td>US</td>
<td>9,538</td>
<td>1,543</td>
</tr>
</tbody>
</table>

Source: China Water Risk (2018)
Having a balanced economic mix is important in helping water stressed countries manage their water resources. Looking at Figure 15, agriculture heavy sectors are represented in the lower left quadrant, while service economies have higher GDPs. Countries with high GDPs varies drastically in water usage, due to trade. US, Canada and Australia, for example, are self-sufficient in water use, whilst UK, Germany and Japan have a low footprint due to imports of water intensive goods from other countries.

**FIGURE 15**

**Water Use Corresponds to Economic Development – Changing GDP Mix Matters**

G20 Per Capita Water Use vs. GDP

Source: China Water Risk based on FAO Aquastats, World Bank, NBSC

If all things remain equal, the supply and demand for agriculture product will look like Figure 16. The supply curve for agriculture would shift from $S_1$ to $S_2$ due to limited resources, resulting in a higher price and lower output. The shift in the supply curve would be caused by climate factors such as reduction in land availability, extreme weather, flooding and water scarcity. When prices are high, cheaper alternatives will be needed to close the gap in the market for other protein sources. The supply and demand chart doesn’t show what an increase in demand would do to the demand curve. If increase in demand is considered, the price would be even more inflated than the current $P_2$ level. In other words, food will be very expensive in the future and we need to come up with cheaper options that are affordable to all.
Imagining Our Future Food Supply Chain – Biotech Revolution

It is clear that drastic action is needed to meet the overwhelming demand projections for the next couple of decades and it is difficult to imagine what our future food system will look like. One thing is clear – we can no longer keep calm and carry on. Winston Churchill (1931) stated in an essay that there are two processes we adopt when we try to prophesy:

“We can seek a period in the past whose conditions resemble as closely as possible those of our day, and presume that the sequel to that period will, save for some minor alterations, be repeated. Secondly, we can survey the general course of development in our immediate past, and endeavour to prolong it into the near future.”

The first way of thinking is the method of a historian and the latter is that of a scientist. Our current agriculture systems were established around 11,000 years ago, when we entered the agricultural revolution and went from hunting and gathering to farming. The scientific revolution began around 500 years ago when mathematics, astronomy, physics, chemistry and biology transformed the way society view nature. The information revolution 50 years ago led us to the “internet of things”. 11,000 years later, our method of producing animal protein is still highly inefficient, with a feed-to-animal-protein conversion rate at merely 15% for beef, 30% for pork, and 60% for poultry (Post, 2014).

Could science bring about another drastic agricultural revolution as we deplete our resources and reach the maximum production limit? In the same essay, Churchill predicted scientists growing cultured meat. Could this be our future?
Current Alternative Protein Technologies

Currently, bio-technology for alternative protein can be grouped into three categories:

**Advanced plant-based** – this category uses novel plant sources and/or novel processing methods (such as shear-cell technology) to optimise taste, nutrition and texture of plant-based products to mimic meat.

Companies in this category are:

- Impossible Meat
- Algama
- New Wave Foods
- Kite Hill
- Ripple

**Fermentation** – using brewing processes to turn yeast organisms into proteins. This category expands beyond food products and includes vegan chemical alternatives for cosmetics and consumer products. For example, Impossible Meat uses a process to make soy leghemoglobin (heme), where yeast is grown then soy leghaemoglobin (containing heme) is isolated from the yeast to create a blood-like iron flavour. This process of creating heme is a type of genetic engineering (GMO). This star ingredient has gained media attention due to a weaker regulatory process passed by U.S. Food & Drug Administration (FDA) for this GMO process called “GRAS” (Generally Recognised As Safe).

Companies in this category are:

- Geltor
- Quorn
- Prime Roots
- Clara Foods
- Perfect Day
- Impossible Meat

**Cell Culture** – this category is the most high-tech and uses stem cells to grow meat cells (muscle and fat) in a nutrient-rich culture medium to create whole pieces of tissue. This category is not yet commercialised.
Companies in this category are:

<table>
<thead>
<tr>
<th>Hampton Creek</th>
<th>SuperMeat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finless Foods</td>
<td>MosaMeat</td>
</tr>
<tr>
<td>Integriculture</td>
<td>Menphis Meat</td>
</tr>
</tbody>
</table>

In the cell culture category, studies on the real environmental impacts compared to traditional agriculture are still lacking. The economic and environmental results for cell expansion in terms of spent material resources are heavily dependent on the methods used to scale the production process (Post, 2014).

According to Post’s (2014) preliminary assumptions, cultured beef will be six-fold more efficient than conventional livestock beef. It takes 225g of nutrients to produce 200g of cultured beef as compared to 1.33kg for livestock beef.

New Harvest (2014) evaluated the potential for cultured meat to mitigate environmental degradation (Figure 17). Energy use will increase significantly due to the energy intensive bioreactors in which cultured meat are produced. However, renewable sources could be used. GHG emissions are very low compared to traditional animal protein production. Water use will be less when compared to most traditional animal protein production. However, these assumptions are highly preliminary.

**FIGURE 17** Comparison of Environmental Impacts of Cultured Meat with European Livestock Meat

![Comparison of Environmental Impacts of Cultured Meat with European Livestock Meat](image-url)
The Yuck Factor – Cultured Meat

It will take time for consumers to fully accept these new food technologies. Cultured meat or the rebranded “clean meat” can be foreign and can certainly trigger the “yuck-factor”. Considering the number of people who can’t even eat meat on the bone, food neophobia is common.

A study by Wilks and Phillips (2017) suggests that the awareness of the environmental impact and ethical outcomes of meat consumption is rising but there is still a resistance to removing meat from our diets. A survey (Bryant et al, 2019) found that consumers in different geographical regions exhibit varied preference for cultured meat. Consumers in China and India are more likely to try cultured meat than those in the U.S. (Figure 18).

Gender also plays an interesting role. Men are more receptive to cultured meat than women. People following a vegetarian or vegan diet were less likely to try cultured meat than meat eaters. A couple of barriers were identified: 1) taste appeal of the product (79% of respondents were cited); 2) ethical concerns (24%) and 3) price (20%). Taste and appeal are the key barriers against consumer acceptance.
Protein Diversification Investments

Since 2010, plant-based meat alternatives sales have grown an average of 8% per annum globally. The growth of plant-based meat is around twice the rate of processed meat, with annual sales of about US$2bn (Bloomberg, 2018). Research and Markets (2017) estimates that the sector will expand 8.29% CAGR globally (2017-2021), and that the plant-based meat market will reach US$5.2bn by 2020.

Protein diversification is increasingly recognised by institutional investors as a relevant ESG theme as it is intrinsically linked to multiple environmental and social issues. It helps investors to improve portfolio contribution towards SDGs. It also helps to increase a company’s competitiveness, climate readiness, and, ultimately, financial and operational resilience. With the growing concerns of climate change-related risks, investors are assessing both the risks associated with intensive production and consumption of animal proteins as well as the opportunities associated with such risks.

As of May 2019, investments in plant-based food brands have topped US$17bn. The investments include 233 deals and 228 investors, with the largest share of the investments happening in the past two years (GFI 2018, Figure 19).

**FIGURE 19  Investments in Plant-Based Food Brands**

<table>
<thead>
<tr>
<th></th>
<th>PLANT-BASED MEAT, EGGS &amp; DAIRY (US-based or selling in the US)</th>
<th>CELL-BASED MEAT (Global)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ Invested Total</td>
<td>US$17.1 billion</td>
<td>US$73.3 million</td>
</tr>
<tr>
<td>$ Invested 2018</td>
<td>US$673 million</td>
<td>US$49.4 million</td>
</tr>
<tr>
<td># Completed Deals</td>
<td>233</td>
<td>22</td>
</tr>
<tr>
<td># Unique Investors</td>
<td>229</td>
<td>70</td>
</tr>
<tr>
<td>% Change - Deal Count (2017-2018)</td>
<td>+39.4%</td>
<td>+160%</td>
</tr>
<tr>
<td>Biggest Deal</td>
<td>$12.5 billion</td>
<td>$17 million</td>
</tr>
</tbody>
</table>

The largest share of deals are from venture capitals and high net worth individuals. Corporate investments are limited but there could be an increase in upcoming years as we start to see larger names such as Danone and Unilever acquiring alternative protein companies (Figure 20).
The table below summarises recent deals by large MNCs in the alternative protein space by category:

<table>
<thead>
<tr>
<th>ACQUISITION</th>
<th>VENTURE INVESTMENTS</th>
<th>PRODUCT DEVELOPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danone’s US$12.5bn acquisition of WhiteWave</td>
<td>Tyson Venture’s 5% stake in Beyond Meat</td>
<td>Ingredient maker ADM developing plant-based ingredients and protein ranges for B2B</td>
</tr>
<tr>
<td>Campbell’s US$700m acquisition of Pacific Foods</td>
<td>Cargill and Tyson investment in Memphis Meat</td>
<td>Unilever developing plant-based steak with shear cell tech</td>
</tr>
<tr>
<td>Pinnacle’s US$158m acquisition of Gardein</td>
<td>Kellogg’s US$100m investment fund, which led a fundraising round for plant-based smoothie-maker Bright Greens and its investment in Kuli Kuli, makers of plant protein products</td>
<td>Kroger, Ralphs, Target, Trader Joe, Wegmans and Wholefoods developing multiple meat replacements</td>
</tr>
<tr>
<td>Maple Leaf’s acquisition of Lightlife and Field Roast</td>
<td>General Mills’ incubator ‘301 Inc.’ and investment in Beyond Meat and Kite Hill</td>
<td></td>
</tr>
<tr>
<td>Unilever acquisition of The Vegetarian Butcher and Sir Ensington</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nestle acquiring Sweet Earth Foods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keystone Nature Holdings acquiring WestSoy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Milk Alternatives

The dairy alternatives market was valued at US$15.4bn in 2018 with half of that concentrated in China (biggest market because of high lactose intolerance). It is expected to grow at a CAGR of 12.2% and reach US$41.8bn by 2026 (Reports and Data, 2019). The chart below summarises the key companies producing milk alternatives across various markets (Figure 21).

**FIGURE 21**
Largest Producers of Milk Alternatives
Market share by sales, 2016 (%)

Analyzing consumer internet search patterns can provide us with a guesstimate of future sales patterns and market opportunities. According to Google Trends, from 2004 to 2019, searches for the five popular plant-based milk alternatives (Oat, Soy, Almond, Cashew, Coconut) have gained popularity worldwide. Coconut and almond milk are the top two most popular search terms out of the five, whilst oat milk gains traction in late 2017 (Figure 22).
The below chart shows emissions, land use and water use for each type of milk (Figure 23).

### FIGURE 23 Environmental Impact of One Glass (200ml) of Different Milk

<table>
<thead>
<tr>
<th>Type</th>
<th>Emissions (kg)</th>
<th>Land Use (m²)</th>
<th>Water Use (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Milk</td>
<td>0.2</td>
<td>0.5</td>
<td>40</td>
</tr>
<tr>
<td>Rice Milk</td>
<td>0.4</td>
<td>1.0</td>
<td>80</td>
</tr>
<tr>
<td>Soy Milk</td>
<td>0.6</td>
<td>1.5</td>
<td>120</td>
</tr>
<tr>
<td>Oat Milk</td>
<td>0.0</td>
<td>0.5</td>
<td>40</td>
</tr>
<tr>
<td>Almond Milk</td>
<td>0.0</td>
<td>0.0</td>
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Source: Poore & Nemecek (2018), Science, Additional calculations, J. Poore, BBC
What are the Raw Materials Used for Protein Alternative Production?

For a long time, soy protein and wheat gluten have been the dominant raw materials for meat substitutes. Over recent decades, protein products from other plant based raw materials such as peas, chickpeas, lupins, rice, maize and canola have gained popularity. Although, the bulk of the harvest is still used for livestock feeds (Figure 24).

![Figure 24](image-url)

**Trendy ingredients such as jackfruit and banana blossom have also gained traction in recent years due to their natural textures that mimic pulled pork and fish. Major supermarket chains such as Asda and Traders Joe’s have recently added these ingredients to their own-brand range.**

As for milk alternatives, coconut and almond are the most popular currently. Oat is starting to become more popular, whilst soy has been a staple. Other notable mentions include cashew and rice milks.
Grandview Research (2018) highlighted the key companies in the plant-based protein sector, which include DuPont, Bunge, Cargill, Archer Daniels Midland (ADM) and Mead Johnson. In July 2018, ADM acquired Neovia, which has 72 production facilities of animal nutrition solutions across 25 countries. The market is led by integrated participants such as ADM and Cargill. Major manufacturers are focusing on strengthening their presence in Asia Pacific due to low manufacturing cost and availability of raw material.

Quick facts on commodities complementary to the production of alternative proteins are provided in the appendix.

Using CRISPR/CAS9 to Improve Yields, Health and Efficiency of Crops

Due to the restricted resources we have on earth and a growing population, genetic engineering could help to improve the yield, resilience and efficiency of crops. The versatility of CRISPR/CAS9 stretches beyond medicine and can be applied to the crops in our fields today.

CRISPR/CAS9 is a technique of genetic engineering but depending on which country it is used in, the GMO title and tight regulation may or may not be enforced. In the U.S., regulators argue that as CRISPR/CAS9 does not contain foreign DNA, thus it does not fall under the GMO umbrella. On the other hand, the European Union has subjected CRISPR/CAS9 plants to the stringent GMO laws and regulations (Nature, 2018, National Geographic, 2018).

In very basic terms, CRISPR/CAS9 is a molecular tool used to delete (remove) or introduce (knock in) a specific gene into cells. CRISPR/Cas9 is an extremely accurate and cost-effective gene-editing tool. It can be used to remove bad genes that cause poor health or death in an organism. Conversely, it can be used to introduce beneficial or good genes into organisms and plants.

The conventional genetically modified organism (GMO), on the other hand is an organism whose genetic material is altered using recombinant DNA technology. Recombinant DNA technology can combine DNA fragment/gene with a vehicle (such as an adenovirus) to transport the DNA into cells. After delivering the DNA, the adenovirus remains in the genome of the transfected cells. This makes GMO problematic.
An example of the differences between these technologies could be explained with the application of glyphosate resistance plants. Glyphosate is an herbicide commonly used in row crops (soybeans, maize and cotton). The substance inhibits the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) from converting acids essential to the biosynthesis of vital plant compounds which will kill the plant. In the 80s, glyphosate tolerance was introduced through genetically engineering the plant to producing more EPSPS in the chloroplast of the plant’s cells, so it won’t die when glyphosate is applied. Scientists inserted a wild variant (foreign DNA) of the enzyme so the plant would produce 40-80 times more EPSPS to stay alive. Hypothetically, if CRISPR/Cas9 were to be used to knock-in more EPSPS genes to create a highly glyphosate resistance plant, no “vehicle” (adenovirus) will remain in the host plants.

CRISPR/Cas9 also helps to improve yields and health of plants. The Cavendish bananas, for example, could benefit from this technology. 95% of bananas are produced from this single cultivated variety. These bananas are sterile and can only reproduce by cloning, as they do not have seeds. The lack of genetic diversity makes them extremely vulnerable.

Currently, there is a powerful banana fungal strain called Tropical Race 4 (TR-4) that is devastating the Cavendish variety worldwide. Colombia declared a National State of Emergency in August 2019 due to this TR4 pathogen. Scientists in Brisbane and agritech companies in the U.K. are experimenting with CRISPR/Cas9 to create TR-4 resistant Cavendish bananas. If no actions are taken, the Cavendish bananas could go extinct, like the Big Mike bananas which were wiped out by the Tropical Race 1 (TR-1), an earlier strain of the TR-4 fungus in the 50’s (National Geographic, 2019).

Dealing with Food Waste and Food Loss

Better waste management is another way to improve the future of our food system. The latest available food waste data is from researchers at the Swedish Institute for Food and Biotech hired by FAO in 2011. It is estimated that one-third of the food produced in the world for human consumption is lost or wasted, amounting to 1.3 billion tonnes per year. The global food loss and food waste cost about US$1 trillion per year (FAO, 2014).
In developed economies, retail level food is wasted due to quality regulations and aesthetic standards. In developing economies, food is wasted due to a lack of suitable infrastructure and poor harvest techniques. Over consumption (consumption in excess of nutrient requirements) also contributes to GHG emissions (Alexander et al., 2017). According to Hadjikakou (2017), over consumption contributes to around 33% GHGs associated with food in Australia. According to IPCC (2019), changes in consumption patterns and over consumption have contributed to about 2 billion adults being overweight while 821 million people are currently undernourished.
According to a white paper by The Economist Intelligence Unit (2016), on a per capita basis, the following three countries produce the most food waste/loss globally: Saudi Arabia (427kg/person/year), Indonesia (300kg/person/year), and U.S. (277kg/person/year). Companies such as Greenbelt Resources Corporation has begun implementing its “ECOsystem process” in Indonesia to convert food waste into bioproducts such as high value protein, potable water and bioethanol. Furthermore, the Food and Land Use Coalition is currently building a cross-sector programme to reduce food loss and waste in Indonesia by 50% by 2030 (WBCSD, 2018).

A report published by the World Economic Forum in collaboration with McKinsey (2018) estimates that food-sensing technologies for food safety, quality and traceability could reduce food waste by 5%-7% by 2030. Fresh food is most vulnerable to loss. Optimal technology will not only help retailers but also smallholders to prevent food loss.

Around the world, supply chain technology is also helping to reduce food loss. For example, CoolAsia, a Singaporean fleet management technology company, offers multiple tracking solutions, such as temperature and humidity tracking at different locations within a refrigerated container. This helps companies make better decisions to prevent food spoilages. Traceability in the supply chain also provides additional benefits such as transparency for smallholder farmers.
SUMMARY

This paper has looked at the future of our food supply chain through the lens of supply and demand. It is clear that the demand for animal protein from emerging markets will not be sustainable. If we want to meet UNFCCC’s key goal “to ensure that food production is not threatened” in a “time-frame sufficient to allow ecosystems to adapt naturally to climate change”, radical measures are needed from both the supply and demand side.

From the demand side, consumers will need to be educated on the impact of animal protein on the environment. This needs to be extended to emerging markets, which are large drivers of demand. Culture is also a driver of diet choice, thus, education needs to be tailored to specific cultural needs. For aging populations, the health benefit of a plant-based diet will need to be advertised as this demographic will grow in importance. Reducing domestic food waste will also make a drastic difference.

From the supply side, companies are working hard to create plant-based alternatives, but this is limited to Western markets, apart from milk alternatives due to lactose intolerance in the East Asia, Africa, South America. China, India and Indonesia will be the key markets to introduce protein alternatives to due to the volume of demands. Biotech (including CRISPR/CAS9) in food production will increase in importance and we will continue to see investors picking up interest in this sector. Food loss and waste in the supply chain cannot be overlooked as our resources tighten.
APPENDIX  QUICK FACTS ON ALTERNATIVE PROTEIN KEY INGREDIENTS

UNDERSTANDING SOY
(Sources: USCUSA, WWF, USDA, FT, IPCC)

- 6% soybeans grown worldwide are for direct human consumption, while 70-75% ends up as feeds for cattle, poultry, etc.

- Brazil (31%), US (32%), Argentina (19%) are the largest producers of soy. The largest importers are China, EU-28 and other Asian countries.

Soy Production

- China was the largest importer of US soybeans, buying around 25m-30m tonnes annually. Shipments have plummeted recently due to US-China trade war (5.3m tonnes first five months of 2019 vs 15.2m tonnes same period in 2018).

- According to Grandview Research (2018), Soy protein concentrate was the highest consumed form of plant-based ingredient, accounting for over 34% of the global demand in 2018. The key reason for the high market share of this segment is the fact that soy has a negligible amount of cholesterol and saturated fats. Soy protein isolate was the second largest segment accounting for over 30% of the global demand in 2018. It is a refined form of soy protein, comprising of 90% protein content. It is utilised in meat products for improvising the quality and texture. Also, these are rarely found in stores and mostly used in food industry.

- In the 20 years from 1993 to 2013, a production increase of 141% can be observed (117m tonnes to 284m tonnes), while the agricultural area only increased by 88% (60m ha to 113m ha). Besides a massive increase in soy production over this period of time, there was also a significant increase in productivity.

- Soy has been associated with significant deforestation in Brazil. In the new IPCC Special Report on Climate Change and Land (2019), government data has revealed that three football pitches are deforested per minute in the 7 months since president Bolsonaro came to power.

- Argentina and Brazil are reported to export 60 percent of their production and the USA about 16 percent. The market for non-GM soy seems to be growing and may be increasingly important in the future.

- Genetically modified soy has reached 50% of global GMO crop area in 2017.
UNDERSTANDING VITAL WHEAT GLUTEN
(Sources: Mordor Intelligence, Grand View Research, FAO)

• Wheat gluten is widely used in meat alternative products. Wheat gluten is made by washing wheat flour dough with water until all the starch granules have been removed, leaving the sticky insoluble gluten as an elastic mass, which is then cooked before being eaten.

• Wheat gluten emerged as the largest product segment in 2015 and is estimated to generate over US$840.1 million in revenue by 2025.

• According to latest research, the global wheat gluten market is expected to register a CAGR of 8.21% during the forecast period, 2018 to 2023.

• The industry in Asia Pacific is projected to witness substantial growth over the next decade owing to various developments across major economies. The regional market is expected to grow at a CAGR of 4.8% from 2016 to 2025.

• Archer Daniels Midland (ADM), Agridient, MGP Ingredients, AB Amilina, Cargill Inc. and Manildra Group are few of the key players in the global wheat protein market.

• From the latest available data in 2014, China produces the most wheat at 126m tonnes (17%), followed by India at 96m tonnes (14%) and Russia at 60m tonnes (8%).

Wheat Production, 2014
Annual agricultural production of wheat, measured in tonnes per year

Source: UN Food and Agriculture Organisation (FAO)
UNDERSTANDING ALMONDS
(Sources: Almond Board of California, Almond Board of Australia, International Dried Fruit Council, Absolute Report, IPCC)

- The global Almond market is valued at US$6,140 million in 2018 and will reach US$8,930 million by the end of 2025, growing at a CAGR of 4.8% between 2019-2025.

- The US produces 82% of almonds worldwide, largely in California. Of this, 33 per cent is consumed in the US and Canada, while 67 per cent is exported to 90 countries.

- The majority of growers are small family farmers (91% in California).

- California’s drought, wildfires and increase in temperature caused by climate change could heavily impact the world’s almond production. The water intense crop also faces high risks from California’s increasing droughts.

- Wonderful Pistachios and Almonds, Blue Diamond, Panoche Creek Packing, Spycher Brothers, Select Harvest, Mariani Nut Company, Waterford Nut Co, Treehouse, Belehris Estates, California Gold Almonds, Hilltop Ranch, The Almond Company, D.V.Enterprise, Harris Woolf California Almonds, Patrocinio Lax and Sran Family Orchards are the key players in the global almond market. These 15 players took up about 60% of the global market in 2016/2017.

- Almond hulls and hash are used for animal feeds.

Almond Tree Fruit Weight
crop year 2017/18

- Hulls 4,527 billion lbs
- Kernels 2,264 billion lbs
- Shells 1,593 billion lbs

World Almond Production
crop year 2017/18

- US 82%
- Australia 5%
- EU 5%
- All others 2%
- Chile 1%
- Tunisia 1%
- Morocco 1%
- Turkey 1%
- Iran 1%

Top Global Destinations
crop year 2017/18

- Top 10 export markets represent 71% of total export shipments

Sources: Almond Board of California, Almond Board of Australia and International Dried Fruit Council

APPENDIX
APPENDIX

UNDERSTANDING OATS
(Sources: Research and Markets, USDA)

- Oats are predominantly used as animal feed, cosmetics and consumer food. Majority of the produced oats is used as animal feed (95% in the United States and 70% in Germany), while cosmetics constitute a minute fraction of oats consumption.

- The global oatmeal market was valued at US$10,475 million in 2017, and is projected to reach US$11,907 million by 2027, growing at a CAGR of 1.3% from 2018 to 2027.

- According to USDA, in 2018/19 (preliminary) the total world production for oats is estimated to be 22.01 million metric tons. The EU produces 35% of the world’s oats (USDA doesn’t provide the breakdown of the countries), Russia produces 21% and Canada 16%. US, Brazil and Australia produce 4% each.

- In case of the demand for oats, US companies have gained preference over multinationals due to the strong market power. The global leaders in the oats market are The Quaker Oats Company, Grain Millers Inc., Blue Lake Milling, Avena Food Ltd and Richardson International, among others. Food market giants like PepsiCo are trying to enter the market in an effective way. PepsiCo opened its first Quaker Oats plant in China in October 2015 in an effort to expand its nutritional business in the country. Companies, both at local and international levels, are focusing on addressing specific challenges, such as crop protection, sustainable protein production, food processing and manufacturing efficiency, among others.

UNDERSTANDING COCONUT
(Sources: FAO, Gro-intelligence, APCCSEC, USDA)

- Coconut is grown in over 90 countries worldwide, but the majority of global supply comes from Asia.

- Asian and Pacific Coconut Community (APCC) is an 18-member intergovernmental organisation covering >90% of global production.

- 72% is produced by Indonesia, the Philippines and India. 2016 global production was 59.3 million metric tonnes, of which Indonesia produced 17.7 million metric tonnes, Philippines 13.8 and India 11.1.

- Copra production was ~5.5 million MT globally in 2017, of which ~4.2 million came from Asia.

- Coconut oil production was around 3.4 million MT in 2017. Philippines is the largest producer and exporter of coconut oil (~1.1 million MT, 36% global market share), followed by Indonesia (~0.9 million MT, 29% global market share).

- FAO data is commonly referenced, but significant discrepancies in statistics is evident. FAO can underestimate.

- Approx. 12.2 million hectares of coconut plantations were harvested globally in 2016.

- Over 95% of this was farmed by smallholders of 0.5-4 Ha each, with no cooperative structures.

- Some state & private industrial plantations using monoculture do exist, but are not generally commercially viable.

- There are approximately 16 million smallholder coconut farmers worldwide.
• 80-100 million people globally depend on coconut and its processing for livelihoods.

• Area harvested has steadily increased over time, but production has stagnated in the last decade.

• Yields have fallen by ~10% in the last 10 years.

• Worldwide demand for coconut is growing at a rate of ~10% a year due to the rising popularity of coconut water, coconut milk and virgin coconut oil.

• Increasing publicity over numerous health benefits with “superfood” status (e.g. coconut water as a healthier sports drink substitute, virgin coconut oil as a treatment for Alzheimer’s, among many other health claims).

• Main importers of raw coconuts are China and the US.

• Main importers of coconut oil are the US, the Netherlands (distribution point for across Europe, but also has large major food companies such as Unilever, Mars and Friesland Campina), Germany (mainly in production of cosmetics) and Malaysia.

• Demand for organic virgin coconut oil is projected to grow at ~11% CAGR between 2019 and 2022.

• Demand for coconut milk is projected to grow at ~15% CAGR between 2019 and 2020, largely driven by the US.
UNDERSTANDING PEA PROTEIN
(Sources: Grand View Research, FAO, Fior Markets)

• Pea protein is a food with a neutral taste that is used in dairy alternatives such as cheeses and yogurt. It is extracted from the yellow pea, Pisum sativum, and has a typical legume amino acid profile.

• Green and yellow peas are used as raw materials for processing pea protein. Rising importance of organic farming owing to strong regulatory scenario in U.S., Australia, and Brazil will provide incentives to farmers, increasing the production of pea crops and enhancing raw material availability. This in turn, is expected to boost the market growth during the next few years.

• Canada is the largest producer of dry peas followed by Russia and the US.

• Majority of manufacturers are located in U.S. and Western Europe owing to easy access to raw materials and equipment.

• North America held the largest market share for consumption of 37.6% in terms of volume in 2018. Europe was the second-largest consumer in 2018. Asia Pacific is likely to witness the fastest growth during the forecast period. It is likely to expand at a CAGR of 15.3% till 2025.

• According to Fior Markets, the global pea protein market is expected to reach US$189.3m by 2025 at a CAGR of 24.3% (2018-2025).


• In December 2018, Axiom Foods introduced Cannatein, a hemp protein ingredient, and Vegotein N, a pea protein ingredient. Because of the ingredients’ neutral taste, flavor-masking agents are not needed in applications containing the ingredients.

Global Pea Protein Market Share by Application 2018

Source: Grand View Research


Break Through (2018). [online] Available at: https://docs.wixstatic.com/ugd/148cb0_a0d7c18a1b64e68a98c8c8f18a42889.pdf [Accessed 19 Aug. 2019].


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